VLBA Technical Report No. 25

VLBA Frequency Converters
Modules T101 - T110

Paul Lilie David Weber
January 1994

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1.0 INTRODUCTION

Manual Description

This manual describes nine VLBA Frequency Converter modules T101 through T110. T109 has not yet been implemented. This is a "How does it work?" manual; the emphasis is on the Frequency Converter's theory of operation, alignment and bench tests. Construction details are not included but all drawings used in converter fabrication are listed in the Bill of Materials drawings. Section 5 contains Data Sheets for the special-purpose components used in the Frequency Converters. The Appendix, Section 6 lists VLBA Technical Reports and other references that are relevant to the frequency converters. Section 6 also contains a list of all converter module's functional drawings and a list of the LO frequencies that are used with the converters.

This manual is an upgrade of the earlier undated draft entitled Frequency Converter Technical Manual for CONVERTER MODULES by Erich Schlect, for six converters T101 through T108, and describes the modules in more detail. Since the publication of this earlier manual, modules T102 and T110 have been developed and other changes have been made, such as the addition of transfer switches to all frequency converter modules. The details of these changes will not be described; this manual deals with the current design state. The tables, drawings, figures, design descriptions, etc. contained in this earlier manual have been retained. The test procedures of this earlier manual are included in Section 2.7. VLBA Technical Report No. 15 (Rev. A), AN INTRODUCTION TO THE VLBA RECEIVING AND RECORDING SYSTEM was also an important reference for this manual.

A brief scrutiny of the frequency converter block diagrams (Section 3) shows that the converters have similar features but they differ in some details. This commonality suggests that important Frequency Converter properties can be generically described in a single section and the features and specifications unique to each type of converter can be described in dedicated sections. This dual treatment is used in this manual because it eliminates redundant descriptions of common features.

Accordingly, Section 2 contains the first part of the Theory of Operation and is a general description of the operation of a frequency converter. It cites important parameters and their influence on the RF conversion process. Section 2.5 contains descriptions of NRAO subassemblies and data sheets for components used in two or more converter modules. Section 2.7 describes converter alignment and performance test procedures.

The second part of the Theory of Operation in Sections 3.1 through 3.9 for converters T101 through T110 describes the operation and features unique to each type of frequency converter. Each Frequency Converter description includes the converter Block Diagram, Assembly Drawing, Bill of Materials (BOM) and data sheets for components peculiar to the converter.

Converter Components and Physical Description

Converter implementation dissimilarities result in part from the fact that the components used in each converter type are frequency dependent over a fairly small range, and the T101 - T110 set of converters span a wide range of frequencies. Secondly, some converters have modes and circuitry unique to the type.

For a given circuit function, the component's frequency dependencies generally require the use of different components in these nine frequency converter modules. For convenience, these components are listed in Section 6.

Most of the frequency converter components are standard commercial, connectorized modules that are selected to meet the converter's frequency and performance specifications. The converters also contain some NRAO subassemblies that use commercial components such as mixers, amplifiers, etc. Two NRAO subassemblies (Amp/Attenuator C53500A006 and Amp/Power Divider A53500A007) provide IF signal amplification, gain control and output power drive to the IF system - functions common to all converters. The Amp/Attenuator is a voltage-controlled amplifier/attenuator and the Amp/Power Divider provides the required power drive to the IF system. Because these functions are common across all converters, they provide circuit uniformity and the commonality enhances maintainablilty. These two subassemblies are described in Section 2.5.

NRAO-designed subassemblies are also used in some applications where suitable commercial connectorized components were not available or better performance is realized in a custom-designed assembly. T101 uses an Input Amplifier A53500A017 and a Converter Unit C53500A011 consisting of mixers, amplifiers and a power divider. T102 uses a Converter Input Amplifier A53500A018 and a Filter Unit Assembly A53500A013. The Filter Unit Assembly contains four mixers, eight amplifiers and two power dividers packaged on a PC board, which makes T102 more compact than it otherwise would have been. T103 uses an NRAO LO Amp/Detector C53500A012 because it is necessary to detect the LO signal level. T106 and T110 (dual band converters) have an IF Gain Relay Assembly A53500A009 to switch the Amp/Attenuator control voltages between two sets of front panel gain control potentiometers. T108 has a switch and LED driver PC board because there are four selector switches that must be driven. These subassemblies are described in Sections 3.1, 3.2, 3.3, 3.6, 3.8 and 3.9, respectively.

Figure 1 on the next page shows a typical frequency converter's front and rear panel views. Two front-panel potentiometers permit manual adjustment of the converter's IF gain and two SMA jacks enable the converter's IF outputs to be monitored while performing these adjustments. Two 50 Ohm terminators are normally connected to the jacks and should only be removed to perform gain adjustments or to monitor the signals on the jacks. Five rear-panel OSP plugs are used for the RF and LO inputs and IF outputs. P1 carries the LO drive, P2 and P3 carry the RF inputs from the Front-End and P4 and P5 carry the IF outputs. The rear-panel AMP P11 power connector provides power and switch control signals to the module. P11-42 is analog signal ground and P11-34 is power ground; both are connected to the module frame. P11-16 is +15 volt power and P11-27 is the transfer switch drive. These are the standard connector assignments. The more complex converters use other plug locations and additional control and monitor signals are carried by P11. These additional plug and P11 pin-signal assignments are described in the particular converter sections.

VLBA Receiving Bands

The VLBA is currently equipped to receive nine bands consisting of: P (90 cm/330 MHz and 50 cm/610 MHz); L (20 cm/1.4 GHz); S (13 cm/2.3 GHz); C (6 cm/4.8 GHz); X (4 cm/8.4 GHz); U (2 cm/14 GHz); K (1.3 cm/23 GHz); and Q (0.7 cm/43 GHz). The Front-End and associated frequency converter for the W (0.35 cm/86 GHz) band are not presently implemented. Two separate converters (for 330 MHz and 610 MHz) are used for the P band and T106 functions in both X (4 cm/8.4 GHz) and K (1.3 cm/23 GHz) bands.

The Pie Town VLBA antenna has a prototype X-band converter (T107) installed for the 2.8 cm/10.7 GHz band. There are no current plans to implement this band on the other VLBA antennas.

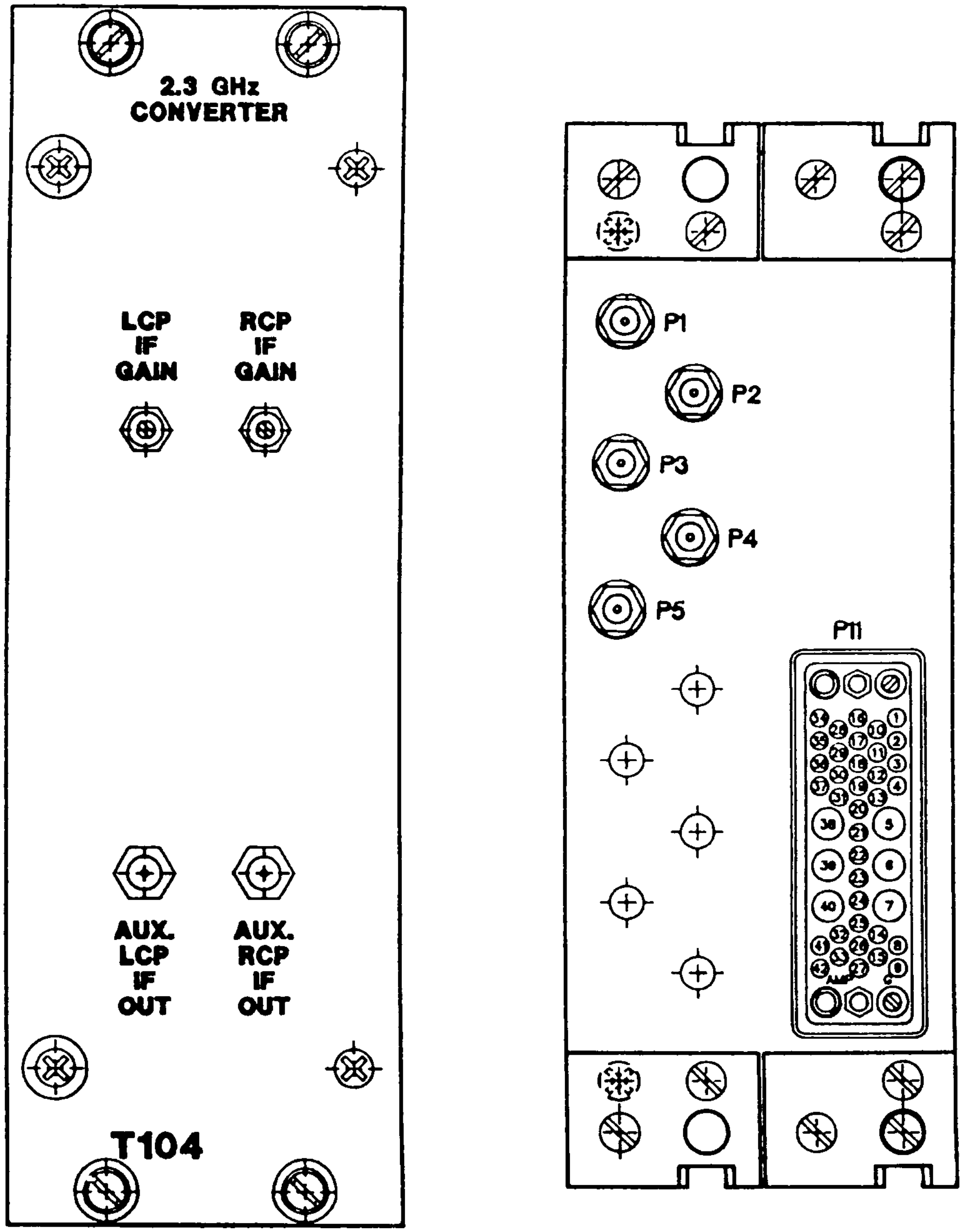

FIGURE 1, TYPICAL CONVERTER FRONT AND REAR PANELS

Frequency Conversion

The VLBA receiving system uses the superheterodyne principle. In a superheterodyne receiver, a local oscillator signal (LO) is mixed with the Received Signal (RF) from a tuned amplifier to create two signals that are the sum and difference of the RF and LO frequencies; these signals are sometimes called side-bands. The lower or difference frequency side-band is usually amplified as an Intermediate Frequency (IF) signal and is converted to produce a base-band output signal for further processing. The upper or sum frequency side-band is usually rejected by a filter. The VLBA receiver implementation details vary between bands but most of them conform to this superheterodyne scheme. The one exception is T102; see the T102 paragraph below.

The function of converting an RF signal to another frequency by the superheterodyne process is called frequency conversion. A frequency conversion is a downconversion if the IF frequency is lower than the RF frequency; if the IF frequency is greater than the RF frequency, it is an upconversion. For example, if the RF frequency is 100 MHz and the LO frequency is 1000 MHz, the lower sideband IF frequency is 900 MHz. T101 (90 cm/330 MHz) uses up-conversion because the RF frequency is so low; T102 (50 cm/610 MHz) uses both down-conversion and up-conversion but the IF output frequency is the same as the RF input frequency. These two converters have narrower IF bandwidths than the higher frequency converters.

In a frequency conversion, the LO frequency can be either higher or lower than the RF frequency to produce a sum or difference IF signal but other considerations may influence the choice of an LO frequency. These are the portion of the RF bandwidth to be selected and the rejection of image and interfering signals discussed below.

Refer to the table of VLBA LO frequencies in the Appendix, Section 6. This table lists possible LO frequencies for modules T103 through T110. Note that the LO frequences may be above or below the observing frequencies; the selection is an observer's option since either set or a suitable combination from either set may be used.

The VLBA Front-End bandwidths are generally much wider than the IF bandwidths; the LO frequency determines the 500 MHz portion of the RF bandwidth selected for IF amplification. For example, the bandwidth of the L-band Front-End is 560 MHz, about 1.1 times the 500 MHz IF bandwidth, so two LO frequencies are required to fully cover the band. The bandwidth of the U-band Front-End is 3.4 GHz, about 6.8 times the IF bandwidth; thirteen LO frequencies are used to cover the band.

To reduce the LO tuning range, the LO frequencies for converters T103 and T104 (1.5 GHz and 2.3 GHz, respectively) are higher than the RF frequencies but the higher frequency converters T104 through T110 use LO frequencies below and above the RF frequencies. If the IF = LO - RF, the spectrum of the IF signal is reversed relative to the RF spectrum; the high end of the RF signal is converted to the low end of the IF signal, and vice versa. When testing a converter, it is important to keep this effect in mind to avoid confusion about the character of the IF spectrum.

In the VLBA, the input stages are the uncooled (P-Band) and cooled Front-Ends. The Front-End is typically an assembly containing a polarization transducer, broadband amplifiers and noise calibration circuitry.

The incoming astronomical signal is split into two components: LCP for Left Circular and RCP for Right Circular Polarization by the polarization transducer. The LCP and RCP signal components follow identical but separate paths through the front-ends, frequency converters, IF system, base-band conversion and recording systems. Implementation details of the IF, base-band conversion and recording systems are beyond the scope of this manual and are not described. Readers interested in these other aspects of the VLBA electronics are referred to VLBA Technical Report No. 15 (Rev. A).

Each Front-End has an associated frequency converter, one of the T101 - T110 modules, that produces the IF signals. These signals are selected by coaxial selector switches in Rack B for transmission to the IF system in

Rack C in the Station Building. The IF signal ranges from 500 to 1000 MHz.

Front-End frequencies for the L through Q bands range from 1.4 GHz (L-band) to 43.0 GHz (Q-band). A single-conversion implementation for this range of frequencies would require a Local Oscillator tuning range of 2.0 GHz to about 40 GHz - a difficult design. To reduce this LO tuning range requirement, frequency conversions have been implemented in the K (1.3 cm/23 GHz) and Q (0.7 cm/43 GHz) Front-Ends. The K-band Front-End outputs a first IF of 9.4 - 9.9 GHz and the Q-band Front-End outputs a first IF of 7.9 - 8.9 GHz. These lower frequency first IF signals drive T106 (K-band) and T110 (Q-band) respectively. The upper limit of LO tuning range is thus determined by the U (2 cm/15 GHz) Front-End so that the required Local Oscillator (L104) tuning range is 2 -16 GHz. L104 frequency settings are determined by the formula: $F_{L104} = 500 \times N \pm 100$ MHz where N is an integer ranging between 4 and 32. Typical L104 frequency settings are: 2.1, 2.4, 2.6, 2.9, 3.1, 3.4, 3.6 .. 12.9, 13.1, ... 15.6 and 15.9 GHz. Note that the differences between frequency settings are alternately 300 MHz and 200 MHz. For consecutive N values, the frequency differences between **500 x N +100** settings and the frequency difference for **500 x N -100** settings are both 500 MHz.

The P-band (90 cm/330 MHz and 50 cm/610 MHz) converters use a fixed LO frequency of 500 MHz and T102 also uses 100 MHz as an LO.

One converter module, T102 is not a superheterodyne converter because the input RF is not converted to an IF; the output frequency is also the RF input frequency because it is within the 500 to 1000 MHz IF band. However, T102 does use downconversion and upconversion for convenience in the implemention of a narrow band filter; for this reason the T102 is called the 610 MHz Filter Module.

2.0 GENERAL FREQUENCY CONVERTER THEORY OF OPERATION

This section is a general description of the function performed by the VLBA Frequency Converter modules. It describes the circuitry, important characteristics, and specifications of these modules. Figure 2 below is a general block diagram of these modules.

2.1 GENERAL VLBA CONVERTER FUNCTIONAL DESCRIPTION

As shown in Figure 2, the frequency converter has two parallel signal paths left to right for the RCP and LCP signals; the Front-End RF inputs are on the left and the corresponding IF outputs are on the right. The LO input drives two mixers through an LO signal amplifier, power divider and LO isolation filters.

The frequency converter consists of the following circuit groups: Transfer Switch, RF Circuitry, Mixer, LO Drive Circuitry and IF circuitry.

Transfer Switch

A transfer switch at the input enables the two RF inputs to be interchanged for diagnostic purposes and to verify that the two signal paths have identical gains. Transfer switch configurations vary between converters but this is a common feature.

The transfer switch must provide very good isolation between the LCP and RCP signal paths (typically about 60 dB), low insertion loss (typically about 0.2 to 0.4 dB) and a low VSWR (typically about 1.2 to 1.5)

RF Circuitry

The two RF signals from the transfer switch outputs are fed to two sets of RF Circuitry that consist of isolators and, in some converters, RF amplifiers and bandpass filters. Bandpass filters may be used in the RF signal path to define the receiver signal bandwidth and to reject out-of-band signals. In some bands, the bandpass filters

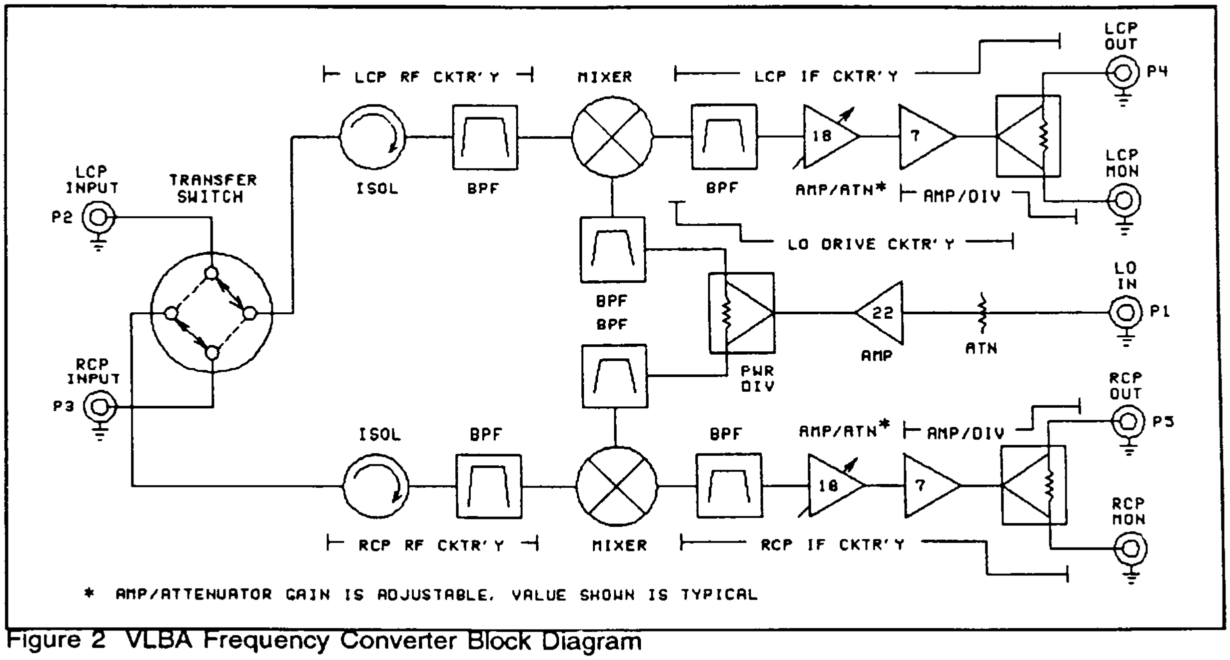

Figure 2 VLBA Frequency Converter Block Diagram

are located in the Front-Ends; if not in the Front-Ends, they are installed in the frequency converter input circuitry.

Some of the lower frequency bands have strong interfering signals adjacent to the Radio Astronomy bands. To limit these interfering signals early in the signal path, the L (20 cm/1.5 GHz), S (13 cm/2.3 GHz) and C (6 cm/4.8 GHz) Front-Ends contain band-limiting filters. Bandpass filters are also installed in the higher band (K 1.3 cm/23 GHz and Q 0.7 cm/43 GHz) Front-Ends on the mixer's first IF output. Therefore, the T106 (K) and T110 (Q) do not contain bandpass filters in the input circuitry. The two P-band, the X-band path in T106 and the U-band T108 converters contain bandpass filters.

The isolators in the input circuitry reduce the effect of line reflections and because of their directivity, they prevent mixer-generated energy from leaking back into the Front-Ends. See the mixer discussion below. Isolators are non-reciprocal transmission path devices; microwave energy may travel the transmission path in one direction with little loss but will be greatly absorbed when applied in the other direction.

Losses in the RF Circuits are the insertion losses of the RF Bandpass filter and the Isolator. Losses for the filters range from 0.2 dB (T106) to 2.3 dB (T102) and 0.2 dB for the Isolator.

LO Drive Circuitry

The LO Drive Circuitry consists of an amplifier, attenuator, bandpass filter and power divider.

The amplifier boosts the LO signal power. The attenuator is selected to provide the appropriate power level to the mixers.

The power splitter provides the LO drive to each mixer through LO frequency bandpass filters. The power divider and filters minimize cross-coupling between the LCP and RCP signal paths to preserve signal polarization effects. The power divider provides about 30 dB of isolation between its two LO ports and has an insertion loss of 0.3 dB.

Mixers

Mixers are the circuit elements that combine the RF and LO signals to produce the sum and difference signals: $F_{RF} \pm F_{LO}$. The difference frequency (F_{RF} - F_{LO}) or (F_{LO} - F_{RF}) is selected by the IF Circuitry for output to the IF system. T102 selects $F_{RF} + F_{LO}$.

The converter modules use double-balanced mixers. Section 2.2 describes important mixer properties.

Mixers are not lossless devices. Some of the RF input power is dissipated in I^2R losses and the balance is lost in the form of RF power of frequency terms produced by the mixers but not used by the converters. Examples are the undesired sideband and intermodulation products. This loss is termed conversion loss and is described in Section 2.2. Mixer conversion loss is typically 6 to 9 dB.

IF Circuitry

The IF Circuitry consists of IF Bandpass filters and two NRAO subassemblies, the Amp/Attenuator and Amp/Divider.

IF Bandpass filters (bandpass of 500 to 1000 MHz) select the desired sideband frequency, and eliminate the undesired sideband and unwanted harmonic and intermodulation products that are described in Section 2.2.

The filter outputs are amplified by adjustable-gain NRAO Amp/Attenuator module C53500A006 and the

NRAO Amp/Power Divider module A53500A007. The Amp/Attenuator module uses a front-panel potentiometer to adjust the converter's IF output to a -40 dBm level. The Amp/Attenuator gain shown on the block diagram is a typical value; the gains are adjusted to equalize the two outputs at this level. The Amplifier/Power Divider module typically provides 4.2 dB of gain for transmission of the IF signals to the baseband converters in the Station Building. The power divider on the output of this amplifier evenly divides the IF output to drive a front panel monitor jack for monitoring and gain adjustment purposes and a rear panel output to the IF system via the B-Rack IF selector switches. Since it is a two-way splitter, each output is 3 dB below the splitter input power level. The power divider also provides about 30 dB of isolation between these front and rear panel outputs. The converter IF output signal levels have a power spectral density of -67 dBm/MHz (-40 dBm in the 500 MHz bandwidth). The front panel jack is normally terminated in a 50 ohm terminator load.

The Amp/Attenuator, Amp/Power Divider, K&L 6B120-750/X550 IF Bandpass Filter and transfer switches are described in Section 2.5.

The losses in the IF output circuitry are the IF bandpass filter insertion loss of 0.38 dB and the 3 dB loss of the power divider in the Amp/Divider module. The Amp/Attenuator and Amp/Divider offset these losses and provide a settable net gain ranging from 19.5 to 38.7 dB.

2.2 IMPORTANT PROPERTIES OF A VLBA FREQUENCY CONVERTER

Inter-Channel Isolation

The LCP and RCP signal paths should be electrically isolated to prevent cross-coupling of RF and IF signals between the two polarization paths; this is important because the signals in each path may contain astronomical features distinct to the path. Since the signal paths between components are solid-sheath coax with negligible leakage, the only coupling between the LCP and the RCP signal paths are the transfer switch leakage and the LO signal drive circuitry. Note that these two coupling paths are paralelled between the LCP-RCP signal paths; therefore, the isolation of each of these shunt paths must be very good to realize a good module inter-channel isolation. The interchannel isolation specification for all frequency converters is 65 dB.

The converters do not require extensive isolation measures because the RCP-LCP signal separation provided by the Front-End polarization splitters are seldom better than 30 dB.

The isolation of transfer switches decreases with increasing frequency; the highest frequency to be converted is 14 GHz in T108. The 23 GHz (K) and 43 GHz (Q) Front-Ends have mixers that produce a first IF of about 9 GHz.

The data sheet for the Transco 710C70100 transfer switch that is used in all T-modules except T102 and T108 shows a RF typical path-to-path leakage of 90 dB at 100 MHz, flat to 7 GHz; linearly decreasing to 60 dB at 18 GHz. The RLC SR-TC-R-D transfer switch used in T108 has a typical RF isolation 90 dB at 1 GHz and 70 dB at 14 GHz, the highest conversion frequency.

The LO drive circuitry has a two-way power divider and two bandpass filters at the LO frequency. To preserve isolation, the LO drive to each mixer must not contain RF or IF signal components coupled out of the other path's mixer LO port. The mixers provide relatively good isolation; the isolation between the mixer's RF-LO and IF-LO ports is typically about 30 dB. Additional isolation is provided by the two series elements in each mixer's LO drive path - the bandpass filters and power divider. The power divider typically provides about 30 dB of isolation between the power divider's LO ports and the LO filters provide additional attenuation of the RF and IF signals.

Converters T104, T105, T106, T108 and T110 have bandpass filters installed in the LO drive to the mixers. Consider a typical example, the T104. Examination of the attenuation curves for the K&L 3250-3000/600 filter used in T104 shows that the two filters add about 60 dB of attenuation at the RF frequency (2.3 GHz) and about 100 dB at the IF frequency (500-1000 MHz). In conjunction with the isolation provided by the mixers and power dividers described above, the LO filter's attenuation makes this shunt path isolation greater than 100 dB at the RF frequency and greater than 160 dB at the LO frequency.

LO-drive bandpass filters are not installed in T101, T102, T103 and T107. As mentioned above, each double-balanced mixer provides about 30 dB of RF and IF isolation to the LO port and the LO power splitter typically provides an additional 30 dB of LCP mixer LO-port to RCP mixer LO port isolation. Thus the isolation of this shunt path is on the order of 90 dB (30 dB for each mixer plus 30 dB for the power divider).

Mixer Characteristics

Frequency mixing is a complicated process with many subtle considerations. A frequency mixer accomplishes frequency conversion as a result of a circuit element's non-linear voltage-current response. Forward-biased diodes, the emitter-base junction of a transistor and single and double-balanced mixers are commonly used mixer devices.

All mixers generate signals (sidebands) that are not only the sums and differences of the RF and LO inputs but also **harmonics** of the RF and LO; thus, the output frequencies are of the form $NF_{RF} \pm MF_{LO}$, where N and M are integers. These harmonic components are the result of the diode's nonlinearity. The current through a diode can be described by a power series in the applied voltage V[1]:

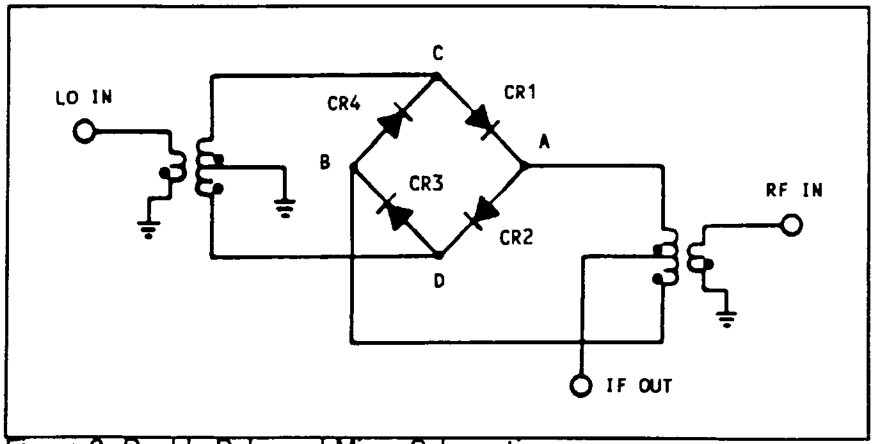

Figure 3 Double-Balanced Mixer Schematic

$$i = a_0 + a_1 V + a_2 V^2 + a_3 V^3$$

The sideband signals produced when N and M are 1 are the sum and difference signals commonly associated with mixing. If no other sidebands were produced in a mixer (i.e. M and N are 1, **only**) and there were no loss in the mixer, the sum and difference signals (first sidebands) would each be 3 dB down relative to the RF input power level. This is the simplest case of mixer **Conversion Loss**. See the discussion below.

If M and N become greater than 1 as is the actual case for a diode mixer, the amplitudes of the first sidebands are lower than -3 dB relative to the RF level because most of the RF input power is dissipated as I^2R loss in the diode resistance; the balance is distributed over the higher order sidebands. The amplitude of the higher order (i.e. N and M greater than 1) sidebands diminish as a function of the magnitude of the power series coefficients a_n. In general, a diode characterized by a sharply curved iV plot will have larger a_n than a diode with a less sharply curved iV plot. Schottky diodes are often used in mixers because of their fast recovery and low forward drop, typically about 0.25 volts. Consider the following example of harmonic mixer outputs. If a harmonic mixer had an RF input of 25 MHz and an LO input of 20 MHz, the sum and difference frequencies would be 45 MHz and 5 MHz respectively (for M and N = 1), and the low order harmonic (M and N greater than 1) frequencies would be 15 MHz, 65 MHz, 35 MHz, 85 MHz, etc.

The VLBA Frequency converters use double-balanced mixers, a more complicated diode mixer circuit. A double-balanced mixer consists of a diode ring driven by two well-balanced, center-tapped transformers. Since diodes are used, the power series terms mentioned above are a factor in the mixer's conversion process shown below. Figure 3 shows the schematic of a double-balanced mixer. Note that the LO drive transformer secondary winding center-tap is connected to ground and the IF port is connected to the secondary winding center-tap of the RF drive transformer. If CR_1 and CR_2 are identical and the LO drive transformer is balanced, then the voltage at point A is the same as the center-tap of the LO transformer, or ground. Similarly if CR_3 is equal to CR_4, the voltage at B is the same as ground. Therefore, there is no LO voltage across A and B and no LO voltage across the IF or RF ports; the LO port is thus **isolated** from the IF and RF ports.

Now consider the RF input. If CR_4 is equal to CR_1 and CR_2 is equal to CR_3, the RF voltage at C will be equal to the RF voltage at D. There will be no RF voltage difference between C and D and thus no RF voltage will appear at the LO port; the RF port is isolated from the LO port. From symmetry, it can be seen that the RF voltage

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[1] Interferometry and Synthesis in Radio Astronomy by Richard A. Thompson, James Moran and George W. Swenson, Jr.

at the IF port is the same as the RF voltage at C and D, or zero. Thus there is no RF output on the IF port; the RF port is **isolated** from the IF port.

The isolation between the RF, LO and IF ports is typically better than 30 dB. Imperfections in the component's characteristics reduce the isolation.

Since the LO input is "driving" the mixer, double-balanced mixers require a fairly high LO drive level. Standard LO drive levels are +7, +10, +13 and +20 dBm.

In contrast to the single diode mixer, the double-balanced mixer produces reduced levels of harmonic sum frequencies of the form $NF_{RF} \pm MF_{LO}$ for N and M greater than 1. The double-balanced mixer produces the desired sum and difference frequencies ($F_{RF} \pm F_{LO}$), and also produces intermodulation product frequencies of the form XF_{RF} x YF_{LO} where X and Y are integers and either or both is/are greater than 1. The generation of these intermodulation product frequencies is a disadvantage of the double-balanced mixer but these intermodulation products have low levels relative to the $F_{RF} \pm F_{LO}$ levels.

An important property of the double-balanced mixer's isolation/symmetry is the suppression by common-mode cancellation of all internally-generated harmonic (i.e. $NF_{RF} \pm MF_{LO}$) frequencies which result from even-order harmonic components of the LO and/or RF input signals. Examples of the suppressed harmonics are: $2F_{RF}$, $4F_{RF}$, ($2F_{RF} \pm F_{LO}$), ($F_{RF} \pm 2F_{LO}$) and ($2F_{RF} \pm 2F_{LO}$). The suppression is not perfect; stray unbalances and differences in component characteristics degrade the cancellation effect.

Odd order terms such as $3F_{LO} \pm F_{RF}$ and $5F_{LO} \pm F_{RF}$ are not suppressed and are solely a function of the a_n coefficients associated with the diode's transfer characteristic mentioned above. These higher frequency terms are typically about 60 or more dB down relative to the $F_{RF} \pm F_{LO}$ level and are rejected by the IF bandpass filter.

The formulas above illustrate various "spur" (spurious) frequencies generated by discrete frequencies. Although the LO is always a discrete frequency, in radio astronomy the received signal is usually a continuous band of noise or noise-like radiation.

These $NF_{RF} \pm MF_{LO}$ spurs are usually of little concern since they fall far from the frequencies of interest and can be easily filtered out.

Intermodulation products can be more troublesome, especially if there are strong interference signals present. Intermodulation products usually refer to spurious signals generated by two or more strong RF signals entering the mixer (or other non-linear components).

The most troublesome "Intermods" are the third-order, $2F_1 - F_2$ and $2F_2 - F_1$. Since these spurious appear close to F_1 and F_2, they cannot be filtered out if F_1 and F_2 are not filtered. Since these spurs are generated by the a_3V^3 term in the power series expansion mentioned above, they are called third-order. Similarly, there are fifth-order frequencies generated by the a_5V^5 term and so on.

By expanding these power series it can be shown that for equal power in F_1 and F_2, the power in the third-order terms will increase 30 dB for every 10 dB increase in F_1 and F_2. Therefore, if the fundamental power in F_1 and F_2 is increased indefinitely, the power in the intermods must eventually catch up and cross over the power in F_1 and F_2. This is illustrated in Figure 4 on the next page. The point at which the fundamental power and the intermod power cross is called the third-order intercept point.

In real life, this relationship holds very closely for low powers. At higher powers, compression will occur before the intercept point is reached, so it must be calculated by extrapolating the low-power lines on the graph.

A useful rule-of-thumb is that the 1 dB compression power is usually about 12 dB below the third-order intercept point. Some manufacturers specify one, some the other, some both.

The third-order intercept points of mixers and amplifiers are specified differently. Amplifiers are specified with respect to the output power levels, mixers with respect to the input power levels. This is not unreasonable since the highest power levels are found at the output stages of amplifiers and at the inputs of mixers (which are lossy).

When one or both of the "F_1, F_2" signals are broadband noise instead of discrete signals, the calculation of intermodulation levels becomes more difficult and requires Fourier analysis.

With either discrete or broadband signals, however, the effects of intermodulation products can be troublesome if interference that would normally be harmless is translated to a desired observing frequency.

Each mixer type's third-order intercept point is a function of the mixer's design but the 1:1 and 1:3 slopes are universal. Mixer specifications usually state the third order intercept point and third order IM products power level at some two-tone RF input power level, typically 0 dBm.

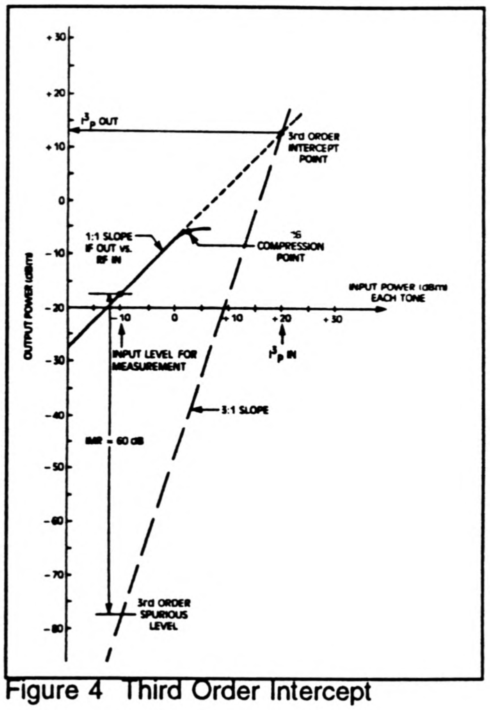

Figure 4 Third Order Intercept

Isolation is a measure of the circuit balance within a mixer. When the isolation is high, the amount of "leakage" or "feed through" between the mixer ports will be small. The isolation chart on the Watkins-Johnson M80C (used in T108) data sheets show that at an LO level of +7 dBm, an RF of 7 to 18 GHz and an IF of DC to 3 GHz, the LO to IF isolation is about 32 dB and the LO to RF isolation is about 33 dB.

The sum and difference frequencies output by a double-balanced mixer have equal power levels; a bandpass filter is required to select the desired frequency as the IF output. Most converter IF signal bandwidths are 500 MHz, using a 550 MHz bandpass filter with a center frequency of 750 MHz. The exceptions are the P-Band T101 and T102 converters, which have narrower IF bandwidths.

Input and Output VSWR

VSWR is a measure of impedance match and determines a circuit's power transfer. If there is an impedance mismatch in a power transmission system, a portion of the incident power is reflected back toward the source (hence lost) and the amount of reflected power is determined by the reflection coefficient, p. The reflection coefficient is given by $p = E_F/E_R$, where E_F is the forward wave voltage and E_R is the reflected wave voltage. VSWR is related to p by:

$$VSWR = \frac{1 + [\rho]}{1 - [\rho]}$$

where [p] is the absolute value of p. VSWR may also be expressed by: VSWR = $[E_{MAX}/E_{MIN}]$, the absolute value of the ratio of the maximum and minimum standing wave voltages.

VSWR is an important specification of a device's mismatch to a stated impedance (typically 50 Ohms) and is usually specified over a frequency range. VSWR is also a commonly-used composite measure of an RF circuit's component impedance mismatches. The composite VSWR is dominated by the largest VSWR in the component set. In this manual, the converter's input and output VSWR's are the composite VSWR's seen at the input and output ports.

A perfect impedance match implies a VSWR of 1:1 and consequently there are no reflections; all incident power is delivered to the load. Return loss is a commonly used measure of reflected power. Forward power is the power that is delivered to the load and return loss is the power reflected back toward the signal source.

Return loss may be calculated from VSWR by the following:

$$RL_{dB} = 10\ LOG_{10}\left[\frac{VSWR - 1}{VSWR + 1}\right]^2$$

Some VSWR, return loss, reflection coefficient, forward power and reflected power values are tabulated below.

VSWR	RETURN LOSS (dB)	REF COEFF (p)	FORWARD POWER (%)	REFLECTED POWER (%)
1.00:1	∞	0	100.0	0
1.10:1	26.4	0.05	99.8	0.2
1.2:1	20.8	0.09	99.2	0.8
1.3:1	17.7	0.13	98.3	1.7
1.4:1	15.6	0.17	97.2	2.8
1.5:1	14.0	0.20	96.0	4.0
2.0:1	9.5	0.33	88.9	11.1

Most of the converter component VSWR's are in the neighborhood of 1.2:1 or 1.3:1; thus about 98% of the incident power is passed to the load. Even with a VSWR as large as 2.0:1, 90% of the incident power is passed to the load.

Tables of VSWR, forward and return loss are sometimes found in RF device data books. A VSWR-Forward and Return Loss table is included in the Appendix, Section 6.

VSWR in a double-balanced mixer is a time average value with diodes shorting and opening at an LO rate. In addition, diode impedance and stray reactances vary over a frequency band; this tends to make impedance matching difficult. Examination of the Watkins-Johnson M77C (used in T106) data sheets show that the RF port VSWR is about 1.5 over the RF frequency range of 7 to 13 GHz. The isolators in the converter's input circuitry improve the module input VSWR by preventing mixer intermodulation and switching noise products from being reflected back toward the Front-Ends.

The input VSWR of T101 and T102 is determined by the RF input circuitry components VSWR's. The K&L bandpass filters both have a VSWR of 1.5:1 and the amplifiers both have an input VSWR of 1.5:1. T101's transfer switch VSWR is described below. (T102 does not have a transfer switch.) Thus T101 and T102's input VSWR's are probably about 1.5:1.

For converters T103 through T110, the input VSWR is a composite of the transfer switch VSWR and the isolator VSWR. With the exception of T107, Ditom Isolators are used as RF input isolators in T104 through T110. These Ditom isolators have typical VSWR's ranging from 1.18:1 (T105, T106, T110) to 1.3:1 (T104 and T108). T103 and T107 use Virtech isolators. Virtech data sheets were not obtainable at the time that this manual was written; the VSWR's of these two isolators are probably about the same as the Ditom isolators with the same part number.

Two transfer switches are used - the Transco 710C70100 and the RLC SR-TC-R-D. The Transco switch has a typical VSWR less than 1.01:1 at 100 MHz that increases linearly to 1.15:1 at 1 GHz, flat to 2 GHz, then increases to a peak of 1.3:1 at 12 GHz, and continues at this peak level through 14 GHz. The RLC SR-TC-R-D transfer switch has a typical VSWR of 1.05:1 at 1 GHz and linearly increases to 1.3:1 at 14 GHz. (Refer to the VSWR plots on the 701C70100 and RLC SR-TC-R-D data sheets in Section 2.5.) These VSWR's are about the same as the VSWR's of the input isolators so the input VSWR for converters T103 through T110 is probably about 1.3:1.

The converter's output VSWR presented to the IF system is the Amp/Divider's output VSWR. This is a composite of the VSWR's of the WJ A19 amplifier output and the Anzac DS-313 power divider. The A19 amplifier output VSWR linearly increases from 1.5:1 at 500 MHz to 1.75:1 at 1000 MHz). The DS-313 VSWR is about 1.2:1 over this frequency band; thus the converter's output VSWR is probably about 1.5:1.

LCP-RCP Path Phase Matching

Although it was not essential, during construction corresponding runs (in the LCP and RCP paths) of semi-rigid coax were connected with known, identical length pieces. This provides both path phase-matching of the paths and uniformity between converter units.

Compression

Compression is a effect which limits an electronic device's dynamic range. In the case of a mixer, as the RF level is increased, the IF output should correspondingly increase in a linear manner. At some point IF outputs begin to depart from this linear behavior, further increases in RF input produce smaller increases and eventually, the IF output becomes fairly constant. Additional increases in RF input do not produce additional IF output. The 1 dB compression point is frequently used as a reference point for compression. This is the point at which the IF output deviates from linearly following the RF input by 1 dB.

Amplifiers also exhibit compression. All converters use the Amp/Divider subassemblies to drive the IF lines to the IF system in the Station Building. This amplifier uses the Watkins-Johnson A19 amplifier. The data sheet for this amplifier shows a minumum power output of 21 dBm at the 1 dB compression point. The converter outputs have a power spectral density of -67 dBm/MHz or -40 dBm in the 500 MHz bandwidth. This is a margin of about 57 dB to prevent compression during solar observations. See the desription of the Amp/Divider unit in Section 2.5.

Although the mixer compression levels are lower than the other components, they are not necessarily the determining factor in the compression limit of the converter module as a whole. The G1 gain control hybrid in the Amp/Attenuator subassembly has a third-order intercept of about +21 dBm over most of its range, implying a 1 dB compression point of +8 dBm. This power level at the input of the G1 is produced by -7 dBm at the input to the mixer, which is less than the 1 dB compression level of the mixers used in the converters.

A major VLBA specification is the requirement that in any band, no more than 1% gain compression shall occur in the Front-Ends and Converters when the antenna temperature reaches 200,000 K in a bandwidth of 1 GHz.[2] This compression level occurs at a power level 12 dB below the 1 dB compression point and represents the worst-case upper limit of converter linear operation. The 1% compression power level is one of the converter specification parameters shown on the converter specifications table in Section 2.3.

The following compression analysis was abstracted from the earlier manual. Assuming that the converter alone shall not exhibit more than 1% gain compression with a 200,000 K input to the Front-End, compression considerations are: Assuming an input signal of 200,000 K, a Front-End with 38 dB of gain, 3 dB of loss between the Front-End and mixer, and a 1 GHz filter noise bandwidth, the power to the mixer is -20.6 dBm. The mixer with the lowest LO power drive is the 15 GHz mixer with a specified 1 dB input compression power of +3 dBm. Assuming the 1% compression point is 12 dB less than this, the RF signal power to the mixer does not exceed -9 dBm. Thus the design requirement is met by the mixer and the margin is about 10 dB. Front-Ends at other frequencies generally have about 10 dB more gain, but the mixers have 3 to 10 dB higher LO powers and correspondingly higher gain compression points. The IF amplifiers were chosen to meet these gain compression point requirements. Converter compression is discussed in more detail in VLBA Electronics Memos No. 39 and 62.

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[2] VLBA Electronics Memos Nos. 30 and 39.

Dynamic Range and Compression

Dynamic range and compression are important considerations. The receiving system is designed to avoid compression in solar observing which can produce antenna temperatures in excess of 100,000 K. The compression discussion above cited the 1% maximum compression specification for a 200,000 K Front-End input. This input level is the upper limit of linear operation and the converter's output levels are about +5 dBm.

Over the 1.5 to 15 GHz bands, the typical system temperature (i.e. Receiver Temperature + Antenna Temperature) is roughly 30 K for non-solar observing; this is about 38 dB below the 200,000 K input.[3]

The converter output power levels are typically about -40 dBm for normal 30 K observing and about +5 dBm for the 200,000 K level inputs. The converter's dynamic range is thus -40 to +5 dBm, a 45 dB span. These two power levels are listed in the converter specification table in Section 2.3.

Conversion Loss

The frequency conversion mechanism is not a lossless one. As described above, many frequencies can be produced by the mixing action. Because of losses inherent within both the diodes and the tranformers, the desired output signal will always be significantly lower than the input signal power. This difference in power is called the conversion loss of the mixer and is defined as the ratio of the mixer's IF power (in an upper or lower sideband) to RF input power and is normally expressed in dB.

A simple conversion model loss that does not include losses in the diodes and transformers or power diverted to harmonic frequency (i.e. $NF_{RF} \pm MF_{LO}$) terms is the trigonometric cosine product identity, $\cos A^{*}\cos B = \frac{1}{2}[\cos(A + B) + \cos(A - B)]$. If $V_{RF}\cos(2\pi F_{RF}t)$ is the RF signal and $V_{LO}\cos(2\pi F_{LO}t)$ is the LO signal, the product of $V_{RF}\cos(2\pi F_{RF}t)^{*}V_{LO}\cos(2\pi F_{LO})$ is: $V_{RF}{}^{*}V_{LO}\{\frac{1}{2}\cos[2\pi(F_{RF} + F_{LO})t] + \frac{1}{2}\cos[2\pi(F_{RF} - F_{LO})t]\}$. These two signals are the sum and difference sidebands introduced above. This model shows that the amplitudes (voltage) of the two sidebands are proportional to $\frac{1}{2}V_{RF}$, which is 6 dB (voltage) below V_{RF}. In terms of power, this a 3 dB (power) conversion loss which is what we would expect from this simple lossless model. Typical conversion losses of real mixers are about 6 to 8 dB (power).

The WJ M77C double-balanced mixer is used in T106; refer to the Watkins-Johnson M77C data sheets in Section 3.6. The data sheets show that the typical conversion loss (for an F_{RF} of 8 to 12.5 GHz) is 5.5 dB and the max is 7.5 dB. Note the data sheet plot of conversion loss versus LO drive power. Conversion loss is essentially constant for LO levels above 7 dbm but rapidly increases when the LO drive drops below 7 dBm. It is important to keep this LO drive level within specifications.

Secondly, note the frequency-dependency of conversion loss from the plots of conversion loss versus frequency; the M77C conversion loss is minimum over a frequency range of 8 to 12 GHz. Note also the plot of RF port VSWR with frequency; outside this frequency range, the mixer reflects a significant fraction of the input RF signal. This example illustrates the reason for the diversity of components in the converter modules.

Noise Temperature and Noise Figure

Noise temperature is a measure of the noise added by a device. A resistor at any absolute temperature produces a noise power which is proportional to that temperature. The power is given by $P(T) = kTB$, where B is the bandwidth of the power measurement, T is the temperature, and k is Boltzmann's constant.

At 1 degree Kelvin, in 1 Hz bandwidth, a resistor will produce -198.6 dBm (into a matched impedance).

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[3] VLBA Electronics Memo No. 62.

It is convenient to refer to levels of noise power in terms of the temperature (in Kelvins) which would produce it. For example, 200,000 Kelvins antenna "temperature" means the antenna is delivering as much power as a theoretical resistor would if it were at 200,000 K. (Of course a real resistor would have vaporized long before reaching such an astronomical temperature!)

Since the ratio of 200,000 to 1 is 53 dB, we can calculate that the antenna's output power would be -198.6 + 53 dBm = -145.6 dBm in 1 Hz bandwidth. In a 1 GHz bandwidth, the power would be 10^9 times as much, or 90 dB more: -145.6 + 90 = -55.6 dBm. 35 Db amplification following the antenna would then raise this to -20.6 dBm.

Noise temperature is used as a method of specifying the noise added by an amplifier: The input of the amplifier is terminated in a matched resistance. If the amplifier were perfect and contributed no noise of its own, the output power would be the product of the amplifier gain and the temperature of the input termination. Since real amplifiers do contribute some extra noise of their own, we say that the extra noise output is the product of the amplifier's gain and its **noise temperature**.

Another way of expressing noise contribution is the **Noise Figure**. Although older and more widely used, Noise Figure is less convenient for low-noise systems, and especially for systems which are at temperatures other than 290 K. For a noise figure F (convert to ratio if in dB), the noise temperature is $T_{noise} = 290*(F - 1)$.

The converter's noise temperature is a composite value that is a function of the components. For example, the noise temperature of a cascade of 4 amplifiers with noise temperatures T_1, T_2, T_3 and T_4, and gains (expressed as ratios, not dB) g_1, g_2, g_3 and g_4 is::

$$T_N = T_1 + \frac{T_2}{g_1} + \frac{T_3}{g_1 g_2} + \frac{T_4}{g_1 g_2 g_3}$$

Note that the contribution of each amplifier is just its noise temperature divided by the gain of all of the preceding stages.

If the cascade contains an element with **loss** (i.e. its gain is a ratio less than 1), it will **increase** the noise contribution from the following stages. It will also contribute an amount $T_p*(1/g-1)$, divided by the gain of the previous stages. Here T_p is the physical temperature of the lossy device, in Kelvins.

Since it is used in all the converter modules, let us consider the 500 - 1000 MHz output cascade consisting of the K&L 750/X550 filter and the Amp/Attenuator and Amp/Divider subassemblies. The cascade is as follows:

Device	G	g	g'	T	T'
Filter	-0.38	0.92	1	27	27
A18-1	14.7	29.5	0.92	527	573
A19	7.5	5.6	27.1	2014	74
G1	-12	0.063	152	4454	29
A18-1	14.7	29.5	9.6	527	55
A19	7.5	5.6	282	2014	7
DS-313	-3.6	0.44	1579	387	≈0
				Total =	765 K

Where:

G is the device gain in dB.
g is the device gain as a ratio.
g' is the cumulative gain preceding the device.
T is the noise temperature of the device.
For amplifiers, T is from the typical Noise Figure data.
For losses, T = 300*(1/g - 1).
T' is the contribution of the device to the cascade.

This calculation is done with G1 set to the middle of its range. If the G1 is set to -2 dB, the cascade noise temperature is about 685 K. If G1 is set to -22 dB, the cascade noise temperature becomes about 1600 K.

For purposes of noise temperature calculation, a double-balanced mixer can be considered a lossy device at ambient temperature, usually taken to be about 300 K. Thus a mixer with conversion loss of 7.5 dB (g = .18, 1/g = 5.6) would contribute 300*(5.6-1) = 1400 K, divided by the preceding gain.

In most of the converter modules there is no amplifier (the exceptions are T101, T102 and T108) preceding the mixer, and we can take the combined loss of the transfer switch, isolator and mixer to be about 7.5 dB. The mixer's direct contribution of 1400 K must be added to the noise temperature of the following cascade. From the analysis above, this is between 685 K and 1600 K (depending upon the loss in G1), which must be divided by the gain of the preceding mixer, transfer switch and isolator which is 0.18. Thus we should expect the converter noise temperature to be between 1400 + 685/.18 = 5200 K and 1400 + 1600/.18 = 10,300 K.

An important specification of the converter modules is that they should add no more than 1 K to the overall system temperature. The preceding gain must be at least 10,000 or 40 dB since the converter's contribution to the overall system temperature is its noise temperature (which may be as high as 10,000 K) divided by the preceding gain. Most of the VLBA Front-Ends have a gain of more than 40 dB.

IF Path Gain, Flatness and Adjustability

Converter gain is the ratio of the converter's IF output power to the RF input power over the specified converter bandwidth. This gain is the composite gain of the module including the insertion losses of the transfer switch, the isolator, RF and IF bandpass filters, the mixer conversion loss, and the two amplifier gains. The table in Section 2.3 shows converter gains that range from 12 to 15 dB.

The converter's gain flatness specification from the table in Section 2.3 is ± 2 dB over the operating bands. This includes bandpass filter ripple and amplifier responses.

Two NRAO IF amplifier subassemblies are used in the converters - the Amp/Attenuator and the Amp/Divider. The Amp/Attenuator serves as a gain-controllable amplifier that drives the Amp/Divider unit, which drives the IF system in the Station Building and the front panel monitor jack.

The IF power gain in dB is the sum of the insertion loss of the K&L 6B120-750/X550 bandpass filter (0.38 dB) and the Amp/Attenuator and Amp/Divider gains. This ranges between 19.5 dB to 38.7 dB as a function of the Amp/Attenuator gain adjustment.

Section 2.5 describes the Amp/Attenuator, Amp/Divider and K&L 6B120-750/550 bandpass filter in more detail.

IF Passband and Out-of-Band Signal Rejection

The IF passband for modules T103 to T110 is 500 to 1000 MHz and is determined by the IF bandpass filter, a K&L 6B120-750/X550 that has a 750 MHz center frequency and a 550 MHz bandpass. Figures 5 and 6 in Section 2.5 shows the filter passband and ripple. The filter bandwidth is much less than the Front-End bandwidths shown on the table in Section 2.3. For example, the attenuation of nearby out-of-band 200 MHz and 1100 MHz signals (plus one and minus one 3 dB bandwidth) are -22 dB and -20 dB respectively, relative to the 750 MHz center frequency. The attenuation at 100 and 1200 MHz is -40 dB. Figure 12 in Section 2.7 shows a typical converter output spectrum.

The converter descriptions in Section 3 contain plots of the attenuation vs. frequency characteristics of the RF and LO bandpass filters used in the converters. The RF filters determine the bandwidth of the signal input to the mixers and the LO filters attenuate mixer noise signals outside the LO filter bandwidth.

The two P-band IF output filters have different center frequencies and a narrower bandpass. T101 has a K&L 6B120-327/X30 RF input bandpass filter (30 MHz bandpass) and a K&L 3B120-827/50 IF bandpass filter (50 MHz bandwidth). In this module the 30-wide MHz RF input filter determines the overall passband of 30 MHz. T102 has two switch-selectable bandwidths, 30 MHz and 4 MHz. See Section 3.2 for a description of the implementation of these two IF frequency modes.

Out-of-band signal rejection is a measure of the converter's frequency selectivity and is determined by the response of the output IF filter. The filter rejects the undesired sideband and LO feedthrough, LO harmonics, etc. from the mixer, and signals adjacent to the frequency band of interest. By sharply defining the bandwidth of the system, the filter makes it possible to control the power levels at this and further stages in the receiving system.

As the RF and LO frequencies increase from T103 to T108, harmonic product frequencies of the form $NF_{RF} \pm MF_{LO}$ also increase and are far outside the filter passband and strongly suppressed, except for the desired case, $N = M = 1$.

An important spurious response which cannot be suppressed after the mixer is that at the **image frequency**. To convert a signal at 14 GHz to an IF of 0.6 GHz we would use an LO of 13.4 GHz (14 - 13.4 = .6). However, with the same LO and IF, the converter would also respond to a signal at 12.8 GHz (13.4 -12.8 = .6). The 12.8 GHz signal is called the **image frequency**. Any signal at the image frequency must be made negligible (for example, by a filter) before the RF signal reaches the mixer.

At some frequency bands, this filtering is done in the Front-End and at others, it is done in the converter module.

Since the image frequency is only twice the IF away from the desired frequency, a problem arises when it is necessary to tune the converter over a range wider than this. At 23 GHz and higher, the problem is avoided by a first frequency conversion to a rather high ($\approx$9 GHz) first IF in the Front-End. At 14 GHz, one of four filters is switched in ahead of the mixer. The filter bandwidth is narrow enough to suppress the image. The filter's center frequencies are offset to allow the entire band to be covered by changing filters.

Transfer and Selector Switch Drive

Two types of electrically-driven transfer switches are used in the converter modules. The Transco 710C70100 is a failsafe, non-latching switch with a 120 mA, 28 volt coil. The RLC SR-TC-R-D transfer switch is also a failsafe switch with a 200 mA, 28 volt coil. Switch actuation times are 20 and 15 milliseconds, respectively. These switches are interchangeable.

The transfer switches are driven by the B-Rack Interface Module, M102 which supplies a sustained +28 volt drive that sources current through the switch coils to 28 volt module common. The transfer switch coils are connected to P11-27.

In addition to transfer switches, electrically-driven selector switches are used to select modes and filters. The selector switches are driven by the LO/RF/IF Switch Controller module L107, which supplies a sustained +28 volt drive that sources current through the switch coils to 28 volt module common.

SPDT Transco 909C70100 SPDT selector switches are used in T102, T106 and T110. This switch is a latching switch with two coils that are are alternately driven to effect switching action. Coil voltage is 28 volts and the current is 95 mA (max). Switching time is 20 milliseconds. Although this is a latching switch, it operates satisfactorily from the sustained switch drive provided by L107.

T108 uses a Transco 4PST (146C70600) selector switch. This switch uses four solenoids to effect the contact closures. Coil current is 170 mA with a 28 volt drive and switching time is 20 mS. The L107 switch drive logic provides a sustained +28 volt drive to one of these solenoids.

2.3 FREQUENCY CONVERTER SPECIFICATIONS

The table below shows important properties of the T101 - T110 converter modules and inputs from the Front-Ends. This data was taken from the Technical Manual for CONVERTER MODULES by Erich Schlect, VLBA Technical Report No. 15 (Rev. A) and recent measurements.

Module Type	T101	T102[6]	T103	T104	T105	T106[2]	T107	T108	T106[2]	T110
Band	P	P	L	S	C	X	X	U	K	Q
Wavelength, cm	90	50	20	13	6	4	2.8	2	1.3	0.7
Frequency, MHz or GHz	330 M	610 M	1.5 G	2.3 G	4.8 G	8.4 G	10.7 G	15 G	23 G	43 G
Rcv'r BW, MHz or GHz	30 M	30 M	560 M	800 M	700 M	960 M	1.2 G	3.8 G	900 M	1.4 G
Conv Band Edge, MHz or GHz[1]										
Lower	312 M	596 M	1.27 G	2.0 G	4.5 G	7.92 G	10.1 G	11.8 G	9.3 G	7.7 G
Upper	342 M	626 M	1.83 G	2.8 G	5.2 G	8.88 G	11.3 G	15.6 G	10.2 G	9.1 G
Min LO Freq, GHz[1,5]	0.5	0.5	2.1	3.1	4.1	7.4	9.6	11.4	8.9	7.4
Max " " , GHz	N/A	N/A	2.4	N/A	5.6	9.4	11.9	15.9	10.4	9.4
Nominal Gain, dB	30	30	15	14	14	14	14	13	14	14
Gain Flatness, dB +/-	2	2	2	2	2	2	2	2	2	2
Nominal Total Output Power @ Std Syst Temp, dBm	-50[7]	-61[7]	-40	-40	-40	-40	-40	-40	-40	-40
Minimum output power at 1% compression, dBm	0.0	0.0	4.9	4.0	3.9	6.0	6.3	5.3	4.0	4.0
Nominal Output Power Density, dBm/MHz	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67
Nominal LO Input Power, dBm	5	5[8]	2	2	1	2	1	0	2	2
Avg Noise Temp, K	1000	1000	10,000	10,000	9,000	17,000	14,000	7,000	15,000	6,500
Noise Temp for 1° Added Syst Noise, K	6000	300[10]	25,000	20,000	25,000	25,000	20,000	20,000	32,000	32,000
Avg Noise Figure, dB[4,9]	6	6.5	15.5	15.2	15.2	17.7	17.0	14.1	17.2	13.7
Noise Figure for 1° Added Syst Noise, dB[3]	16.5	2[10]	19.4	18.4	19.4	19.4	18.4	18.4	20.4	20.4
RCP-LCP Isolation, dB	65	65	65	65	65	65	65	65	>60	65
+15 V Supp Current, mA	2000	760	600[9]	650	680	750	850	660	750	650

Notes:

1 Front-End and LO frequencies from VLBA Technical Report No. 15 (Rev. A), see table in Section 6
2 T106 is used for both the 8.4 and 23 GHz bands
3 This value is the noise figure that would increase the system temperature by 1 K.
4 Average noise figure for the two channels measured on typical modules
5 These are T-module IF frequencies; the 23 GHz and 43 GHz Front-Ends have converters to reduce the Front-End's RF signal output to lower frequencies.
6 T102 has two computer selectable IF bandwidths, the second covers 609 to 613 MHz.
7 See the T101 and T101 gain adjustment procedures in Sections 3.1 an 3.2, respectively.
8 Both 100 and 500 MHz @ +5 dBm.
9 With G1 set for maximum attenuation
10 Contributes more than 1°

2.4 VLBA FREQUENCY CONVERTER DESIGN REQUIREMENTS

This Section briefly describes the specifications and considerations that determined the frequency converter's design. This material was abstracted from the Technical Manual for CONVERTER MODULES by Eric Schlect and rearranged to conform to this manual's format.

Design Specifications and Goals

The most important design goals are:

- No subsystem shall exceed a 1% gain compression for a broadband noise input of 200,000 K into any of the Front-Ends.[4]
- The frequency converters shall not add more than 1 K to the system noise temperature.
- The converter's IF amplifiers gain shall be adjustabile.
- The converter's gain shall be flat within ± 2 dB over any 16 MHz segment of the IF passband.
- Interfering signals adjacent to the band shall be rejected early in the the system to limit interference power going into the mixer.

Design Considerations

The requirement for removing interfering signals and limiting broadband noise power going into the mixer dictates that an RF filter be included in the converter RF input circuitry in some bands. In other bands the filter is installed in the Front-Ends to limit these interfering signals as far up the signal path as possible. Isolators on the converter's RF inputs are used to improve the impedance match between the filter and the long cable run from the Front-Ends in the Feed Tower. Some converters, T106, T107 and T108, have an additional isolator between the RF filter output and the mixer input to improve the filter-mixer impedance match. The inclusion of isolators in the RF input path prevents large variations of gain with frequency.

The mixer typically adds 6 to 8 dB to the noise figure looking into the IF amplifiers. While the converter's noise figure would be improved by using an amplifier between the mixer and filter to overcome this large source of unwanted noise, the system as implemented satisfactorily meets the specification of adding less than 1 degree Kelvin to the system noise temperature. The expense of an additional amplifier is not justified.

In order to compensate for unit-to-unit gain variations in the RF and IF paths, the IF amplifier's gain was made adjustable. The gain control element is a PIN diode, variable attenuator module in the IF amplifier chain. It is desirable to change the gain without changing the output gain compression of the converter. The IF amplifier gain and attenuation blocks are commercial 50 ohm TO-8 case style units made by Watkins-Johnson.

A constraint on gain flatness exists in the mixer, IF filter and first IF amplifier circuitry. As a result of the relatively poor match between the mixer and the IF filter and that between the IF filter and IF amplifier, the filter exhibits some ripple, especially near the edges of the bands. In a lab test it was found that inserting 3 dB of attenuation between the filter and the mixer appreciably reduced the ripple. Although this attenuation reduced the filter ripple, it increased the noise figure. Noise figure was the dominant factor in the ripple-noise figure trade-off so the mixer IF output is connected directly to the filter. The resultant ripple magnitude is small; measurements of the maximum deviation from gain flatness over any 20 MHz passband segment show about a 1

---

[4] VLBA Electronics Memo No. 30.

dB, peak-to-peak deviation for all converter types. This meets the ± 2 dB gain flatness specification.

2.5 DESCRIPTIONS OF COMPONENTS COMMON TO T101 - T110

Two NRAO IF amplifier subassemblies are used in the converters - the Amp/Attenuator and the Amp/Divider. The assembly drawings for these two units include circuit block diagrams and parts lists. These drawings and the associated components parts data sheets are included at the back of this section. The K&L 6B120-750/X550 bandpass filter is common across T103 to T110; plots of filter attenuation and ripple are shown below. The RLC SR-TC-R-D and Transco 710C70100 transfer switches are used in the converters; they are briefly described below. Transco 909C70100 SPST selector switches are used in T102, T106 and T110 for signal selection as a function of module mode state. Data sheets for the switches are included at the back of this section. The IF Gain Relay is used in T106 and T110 to select IF gain control potentiometer outputs as a function of the module mode. C53500A009, the IF Gain Relay assembly drawings are included in this section.

Amp/Attenuator

The Amp/Attenuator subassembly C53500A006 serves as a gain-controllable IF amplifier that drives the Amp/Divider unit.

The Amp/Attenuator uses Watkins-Johnson components consisting of two A18-1 cascadable amplifiers, one A19 cascadable amplifier and a G1 Voltage-Controlled Attenuator. These units are all in cascade; the input signal is fed to an A18-1 that drives an A19. The A19 in turn drives the G1 and the G1 output drives the final A18-1. The circuit configuration is shown on the T101 to T110 converter block diagrams and the Amp/Attenuator assembly drawing, C53500A006. The A18 and A19 amplifiers provide about 36.9 dB of power gain (using typical gain values) over the IF 500 to 1000 MHz frequency band and the composite frequency response over this band is flat within <± 0.3 dB. The G1 attenuator insertion loss varies between 2 dB to 22 dB over the IF band; thus the Amp/Attenuator gain is adjustable over the range of 14.9 to 34.9 dB, as a function of the control voltage. For these two extremes of attenuation, the control voltage is +15 and +2.4 volts, respectively. The G1 is actually capable of a much higher attenuation but the bandwidth is seriously degraded when the attenuation exceeds 22 dB; **therefore, the control voltage setting should never be less than +2.4 volts.**

Refer to the Noise Temperature and Noise Figure discussion in Section 2.2. As a stand-alone amplifier, the Amp/Attenuator noise temperature is 673 K and the noise figure is 5.2 dB.

Amp/Divider

The Amp/Divider subassembly A53500A007 provides the IF output drive to the IF system via the rear panel and the front panel monitor jack.

The Amp/Divider uses a Watkins-Johnson A19 amplifier with a gain (typical) of 7.5 dB over the IF band; this drives the ANZAC DS-313 power divider, which has a 0.6 dB insertion loss. Since the DS-313 is a 2-way divider, the output port levels are 3 dB (plus the insertion loss) below the divider input; thus the net gain of the Amp/Divider is 4.2 dB.

The power divider provides 23 dB of isolation between the two outputs. The Amp/Divider's output VSWR is about 1.5:1 (see the VSWR discussion above). Since the Amp/Divider is the converter's output amplifier, the converter's output VSWR is about 1.5:1.

Refer to the Noise Temperature and Noise Figure discussion in Section 2.2. As a stand-alone amplifier-power divider, the Amp/Divider noise temperature is 2083 K and the noise figure is 9.1 dB.

K&L 6B120-750/X550 Bandpass Filter

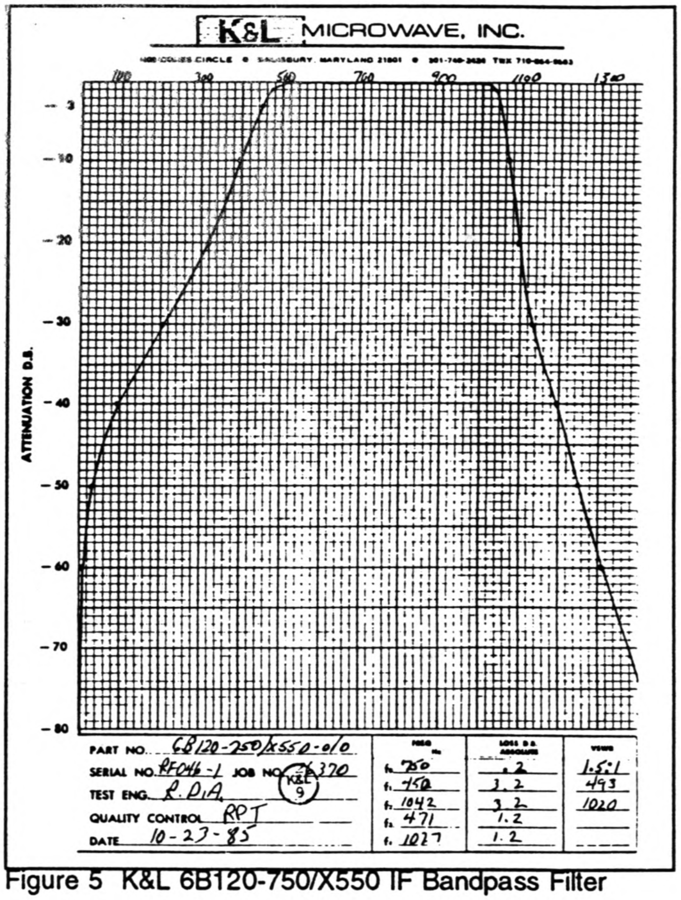
This IF bandpass filter is used in all converter modules except T101 and T102, which use narrower bandwidth filters. Two attenuation vs. frequency plots for the 6B120/X550-O/OP are Figures 5 and 6, (next two pages). The K&L plot is a linear frequency sweep from DC to 1400 MHz. The AOC filter ripple plot is a linear frequency sweep from DC to 1500 MHz and 750 MHz is the plot center frequency.

For K&L filters, the X supplemental code in the K&L part number indicates that the bandwidth is defined by the -1 dB points; if the X code is not used the bandwidth is defined by the -3 dB points.

The center frequency of this six-section filter is 750 MHz and the bandwidth is 550 MHz. The -1 dB frequencies are 475 and 1025 MHz, respectively.

Using K&L formulas for this filter, the 3 dB percentage bandwidth is 73.3% (i.e. 550/750 x 100) and the predicted center-frequency insertion loss is 0.38 dB. Note that the plots show that the 3 dB frequencies and the insertion loss are very close to the values predicted by the K&L formulas. Also note that the peak-to-peak filter ripple is about 0.25 dB and the attenuation at DC and 1500 MHz is about 54 dB. Section 6 has a data sheet for the K&L tubular bandpass filters.

For many observations it is desireable to use the widest possible bandwidth. The 500 MHz IF bandwidth was chosen in consideration of the bandwidth practical for the Baseband Converters, Data Recorders, and other sytem equipment.



PART NO. 6B120-750/X550-010
SERIAL NO. RF046-1 JOB NO. 6370
TEST ENG. R. D.A.
QUALITY CONTROL RPT
DATE 10-23-85

K&L 9

	FREQ MHz	LOSS DB ABSOLUTE	VSWR
f_0	750	.2	1.5:1
f_1	450	3.2	493
f_2	1042	3.2	1020
f_1	471	1.2	
f_2	1027	1.2	

Figure 5 K&L 6B120-750/X550 IF Bandpass Filter

The bandwidths available for the 2.3 through 43 GHz Front-Ends are wider than 500 MHz, so the LO frequency to the converter modules is selectable to allow coverage of any desired portion of the a Front-End band. The frequencies available from the L104 synthesizer module are given by $F_{104} = 500N \pm 100$ MHz where N is an integer between 4 and 32. This gives alternate frequency steps of 200 and 300 MHz, about half the IF bandwidth, allowing the observation band to be placed conveniently within the IF passband.

Transfer Switch

Two types of transfer switches are used in the converter modules, the Transco 710C70100 and RLC Electronics SR-TC-R-D. The physical dimensions, drive characteristics, signal and switch connections are identical. The VSWR, isolation and insertion loss characteristics are very similar although there are some small differences as a function of frequency. Although a converter a drawing may specify either switch, a converter may contain the other type; over the course of module construction, the units with the best price quotes were purchased.

Important features of these switches were described in the LCP-RCP Isolation and Transferand Selector Switch Drive descriptions above. Data sheets for these two switches follow this section.

Transco SPDT Selector Switch

The Transco 909C70100 SPDT selector switch is used in T102, T106 and T110 for input signal selection.

The Transco switch is a two-coil latching relay with two drive inputs; alternate excitation of either coil causes the contact transition. The switch coil common is connected to the module common distribution. The drive characteristics were described in the Transfer and Selector Switch Drive discussion above.

IF Gain Relay Assembly

A DPDT IF Gain Relay Assembly C53500A009 is used in T106 and T110 to select the appropriate pair of front panel IF gain control potentiometers in dual-frequency (T106 and T110) converters. The IF Relay Assembly drawings follow this text.

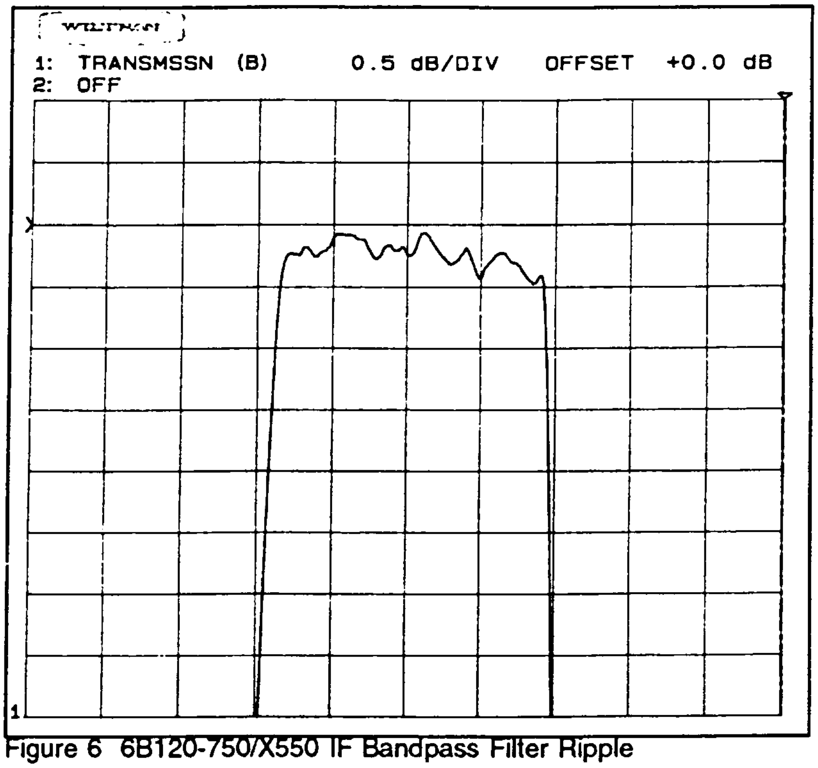
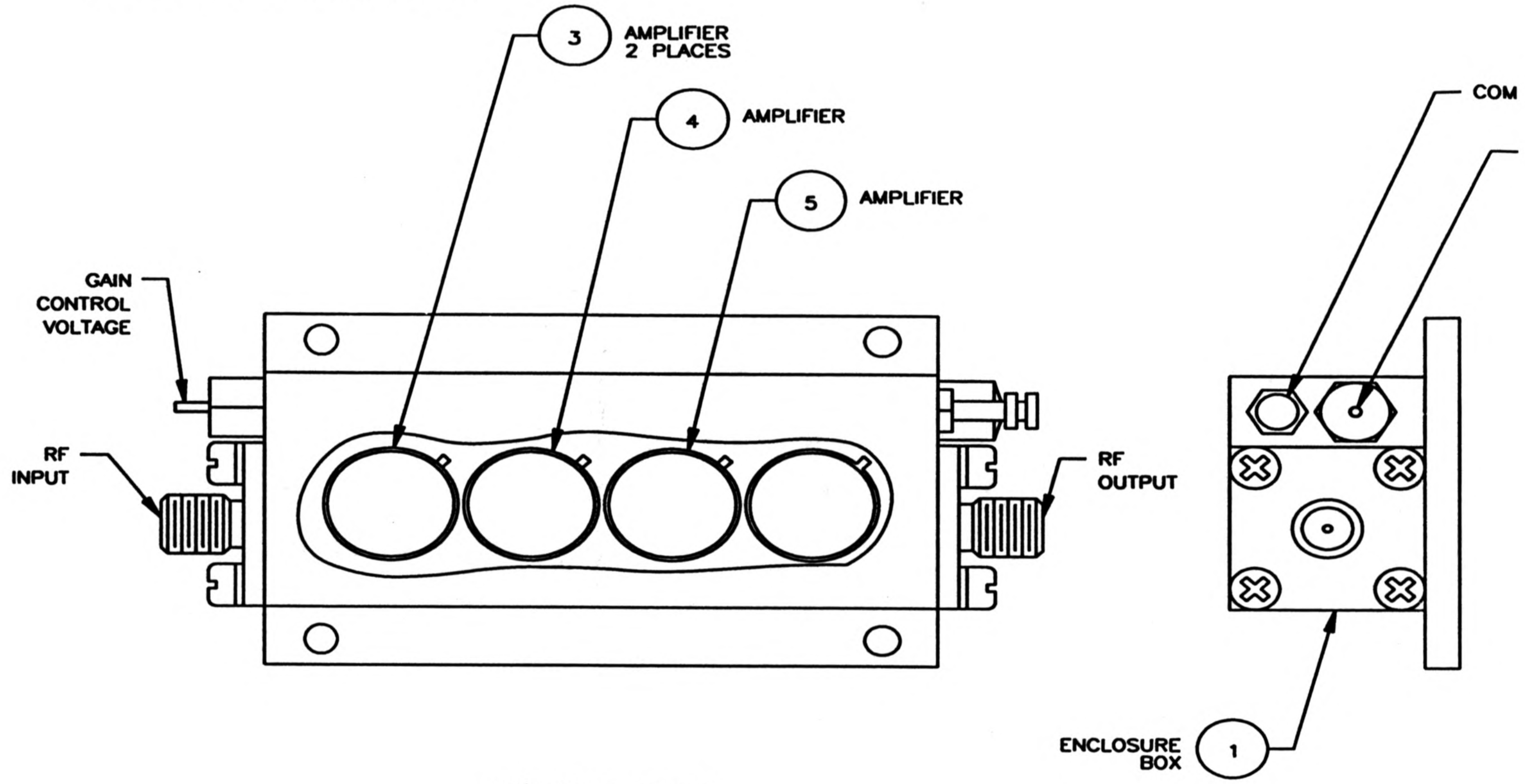


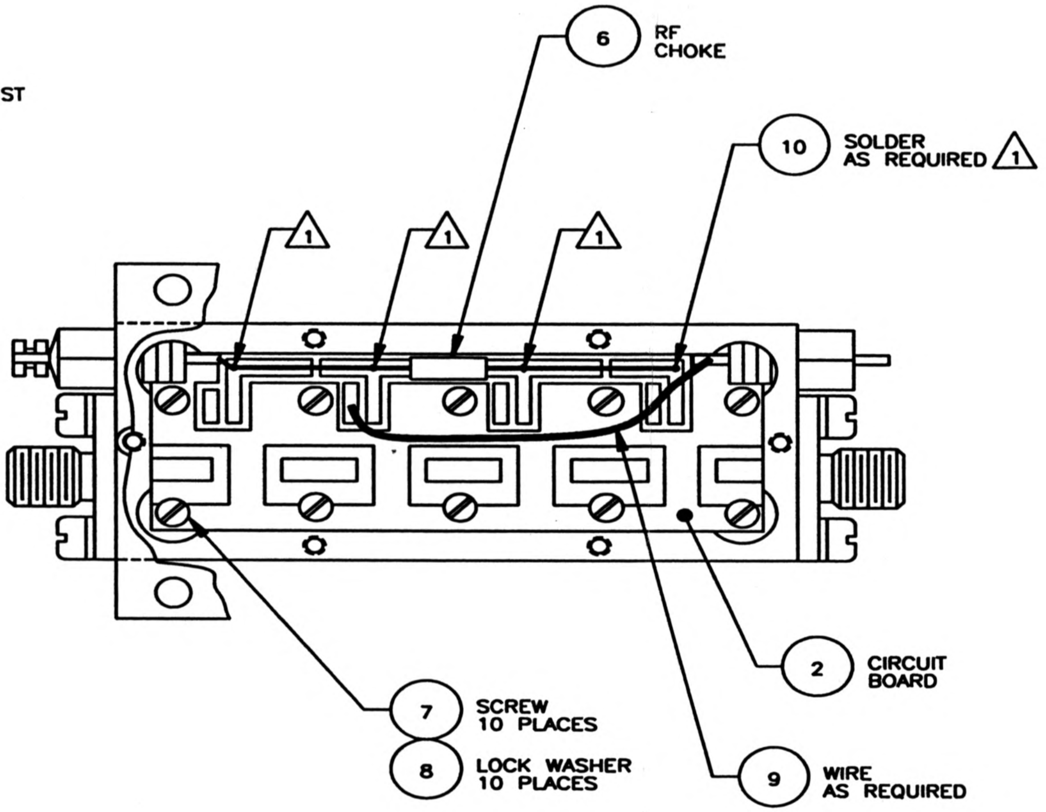
Figure 6 6B120-750/X550 IF Bandpass Filter Ripple

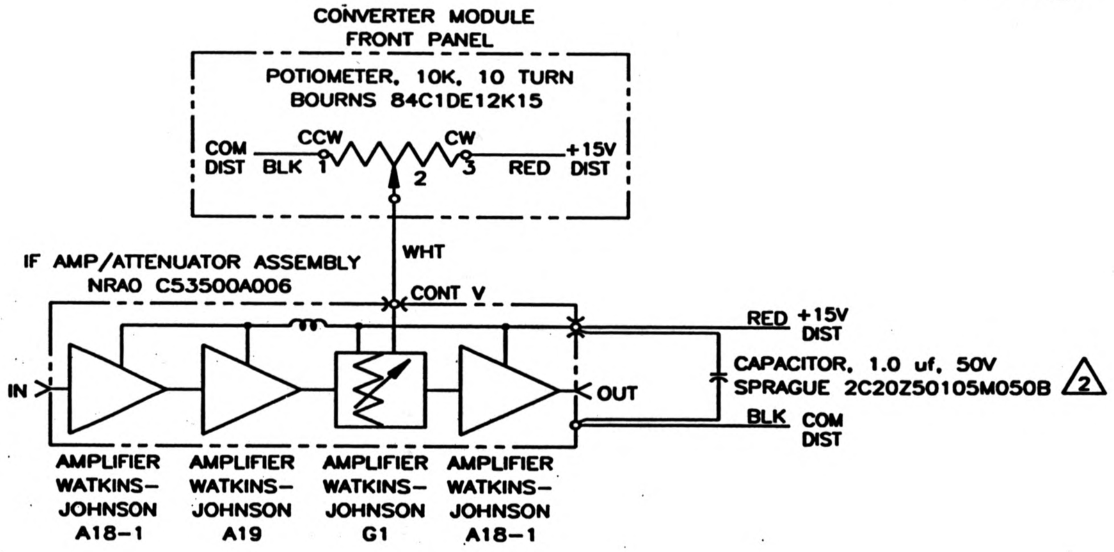
NOTES:

1. SOLDER RF CHOKE LEADS (ITEM 6) TO CIRCUIT BOARD (ITEM 2) AS INDICATED
2. INSTALL CAPACITOR AT TIME OF ASSEMBLY INTO CONVERTER MODULE

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	11-90	DGS	SCHLECHT	CHG ORDER 901114-1
B	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STDS







IF AMP/ATTENUATOR ASSEMBLY AND GAIN CONTROL BLOCK DIAGRAM

ACAD : 53500A06

PROPERTY OF NRAO

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
10			SN-62	SOLDER, SILVER	AR
9		ALPHA	7055	WIRE, WHT, #22	AR
8				WASHER, LOCK, #0	10
7				SCREW, PAN HEAD, SS, #0-80UNF-2A x .188	10
6			CC-09-101K	CHOKE, RF, 100UH	1
5		WATKINS-JOHNSON	G1	AMPLIFIER	1
4		WATKINS-JOHNSON	A19	AMPLIFIER	1
3		WATKINS-JOHNSON	A18-1	AMPLIFIER	2
2		AVANTEK	TB-4	BOARD, CIRCUIT	1
1		AVANTEK	TC-4M	BOX, ENCLOSURE	1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

NEXT ASSEMBLY | DWG. TYPE

PROJECT: VLBA CONVERTER MODULE

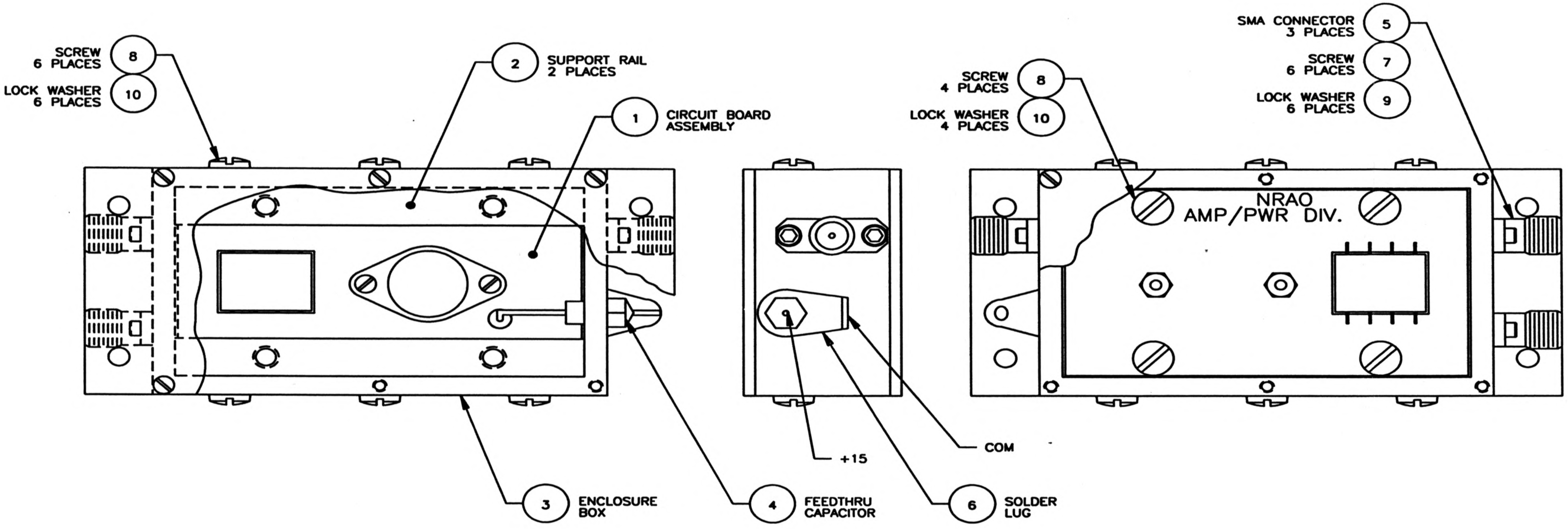
TITLE: CONVERTER MODULE IF AMP/ATTENUATOR ASSEMBLY

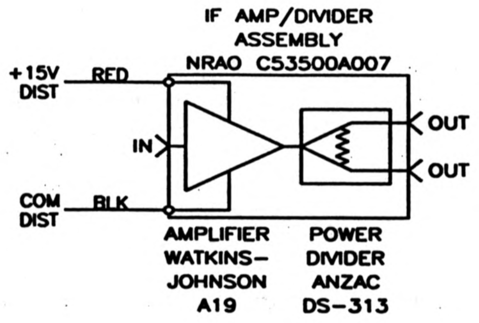
NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY	MORRIS	DATE 8-87
DESIGNED BY	SCHLECHT	DATE 8-87
APPROVED BY	SCHLECHT	DATE 8-87

SHEET NUMBER 1 OF 1 | DRAWING NUMBER C53500A006 | REV. B | SCALE 2/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STDS





IF AMP/DIVIDER BLOCK DIAGRAM

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
10				WASHER, LOCK #4	10
9				WASHER, LOCK #2	6
8				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	10
7				SCREW, PAN HEAD, SS, 2-56UNC-2A x .19	6
6		H.H. SMITH	1412-9	LUG, SOLDER	1
5		SOLITRON	2950-6200	CONNECTOR, SMA	3
4		MURATA ERIE	1250-492	CAPACITOR, FEEDTHRU	1
3		NRAO	C53500M016	BOX, ENCLOSURE	1
2		NRAO	C53500M012	RAIL, SUPPORT	2
1		NRAO	C53500A024	ASSEMBLY, PCB	1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

NEXT ASSEMBLY | DWG. TYPE

VLBA PROJECT: CONVERTER MODULE

TITLE: CONVERTER MODULE
IF AMP/DIVIDER
ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY	MORRIS	DATE 8-87
DESIGNED BY	SCHLECHT	DATE 8-87
APPROVED BY	SCHLECHT	DATE 8-87

SHEET NUMBER 1 OF 1 | DRAWING NUMBER C53500A007 | REV. A | SCALE 2/1

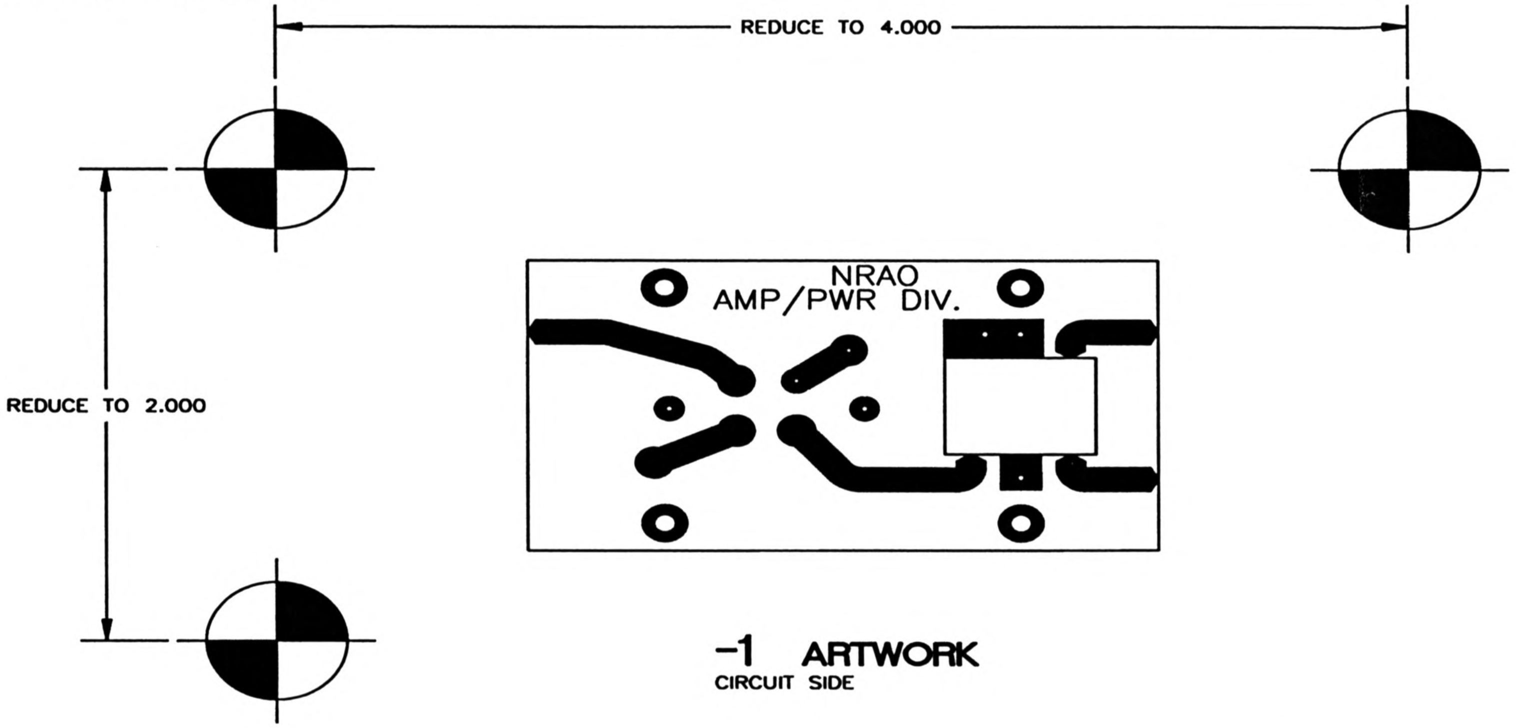
ACAD : 53500A07

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
–	10-93	K. TATE	D. WEBER	REPLACES DWG. B53500Q001

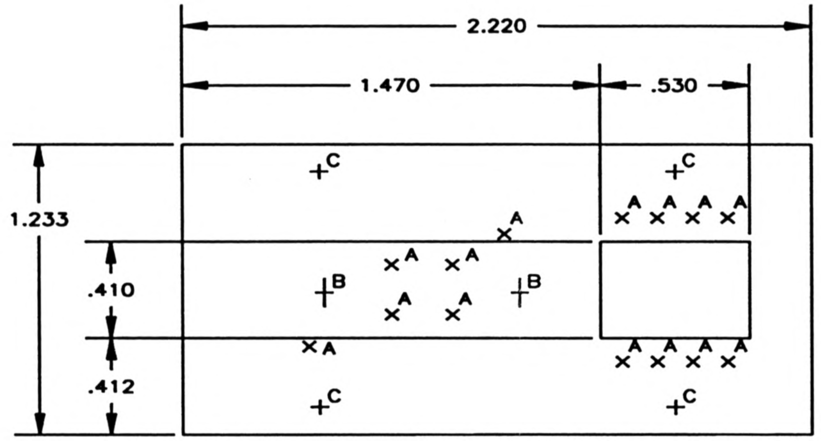
NOTES:

1. MATERIAL: G10 GLASS EPOXY, .063 THICK
2. REMOVE ALL BURRS AND SHARP EDGES
3. ALL HOLES TO BE PLATED THROUGH
4. ELECTROLITICALLY DEPOSIT 2 OZ. OF COPPER TO BOTH SIDES OF BOARD AND INSIDE WALL OF ALL HOLES
5. PLATING: 60/40 SOLDER PLATE PER QQ-S-571, OR ELECTRO-TIN PER MIL-T-10272

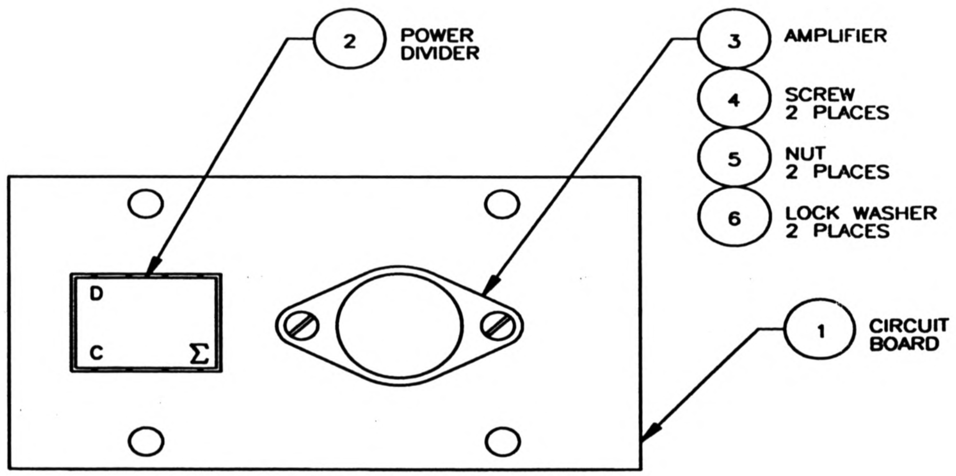
DRILL CHART		
HOLE	FINISHED SIZE	QTY
A	ø.028	14
B	ø.070	2
C	ø.116	4



-1 ARTWORK
CIRCUIT SIDE



-1 DRILL DRAWING 1
CIRCUIT SIDE



-10 ASSEMBLY
COMPONENT SIDE

ACAD : 53500A24

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
6				WASHER, LOCK, #0	2
5				NUT,HEX,SS,0-80UNF-2B	2
4				SCREW, PAN HEAD, SS, 0-80UNF-2A x .188	2
3		WATKINS-JOHNSON	A19	AMPLIFIER	1
2		ANZAC	DS-313	DIVIDER, POWER	1
1		NRAO	-1	BOARD, CIRCUIT	1

C53500A007	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT: CONVERTER MODULE

TITLE:
CONVERTER MODULE
IF AMP/DIVIDER
PRINTED CIRCUIT
BOARD ASSEMBLY

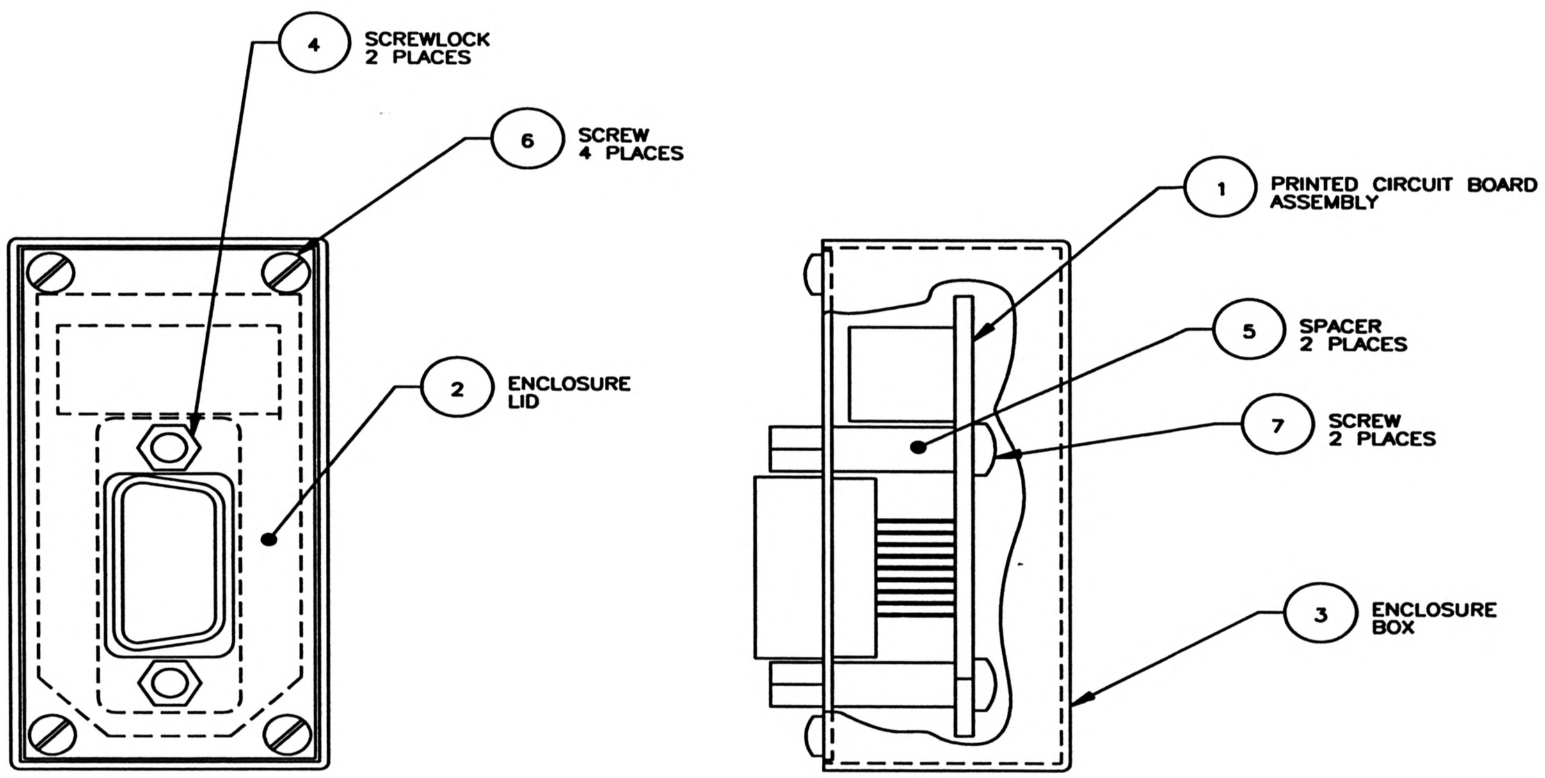
NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE DATE 10-93
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 1 DRAWING NUMBER C53500A024 REV. – SCALE 2/1

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	11-90	DGS	TREACY	CHG ORDER 901108-2
B	9-93	K. TATE	D.WEBER	REDRAWN ON ACAD



ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
7				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	2
6				SCREW, PAN HEAD, SS, 2-56UNC-2A x .25	4
5		H.H. SMITH	8322	SPACER, 4-40UNC-2B x .44	2
4		AMPHENOL	17-D20419-X	SCREWLOCK, FEMALE	2
3		NRAO	B53500M038	BOX, ENCLOSURE	1
2		NRAO	B53500M032	LID, ENCLOSURE	1
1		NRAO	C53500A023-10	ASSY, CIRCUIT BOARD	1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT CONVERTER MODULE

TITLE
CONVERTER MODULE
IF GAIN RELAY
ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY B. TREACY DATE 2-89
DESIGNED BY B. TREACY DATE 2-89
APPROVED BY B. TREACY DATE 2-89

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A009
REV. B
SCALE 2/1

NEXT ASSEMBLY	DWG. TYPE

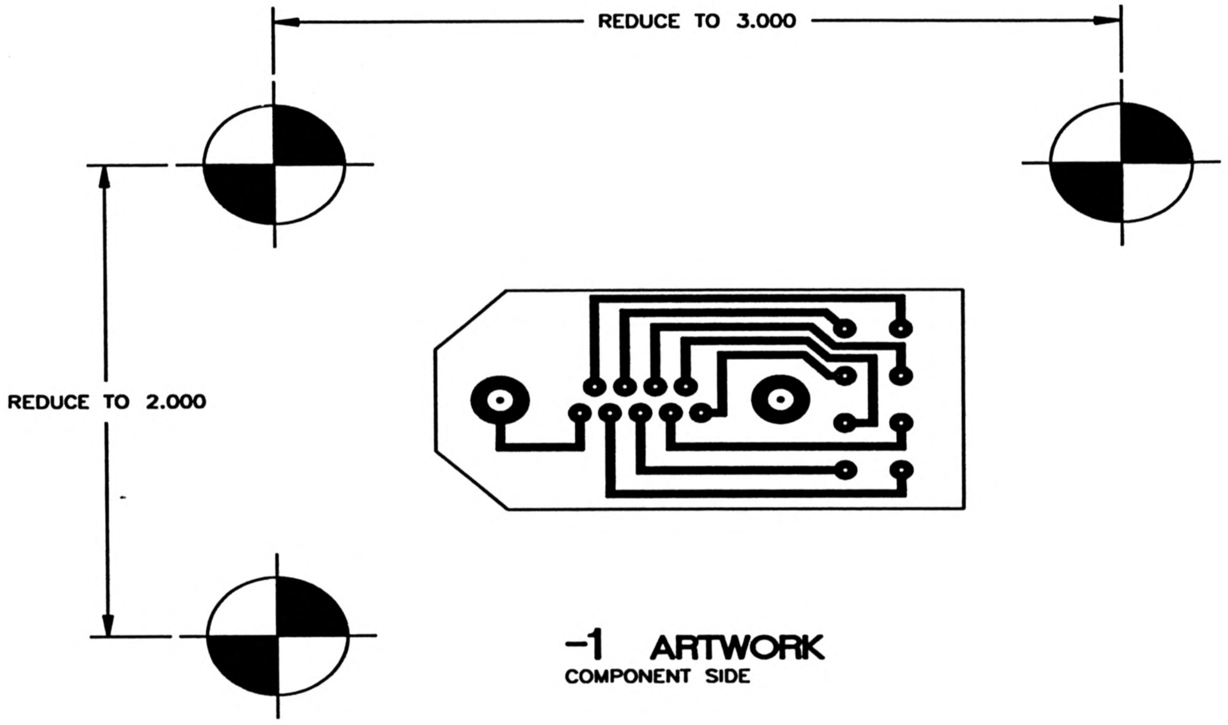
ACAD : 53500A23

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

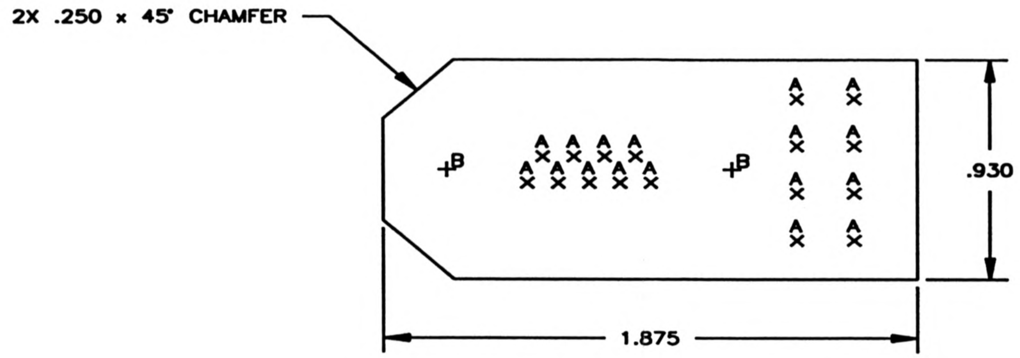
NOTES:

1. MATERIAL: G10 GLASS EPOXY, .063 THICK
2. REMOVE ALL BURRS AND SHARP EDGES
3. ALL HOLES TO BE PLATED THROUGH
4. ELECTROLITICALLY DEPOSIT 2 OZ. OF COPPER TO COMPONENT SIDE OF BOARD AND INSIDE WALL OF ALL HOLES
5. PLATING:
   60/40 SOLDER PLATE PER QQ-S-571, OR
   ELECTRO-TIN PER MIL-T-10272

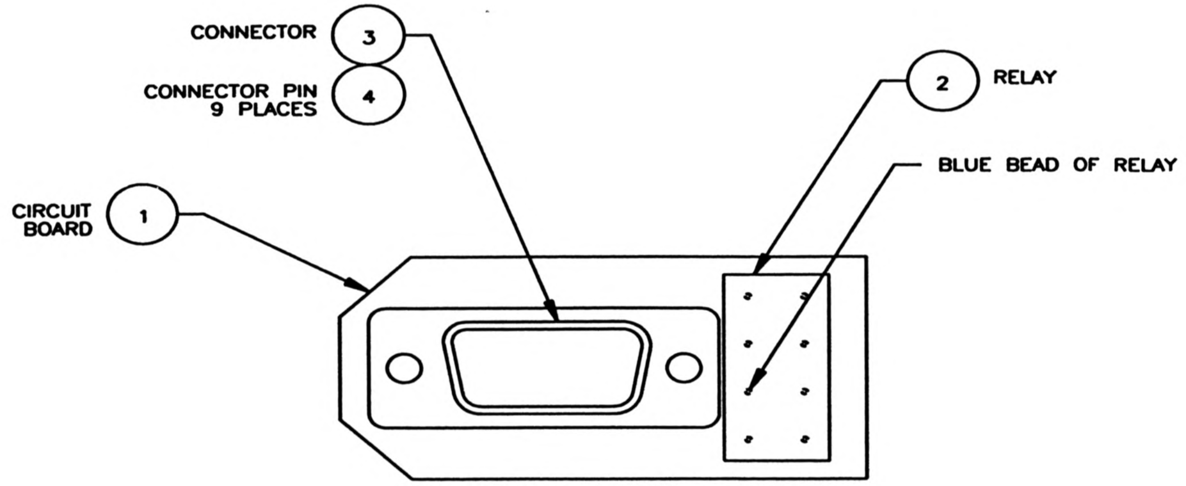
DRILL CHART		
HOLE	FINISHED SIZE	QTY
A	ø.035	17
B	ø.120	2



-1 ARTWORK
COMPONENT SIDE



-1 DRILL DRAWING ⚠1
COMPONENT SIDE



-10 ASSEMBLY
COMPONENT SIDE

ACAD : 53500A23

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
4				PIN, CONNECTOR	9
3		TRW CINCH	DB-9S	CONNECTOR, 9-PIN	1
2		TELEMECHANIQUE	S6A126.5VDC	RELAY	1
1		NRAO	-1	BOARD, CIRCUIT	1

NEXT ASSEMBLY	DWG. TYPE
C53500A009	ASSEMBLY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT: CONVERTER MODULE

TITLE:
CONVERTER MODULE
IF GAIN RELAY
PCB ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

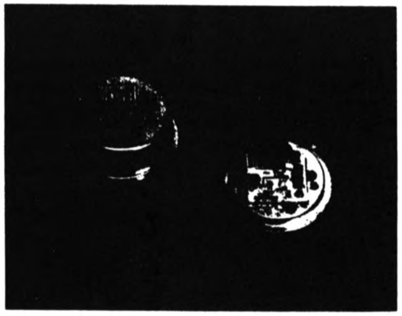
DRAWN BY K. TATE DATE 9-93
DESIGNED BY B. TREACY DATE 2-89
APPROVED BY DATE

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A023
REV. –
SCALE 2/1

WJ-A18-1 / SMA18-1

10 to 1000 MHz
TO-8 CASCADABLE AMPLIFIER

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ HIGH DYNAMIC RANGE
- ◆ HIGH OUTPUT POWER: +16 dBm (TYP.)
- ◆ HIGH THIRD ORDER I.P.: +30 dBm (TYP.)
- ◆ LOW NOISE: 3.8 dB (TYP.)



Specifications*

Characteristics	Typical	Guaranteed 0° to 50°C	Guaranteed - 54° to +85°C
Frequency (Min.)	5-1100 MHz	10-1000 MHz	10-1000 MHz
Small Signal Gain (Min.)	14.7 dB	14 dB	13.5 dB
Gain Flatness (Max.)	< ±0.3 dB	±0.5 dB	±1.0 dB
Noise Figure (Max.)	3.8 dB	5.0 dB	5.5 dB
Power Output at 1 dB Compression (Min.)	+16 dBm	+15 dBm	+14.5 dBm
VSWR (Max.) Input/Output	< 1.5:1	1.8:1	2.0:1
DC Current (Max.) at 15 Volts	44 mA	46 mA	48 mA

*Measured in a 50-ohm system at +15 Vdc Nominal.

Notes:

1 WJ-CA18 is a standard WJ-A18 installed in a miniature SMA connector housing and guaranteed over 0°C to 50°C temperature range.

Typical Intermodulation Performance at 25°C

Second Order Harmonic Intercept Point	+45 dBm (Typ.)
Second Order Two Tone Intercept Point	+42 dBm (Typ.)
Third Order Two Tone Intercept Point	+30 dBm (Typ.)

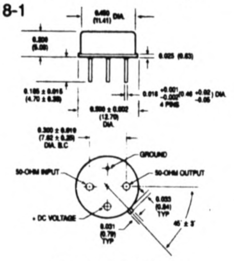
Absolute Maximum Ratings

Storage Temperature	-62°C to +125°C
Maximum Case Temperature	125°C
Maximum DC Voltage	+17 Volts
Maximum Continuous RF Input Power	+13 dBm
Maximum Short Term RF Input Power	50 Milliwatts (1 Minute Max.)
Maximum Peak Power	0.5 Watt (3 μsec Max.)
"S" Series Burn-in Temperature (Case)	125°C

Weight approximately 2.0 grams (0.07 oz.) max.

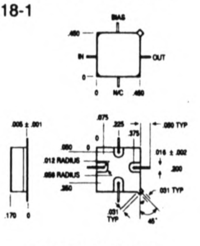
Outline Drawings

A18-1



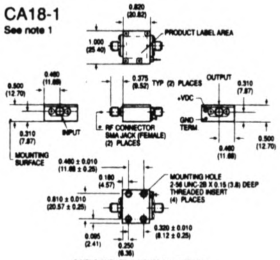
DIMENSIONS ARE IN INCHES (MILLIMETERS)
± .005 (.13) UNLESS OTHERWISE SPECIFIED

SMA18-1



DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

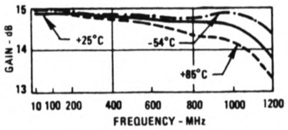
CA18-1
See note 1



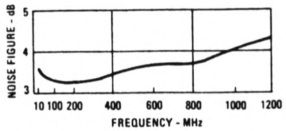
DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

Typical Performance at 25°C

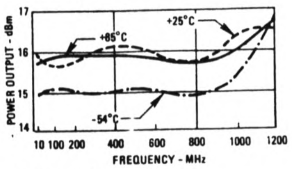
Gain



Noise Figure

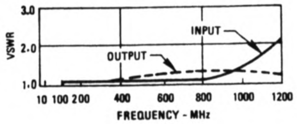


Power Output*

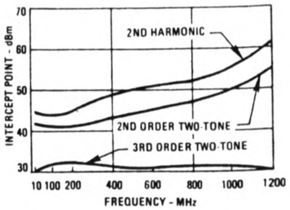


* at 1 dB Gain Compression

VSWR



Intercept Point



Typical Automatic Test Data

V_{CC} = 15.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1.2	14.8
2.0	1.1	1.2	14.8
5.0	1.1	1.1	14.9
10.0	1.0	1.0	14.9
50.0	1.0	1.0	14.8
100.0	1.1	1.0	14.7
200.0	1.1	1.0	14.6
300.0	1.1	1.1	14.6
400.0	1.2	1.1	14.8
500.0	1.2	1.2	15.0
600.0	1.2	1.2	15.1
700.0	1.2	1.3	15.2
800.0	1.1	1.3	15.3
900.0	1.1	1.4	15.4
1000.0	1.2	1.5	15.4
1100.0	1.6	1.6	15.0

Linear S-Parameters

Frequency MHz	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG
1.0	.078	–65	5.517	–174	.107	8	.078	110
2.0	.068	–64	5.511	–175	.107	7	.071	110
5.0	.038	–61	5.543	–179	.109	3	.046	100
10.0	.016	–44	5.529	175	.110	–1	.022	73
50.0	.022	9	5.513	167	.111	–4	.015	42
100.0	.028	9	5.443	159	.111	–7	.014	12
200.0	.040	–5	5.377	147	.112	–11	.020	–28
300.0	.055	–28	5.361	132	.113	–18	.037	–74
400.0	.077	–51	5.495	116	.117	–25	.066	–113
500.0	.075	–76	5.610	100	.119	–33	.089	–147
600.0	.075	–92	5.711	81	.121	–41	.101	–175
700.0	.077	–110	5.758	63	.124	–49	.117	158
800.0	.066	–141	5.836	44	.127	–58	.139	127
900.0	.035	143	5.916	24	.131	–68	.166	93
1000.0	.078	39	5.890	1	.134	–79	.196	55
1100.0	.216	–8	5.651	–24	.134	–93	.223	12

V_{CC} = 5.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.4	1.3	13.2
2.0	1.4	1.3	13.2
5.0	1.3	1.3	13.2
10.0	1.3	1.3	13.3
50.0	1.3	1.3	13.2
100.0	1.3	1.3	13.1
200.0	1.3	1.3	13.0
300.0	1.3	1.3	13.0
400.0	1.4	1.4	13.1
500.0	1.3	1.5	13.2
600.0	1.3	1.5	13.3
700.0	1.3	1.5	13.4
800.0	1.3	1.6	13.3
900.0	1.4	1.6	13.2
1000.0	1.7	1.6	12.8
1100.0	2.2	1.6	12.0

Linear S-Parameters

Frequency MHz	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG
1.0	.158	–24	4.554	–174	.120	8	.122	50
2.0	.153	–23	4.581	–175	.121	7	.118	45
5.0	.139	–18	4.587	–179	.122	3	.115	26
10.0	.127	–18	4.607	174	.123	–1	.119	2
50.0	.133	–21	4.582	166	.123	–4	.120	–14
100.0	.134	–35	4.537	158	.123	–7	.120	–26
200.0	.140	–54	4.478	145	.124	–11	.127	–46
300.0	.145	–79	4.446	129	.126	–18	.143	–73
400.0	.150	–106	4.539	112	.131	–24	.169	–103
500.0	.146	–137	4.582	95	.135	–32	.188	–132
600.0	.137	–168	4.632	75	.139	–41	.201	–161
700.0	.128	157	4.651	56	.144	–50	.211	172
800.0	.128	112	4.624	35	.148	–60	.224	141
900.0	.170	63	4.557	14	.153	–71	.233	107
1000.0	.251	17	4.345	–9	.152	–84	.236	70
1100.0	.371	–22	3.970	–33	151	–96	.225	29

Thermal Data: V_{CC} = 15 Vdc

Thermal Resistance θ_{jc}	45°C/W
Transistor Power Dissipation P_d	0.407 W
Junction Temperature Rise Above Case T_{jc}	18°C

WJ-A19 / SMA19

10 TO 1000 MHZ
TO-8 CASCADABLE AMPLIFIER

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ HIGH OUTPUT POWER: +21 dBm (TYP.)
- ◆ HIGH THIRD ORDER I.P.: +34 dBm (TYP.)

Specifications*

Characteristics	Typical	Guaranteed 0° to 50°C	 -54° to +85°C
Frequency (Min.)	5-1050 MHz	10-1000 MHz	10-1000 MHz
Small Signal Gain (Min.)	7.5 dB	6.0 dB	5.5 dB
Gain Flatness (Max.)	< ±0.3 dB	±1.0 dB	±1.3 dB
Noise Figure (Max.)	9.0 dB	10.5 dB	11.0 dB
Power Output at 1 dB Compression (Min.)	+21 dBm	+20 dBm	+19 dBm
VSWR (Max.) Input/Output	< 1.8:1	2.2:1	2.2:1
DC Current (Max.) at 15 Volts	100 mA	109 mA	114 mA

*Measured in a 50-ohm system at +15 Vdc Nominal.

Notes:

1. WJ-CA19 is a standard WJ-A19 installed in a miniature SMA connector housing and guaranteed over 0°C to 50°C temperature range.

Typical Intermodulation Performance at 25°C

Second Order Harmonic Intercept Point...+45 dBm (Typ.)
Second Order Two-Tone Intercept Point ....+40 dBm (Typ.)
Third Order Two-Tone Intercept Point ....+34 dBm (Typ.)

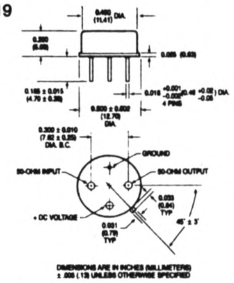
Absolute Maximum Ratings

Storage Temperature..-62°C to +125°C
Maximum Case Temperature ....125°C
Maximum DC Voltage...+ 17 Volts
Maximum Continuous RF Input Power ....+17 dBm
Maximum Short Term RF Input Power..............................100 Milliwatts (1 Minute Max.)
Maximum Peak Power ....0.5 Watt (3 µsec Max.)
"S" Series Burn-In Temperature (Case)...125°C

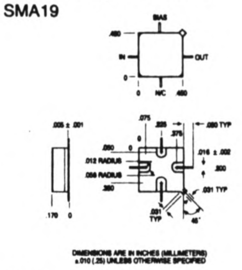
Weight approximately 2.0 grams (0.07 oz.)

Outline Drawings

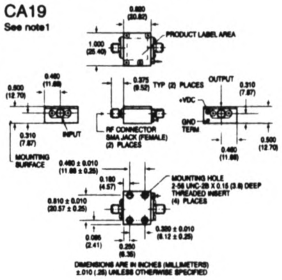
A19



SMA19

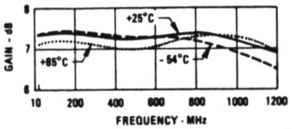


CA19
See note 1

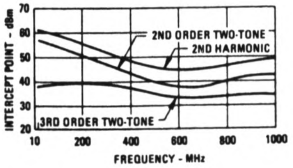


Typical Performance at 25°C

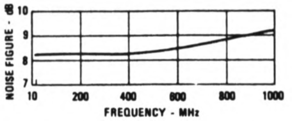
Gain



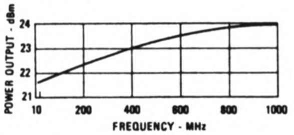
Intercept Point



Noise Figure

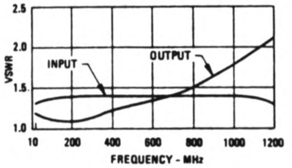


Power Output*



* at 1 dB Gain Compression

VSWR



Typical Automatic Test Data

V_{CC} = 15.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1.4	6.8
2.0	1.1	1.3	6.8
5.0	1.1	1.3	6.9
10.0	1.1	1.4	7.0
50.0	1.0	1.4	7.0
100.0	1.1	1.4	6.9
200.0	1.1	1.4	6.8
300.0	1.2	1.4	6.7
400.0	1.2	1.5	6.8
500.0	1.3	1.5	6.9
600.0	1.4	1.6	7.1
700.0	1.4	1.6	7.2
800.0	1.5	1.6	7.2
900.0	1.6	1.6	7.2
1000.0	1.7	1.6	7.2
1100.0	1.9	1.5	6.9

Linear S-Parameters

Frequency MHz	S11 MAG	 ANG	S21 MAG	 ANG	S12 MAG	 ANG	S22 MAG	 ANG
1.0	.079	−78	2.195	−169	.165	3	.151	35
2.0	.069	−79	2.198	−170	.165	3	.148	32
5.0	.044	−78	2.216	−177	.166	2	.146	19
10.0	.025	−86	2.227	176	.168	−0	.151	6
50.0	.022	−88	2.226	167	.168	−2	.154	−2
100.0	.036	−101	2.203	159	.168	−4	.157	−8
200.0	.054	−116	2.181	147	.170	−6	.164	−17
300.0	.075	−136	2.169	132	.174	−10	.179	−30
400.0	.101	−155	2.199	116	.180	−14	.196	−47
500.0	.131	180	2.218	99	.185	−18	.209	−65
600.0	.155	156	2.264	83	.191	−23	.222	−83
700.0	.174	133	2.284	66	.199	−28	.230	−102
800.0	.194	110	2.295	48	.207	−34	.233	−122
900.0	.232	85	2.289	32	.220	−39	.227	−143
1000.0	.269	58	2.282	13	.230	−46	.217	−167
1100.0	.301	32	2.221	−5	.242	−53	.200	169

V_{CC} = 12.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1.4	6.8
2.0	1.2	1.4	6.8
5.0	1.1	1.3	6.8
10.0	1.1	1.4	6.9
50.0	1.0	1.4	6.9
100.0	1.1	1.4	6.8
200.0	1.1	1.4	6.7
300.0	1.2	1.4	6.7
400.0	1.2	1.5	6.8
500.0	1.3	1.5	6.9
600.0	1.4	1.5	7.0
700.0	1.4	1.6	7.1
800.0	1.5	1.6	7.1
900.0	1.6	1.5	7.1
1000.0	1.8	1.5	7.0
1100.0	1.9	1.4	6.8

Linear S-Parameters

Frequency MHz	S11 MAG	 ANG	S21 MAG	 ANG	S12 MAG	 ANG	S22 MAG	 ANG
1.0	.074	−76	2.178	−169	.165	3	.153	33
2.0	.071	−77	2.180	−171	.165	3	.150	29
5.0	.040	−78	2.197	−177	.166	1	.149	18
10.0	.026	−95	2.207	176	.168	−0	.154	4
50.0	.023	−92	2.206	167	.168	−2	.158	−3
100.0	.030	−103	2.187	159	.169	−4	.160	−10
200.0	.053	−115	2.169	147	.170	−6	.165	−19
300.0	.081	−135	2.153	131	.175	−9	.178	−33
400.0	.102	−155	2.190	115	.181	−13	.193	−51
500.0	.133	180	2.203	99	.187	−18	.205	−69
600.0	.158	155	2.246	82	.194	−22	.214	−87
700.0	.179	133	2.276	65	.203	−27	.219	−107
800.0	.204	109	2.277	47	.213	−33	.219	−127
900.0	.243	84	2.263	31	.227	−39	.212	−150
1000.0	.278	57	2.246	12	.237	−46	.199	−175
1100.0	.309	30	2.179	−6	.249	−53	.181	160

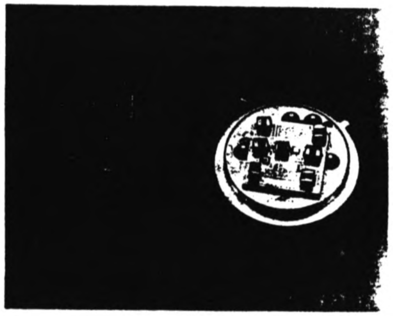
Thermal Data: V_{CC} = 15 Vdc

Thermal Resistance θ_{jc} ....45°C/W
Transistor Power Dissipation P_d ....0.944 W
Junction Temperature Rise Above Case T_{jc} ...42°C

WJ-G1/SMG1

5 TO 2000 MHz
TO-8 VOLTAGE-CONTROLLED
ATTENUATOR MODULE

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ LOW VSWR: < 1.8:1 (TYP.)
- ◆ LOW INSERTION LOSS:
  2.0 dB to 1000 MHz (TYP.)
- ◆ LOW DISTORTION: -25 dBc (TYP.)
  AT $V_{CONTROL}$ = +15V



Specifications*

Characteristics	Typical	Guaranteed
Frequency Range	5 to 2200 MHz	5 to 2000 MHz
Maximum Attenuation Available (Min.)		
5 - 500 MHz	36 dB	31 dB
500 - 1000 MHz	30 dB	25 dB
1000 - 2000 MHz	23 dB	18 dB
Insertion Loss (V_{ctrl} = +15 V) (Max.)		
5 - 1000 MHz	2.0 dB	2.5 dB
1000 - 2000 MHz	2.5 dB	3.0 dB
VSWR (Worst case in attenuation range)		
5 - 2000 MHz	≤1.8:1	2.2:1
Flatness Over Frequency (Max.)		
(Attenuation = min. to 15db, 5 - 1000 MHz)	±0.5 dB	±1.0 dB
Bias Voltage		+15V
Bias Current (Max.)		15 mA
Control Voltage		0 V to + 15V
Control Current (Max.)		7 mA
Switching Speed (Max.)		
10% - 90%	60 µsec	120 µsec
0% - 100%	75 µsec	125 µsec

*Measured in a 50-ohm system at +15.0 Vdc, guaranteed at 25°C.

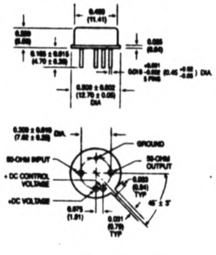
Absolute Maximum Ratings

Storage Temperature .... -62°C to +125°C
Maximum Case Temperature .... 125°C
Maximum DC Voltage .... +18 Volts
Maximum Continuous RF Input Power .... +20 dBm
Maximum Short Term RF Input Power (1 Minute Max.) .... 200 Milliwatts
Maximum Peak Power .... 1 Watt (3 µsec Max.)
"S" Series Burn-In Temperature (Case) .... 125°C

Weight 2.27 grams (0.08 oz.) max.

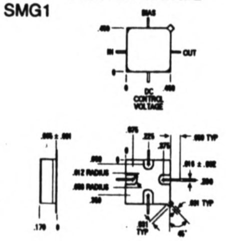
Outline Drawing

G1



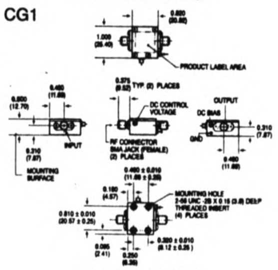
DIMENSIONS ARE IN INCHES (MILLIMETERS)
± .005 (.13) UNLESS OTHERWISE SPECIFIED

SMG1



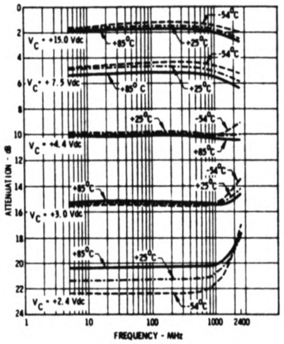
DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

CG1

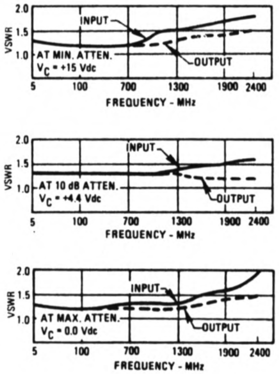


DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

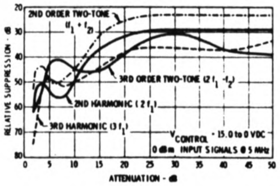
Typical Performance at 25°C



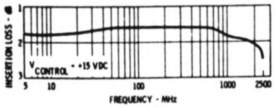
Attenuation vs. Frequency



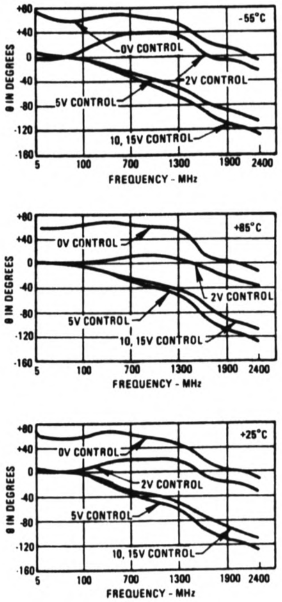
VSWR vs. Frequency



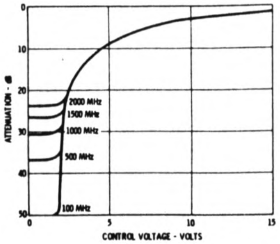
Distortion Products



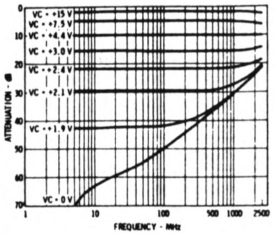
Insertion Loss vs. Frequency at $V_{CONTROL}$ = 15 V



Phase vs. V_{CTL} vs. Frequency vs. Phase of the Moon

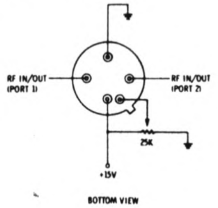


Attenuation vs. Control Voltage

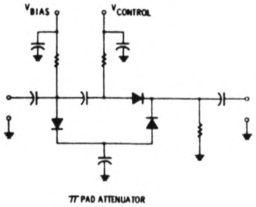


Attenuation vs. V_{CTL} vs. Frequency

Typical Test Circuit



Schematic Diagram



π PAD ATTENUATOR

Type C Transfer Coaxial Switches

RLC Electronics' Type C Transfer Switch line provides extremely high reliability, long life and outstanding electrical performance by utilizing high density packaging. The mid-size transfer electrical characteristics feature extremely low insertion loss and VSWR over the entire DC-18 GHz range with option to 40 GHz, while maintaining high isolation. The switch is available in the following configurations — manual or remote, BNC, TNC, or SMA connectors, 28 Vdc or 115 Vac operation, with or without indicator terminals, failsafe or latching cut throat.

Specifications

S^1-$TC^{2,3,4,5,6,7}$

Switch Type	Transfer		
Freq. Range	DC-18 GHz	DC-40 GHz (Opt. 40)	
Ins. Loss: (dB Max)		Ins. Loss: (dB Max)	
DC-4 GHz 4-12.4 GHz 12.4-18 GHz	0.2 0.3 0.4	DC-6 GHz 6-12 GHz 12-18.5 GHz 18.5-26.5 GHz 26.5-40 GHz	0.25 0.4 0.5 0.7 1.0
VSWR: Max		VSWR: Max	
DC-4 GHz 4-12.4 GHz 12.4-18 GHz	1.2 1.3 1.5	DC-6 GHz 6-12 GHz 12-18.5 GHz 18.5-26.5 GHz 26.5-40 GHz	1.3 1.4 1.5 1.7 2.0
Isolation: (dB Min)		Isolation: (dB Min)	
DC-4 GHz 4-12.4 GHz 12.4-18 GHz	80 70 60	DC-6 GHz 6-12 12-18.5 18.5-26.5 26.5-40	70 60 60 55 45

Power Rating, RF, Cold Switching: See page 5.
Impedance: 50 ohms.
Operating Power 25°C:
(Failsafe): 12 Vdc at 500 ma nom., 28 Vdc at 200 ma nom. 115 Vac at 40 ma nom.
(Latching): 12 Vdc at 700 ma nom. 28 Vdc at 300 ma nom. 115 Vac at 225 ma nom. Current applied 10 ms min.; cutthroat standard, recovery time, 100 ms nom.

Connectors, RF: SMA, TNC*, BNC*
Connectors, Power: Feed through solder lugs.
Life: 1,000,000 operations.
Switching Time: 15 milliseconds max.
Weight: 6 oz.
Environmental Conditions: MIL-S-3928
Operating Mode: Manual, failsafe or latching.
Switching Sequence: Break before make.

*BNC not recommended for use above 1 GHz.
*TNC not recommended for use above 12.4 GHz.

To designate the switch desired use:

(1) "M" for Manual or "R" for Remote.
(2) "B" for BNC, "T" for TNC or "R" for SMA type connectors.
(3) "A" for 115 Vac, "H" for 12 Vdc., or "D" for 28 Vdc
(4) "I" for indicators if desired.
(5) "L" for latching cut throat if desired.
(6) "TL" for TTL Driver if desired.
(7) "40" for 40 GHz option.

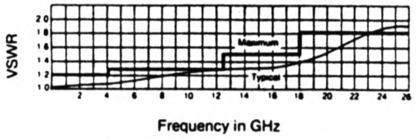
Example: SR-TC-T-D-I-L is a remote TNC, 28 Vdc with indicators, latching cut throat switch.

Specials requiring closer tolerances, different frequency ranges, special connectors, different materials, finishes, etc. can be furnished upon request.

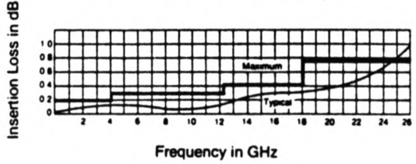
Typical Operating Curves

DC-18 & DC-26 GHz Switches

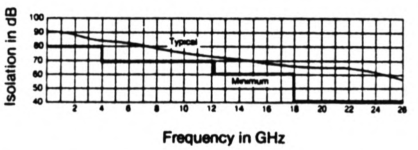
VSWR Vs. Frequency



Insertion Loss Vs. Frequency

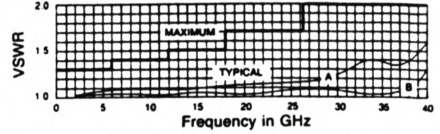


Isolation Vs. Frequency

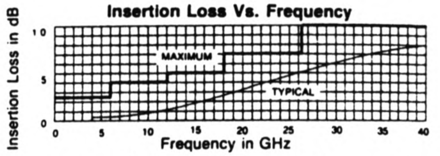


DC-40 GHz Switches

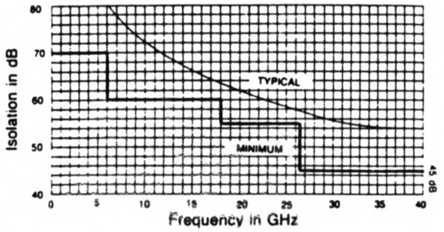
VSWR Vs. Frequency



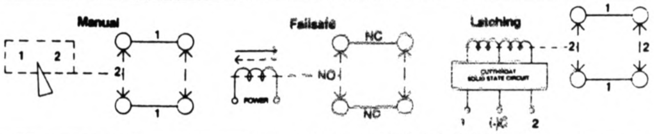
Insertion Loss Vs. Frequency



Isolation Vs. Frequency



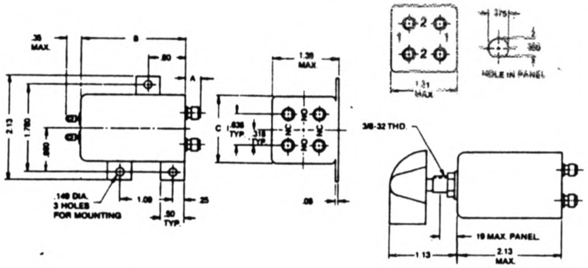
Schematics



Outlines

CONN	A	C
SMA	.30	1.31
BNC/TNC	.56	1.31
OPT 40	.27	1.26*

*OPT 40 does not have mtg plate.



MODEL NO.	B
SR-TC- • -D	2.16
SR-TC- • -D-I	2.16
SR-TC- • -D-L	2.13
SR-TC- • -D-I-L	2.13
SR-TC- • -D-TL	2.50
SR-TC- • -D-I-TL	2.50
SR-TC- • -D-L-TL	2.16
SR-TC- • -D-I-L-TL	2.16
SR-TC- • -D-40	1.85
SR-TC- • -H same as SR-TC- • -D	

Tolerances unless otherwise specified are: .xx, ± .02; .xxx, ± .005.

COAXIAL SWITCH
TYPES HO & HOF
DATA SHEET 104B

RF CIRCUIT	**Transfer**
ACTUATOR	**Fail-Safe**
CONNECTOR	**SMA**
FREQUENCY	**0-18 GHz**

DESCRIPTION

The Type HO TRANSFER Switch has RF geometry optimized for SMA connectors and operates over a 0-18 GHz frequency band. It is also available with or without indicators. Transco's design mechanically links indicating switches to the rotating armature for positive indications.

Actuator features:

1. Balanced rotating armature
2. Low current required to develop the actuating torque
3. Dual holding power—permanent magnet plus electromagnet

The design features a dual magnetic field for high efficiency and long life reliability — also excellent shock/vibration characteristics.

The Type HOF is designed for miniature packaging and is the smallest TRANSFER switch available. This switch utilizes a non-polarized linear solenoid for actuation.

This switch is part of a Transco family of switches. Other types in this family are referenced below.

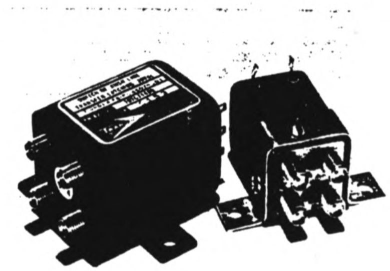
TYPE	CONN	FREQ
H	N	12.4 GHz
HT	TNC	12.4 GHz
HX	SC	6.5 GHz

STANDARD PRODUCTS

P/N	SCHEMATIC	MIL SPEC
710C70100	1	MIL-S-3928/19-02
710C70200	2	
715C70100	3	
710C70100-8	1	**QUALIFIED PRODUCT LIST MIL-S-3928/19-02**

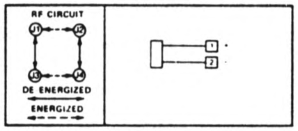
P/N	SCHEMATIC	
710C71400	4*	
710C71400-8	4*	**QUALIFIED PRODUCT LIST MIL-S-3928/19-05**

*With arc suppression diode

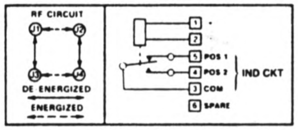


SCHEMATIC

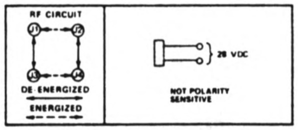
#1. FAIL-SAFE



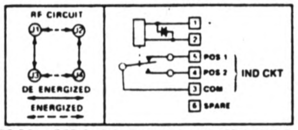
#2. FAIL-SAFE WITH INDICATOR CIRCUIT



#3. FAIL-SAFE



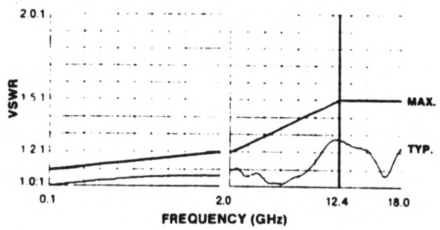
#4. FAIL-SAFE WITH INDICATOR CIRCUIT

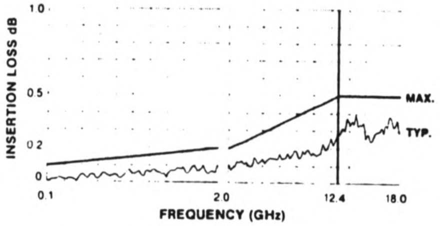


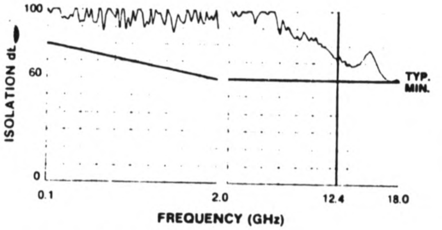
RF CONNECTIONS SHOWN IN FAIL-SAFE POSITION (DE-ENERGIZED)

SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:

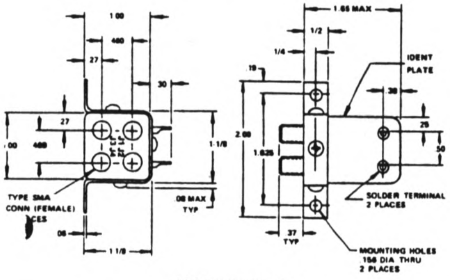






LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

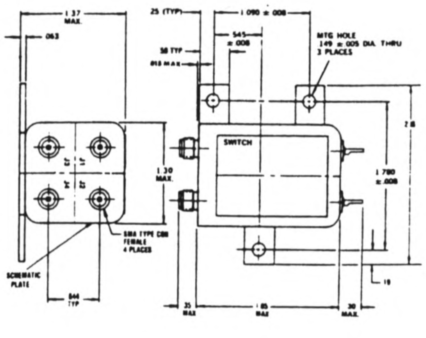


HOF 715C70100

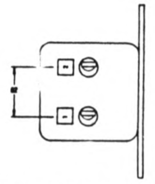
PART NO.	710C70100 & 710C70200
ACTUATING VOLTAGE	20 to 30 Vdc
COIL RESISTANCE	250 ±25 ohms @ 20°C
CURRENT	120 mA @ 28 Vdc & 20°C
SWITCHING TIME	20 mS @ 28 Vdc & 20°C
RF CONTACT	break-before-make
IMPEDANCE	50 ohms nominal
TEMPERATURE	-55°C to 85°C
VIBRATION	20 g's sine/random
LIFE	100.000 cycles min
WEIGHT	3.5 oz max

PART NO.	715C70100
ACTUATING VOLTAGE	24 to 32 Vdc
COIL RESISTANCE	145 +5% ohms @ 20°C
CURRENT	200 mA @ 28 Vdc & 20°C
SWITCHING TIME	20 mS @ 28 Vdc & 20°C
RF CONTACT	break-before-make
IMPEDANCE	50 ohms nominal
TEMPERATURE	-55°C to 85°C
VIBRATION	10 g's sine up to 500 Hz
LIFE	100.000 cycles min
WEIGHT	3.0 oz max

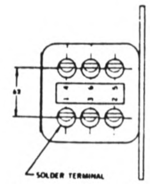
DIMENSIONS



HO 710C70100 & 710C70200



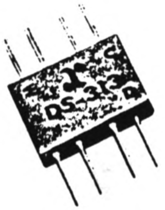
WITHOUT INDICATOR



WITH INDICATOR

MODEL DS-313 | TWO-WAY IN-PHASE POWER DIVIDER 10-2000 MHz

- 0.6 dB Typical Midband Loss
- 28 dB Typical Midband Isolation
- 1.2:1 Typical Midband VSWR



Guaranteed Specifications*

(From −55°C to +85°C)

Frequency Range		10-2000 MHz
Insertion Loss (Less coupling)	20-1000 MHz	1.1 dB Max
	10-1500 MHz	1.3 dB Max
	1500-2000 MHz	1.8 dB Max
Isolation	20-1000 MHz	23 dB Min
	10-1500 MHz	18 dB Min
	1500-2000 MHz	12 dB Min
Amplitude Balance	20-1000 MHz	0.3 dB Max
	10-1500 MHz	0.4 dB Max
	1500-2000 MHz	0.6 dB Max
Phase Balance	20-1000 MHz	4° Max
	10-1500 MHz	6° Max
	1500-2000 MHz	8° Max
VSWR (All Ports)	20-1000 MHz	1.5 Max
	10-1500 MHz	1.6 Max
	1500-2000 MHz	1.8 Max

Operating Characteristics

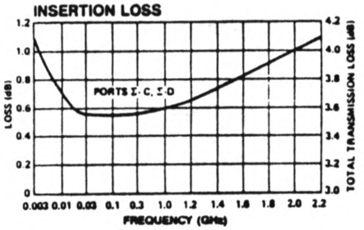
Impedance	50 Ohms Nominal
Maximum Power Rating or Input Power	250 mW Max
Internal Load Dissipation	50 mW Max
Package Type	Flatpack (FP-2) (See page 474 for physical dimensions.)

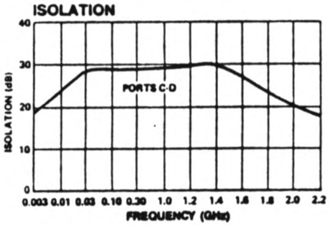
Environmental
These units are designed to meet the environmental and screening requirements of Table 1A, page 496 of the Adams-Russell catalog.

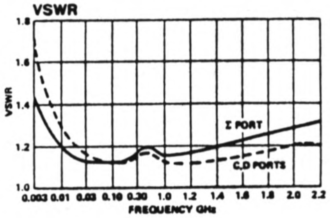
Pin Configuration	Σ; P1, Output 'C'; P4, Output 'D'; P8 Case and all other pins ground.

*All specifications apply with 50 ohm source and load impedance.

Typical Performance







Ordering Information

Model No.	Part No.	Connectors	Unit Price (5-9 Units)
DS-313	8559	Pin	$67

Delivery is from stock

COAXIAL SWITCH

TYPE DO

DATA SHEET 103B

RF CIRCUIT	**SPDT**
ACTUATOR	**Latching**
CONNECTOR	**SMA**
FREQUENCY	**0-18 GHz**

DESCRIPTION

The Type DO Latching SPDT Switch has RF geometry optimized for SMA connectors and operates over a 0-18 GHz frequency band. It is magnetically latched and available with or without Actuator Cut-off Circuit. It is also available with or without Indicating Switches. Transco's design mechanically links indicating switches to the rotating armature for positive indication.

Actuator features:

1. Balanced rotating armature
2. Reliable actuation with low current
3. Positive latching with permanent magnets
4. Basic design concept qualified for space applications

A single voltage pulse of 20 milliseconds is all that is required to change positions; no holding power is required in position.

Magnetic latching offers distinct advantages over other mechanisms since it uses no springs or mechanical detents which are prone to fatigue and wear. Transco considers magnetic latching to be the optimum design for applications which require high vibration levels, environmental extremes, long life and reliability.

This switch is part of the Type D family of switches featuring different RF connectors and frequencies.

TYPE	CONN.	FREQ.
D	N & TC	12 GHz
DO	SMA	18 GHz
DX	SC	6 GHz
DO	3.5 mm	26.5 GHz

DESIGNED TO MEET:
MIL-S-3928/15-07 SCHEMATIC 1
MIL-S-3928/15-08 SCHEMATIC 2

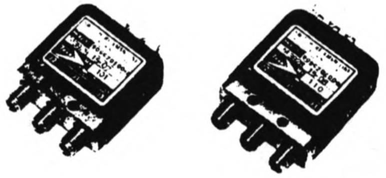
STANDARD PRODUCTS

P/N	SCHEMATIC	
909C70100	1	
909C70200	2	
909C71100	3	
909C71200	4	
909C70100-8	1	**Qualified Product List MIL-S-3928/15-07**
909C70200-8	5	**MIL-S-3928/15-08**

SPECIAL CONFIGURATION

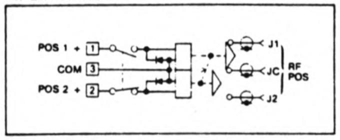
Actuating Voltage	Mounting Configuration
Transient Circuit	Terminal Location
TTL Logic Circuit	

(For dimensions and circuit diagrams see page 20)

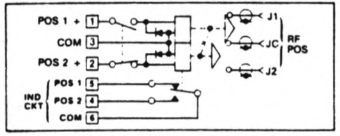


SCHEMATIC

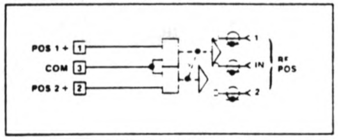
#1. LATCHING



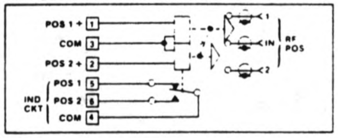
#2. LATCHING WITH INDICATOR



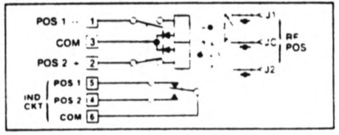
#3. PULSE LATCHING



#4. PULSE LATCHING W/INDICATOR

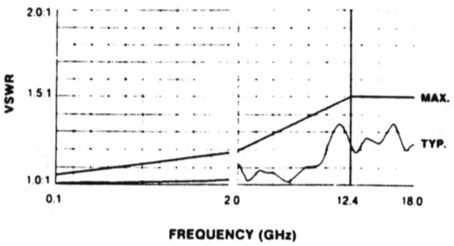


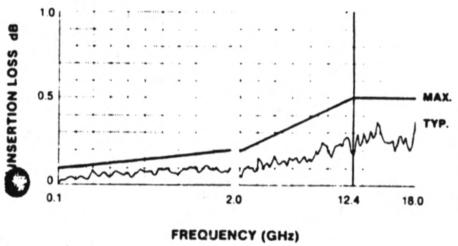
#5. LATCHING WITH INDICATOR

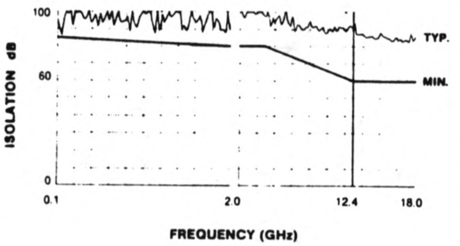


SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:





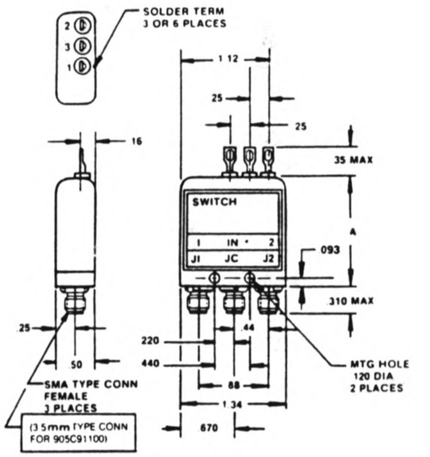


LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

VOLTAGE	20 to 30 Vdc
COIL RESISTANCE	310±15 ohms @ 20°C
CURRENT	95 mA max @ 28 Vdc & 20° C
SWITCHING TIME	20 milliseconds
RF CONTACTS	break-before-make
IMPEDANCE	50 ohms nominal
TEMPERATURE	-55° C to 85° C
VIBRATION	20 g's sine/random
LIFE	1 000.000 cycles min
WEIGHT	909C70100 909C71100 1.5 oz
	909C70200 909C71200 2.0 oz

DIMENSIONS



P/N	A
909C70100 909C71100 905C91100	1.30
909C70200 909C71200	1.50

2.6 CONVERTER REPLACEMENT PROCEDURE

When replacing a frequency converter, it is necessary to adjust the replacement converter's LCP and RCP channels. This requires an HP 436A power meter, preferably equipped with an 8484A sensor. The 8481A sensor may also be used. The antenna should be pointing at the zenith.

Connect the power meter sensor to the LCP IF output jack on the front panel. Set the converter LO band switches to the correct positions for the converter under test, and set the LO frequencies to the values listed in the table in Section 2.3.

Adjust the front panel LCP gain adjustment potentiometer until the meter reads the power level indicated in the "Nominal Total Output Power @ Std Syst Temp, dBm" row in the Section 2.3 table.

Repeat this procedure for the RCP IF channel.

Repeat the LCP and RCP adjustment procedures for the range of LO frequencies listed in the table. The potentiometers should be set so that the average measured power level over the LO frequency settings is the value listed in the table.

When replacing T101 or T102, use the gain adjustment procedures described in Section 3.1 or 3.2 instead of this procedure.

2.7 CONVERTER TEST PROCEDURES

The test procedures in this section were abstracted from the Technical Manual for CONVERTER MODULES cited above and have been adapted for use at the VLBA AOC. These procedures are general and apply to all converter modules to verify performance and adjust IF gain. In the case of T101 and T102, gain adjustment procedures particularized to these modules are included in Sections 3.1 and 3.2. The test procedures specify the required test equipment and set-up. Modules that have mode or frequency-dependent switching features should have provisions to set these switches to the appropriate state. The procedures reference tabulated frequencies, gains and levels; these are the values found in the Section 2.3 table. All tests require an SMA to OSP adapter bracket to simulate the module-bin interface. The tests performed are:

I. Adjustment of LO power, converter gain and flatness.

II. Measurement of power output at the 1 dB compression point.

III. Test of inter-channel isolation.

IV. Noise Figure test.

V. Test for spurious output signals.

I. LO Power, Gain and Flatness

Equipment Requirements:

1. An LO signal generator that covers the tabulated LO frequencies and is capable of at least +5 dBm output power.

2. An RF sweeper that sweeps the RF band tabulated in the specification table of Section 2.3 above.

3. A scalar network analyzer (SNA) such as the HP 8757 or PM 1038 with a detector covering the RF frequency range tabulated above, and the IF range of 500 to 1000 MHz.

Test Procedure:

1. Refer to Figure 7, below. Connect the sweeper and SNA as detailed in the manufacturer's instructions. Set the sweeper to sweep the RF input band at a power level of about -20 dBm and calibrate the SNA with the detector connected to the sweeper output.

2. Connect the LO signal to the module's LO input. Set the LO source's level 1.5 dB below the nominal level tabulated above. Connect the RF sweeper output to the module's RF LCP input. Connect the detector to the module's IF LCP output. Connect a +15 volt DC power source to the module's power connector (P11). Verify that the transfer switch is not set to interchange the two channels. In converters with selector switches, set the selector switch to the mode or frequency channel under test.

3. Measure the LO power at the input to the mixers. Select an input LO attenuator that will produce the appropriate level of LO power at the input to each mixer.

4. Reconnect the mixers to the LO lines. Rotate the front-panel gain adjustment through its range while observing the SNA. The gain should change smoothly over a ≥ 20 dB range while remaining flat over the IF band.

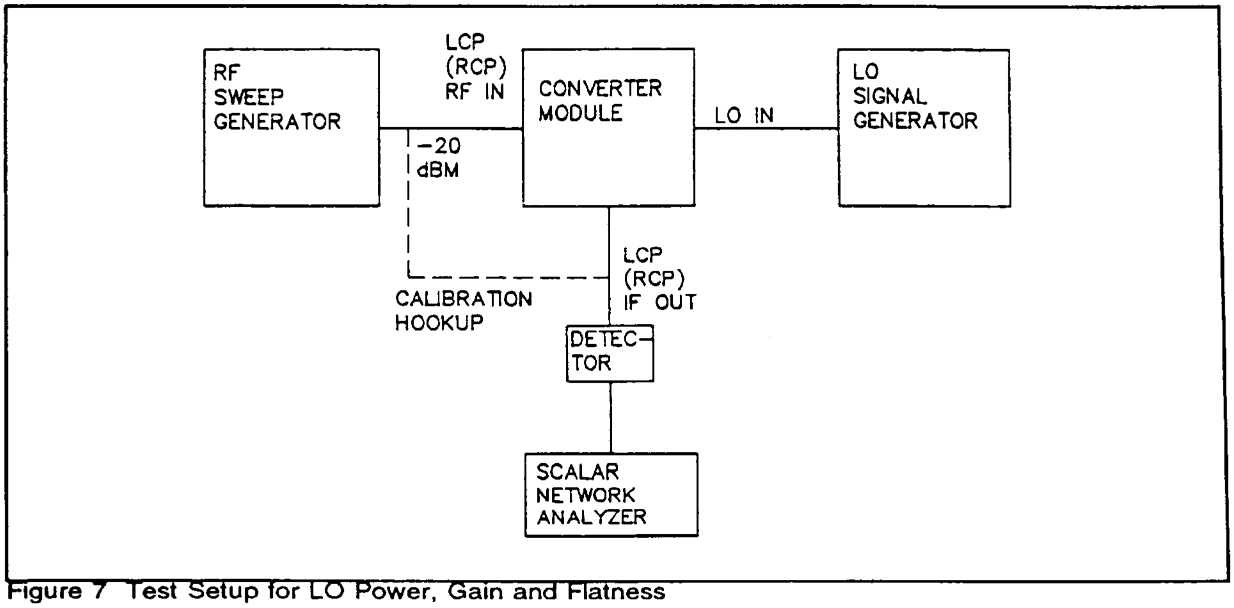


Figure 7 Test Setup for LO Power, Gain and Flatness

5. Set the gain control to about the middle of its range. This should give about 12 dB gain for converters without input amplifiers. Use this gain setting for the remainder of the tests.

6. Disconnect the RF source and the SNA detector from the LCP RF input and IF outputs; then connect them to the RCP counterparts. Repeat steps 3 and 5.

7. This concludes the LO power, gain and flatness tests.

II. Power Output at the 1 dB Gain Compression Point

Equipment Requirements:

1. Three signal generators, one for the LO signal and two for the RF signals. These need not be sweepers. One of the RF generators should be capable of square-wave modulation.

2. A directional coupler, 10 or 20 dB isolation. The coupler must work across the entire input RF band.

3. A spectrum analyzer good to 1000 MHz.

4. Isolator for the RF frequency range being used. Fixed attenuators may be substituted at lower frequencies.

Test Procedure:

Note that this is a "desensitization" ("de-sense") measurement - measuring the change in level of a desired signal due to the presence of a strong, undesired signal. A true compression test would use only one signal, increasing its power until the gain for that signal decreased from the predicted power by 1 dB.

Although compression levels in radio astronomy are typically specified in terms of the 1% compression level, this compression level is quite difficult to measure on the bench. A more convenient alternate is the measurement of the 1 dB compression level, which is simpler and more directly corresponds to the manufacturer's specifications.

This procedure is based upon the rule of thumb that the 1% compression level is about 12 dB below the 1 dB level. This rule seems to be roughly correct for the types of devices that are used in the converters, but has no theoretical foundation. (If converters were perfectly "hard" limiters, 1 dB compression would only be slightly less than 1 dB above 1%.)

1. Connect the equipment shown in Figure 8. The LCP input is connected to the output of the directional coupler and the spectrum analyzer is connected to the LCP IF output. RF signal generator #1 represents the strong, undesired signal. Set it at midband. RF signal generator #2 represents the desired, weaker signal. Set its

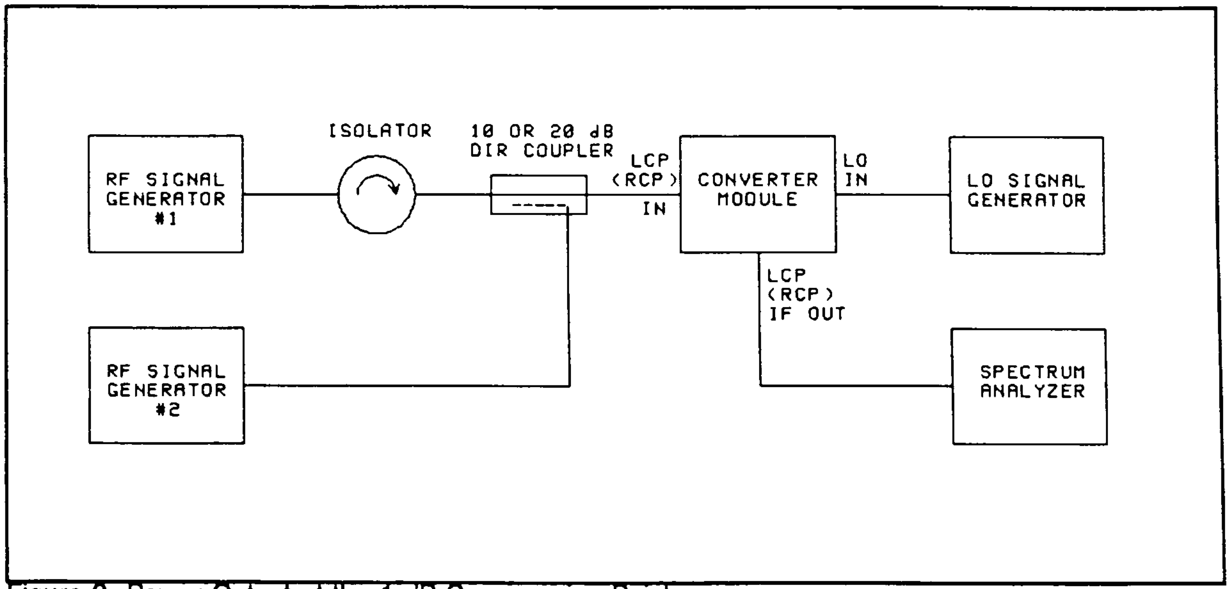


Figure 8 Power Output at the 1 dB Compression Point

frequency close to generator #1, but far enough away so that the spectrum analyzer can separate them easily.

2. Turn on the square-wave modulation on Signal Generator #1. It should be 100% modulation, chopping the power from full on to full off.

3. Tune the spectrum analyzer to the IF output corresponding to generator #2. It should be possible to distinguish generator #2's signal from generator #1 since it will be weaker and not modulated.

4. Set the generator #2 signal to the center of the spectrum analyzer screen and set the analyzer sweep width to 0. The spectrum analyzer is now acting as a fixed-frequency receiver, and the trace will show the amplitude of any modulation on the carrier. Set the vertical scale to its most sensitive, usually 2 dB/div. Slowly increase the power output from generator #1 while observing the spectrum analyzer trace. At some point, modulation will begin to be visible as the power from generator #1 begins modulating the gain of the converter. Increase the power until 1 dB modulation is seen.

   Verify that the modulation is happening in the converter module and not the spectrum analyzer by increasing the attenuation at the spectrum analyzer input by 10 dB. The trace should drop 10 dB (bring it back on screen by adjusting the gain, not the input attenuation) but the modulation depth should remain the same.

5. Measure the power out of generator #1 (with the modulation off) at this point. This is the 1 dB de-sense level.

6. The accuracy of the 12 dB rule may be verified by noting the rate at which the modulation increases with power. 1% is 1/23 dB or 1/46 divisions at 2 dB/division. This is too small to see on the Tektronix 2710-2172 analyzers where one pixel is 1/30 div. Also note that these, and probably other analyzers, are not very "linear" for changes of less than 2 dB.

7. Repeat the above for frequencies at the low end and the high end of the band.

8. Repeat the above for the RCP channel.

9. This concludes the 1 dB compression (de-sense) test.

III. Inter-Channel Isolation Test

Equipment Requirements:

1. LO signal generator that covers the specified LO frequencies, and is set to the nominal power level listed in the table.
2. RF sweeper that covers the converter's nominal input frequency band. The RF output power should be about -15 dBm.
3. A spectrum analyzer with a bandwidth of at least 1000 MHZ.

Test Procedure:

1. Set up the equipment shown on Figure 9, below. Connect the RF sweeper to the LCP input. Connect the spectrum analyzer to the LCP IF output.
2. Allow the sweeper to sweep slowly across the converter's frequency range.
3. Set the spectrum analyzer to display the the swept output. At 10 dB/division, it should be flat across the band. Set the gain and attenuator so that the trace is about 10 dB below the top of the spectrum analyzer display. Note the gain and attenuator settings.
4. Connect the sweeper to the opposite (RCP) input. Note the level of the trace on the spectrum analyzer and the reference level. It may be necessary to increase the gain or decrease the attenuation of the analyzer to

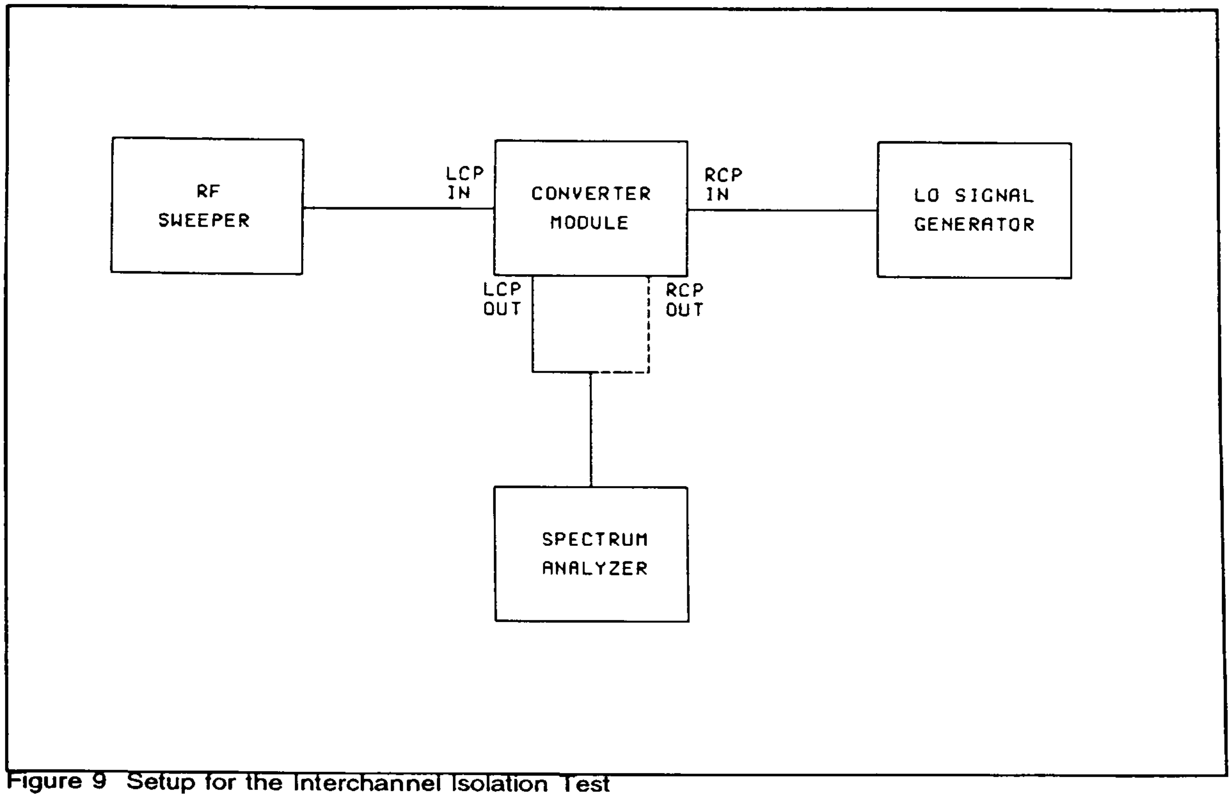


Figure 9 Setup for the Interchannel Isolation Test

bring the trace to a convenient level. The sum of the change in level on the screen and the change in reference level is the interchannel isolation.

For example: Suppose the trace is at the -8 dB level with the reference level set to +10 dBm. After moving to the other input, it is necessary to change the reference level to -30 dBm to bring the trace to -35 dB. The isolation is then +10 - (-30) + (-8) - (-35) = +10 + 30 - 8 + 35 = 67 dB.

5. Connect the sweeper and analyzer to the RCP ports and repeat the measurement.

6. This completes the interchannel isolation test.

IV. Noise Temperature and Noise Figure Test

Equipment Requirements:

1. LO signal generator that covers the nominal LO frequencies and is set to the nominal power listed in the table above.
2. Noise source, HP 346C or similar that covers the RF input band.
3. Power meter with a sensor head.
4. Amplifier with 30 to 40 dB of gain; the gain may be adjusted by attenuator pads on the input. When testing the 330 MHz converter (T101), use an amplifier with 40 to 50 dB of gain.
5. Filter: for bands other than 330 MHz (T101) and 610 MHz (T102), use a K&L 6B120-750/X550-O/OP. In the case of T101, use a K&L 6B120-827/50-OP/O and for T102, use a K&L 6B120-611/30-OP/O filter.
6. Two 50 Ohm terminations.

Test Procedure:

1. Connect the equipment as shown in Figure 10 on the next page, using the broken line connections with the SMA termination on the LCP RF input.
2. Set the converter gain adjustment to minimum gain.

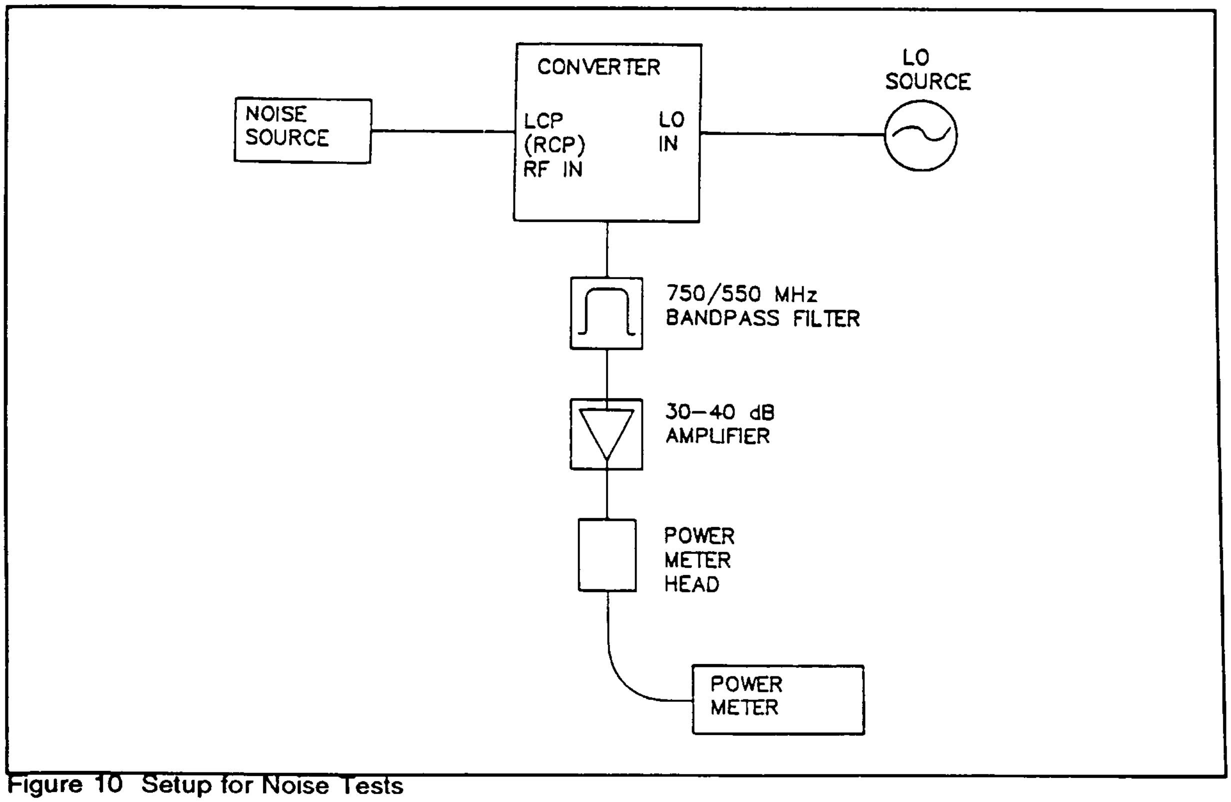


Figure 10 Setup for Noise Tests

2. Record the power level on the power meter as P_1.

3. Replace the SMA termination by the noise source on the RF input.

4. Record the reading on the power meter as P_2.

5. Calculate the LCP channel noise temperature from P_1 and P_2 using the following formulas:

   $T_e = (T_2 - YT_1)/(Y-1)$

   where $Y = P_2/P_1$ if P_1 and P_2 are in mW.

   or $Y = 10^{(P2 - P1)/10}$ if P_1 and P_2 are in dBm.

   T_1 = room temperature in Kelvins

   $T_2 = [10^{(ENR/10)} + 1] \times 290$

   ENR = Effective noise ratio of the noise source at the midband RF frequency listed on the noise source.

6. Repeat steps 1 through 6 for the RFC RF input and IF output. The two noise temperatures should meet the specification tabulated above.

7. Then Noise Figure = $10\log((290 + T^{e})/290)$ dB.

8. This concludes the noise temperature tests.

V. Spurious Signals Test

Equipment Requirements:

1. This test should be performed in the equipment racks as a part of the system integration tests. The LO synthesizer (L104) should be switched to the converter and set to an appropriate LO frequency from the table in Section 6.

2. Spectrum analyzer with a range of at least 1.5 GHz. Set the analyzer to sweep the full range, 10 dB/division, 3 MHz bandwidth.

3. SMA 50-Ohm termination.

Test Procedure:

1. Connect the equipment as shown in Figure 11 below. Set the center frequency to 750 MHz and the span to 1500 MHz.

2. Set the converter module gain to the maximum. Set the analyzer input attenuation to 0 dB. The analyzer should show a spectrum similar to that in Figure 12, below. It may be necessary to add amplification following the converter to overcome the noise level of the spectrum analyzer.

3. Now examine the frequency span for spurious signals. The most important frequency range is the 500 to 1000 MHz IF band. Reduce RBW and sweep speed to look for low-level spurs. There should not be any spurious signals. If there are spurious signals present, look for:

   A. Leakage from other modules in the system.
   B. Parasitic oscillations.
   C. Spurious garbage on power supply lines.
   D. Radio or TV signals getting into test cables.

4. This concludes the spurious signals test.

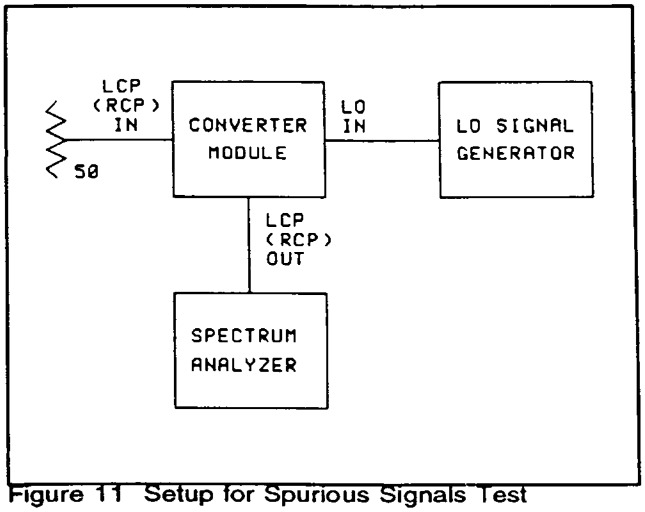


Figure 11 Setup for Spurious Signals Test

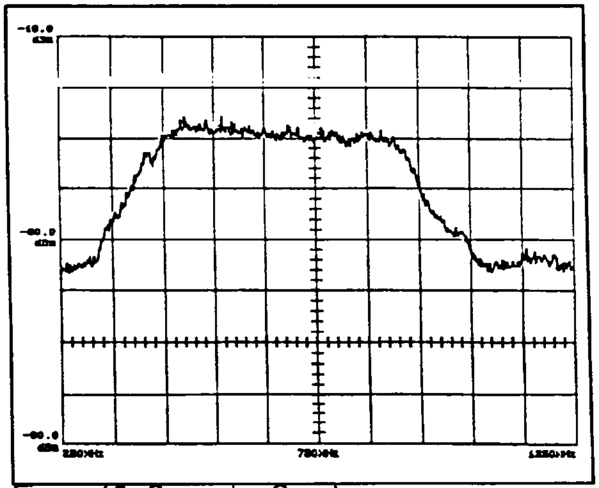


Figure 12 Converter Spectrum

3.0 FREQUENCY CONVERTER DESCRIPTIONS

The following sections describe the operation of the nine converter modules. For convenience in usage, the descriptions are based upon a common format.

The converter descriptions below refer to selector and transfer switches. Typical examples are S101A, S106D, S108E, etc. These designations are not shown on the converter block diagrams; they are VLBA system control designations and are included in the descriptions to relate the converter switches to the VLBA system control functions. These switching functions are shown on drawing D58001K001, Rev E, Electronic System Block Diagram (Antenna Electronics). These designations are also used in VLBA Technical Report No. 5, Rev June 1990 which lists the VLBA monitor and control functions.

3.1 T101, 330 MHz CONVERTER MODULE

T101 Band Coverage and LO Frequency

This section describes the T101 frequency converter. It also includes a T101-peculiar procedure for adjustment of the IF gain.

T101 upconverts the P-Band 90 cm/330 MHz Front-End signal to an 812-842 MHz IF signal using a fixed LO frequency of 500 MHz. The Front-End's RF output is limited to a bandwidth of 30 MHz by T101's RF circuitry bandpass filter, a K&L 6B120-327/X30. For VLBA K&L filters, the X supplemental code indicates that the bandwidth is defined at the -1 dB points; the -1 dB band edges are 312 and 342 MHz.

The LO frequency is 500 MHz because a phase-stable 500 MHz signal is conveniently available. The 500 MHz LO signal level drive to T101 is +1.7 dBm.

F102, the 330/610 MHz (90/50 cm) Front-End, has a K&L X3DFV-327/610 diplexer to separate the 327 and 610 MHz signals. This is a dual-frequency filter with 327 and 610 MHz ports. The bandwidth of the 330 Mhz port is about 50 MHz and the bandwidth of the 610 MHz port is about 75 MHz. The 327 MHz signal is a potentially interfering signal on the 610 MHz port and the converse; the 327 and 610 MHz port signals are each about 25 dB below the other port's levels. T101 must reject the 610 MHz, 75 MHz bandwidth signals in the F102 327 MHz port spectrum.

T101 Size and Location

T101 is a double-width module installed in Rack B, Bin D, Slots 11-12.

T101 Drawings and Data Sheets

The following T101 functional and assembly drawings are found at the end of this section.

C53500K005, Rev C	- T101 330 MHz Converter Module Block Diagram
D53500A015, Rev C	- T101 330 MHz Converter Module Assembly
A53500B002, Rev B	- T101 330 MHz Converter Module Assembly BOM

C53500A011, Rev A	- T101 330 MHz Converter Module Converter Unit Assembly
C53500A025	- T101 330 MHz Converter Module Converter Unit PCB Assembly
C53500A017	- T101 330 MHz Converter Module Input Amplifier Assembly

Data sheets for the MCL-TFM-4H mixer and WJ A88 amplifier follow the drawings. Data sheets for the WJ A18-1 amplifier, Narda 4772-X attenuator and Anzac DS-313 power divider are included in the Appendix, Section 6.

T101 Differences From the General Converter Block Diagram

The differences between T101 Block Diagram and the general converter block diagram of Section 2.1 are the use of an Input Amplifier A53500A017, omission of the input isolator and LO bandpass filters and the use of a dual LO drive amplifier rather than a single LO drive amplifier. The mixers, power divider and dual LO amplifiers are packaged in a 330 MHz Converter Unit, C53500A011. This subassembly is described below. The 3B120-827/50 IF filter is used instead of the 6B120-750/X550 filter. Since the converter's band is so low and is so narrow, there are no isolators in the RF circuitry. The RF and IF filters are much narrower (30 MHz and 50 MHz, respectively) than those used in the higher frequency converters. Note that the IF filter has a wider bandwidth than the RF filter.

330 Mhz Converter Assembly

The C53500A011 330 MHz Converter Assembly consists of an Anzac DS-313 two-way power divider, two WJ A88 LO drive amplifiers and two MCL-TFM-4H mixers. The 500 MHz LO signal enters at a power level of about +1.7 dBm and is split into two -1.3 dM signals that drive the two WJ A88 amplifiers. These amplifiers have a typical small signal gain of 18.7 dB. The amplifier output levels are about +17 dBM, the proper LO drive level for the MCL-TFM-4H mixers. The amplifiers have a minimum 1 dB compression point of +20.5 dBm. The A88 amplifiers's gain is flat from 5 to 500 MHz.

T101 Specifications

Nominal Gain, dB	30	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-50	Min Out Pwr @ 1% Compression, dBm	0.0	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temperature, K	1000	Noise Temperature for 1° added Syst Noise, K	6000	Nom LO Pwr input, dBm	5
Avg Noise Figure, dB	6.5	Noise Figure for 1° added Syst Noise, dB	16.5		
15 Volt Power Req't, mA	2000				

Unwanted Sideband and Image Band Attenuation

Because T101 is an upconverter, the IF band is the F_{LO} + F_{RF} mixer output. The unwanted sideband is 158 to 188 MHz and is the result of the F_{LO} - F_{RF} mixer output. The unwanted sideband upper band edge frequency (188 MHz) is about 624 MHz below the lowest frequency (812 MHz) in the IF passband. The unwanted sideband is attenuated by the K&L 3B120-827/50 IF bandpass filter attenuation plot shown in Figure 13, below. This plot shows that at 188 MHz, the filter attenuation is greater than 70 dB.

The image band (148 to 198 MHz) is attenuated by the Front-End's K&L 3DFV-327/610 diplexer.

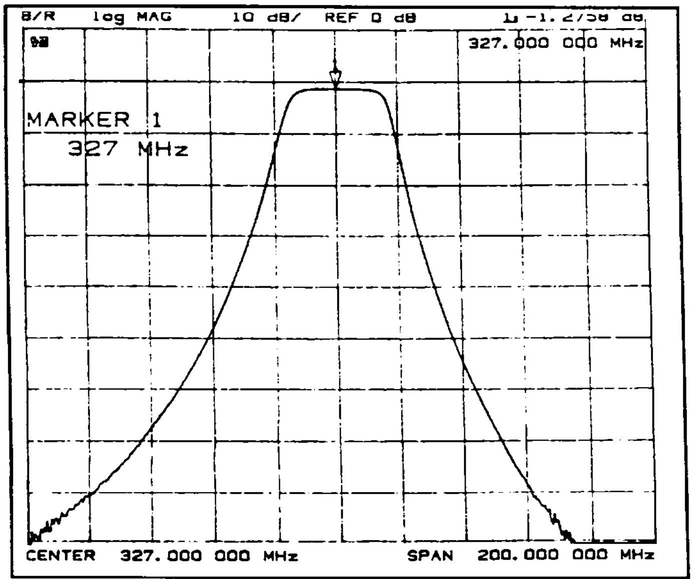


Figure 13 K&L 6B120-327/X30 Bandpass Filter

Noise Temperature

The T101 noise temperature is a composite value that is a function of the noise temperatures of the input amplifier, mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 1000 K. A T101 noise temperature of 6000 would add 1 K to the system temperature.

Mixer

The MCL-TFM-4H mixer is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for RF inputs having a high dymamic range - up to +14 dBm. It accommodates LO and RF frequencies of 5 to 1200 MHz, IF frequencies of DC to 1200 MHz and a LO drive of +17 dBm. In the 330 MHz frequency band, the typical conversion loss is 5.3 dB. Noise figure is not specified. At 330 MHz, LO to RF and LO to IF isolation are each about 30 dB.

RCP-LCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths - the isolation between the two mixer LO ports and the transfer switch leakage. As shown in the table above, the module's specified RCP-LCP path isolation is 65 dB.

Since LO isolation filters are not used, the RCP-LCP path isolation is the 28 dB provided by the ANZAC DS-313 power divider and the 30 dB (typical) between the mixer's LO ports and the RF-IF ports. The isolation of this shunt path is thus about 90 dB.

The typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch at 330 MHz is about 90 dB.

VSWR's

The input VSWR is about 1.5:1 and is the composite of the VSWR's of the transfer switch (1.05:1), RF filter (1.5:1) and WJ A18-1 amplifier input VSWR (<1.5:1). The output VSWR is the composite VSWR of the Amp/Divider, which is about 1.5:1.

RF Circuitry

The RF Input Amplifier A53500A017 uses an Avantek enclosure and printed circuit board. A Watkins-Johnson A18-1 amplifier is the gain element. This amplifier has a typical small signal gain of 14.7 and its gain is flat to about 1000 MHz. The WJ A18-1 amplifier is described in Section 2.5.

The RF circuitry has K&L 6B120-327/X30 bandpass filters that have a 327 MHz center frequency and a -1 dB bandwidth of 30 MHz. This filter determines the receiver's bandwidth. The filter attenuation is shown in Figure 13, below. T101's RF filter must reject the 610 MHz interfering signals present on F102's 327 MHz port. These 610 MHz signals have a bandwidth of 75 MHz and are about 25 dB below the 327 MHz level on the 327 MHz port. T102's RF filter must reject these 610 MHz signals; Figure 13 shows that the filter attenuates them by more than 80 dB. Thus at the filter's output, the 610 MHz signal level is 105 dB below the 327 MHz signal level.

The losses in the RF circuitry are the insertion losses of the transfer switch (0.1 dB) and K&L 6B120-327/X30 RF filter (2 dB).

IF Circuitry

The IF bandpass filters are K&L 3B120-827/50 that have a center frequency of 827 MHz, and a 3 dB bandwidth of 50 MHz. Note that the T101 IF bandwidth is really determined by the RF 327/30 filters which have a narrower bandwidth. Figure 14 on the next page shows the filter attenuation plot.

The IF path Amp/Attenuator and Amp/Divider were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

RF Switching

S010A, the RLC SR-TC-R-D transfer switch is shown on the Block Diagram; the Transco 710C70100 transfer switch may be installed in some T101 modules as an alternate unit. This switch is described in Section 2.5. The transfer switch is driven by M102, address 10H, bit 0.

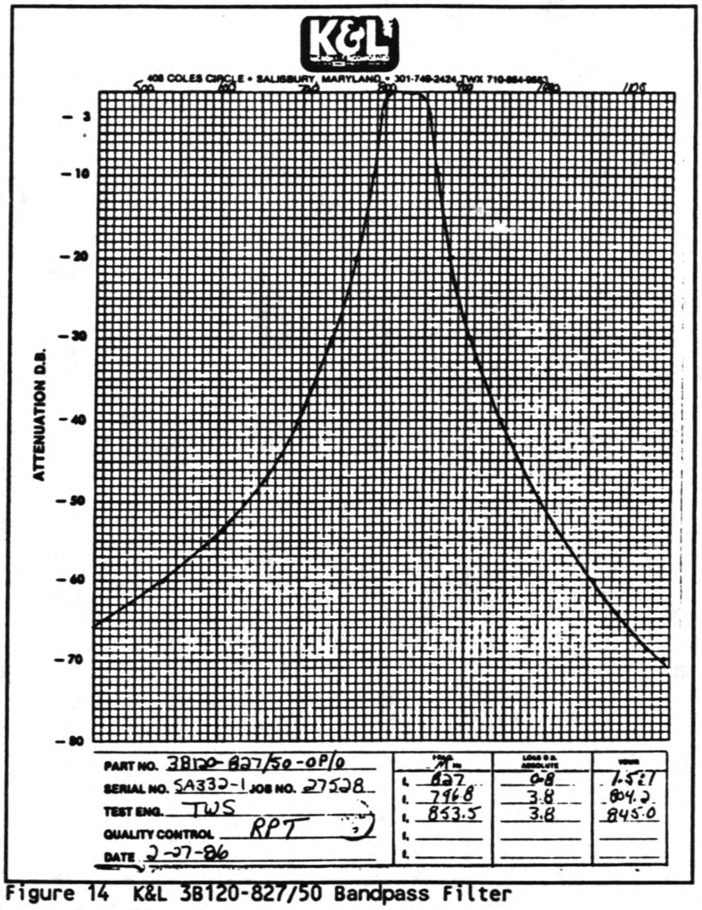
T101 Power Circuitry

All T101 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 3 and 4 where it is distributed to the amplifiers. The common returns for these devices are connected to TB-1 terminals 1 and 2 that are connected to P11-34, P11-42 and a frame ground lug. This ground is also the ground return for the +28 volt drive to the transfer switch. The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

T101 Gain Adjustment

Section 2.6 describes a gain adjustment procedure used to set the RCP and LCP front-panel gain potentiometers after replacement of a converter module. This procedure uses an HP 4836A Power Meter equipped with an HP 8484 sensor. In the case of T101, it is difficult to use a power meter with this procedure for the following reasons:

1. The T101 signal bandwidth is 30 MHz but the bandwidth of the IF Amp/Attenuator and Amp/Divider may exceed 1000 MHz. Thus these amplifiers contribute noise over a much larger bandwidth than the T101 signal band. When attempting to adjust T101's gain, this wideband noise tends to obscure the measurements.



PART NO. 3B120-827/50-0P/0
SERIAL NO. SA332-1 JOB NO. 27528
TEST ENG. TWS
QUALITY CONTROL RPT
DATE 2-27-86

827	0.8	1.5:1
796.8	3.8	804.2
853.5	3.8	845.0

Figure 14 K&L 3B120-827/50 Bandpass Filter

2. There may be interference signals within the T101 band.

This alternate procedure uses the Baseband Converters, an HP 436 power meter and a display device that can show the Station Computer Baseband Converter overlays. The overlay digital value proportional to total power is used as a measure of a converter's power spectral density. The converter's power spectral density should be -67 dBm/MHz.

This procedure uses the narrow-band filtering capabilities of the Baseband Converter to facilitate the adjustment of T101's gain. A high frequency converter's output power level is first measured with the power meter to verify that it is -40 dBm (normal power level at standard system temperature); the Baseband Converter is then used to measure the high frequency converter's power spectral density over a 2 MHz bandwidth at an IF frequency of 826 MHz.

Next, T101's output is switched to the Baseband Converter used to measure the high frequency converter's output while retaining the Baseband Converter's setup. T101's IF gains are then adjusted to produce a power spectral density value equal to that produced by the high frequency converter.

Gain Adjustment Procedure

To set the T101 output levels to a -67 dBm/MHz spectral power density (the same level as the other converters) do the following:

1. Set the receiving system to a high frequency band that is not subject to interference. Use a band that has IF signals in the B and D IF's as is the case with the 90 cm/50 cm bands; the 4 cm band is suggested.

2. Route the high frequency converter outputs to a Baseband Converter. Set the Baseband Converter LO to 826 MHz and use a 2 MHz conversion bandwidth.

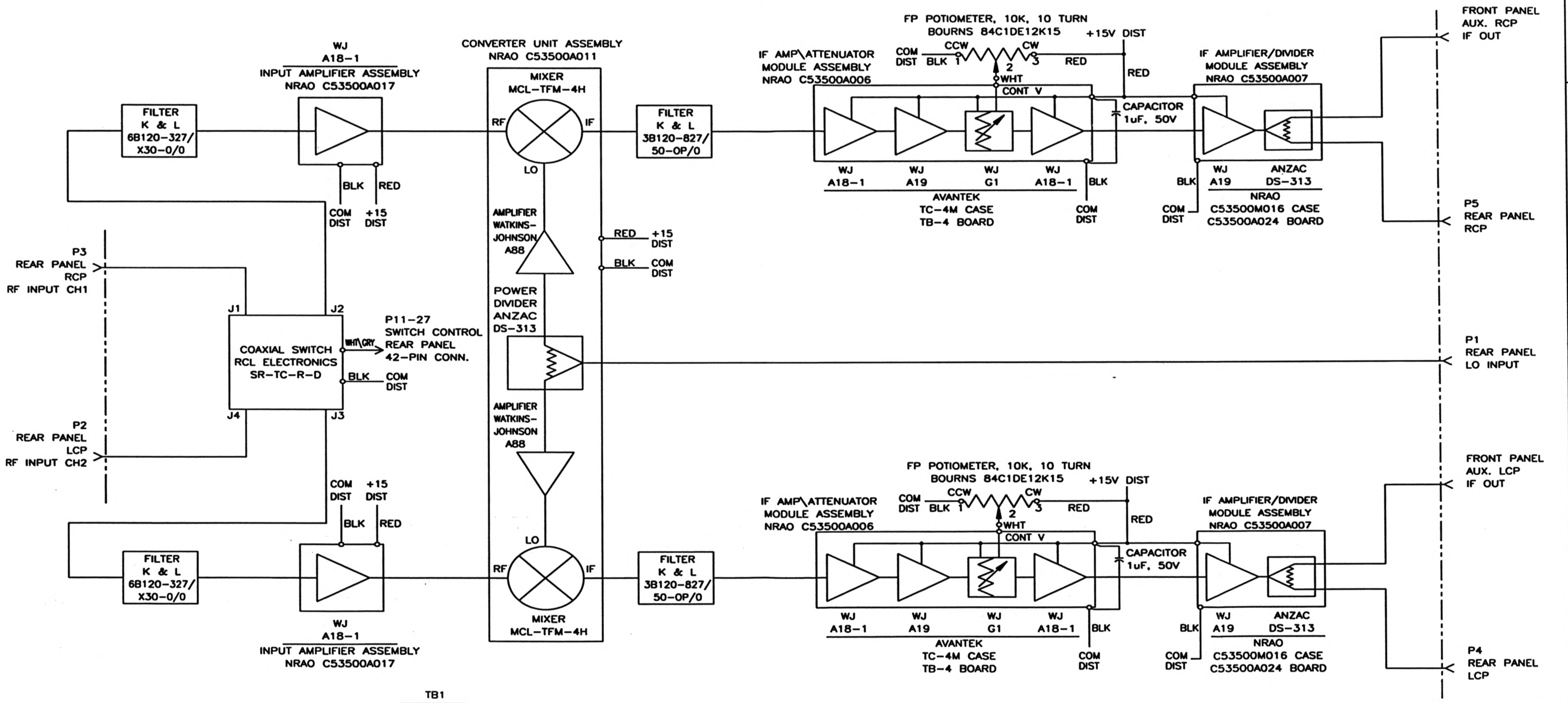
3. Using the power meter, check the high frequency converter power levels on the front panel SMA monitor connectors. The power level should be -40 dBm over 500 MHz bandwidth at standard system temperature.

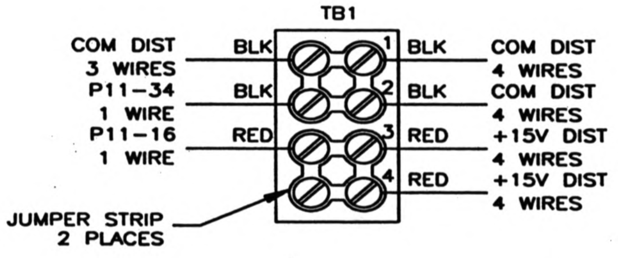
4. Using the Baseband Converter overlays for this high frequency converter, jot down the values (i.e. counts) proportional to LCP and RCP total power.

5. Set the receiving system to the 90 cm band, and without modifying the Baseband Converter's set up, adjust T101's front-panel gain potentiometers to produce a total power value identical (or close to) that obtained in Step 4 above. The gain adjustment error tolerance is ± 0.5 dB or up to 10% of the overlay value proportional to total power.

This procedure can be used to adjust the gains of other converters in bands where external RFI in the IF passband is a problem.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	3-90	DGS		ADDED AMPS; SWITCH
B	4-91	DGS		ADDED BOURNS POT #
C	8-93	K. TATE		UPDATED TO NRAO STDS
D	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS





ACAD : 53500K05

NEXT ASSEMBLY	DWG. TYPE
A53500B008	BOM
D53500A015	ASSEMBLY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

VLBA
PROJECT T101
CONVERTER MODULE

TITLE T101
330 MHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

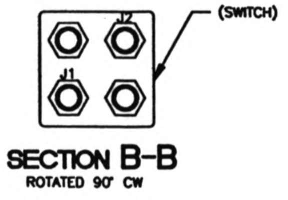
DRAWN BY DGS DATE 3-90
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K005
REV. D
SCALE NONE

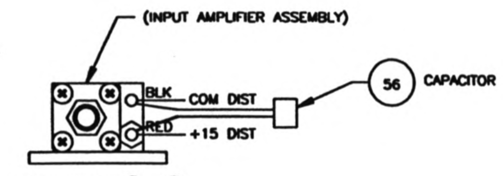
NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 13) AND GUIDE BLOCK (ITEM 8)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN

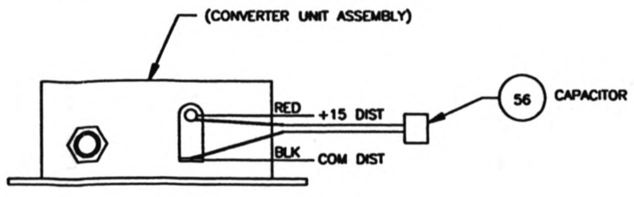
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	3-90	DGS		ADDED AMPS, SWITCH
B	4-91	DGS		ADDED BOURNS POT. #
C	8-93	K. TATE		UPDATED TO NRAO STDS



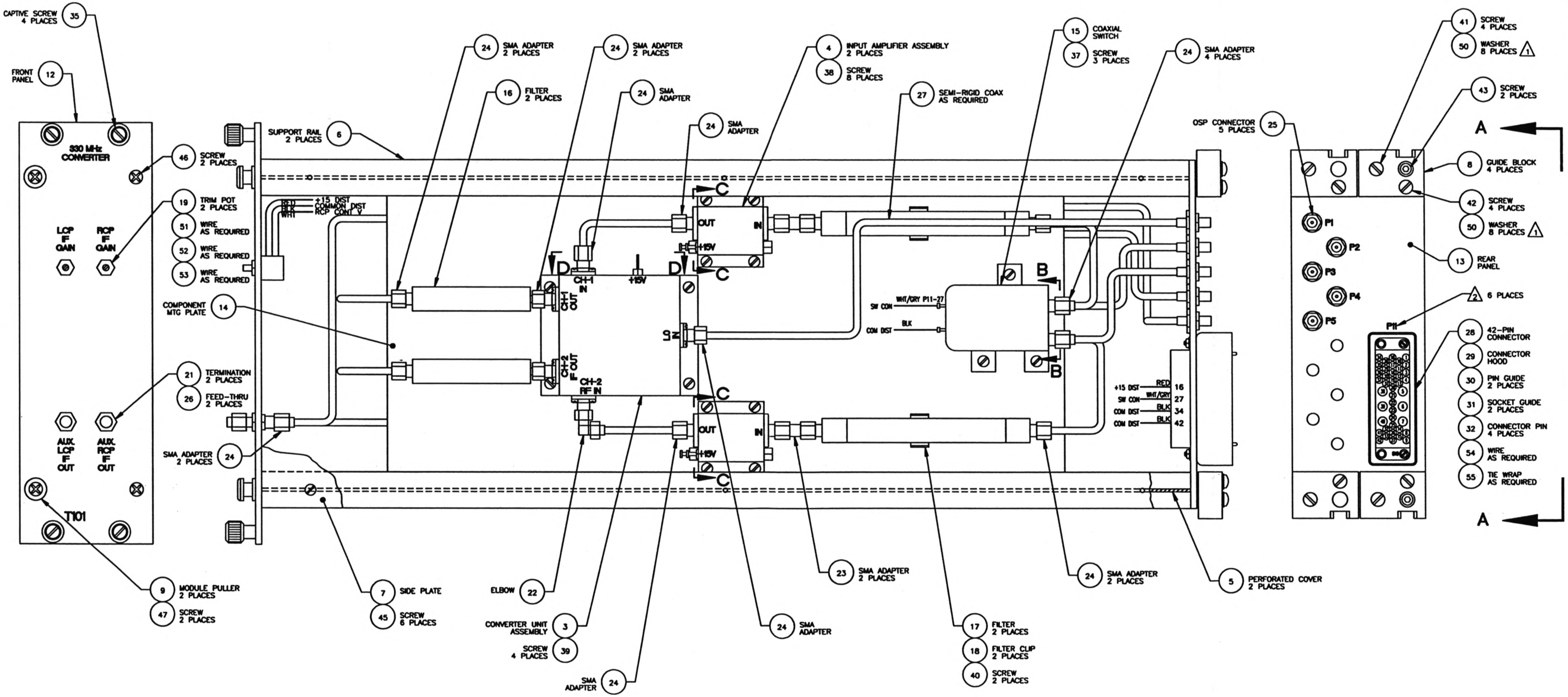
SECTION B-B
ROTATED 90° CW



SECTION C-C
2 PLACES



SECTION D-D
ROTATED 180°



T101 ASSEMBLY - RCP SIDE

ACAD : 3500A15A

C53500K005	BLOCK DIAG
A53500B008	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ± .01
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT
T101
CONVERTER MODULE

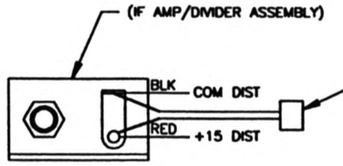
TITLE
T101
330 MHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

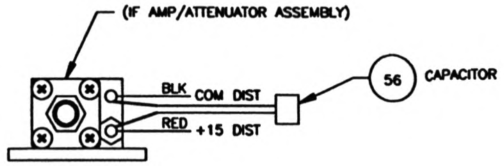
DRAWN BY DGS DATE 3-90
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 2
DRAWING NUMBER D53500A015
REV. C
SCALE 1/1

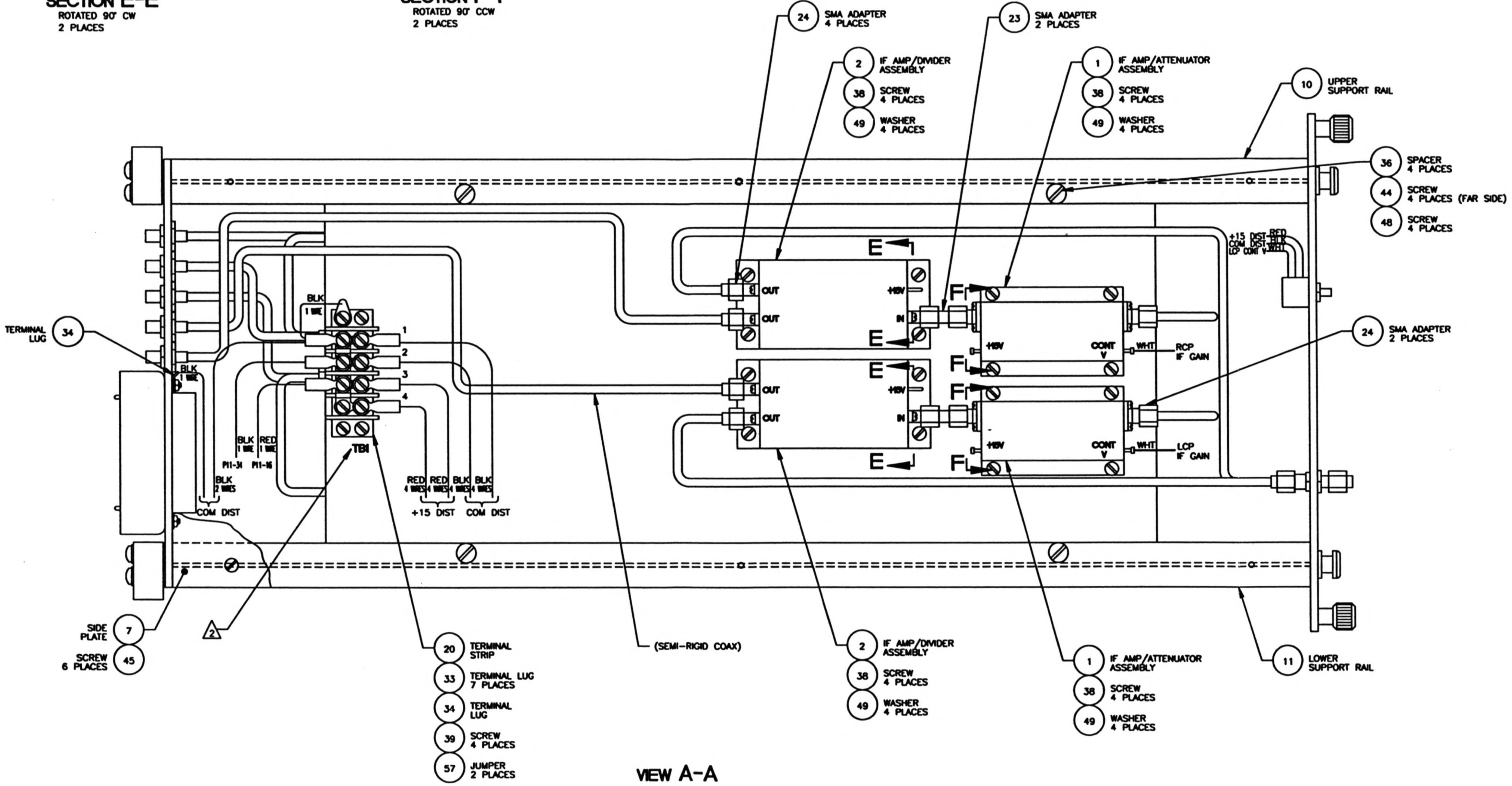
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



SECTION E-E
ROTATED 90° CW
2 PLACES



SECTION F-F
ROTATED 90° CCW
2 PLACES



VIEW A-A
LCP SIDE

ACAD : 3500A15B

C53500K005	BLOCK DIAG
A53500B008	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ± .01
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

VLBA PROJECT T101
CONVERTER MODULE

TITLE T101
330 MHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY DGS DATE 3-90
DESIGNED BY DATE
APPROVED BY DATE

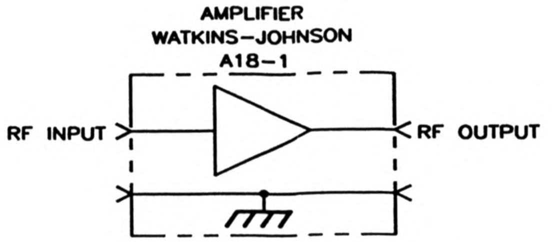
SHEET NUMBER 2 of 2 DRAWING NUMBER D53500A015 REV. C SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

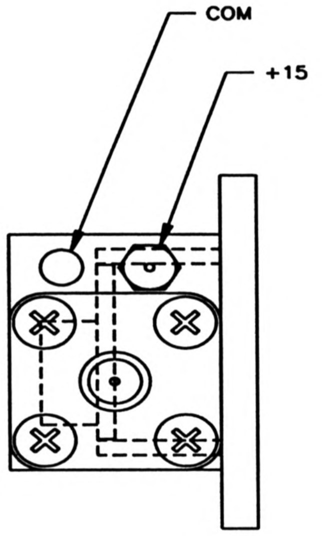
NOTES:

△1 ASSEMBLE CIRCUIT BOARD (ITEM 1) IN ENCLOSURE BOX (ITEM 2) USING APPROPRIATE AMPLIFIERS. DO NOT SOLDER AMPLIFIERS INTO PLACE UNTIL AFTER SCREWS (ITEM 5) ARE TIGHTENED ON CIRCUIT BOARD

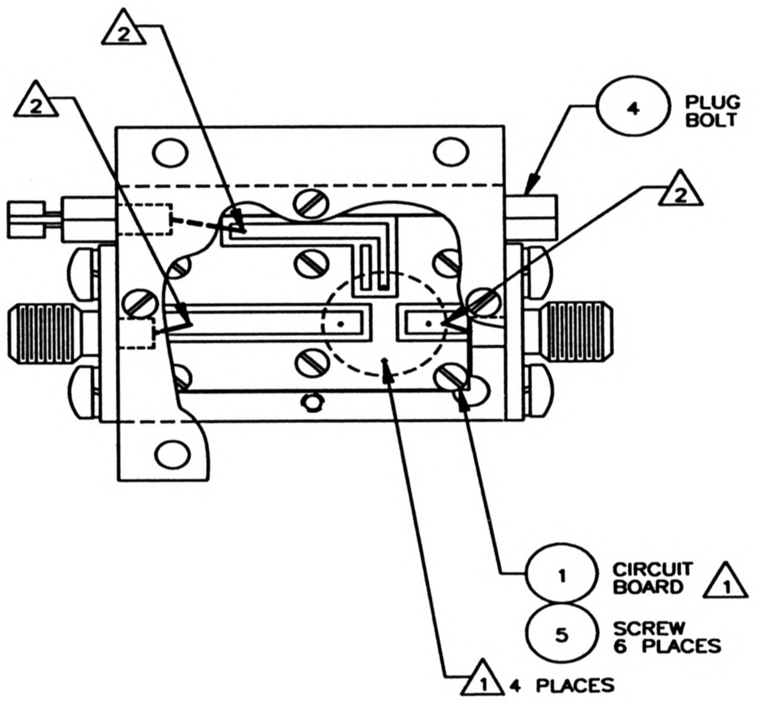
△2 SOLDER LEADS TO CIRCUIT BOARD (ITEM 1). LOCATE APPROXIMATELY AS SHOWN

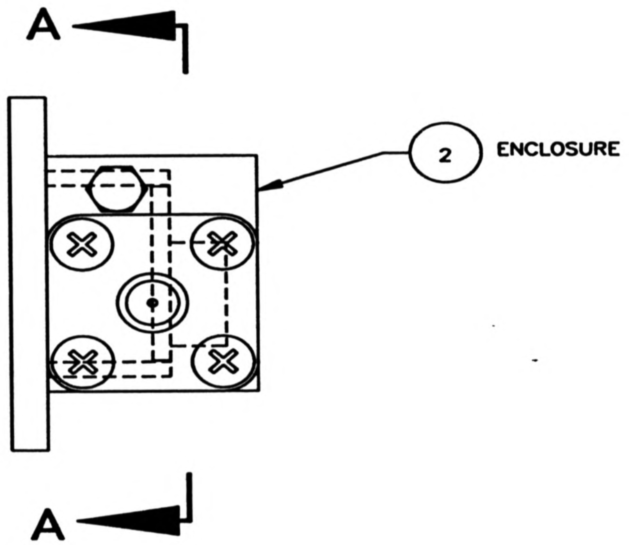


INPUT AMPLIFIER ASSEMBLY BLOCK DIAGRAM

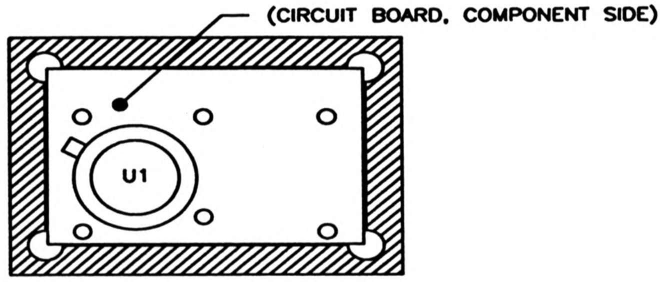


RF OUTPUT SIDE





RF INPUT SIDE



ACAD : 53500A18

SECTION A-A

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
5				SCREW, PAN HEAD, SS, 0-80UNF-2A x .25	6
4		AVANTEK	C22-000401	BOLT, PLUG,12-32 HEX	1
3	U1	WATKINS-JOHNSON	A18-1	AMPLIFIER	1
2		AVANTEK	TC-2M	BOX, ENCLOSURE	1
1		AVANTEK	TB-1	BOARD, CIRCUIT	1

NEXT ASSEMBLY	DWG. TYPE
A53500B008	BOM
D53500A015	ASSEMBLY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T101 CONVERTER MODULE

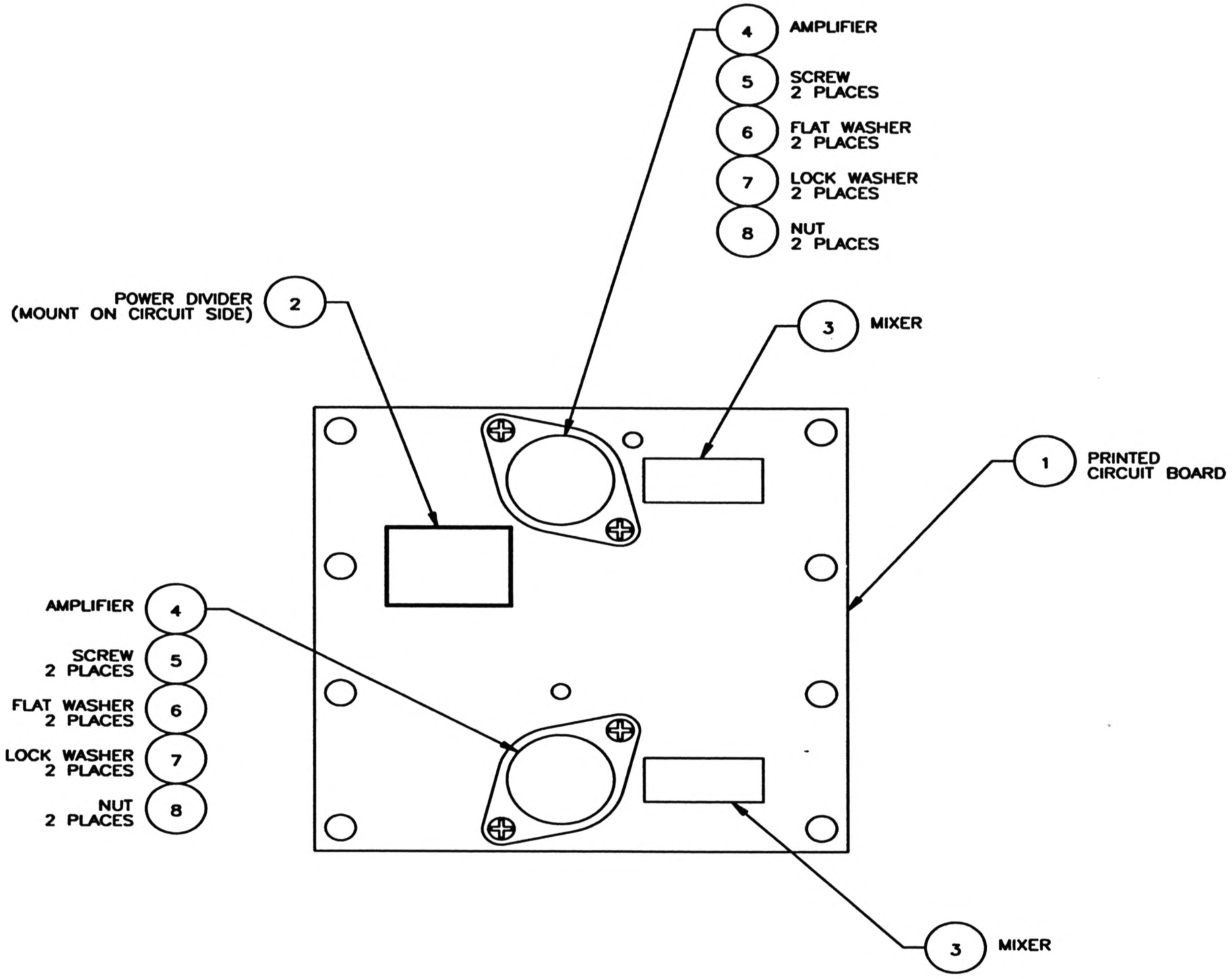
TITLE T101 330 MHZ
CONVERTER MODULE
INPUT AMPLIFIER
ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE DATE 8-93
DESIGNED BY SCHLECHT DATE 8-90
APPROVED BY SCHLECHT DATE 8-90

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A017
REV. —
SCALE 2/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



COMPONENT SIDE

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
8				NUT, HEX, SS, 0-80UNF-2B	4
7				WASHER, LOCK #0	4
6				WASHER, FLAT, #0	4
5				SCREW, PAN HEAD, SS, 0-80UNF-2A x .25	4
4		WATKINS-JOHNSON	A88	AMPLIFIER	2
3		MINI-CIRCUITS	MCL-TFM-4H	MIXER	2
2		ANZAC	DS-313	DIVIDER, POWER	1
1		NRAO	C53500Q002	BOARD, CIRCUIT	1

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T101
CONVERTER MODULE

TITLE T101 330 MHZ
CONVERTER MODULE
CONVERTER UNIT
PCB ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY	K. TATE	DATE 10-93
DESIGNED BY	SCHLECHT	DATE 1-86
APPROVED BY	SCHLECHT	DATE 1-86

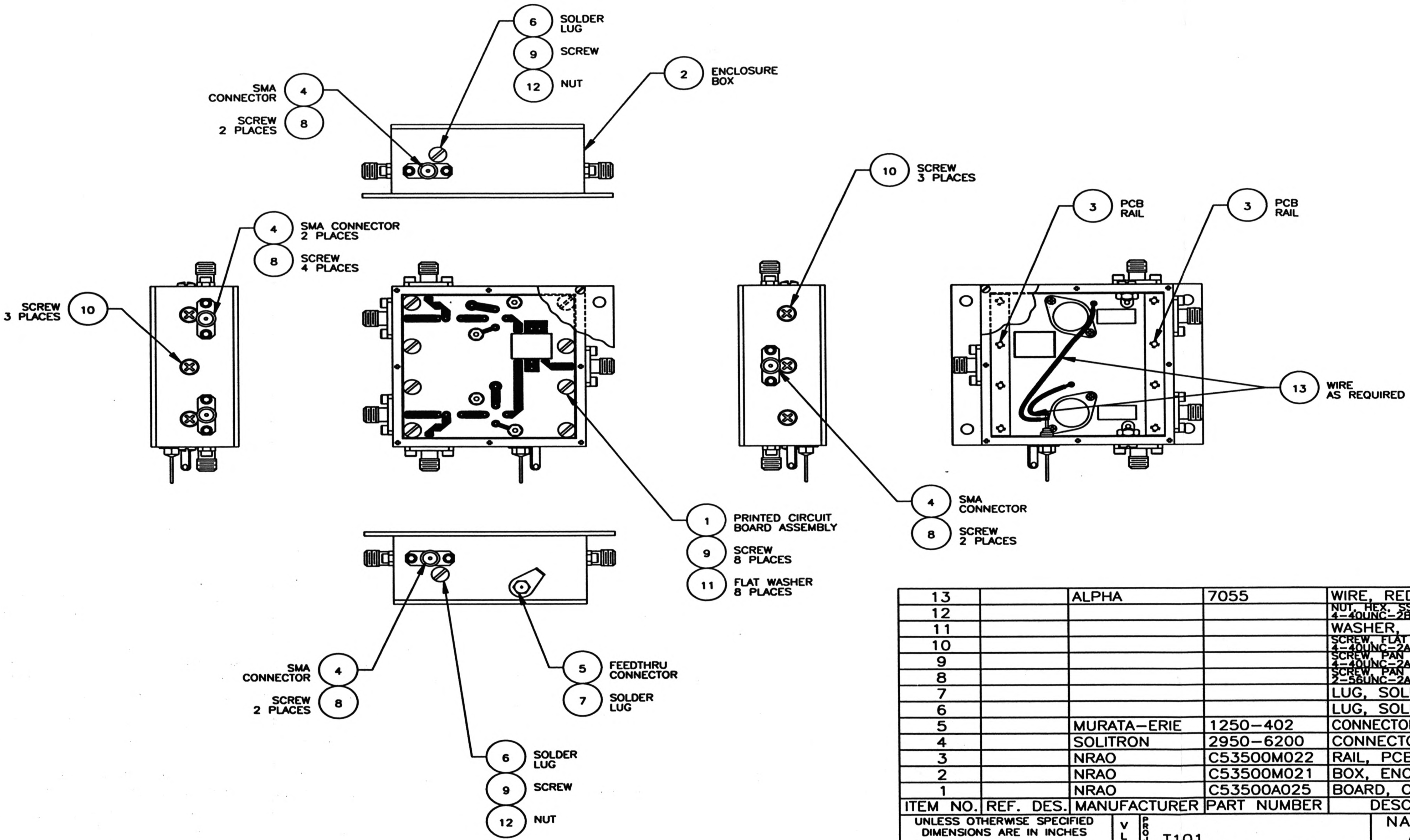
SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A025
REV. —
SCALE 1/1

C53500Q002	ARTWORK
C53500P002	DRILL DWG
C53500K005	BLOCK DIAG
D53500A011	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

ACAD : 53500A25

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STDS



13		ALPHA	7055	WIRE, RED, #22	AR
12				NUT, HEX, SS, 4-40UNC-2B	2
11				WASHER, FLAT #4	8
10				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	6
9				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	10
8				SCREW, PAN HEAD, SS, 2-56UNC-2A x .19	10
7				LUG, SOLDER #8	1
6				LUG, SOLDER #4	2
5		MURATA-ERIE	1250-402	CONNECTOR, FEEDTHRU	1
4		SOLITRON	2950-6200	CONNECTOR, SMA	5
3		NRAO	C53500M022	RAIL, PCB	2
2		NRAO	C53500M021	BOX, ENCLOSURE	1
1		NRAO	C53500A025	BOARD, CIRCUIT	1
ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T101 CONVERTER MODULE

TITLE T101 330 MHZ
CONVERTER MODULE
CONVERTER UNIT
ASSEMBLY

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY DGS DATE 11-90
DESIGNED BY SCHLECHT DATE 1-86
APPROVED BY SCHLECHT DATE 11-90

SHEET NUMBER 1 OF 1 DRAWING NUMBER C53500A011 REV. A SCALE 1/1

A53500B008	BOM
D53500A015	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

ACAD : 53500A11

PROPERTY OF NRAO

REVISIONS

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	8-93	K. TATE		UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 8-93			
DESIGNED BY	DATE		C53500K005	BLOCK DIAG
APPROVED BY	DATE		D53500A015	ASSEMBLY
			NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T101 CONVERTER MODULE

TITLE T101 330 MHZ CONVERTER MODULE
ASSEMBLY BOM

DWG NO. A53500B008 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B008 REV B DATE 8-18-93 PAGE 2 OF 5

MODULE T101 NAME 330 MHZ CONVERTER DWG# D53500A015 SUB ASSY ______ DWG# ______

SCHEM. DWG# C53500K005 LOCATION ______ QUA/SYS. ______ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53500A011	ASSY, CONVERTER UNIT	1
4		NRAO	C53500A017	ASSY, INPUT AMPLIFIER	2
5		NRAO	C53306M014-1	COVER, PERFORATED	2
6		NRAO	C53306M016	RAIL, SUPPORT	2
7		NRAO	C53306M017	PLATE, SIDE	2
8		NRAO	B53306M018	BLOCK, GUIDE	4
9		NRAO	A53306M035	PULLER, MODULE	2
10		NRAO	B53500M001	RAIL, UPPER	1
11		NRAO	B53500M002	RAIL, LOWER	1
12		NRAO	B53500M003	PANEL, FRONT	1
13		NRAO	B53500M004-1	PANEL, REAR	1
14		NRAO	D53500M028	PLATE, COMPONENT MOUNTING	1
15		RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
16		K & L	38120-827/50-0P/0	FILTER	2
17		K & L	6B120-327/X30-0/0	FILTER	2
18		K & L	M12-A	CLIP, FILTER	2
19		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2
20	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B008 REV B DATE 8-18-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		SOLITRON	8018-6005	TERMINATION, 50Ω	2
22		SOLITRON	2993-6005	ELBOW, SMA MALE/MALE	1
23		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	4
24		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 TUBE	22
25	P1 - P5	OMNI-SPECTRA	4503-7941-00	CONNECTOR, OSP .141 MALE	5
26		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
27		PRECISION TUBE	AA50141	COAX, .141. SEMI-RIGID	AR
28	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
29		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
30		AMP	200833-2	PIN, GUIDE	2
31		AMP	203964-5	SOCKET, GUIDE	2
32		AMP	201578-1	PIN, 16 GA. CONNECTOR	4
33		ETC/MOLEX	AA-832-06	LUG, TERMINAL	7
34				LUG, TERMINAL	2
35		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
36		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4
37				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	3
38				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	20
39				SCREW, PAN HEAD, SS, 4-40UNC-2A x .38	8

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B008 REV B DATE 8-18-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
40				SCREW, PAN HEAD, SS, 6-32UNC-2A x .19	2
41				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
42				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
43				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
44				SCREW, PAN HEAD, SS, 8-32UNC-2A x .25	4
45				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	12
46				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
47				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
48				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4
49				WASHER, INT. TOOTH #4	16
50				WASHER, EXT. TOOTH #6	16
51		ALPHA	7055	WIRE, WHT #22	AR
52		ALPHA	7055	WIRE, BLK #22	AR
53		ALPHA	7055	WIRE, RED #22	AR
54		ALPHA	7055	WIRE, BLK/GRY #22	AR
55				WRAP, TIE	AR
56		SPRAGUE	2C20Z50105M050B	CAPACITOR, $1\mu f$, 50V	5

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B08 REV B DATE 8-18-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
57	TB1	TRW CINCH	140J-1	STRIP, JUMPER	2
58					
59					
60					
61					
62					
63					
64					
65					
66					
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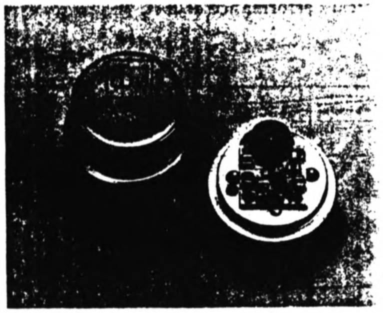
77					
78					

WJ-A88 / SMA88



5 to 500 MHz
TO-8 CASCADABLE AMPLIFIER

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ HIGH GAIN: 18.7 dB (TYP.)
- ◆ HIGH OUTPUT POWER: +20.5 dBm (TYP.)
- ◆ HIGH THIRD ORDER I.P.: +30 dBm (TYP.)

Specifications*

Characteristics	Typical	Guaranteed 0° to 50°C	 -54° to +85°C
Frequency (Min.)	2-500 MHz	5-500 MHz	5-500 MHz
Small Signal Gain (Min.)	18.7 dB	18.0 dB	17.5 dB
Gain Flatness (Max.)	±0.3 dB	±0.5 dB	±0.7 dB
Noise Figure (Max.)			
Vcc= +15 V	6.5 dB	7.5 dB	8.0 dB
Vcc= +12 V	4.5 dB	5.5 dB	6.0 dB
Power Output			
at 1 dB Compression (Min.)	+20.5 dBm	+19.5 dBm	+19.0 dBm
VSWR (Max.) Input/Output	1.5:1	1.8:1	2.0:1
DC Current (Max.) at 15 Volts	79 mA	83 mA	87 mA

*Measured in a 50-ohm system at 15 Vdc.

Notes:
1. WJ-CA88 is a standard WJ-A88 installed in a miniature SMA connector housing and guaranteed over 0°C to 50°C temperature range.

Typical Intermodulation Performance at 25°C

Second Order Harmonic Intercept Point	+41 dBm (Typ.)
Second Order Two Tone Intercept Point	+38 dBm (Typ.)
Third Order Two Tone Intercept Point	+30 dBm (Typ.)

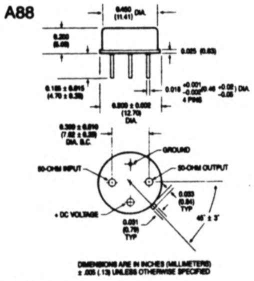
Absolute Maximum Ratings

Storage Temperature	-62°C to +125°C
Maximum Case Temperature	125°C
Maximum DC Voltage	+17 Volts
Maximum Continuous RF Power	+13 dBm
Maximum Short Term RF Input Power (1 Minute Max.)	100 Milliwatts
Maximum Peak Power	0.5 Watt (3 μsec Max.)
"S" Series Burn-In Temperature (Case)	125°C

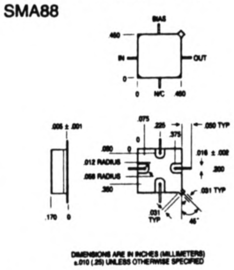
Weight approximately 2.0 grams (0.07oz.)

Outline Drawings

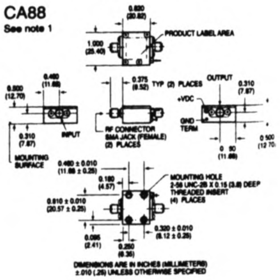
A88



SMA88

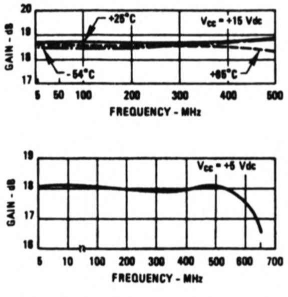


CA88
See note 1

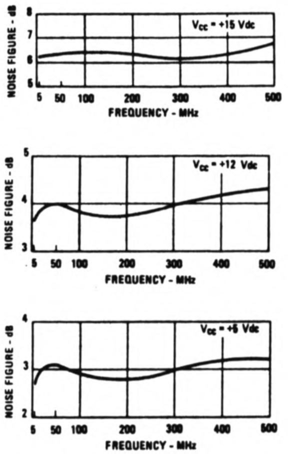


Typical Performance at 25°C

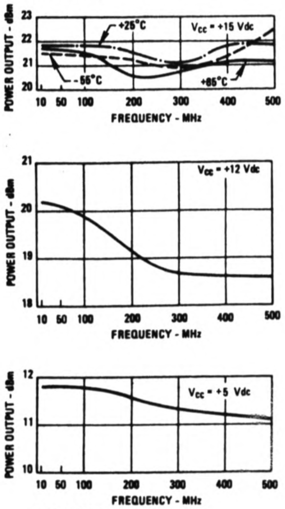
Gain



Noise Figure

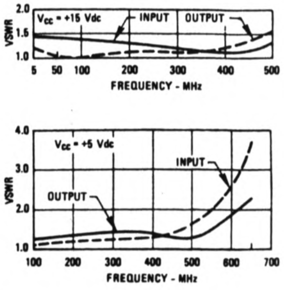


Power Output*

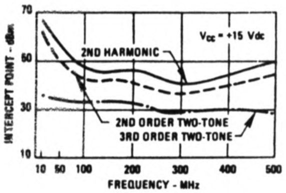


*at 1 dB Gain Compression

VSWR



Intercept Point



Typical Automatic Test Data

V_{CC} = 15.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	2.0	2.0	17.7
2.0	1.5	1.4	18.6
5.0	1.3	1.1	18.7
10.0	1.3	1.1	18.7
50.0	1.3	1.0	18.7
100.0	1.2	1.0	18.6
200.0	1.2	1.0	18.6
300.0	1.1	1.1	18.7
400.0	1.1	1.2	18.8
500.0	1.2	1.4	19.0
600.0	1.3	1.9	18.8

Linear S-Parameters

Frequency	S11		S21		S12		S22	
MHz	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
1.0	.327	−86	7.630	−139	.062	45	.341	166
2.0	.199	−121	8.491	−161	.072	22	.155	127
5.0	.130	−153	8.562	−174	.073	8	.059	115
10.0	.121	−168	8.572	−179	.073	4	.033	117
50.0	.119	161	8.592	167	.073	−2	.010	126
100.0	.107	136	8.526	154	.074	−6	.006	146
200.0	.083	93	8.521	127	.077	−14	.016	159
300.0	.052	36	8.574	100	.080	−22	.038	140
400.0	.042	−61	8.751	72	.085	−31	.064	117
500.0	.071	−154	8.877	41	.093	−42	.166	83
600.0	.117	117	8.742	6	.102	−58	.322	46

Thermal Data: V_{CC} =15 Vdc

Thermal Resistance θ_{jc}	45°C/W
Transistor Power Dissipation P_d	0.706 W
Junction Temperature Rise Above Case T_{jc}	32°C

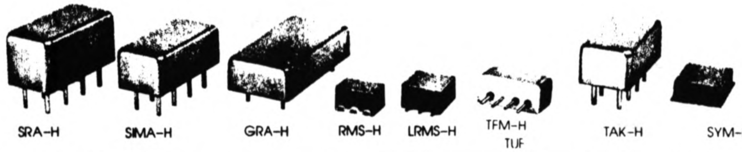
50 KHz to 1.2 GHz

Mini-Circuits

ULTRA-REL™ MIXERS

5-YR GUARANTEE ✱

LEVEL 17S (+17 dBm LO, up to +14 dBm RF)



	MODEL NO.	FREQUENCY MHz		CONVERSION LOSS dB				LO-RF ISOLATION, dB						LO-IF ISOLATION, dB						PRICE $	DISTRIBUTOR	
		LO/RF	IF	Mid-Band m			Total Range	L		M		U		L		M		U			FACTORY	LOCAL
		f_L-f_U		x	σ	Max.	Max.	Typ	Min	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Qty. (1–9)		
o□RMS-H case TT 100	RMS-1H	2-500	DC-500	6 25	034	7 0	8 5	55	44	44	25	33	20	50	34	45	25	37	22	10 95	●	●
	RMS-1WH	5-750	DC-750	7 00	11	8 5	8 8	55	40	43	22	28	20	52	30	38	22	29	20	11 95	●	●
	RMS-2H	5-1000	DC-900	6 98	054	8 5	9 3	55	40	39	22	33	20	52	30	45	22	30	17	11 95	●	●
	RMS-2UH	10-1000	10-750	7 10	083	8 5	9 6	50	40	38	30	30	23	50	30	40	25	34	22	14 45	●	●
	RMS-5H	10-1500	DC-900	6 36	05	8 0	9 8	65	40	36	20	22	15	50	30	30	18	17	7	17 95	●	●
o□LRMS-H case QQQ 130	LRMS-1H	2-500	DC-500	6 25	034	7 0	8 5	55	44	44	25	33	20	50	34	45	25	37	22	10 95	●	●
	LRMS-1WH	5-750	DC-750	7 00	11	8 5	8 8	55	40	43	22	28	20	52	30	38	22	29	20	11 95	●	●
	LRMS-2H	5-1000	DC-900	6 98	054	8 5	9 3	55	40	39	22	33	20	52	30	45	22	30	17	11.95	●	●
	LRMS-2UH	10-1000	10-750	7 10	083	8 5	9 6	50	40	38	30	30	23	50	30	40	25	34	22	14 45	●	●
	LRMS-5H	10-1500	DC-900	6 36	05	8 0	9 8	65	40	36	20	22	15	50	30	30	18	17	7	17 95	●	●
TFM-H case B02	TFM-1H	2-500	DC-500	6 14	11	7 5	8 5	50	45	40	30	30	20	45	40	35	25	25	20	25 95	●	●
	TFM-2H	5-1000	DC-1000	6 12	12	7 0	10	50	45	40	30	30	20	45	40	35	25	25	17	36 95	●	●
	TFM-3H	1-250	DC-250	4 58	11	7 0	8 5	50	45	40	30	28	23	45	40	35	25	26	20	25 95	●	●
case B13	TFM-4H	5-1200	DC-1200	5 24	05	8 0	9 0	50	40	35	25	30	20	50	40	35	20	30	20	39 45	●	●
TAK-H case A05	TAK-1H	2-500	DC-500	5 93	08	7 5	8 5	50	40	40	30	30	25	45	35	35	25	25	20	21 45	●	●
	TAK-1WH	5-750	DC-750	5 71	08	7 5	9 0	50	40	40	30	30	25	45	35	35	25	30	20	25 95	●	●
	TAK-3H	05-300	DC-300	4 82	09	7 0	8 5	55	45	40	30	30	25	50	40	35	25	25	20	23 45	●	●
ZFM-H case K18	ZFM-1H	2-500	DC-500	6 14	11	7 5	8 5	50	45	40	30	30	25	45	35	35	25	25	20	64 95	●	
	ZFM-2H	5-1000	DC-1000	6 12	12	7 0	10	50	40	40	30	30	20	45	40	35	25	25	17	71 95	●	
	ZFM-3H	05-300	DC-300	5 18	11	7 0	8 5	55	45	40	30	30	25	50	40	35	25	25	20	64 95	●	
	ZFM-4H	5 1200	DC-1200	4 97	11	8 0	9 0	50	40	35	25	30	20	50	40	35	20	30	20	73 95	●	
ZLW-SH case M21	ZLW-1SH	2-500	DC-500	5 93	08	7 5	8 5	50	40	40	30	30	25	45	35	35	25	25	20	62 95	●	
	ZLW-1WSH	5-750	DC-750	5 83	07	7 5	9 0	50	45	40	30	30	20	45	40	35	25	30	20	66 95	●	
	ZLW-3SH	05-300	DC-300	4 65	09	7 0	8 5	55	45	40	30	30	25	50	40	35	25	25	20	64 95	●	
ZAD-SH case M22	ZAD-1SH	2-500	DC-500	5 98	08	7 5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	54 95	●	
	ZAD-1WSH	5-750	DC-750	5 64	08	7 5	9 0	50	45	40	30	30	20	45	40	35	25	30	20	56 95	●	
	ZAD-3SH	05-300	DC-300	5 08	09	7 0	8 5	55	45	40	30	30	25	50	40	35	25	25	20	55 95	●	
□TUF-H case B02	TUF-1H	2-600	DC-600	5 9	18	7 0	8.0	68	50	50	30	43	25	62	45	48	30	33	22	9.25	●	●
	TUF-2H	50-1000	DC-1000	6 2	22	7 5	9 0	58	40	47	30	42	25	58	35	44	25	28	18	10 20	●	●
	TUF-3H	0 15-400	DC-400	5 0	33	7 0	8 0	60	50	50	35	40	30	60	40	45	25	35	20	11 10	●	●
	TUF-5H	20-1500	DC-1000	7 5	17	8 5	9 0	62	55	50	40	38	25	40	25	29	18	20	8	14.45	●	●
	TUF-11AH	1400-1900	40-500	7 3	28	9 0	9 0	—	—	35	25	—	—	—	—	30	15	—	—	21 95	●	●
	TUF-860H	800-1050	DC-250	6 8	31	8 3	8 3	—	—	38	25	--	--	—	—	24	18	—	—	14.45	●	●

L=low range (f_L to 10 f_L) **M**=mid range (10 f_L to $f_U/2$) **U**=upper range ($f_U/2$ to f_U)

m=mid band (2f_L to $f_U/2$)

pin and coaxial connections see case style outline drawing

Series	TUF-H TFM-H	TAK-H		ZFM-H	ZLW-H ZLW-SH	ZAD-H ZAD-SH	RMS-H LRMS-H	SRA					GRA-H	SIMA-H	SYM-H
Models	all models	1H 3H	1WH	all models	all models	all models	all models	1H 3H 6H▲	1WH 2H	11H	- 173H Configuration 1	2	all models	5H	all models
LO	4	8	8	1	1	1	1	8	8	8	3.4*	8	1	8	2
RF	1	1	1	2	3	3	4	1	1	1	1	1	6	1	1
IF	2	3.4*	3.4*	3	2	2	5	3.4*	3.4*	3	8	3.4*	4	3	3
GND◆	3	2.5.6.7	2.5.6.7				2.3.6	2.5.6.7	2.5.6.7	2.5.6.7	2.5.6.7	2.5.6.7	2.3.5	4	4.5.6
CASE GND	3	2	2.5.6.7					2	2.5.6.7	2.5.6.7	2.5.6.7	2.5.6.7	—	2.5.6.7	—
NOT USED										4					

*pins must be connected externally ◆Ground externally All measurements made with GND pin(s) grounded externally ▲Pin 2 is not case grounded

3.2 T102, 610 MHz FILTER MODULE

This section describes T102, the 610 MHz Filter Module. It also includes a T102-peculiar procedure for adjustment of the IF gain.

This unit is a special converter implementation; although it does have conversion circuitry, it does not convert the Front-End band output to an IF band. The 610 MHz Front-End band lies within the 500 -1000 MHz IF band and T102's input and output frequencies are identical. T102 downconverts the input RF to reject interfering signals in a 4 MHz, steep-sided filter. The filtered signal is then upconverted to the output frequency and amplified by the Amp/Attenuator and Amp/Divider.

The reason for these down/up conversions and filtering is that the 608-614 MHz radio astronomy band was originally allocated to television channel 37. Since channels 36 and 38 (and other nearby channels) may be strong signals in some VLBA antenna locations, a steep-sided filter must be used on the F102 Front-End output.

F102, the 330/610 MHz (90/50 cm) Front-End, has a K&L X3DFV-327/610 diplexer to separate the 327 and 610 MHz signals. This is a dual-frequency filter with 327 and 610 MHz ports. The bandwidth of the 330 Mhz port is about 50 MHz and the bandwidth of the 610 MHz port is about 75 MHz. The 327 MHz signal is a potentially interfering signal on the 610 MHz port and the converse; the 327 and 610 MHz port signals are each about 25 dB below the other port's levels.

The 610 MHz filter in the diplexer thus encompasses TV channels 29 (560-566 MHz) through 41 (632-638 MHz); these and the 327 MHz potential interference signals must be removed from the F102 610 MHz port spectrum.

In the conversion process, the Front-End center frequency (611 MHz) is converted to 111 MHz by a fixed 500 MHz fixed LO and then downconverted again to 11 MHz using a 100 MHz fixed LO. The resultant 11 MHz signal is filtered by an eight-pole, 11 MHz center frequency, 4 MHz bandwidth filter to reject interfering signal and image responses. The filtered signal is converted back in two corresponding steps to the 610 MHz band. The reasons for the downconversion to perform the filtering is that a 4 MHz bandwidth filter at 610 MHz would require many sections, have a high loss and be very expensive. Other things being equal, bandpass filter costs tend to be inversely proportional to the BW/CF ratio. A second reason for the downconversion is that narrow bandpass filters (i.e a small BW/CF ratio) have higher phase temperature coefficients than wider bandpass filters. The downconversion filtering technique reduces this temperature sensitivity.

T102 has a wideband mode that bypasses the conversion and filtering for use in observations that can tolerate the RFI that may be present. In this mode, the bandwidth is 30 MHz.

T102 Band Coverage and LO Frequencies

In the narrow band mode, the 3 dB band edges 609 and 613 MHz, respectively, are defined by an eight-pole K&L 8B51-11/4 Bandpass filter. In the wide band mode, the 3 dB band edges 596 and 626 MHz, respectively, are defined by the K&L 4B120-611/30 bandpass filter Figure 15 (page 51).

Two fixed LO frequencies are used - 500 MHz and 100 MHz, both at a +5 dBm level.

T102 Size and Location

T102 is a triple width module installed in Rack B, Bin D, Slots 6-10.

T102 Drawings and Data Sheets

D53500K007, Rev E - T102 610 MHz Filter Module Block Diagram
D53500A001, Rev C - T102 610 MHz Filter Module Assembly
A53500B009, Rev C - T102 610 MHz Filter Module BOM

C53500A018, Rev A - T102 610 MHz Filter Module Input Amplifier Assembly
B53500K006, Rev C - T102 610 MHz Filter Module Filter Block Diagram
D53500A013 - T102 610 MHz Filter Module Filter Unit Assembly
D53500A022 - T102 610 MHz Filter Module Filter Unit PCB Assembly

Data sheets for the Avantek UTO-1012, UTO-509 and GPD-1003 amplifiers, QBH-160 amplifier and MCL-TFM-4H mixer follow the drawings. Data sheets for the WJ A18-1 and A19 amplifiers, Anzac DS-313 power divider and Narda 4772-X attenuator are included in the appendix, Section 6.

T102 Specifications

Nominal Gain, dB	30	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-61	Min Out Pwr @ 1% Compression, dBm	0.0	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temperature, K	1000	Noise Temperature for 1° added Syst Noise, K	300	Nom LO Pwr input, dBm Both 500 and 100 MHz LO's	+5
Avg Noise Figure, dB	6.5	Noise Figure for 1° added Syst Noise, dB	2		
15 Volt Power Req't, mA	760				

T102 Differences From the General Converter Block Diagram

Although there are some similarities, T102 differs greatly from the general converter block diagam of Section 2.1. Like the general converter model, T102 has RF bandpass filters in the RF circuitry and uses the Amp/Attenuator and Amp/Divider to amplify the output LCP and RCP IF signals. In contrast, it does not have a transfer switch. It has a wideband input RF preamplifier, uses two LO signals, and has the switch-selectable capability of either filtering the Front-End RF signal with a narrow band filter or a wideband filter.

RF Circuitry Filtering

The RF circuitry filter is a K&L 4B120-611/30 bandpass filter with a 611 MHz center frequency and a 3 dB bandwidth of 30 MHz. The lower and upper band edges are 596 MHz and 626 MHz, respectively. The attenuation plot is shown in Figure 15, (next page). This filter strongly attenuates the 560-596 MHz and 626-638 MHz portions of the F102 output spectrum.

Adjacent Television Channel Frequencies

Nearby TV channels are: 33 (584-590 MHz); 34 (590-596 MHz); 35 (596-602 MHz); 36 (602-608 MHz); 38 (614-620 MHz); 39 (620-626 MHz) and 40 (626-632 MHz). The RF circuitry K&L 4B120-611/30 filter plot on the previous page shows that it will pass channels 35 through 39 without attenuation. Channels 34 and 40 will have some attenuation because the filter's 3 dB frequencies are the upper band edge of channel 34 and the lower band edge of channel 40. Channels 33 (584-590 MHz) and 41 (632-638 MHz) will be attenuated about 20 dB; channels below and above these two will have greater attenuation.

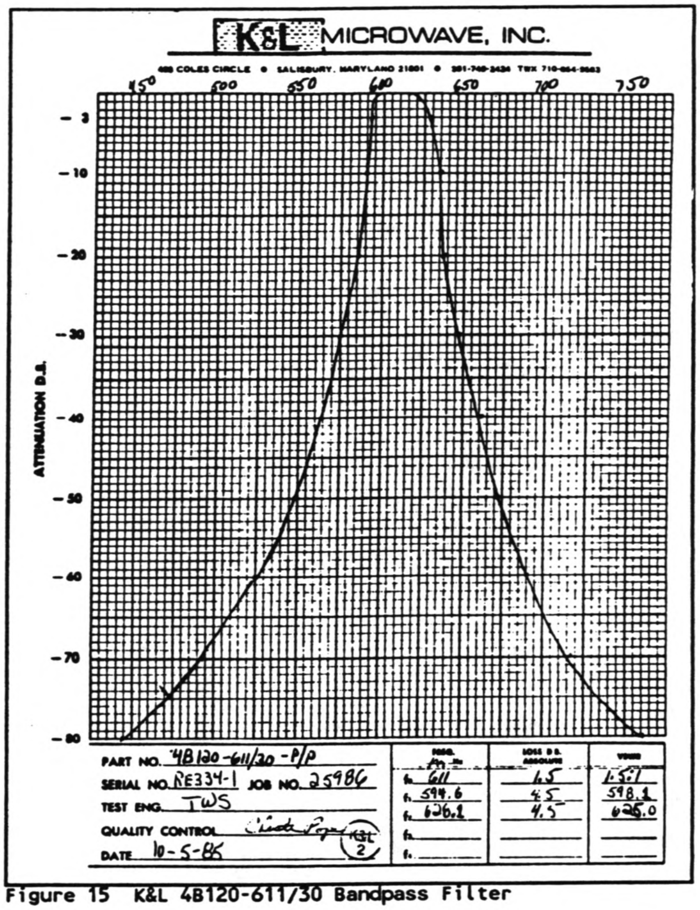
In the filter mode, the filtering function must reject the 596 to 608 MHz and 614 to 626 MHz portion's of the RF circuitry filter's output.

Frequency Downconversion and Filtering

The frequency conversions and filtering are performed by the Filter Unit Assembly D53500A013. Refer to the Filter Unit Block Diagram B53500K006 during the following description. Figure 16 is a simplified rendering of the filter's responses centered on the first and second conversion's center frequencies. This figure illustrates the attenuation of adjacent TV signals by the RF and downconversion filters. The filter responses are all plotted at 1 MHz/division.

The first conversion (using the 500 MHz LO frequency) produces a difference frequency band IF_1, which is 96 MHz through 126 MHz. The converted 610 MHz radio astronomy band's LBE, center and UBE frequencies are 108, 111 and 114 MHz, respectively.

The first conversion's unwanted sideband (sum) is 1096 through 1126 MHz and is greatly attenuated by the 5B120-111/5.5 filter.



PART NO. 4B120-611/30-P/P
SERIAL NO. RE334-1 JOB NO. 25986
TEST ENG. TWS
QUALITY CONTROL K&L 2
DATE 10-5-86

f_0 611	4.5	1.5:1
f_1 594.6	4.5	598.1
f_2 626.1	4.5	625.0

Figure 15 K&L 4B120-611/30 Bandpass Filter

IF_1 is filtered by a K&L 5B120-111/5.5 filter (Figure 17, next page) that has a 111 MHz center frequency and a 3 dB bandwidth of 5.5 MHz, 0.5 MHz narrower than the radio astronomy band's 6.0 MHz bandwidth. This filter's lower and upper band edges are 108.25 and 113.75 MHz, respectively. Thus the filter selects most (5.5 MHz out of 6 MHz) of the allotted 608-614 MHz band and attenuates adjacent TV channels 36 (602-608 MHz) and 38 (614-620 MHz).

The second downconversion operates upon the 5B120-111/5.5 (page 52) filter's output using the 100 MHz LO frequency. The filter's LBE, center and UBE frequencies are 108.25, 111 and 113.75 MHz, respectively. The

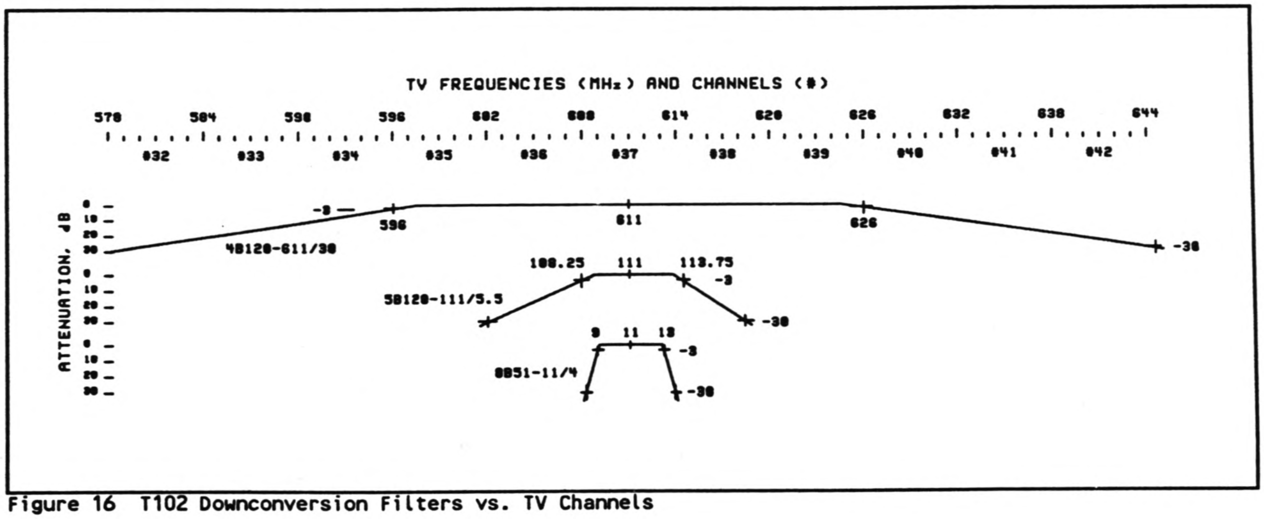
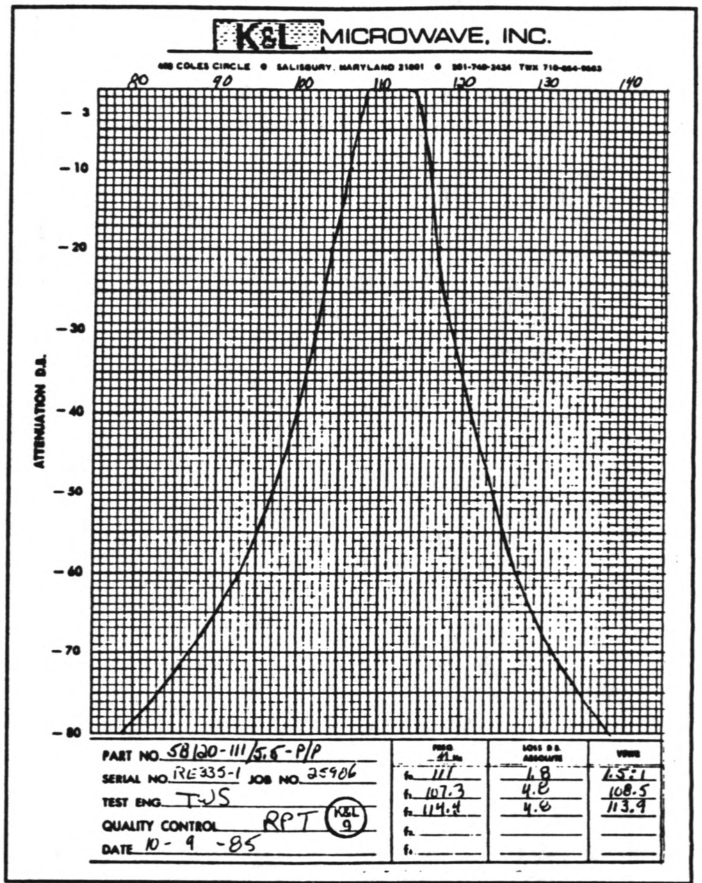


Figure 16 T102 Downconversion Filters vs. TV Channels

resultant IF$_2$ difference frequency LBE, center and UBE are 8.25, 11 and 13.75 MHz, respectively. IF$_2$ is filtered by a K&L 8B51-11/4 filter having a center frequency of 11 MHz and a 3 dB bandwidth of 4 MHz. The resultant lower and upper band edge frequencies are 9 and 13 MHz, respectively. Note that this filter has truncated 1 MHz off each side of the 6 MHz radio astronomy band. Figure 18, page 53, shows the 8B51-11/4 filter attenuation plot.

The second conversion's unwanted sideband (sum) band is 208.25 to 213.75 MHz; the 8B51-11/4 filter attenuation plot shows that the filter attenuates this image by more than 80 dB.

The net result of the two stages of conversion and filtering is that TV channel 36's converted UBE (8 MHz) is attenuated 40 dB by the 8B51-11/4 filter and channel 38's LBE (14 MHz) is attenuated 32 dB by this filter. Remembering that the 5B120-111/5.5 filter above attenuated these band edges 3 dB, the resultant channel 36 UBE and the channel 38 LBE attenuations are 43 and 35 dB, respectively. Figures 16, 17 and 18 show that the attenuation of channels 35 and 39 (and the others in the 4B120-611/30 RF filter's passband) is greatly in excess of 40 dB.



PART NO. 5B120-111/5.5-P/P
SERIAL NO. RE335-1 JOB NO. 25906
TEST ENG. TJS
QUALITY CONTROL RPT
DATE 10 - 9 - 85

FREQ MHz	LOSS DB ABSOLUTE	VSWR
f₀ 111	1.8	1.5:1
f₁ 107.3	4.8	108.5
f₂ 114.4	4.8	113.9
f₃		
f₄		

Figure 17 K&L 5B120-111/5.5 Bandpass Filter

Upconversion and Filtering

The upconversion process is the inverse of the downconversion and uses the same LO frequencies. The first upconversion uses the 100 MHz LO and the resultant IF$_3$ (sum) band edge frequencies are 108.25 and 113.75 MHz. The center frequency is 111 MHz.

The first upconversion unwanted sideband (difference) frequency band is 86.25 to 91.75 MHz; this is attenuated by the K&L 3B120-111/5.5 bandpass filter. The filter attenuation plot (page 54) shows that the filter attenuates this image by about 50 dB.

The second upconversion uses the 500 MHz LO and produces an IF$_4$ (sum) with band edges of 608.25 and 613.75 MHz. The center frequency is 611 MHz.

The second upconversion unwanted sideband (difference) is 386.25 to 391.75 MHz. This sideband is attenuated more than 80 dB by the K&L 4B120-611/30 bandpass filter driven by the output of the Filter Unit Assembly. This filter is identical to the RF filter and the attenuation plot is shown in Figure 15 above.

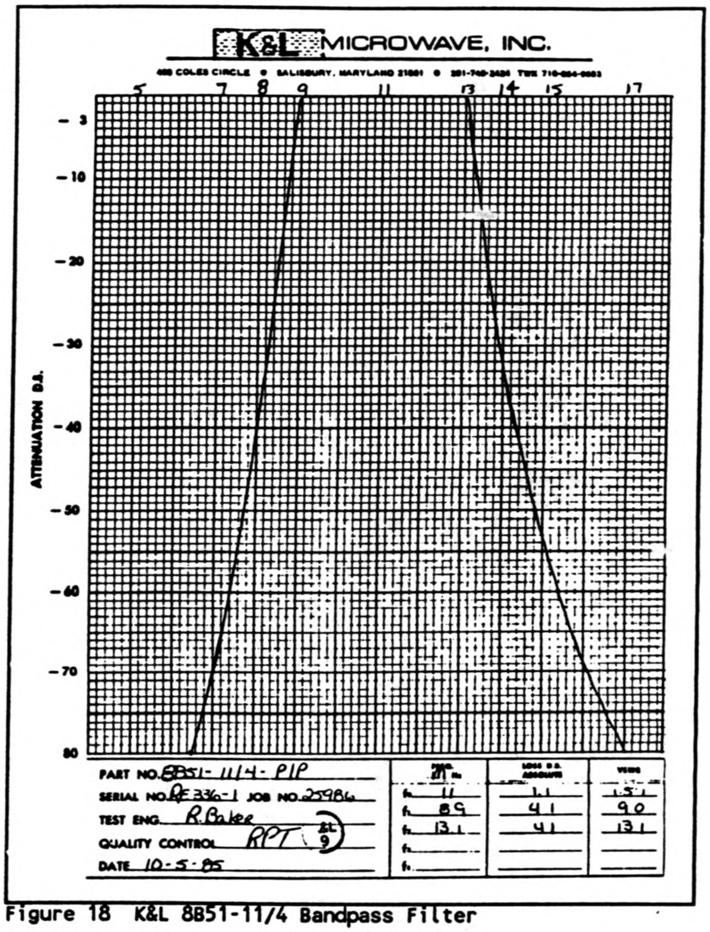
LO Isolation in the Filter Unit Assembly

An important consideration unique to T102 is the isolation that must exist between the pair of 500 MHz LO signals used to perform down/up conversions in the Filter Unit Assembly. The RF inputs to the Filter Unit Assembly cover the 596 to 626 MHz band. This band is input to the RF port of the first downconversion mixer and some of this power will be coupled into the 500 MHz LO port because the mixer's RF-LO isolation is about

30 dB. If these out-of-band signals are coupled into the second upconversion's mixer LO port via a common 500 MHz LO signal, the filtering is compromised. Clearly, the two 500 MHz LO signals must be isolated from each other and the upconversion's LO must not be contaminated by interfering signals. The same consideration applies to the 100 MHz LO used in the second downconversion and first upconversion.

The two 500 MHz LO signals are isolated from each other by the properties of several circuit elements. The isolation between the output ports of the ANZAC DS-313 power divider is 23 dB. Two AVANTEK UTO-509 amplifiers provide individual drive to the first downconversion and second upconversion mixers. S_{12}, the UTO-509's output-input isolation parameter is 28 dB at 500 MHz. Finally, the typical RF to LO and LO to IF isolations of the MCL-TFM-4H mixer are about 30 dB. The net isolation between these two 500 MHz LO signals is the sum of the isolation of these components, about 139 dB.

The net isolation between the two 100 MHz signals is also the sum of the component's isolations and is about 123 dB.



PART NO. 8B51-11/4-PIP
SERIAL NO. RF336-1 JOB NO. 25986
TEST ENG. R. Baker
QUALITY CONTROL RPT
DATE 10-5-85

f_1	11	1.1	1.5:1
f_2	8.9	41	9.0
f_3	13.1	41	13.1
f_4			
f_5			

Figure 18 K&L 8B51-11/4 Bandpass Filter

Unwanted Sideband and Image Band Rejection

Since T102 is not a superheterodyne converter, there are no image signals from the Front-End in the usual sense but the downconversions and upconversions in the filter unit have unwanted sidebands that are attenuated by filters in the filter unit. The unwanted sideband attenuation is described below.

Intermodulation

Intermodulation is a concern in frequency conversion. The worst case is third order, $2F_{RF} - F_{LO}$, that typically produces IM product frequencies in the region of the IF filter passband. Third order intermodulation performance was briefly described in the Mixer discussion of Section 2.2.

The MCL TFM-4H data sheet shows that with two RF tones at 0 dBm, the IM product frequencies are 60 dB below the IF tones. The Filter Unit Assembly output power level is about -72 dBm and the net gain through the assembly is about +5.7 dB. The highest signal level in the Filter Unit Assembly is -56.3 dBm at the RF port of mixer #4, the last mixer. This level and the other mixer input levels in the Filter Unit are so low relative to the 0 dBm level of the TFM-4H intermodulation specification that IM product frequency power levels are vanishingly small.

T102 Gain

Using typical amplifier gain values, filter center frequency insertion loss values, Transco switch insertion losses and typical mixer conversion loss values, T102's net gain is calculated to be 30 dB. The output level is -61 dBm over a 4.0 MHz bandwidth and the output power spectral density is -67 dBm/MHz. The net gain of the Filter

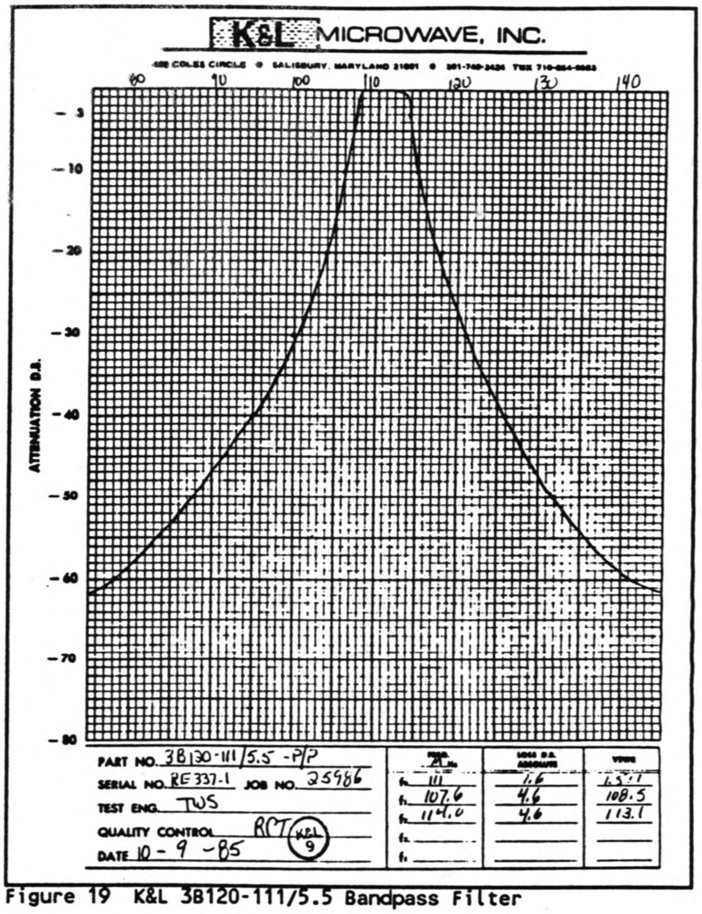
Unit Assembly is +5.7 dB and its input and output levels are -78.1 and -72.4 dBm, respectively.

Noise Temperature

The T102 noise temperature is a composite value that is a function of the noise temperatures of the RF Input Amplifier, Filter Unit Assembly, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 1000 K. A T102 noise temperature of 300 K would add 1 K to the system temperature. Note that T102 does not meet the gain compression specification described in Section 2.4

Mixer

The mixers used in the Filter Unit Assembly are Minicircuits Laboratory MCL-TFM-4H and are designed for RF inputs of 5 to 1200 MHz, an IF of DC to 1200 MHz, and an LO drive of +17 dBm. At a 600 MHz RF frequency and an LO drive of +17 dBM, the typical conversion loss is about 6.7 dB. The RF-LO isolation is 29 dB and the LO-IF isolation is 26.5 dB. A data sheet for this mixer follows the drawings at the rear of this section.



PART NO. 3B130-111/5.5 -P/P
SERIAL NO. RE 337-1 JOB NO. 25986
TEST ENG. TWS
QUALITY CONTROL RCT K&L 9
DATE 10 - 9 -85

	FREQ. MHz	LOSS D.B. ABSOLUTE	VSWR
f_0	111	1.6	1.5:1
f_1	107.6	4.6	108.5
f_2	114.0	4.6	113.1
f_3			
f_4			

Figure 19 K&L 3B120-111/5.5 Bandpass Filter

RCP-LCP Isolation

The only couplings between the RCP and LCP channels are the 500 and 100 MHz LO signals; there is no transfer switch. The two LO signals for the Filter Unit Assembly are each split into RCP and LCP components by a Merrimac PDM-20-500 power divider, which typically provides 30 dB of isolation between the outputs.

Additional isolation is provided by LO drive amplifiers in the Filter Unit Assembly (refer to the Filter Unit Block Diagram, B53500K006). The 500 MHz amplifier is a Q-BIT QBH-160 and S_{12}, (Isolation Out-In) is 25 dB. The resultant isolation between the 500 MHz RCP-LCP LO drives is thus about 90 dB or 45 dB for each LO path. The 100 MHz drive uses two cascaded amplifiers, AVANTEK GPD-1003 and UTO-509. The associated S_{12} isolation values are 21.5 and 18.6 dB at 100 MHz, respectively, so that the resultant isolation between the 100 MHz RCP and LCP LO drives is 120 dB or 60 dB for each LO path.

From the T102 specification table above, the RCP-LCP channel isolation specification is 65 dB.

VSWR's

The input VSWR is the composite of the K&L 4B120-611/30 bandpass filter (1.5:1) and the input VSWR of the Avantek UTO-1012 amplifier (1.25:1 at 600 MHz). The composite input VSWR is about 1.5:1. The output VSWR is the composite VSWR of the Amp/Divider, which is about 1.5:1.

RF Input Circuitry

The RF circuitry consists of a K&L 4B120-611/30 bandpass filter and a wideband input amplifier, C53500A018. The filter's function was described above.

The Input Amplifier block diagram is shown on the assembly drawing, C53500A018. The Input Amplifier consists of a cascade connection of an AVANTEK UTO-1012 amplifier that drives a a Q-BIT QBH-160 amplifier. The UTO-1012 amplifier is a high gain, low power unit and the QBH-160 amplifier is a medium gain, high power unit. This configuration thus provides a high gain, high power drive to the selector switch and Filter Unit Assembly. Both amplifiers have DC blocking capacitors on the inputs and outputs and are cascadable. The Input Amplifier composite gain is 28.6 and the composite noise figure is 3.0 dB.

The AVANTEK UTO-1012 is characterized for a frequency range of 5 to 1000 MHz. At 600 MHz, typical characteristics are: gain, 15.8 dB; gain flatness, ± 0.5 dB; noise figure, 2.6 dB; power output @ 1 dB compression point, +5 dBm; input VSWR, 1.25:1 and output VSWR, 1.2:1.

The Q-BIT QBH-160 is characterized for a frequency range of 20 to 1200 MHz. At 600 MHz, typical characteristics are: gain, 13 dB; gain flatness, ± 0.5 dB; noise figure, 7 dB; power output @ 1 dB compression point, +17 dBm; input VSWR, 1.2:1 and output VSWR, 1.25:1.

Data sheets for the UTO-1012 and QBH-160 follow the drawings at the rear of this section.

IF Circuitry

The IF path Amp/Attenuator and Amp/Divider were described in Section 2.5. In the filtering mode, the 4B120-611/30 bandpass filter on the output of the Filter Unit Assembly functions as an IF bandpass filter. In the wideband mode, there is no IF bandpass filter; the band-limiting function is performed by the RF circuitry 4B120/611/30 bandpass filter.

In the filtering mode, a NARDA 4772-16 attenuator is used on the output of the Filter Unit Assembly to reduce the filtered signal level to approximately the same level as the unfiltered signal. This attenuator value is nominal and should be selected to make the two path gains identical. 10/7

IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

The input 500 and 100 MHz LO signals each have a power level of +5 dBm from B-Rack power dividers.

The 500 MHz level is reduced 3 dB by a NARDA 4772-3 attenuator and input to a Merrimac two-way power divider, so the divider's output level is -4.7 dBm. Each output is fed to the associated Filter Unit Assembly which has additional LO power amplification.

The 100 MHz level is reduced 5 dB by a NARDA 4772-5 attenuator and input to a Merrimac two-way power divider, so the divider's output level is -6.7 dBm. Each output is fed to the associated Filter Unit Assembly which has additional LO power amplification.

The Merrimac PDM-20-500 power divider provides 30 dB (typical) of isolation between the two divider output ports; this provides a portion of the isolation required between the RCP and LCP LO signals. See the RCP-LCP isolation discussion above.

RF Switching

Unlike most of the converters, T102 does not have a transfer switch. Four SPDT selector switches (S102A, S102B, S102C and S102D) are used in pairs to select either the wideband or filter modes. Referring to the T102 Block Diagram, the switching is straightforward; the first switches (S102A and S102C) connect the output of the RCP and LCP Input Amplifiers to the Filter Unit Assembly inputs or to the IF Amp/Divider inputs via switches S102B and S102D. The switches are Transco 909C70100 SPDT electrically driven switches described in Section 2.5. Transfer and Selector Switch drive is discussed in Section 2.

S102A and S102B are driven by L107, address 1BH, bits 0 and 1. S102C and S102C are driven by L107, address 1CH, bits 0 and 1.

T102 Power Circuitry

All T102 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 3 and 4 where it is distributed to the amplifiers. The common returns for these amplifiers are connected to TB1, terminals 1 and 2, which are connected to P11-34 and P11-42 and a frame ground lug at P11. This common return is also the ground return for the +28 volt drive to the transfer switch. The Input Amplifier, Amp/Attenuator and Amp/Divider all have a 1.0 uF bypass capacitor connected across the amplifier power terminals.

T102 Gain Adjustment Procedure

Section 2.6 describes a gain adjustment procedure used to set the RCP and LCP front-panel gain potentiometers after replacement of a converter module. This procedure uses an HP 4836A Power Meter equipped with an HP 8484 sensor. In the case of T102, it is difficult to use a power meter with this procedure for the following reasons:

1. The T102 signal bandwidth is 4 MHz but the bandwidth of the IF Amp/Attenuator and Amp/Divider may exceed 1000 MHz. Thus these amplifiers contribute noise over a much larger bandwidth than the T101 signal band. When attempting to adjust T102's gain, this wideband noise tends to obscure the measurements.

2. There may be interference signals within the T102 band.

This alternate procedure uses the Baseband Converters, an HP 436 power meter and a display device that can show the Station Computer Baseband Converter overlays. The overlay digital value proportional to total power is used as a measure of a converter's power spectral density. The converter's power spectral density should be -67 dBm/MHz.

This procedure uses the narrow-band filtering capabilities of the Baseband Converter to facilitate adjustment of T102's gain.

A high frequency converter's output power level is first measured with the power meter to verify that it is -40 dBm (normal power level at standard system temperature); the Baseband Converter is then used to measure the high frequency converter's power spectral density over a 2 MHz bandwidth at an IF frequency of 611 MHz.

Next, T102's output is switched to the Baseband Converter used above while retaining the Baseband Converter's setup. T102's IF gains are then adjusted to produce a power spectral density value equal to that produced by the high frequency converter.

Gain Adjustment Procedure

To set the T102 output levels to a -67 dBm/MHz spectral power density (the same level as the other converters) do the following:

1. Set the receiving system to a high frequency band that is not subject to interference. Use a band that has IF signals in the B and D IF's as is the case with the 90 cm/50 cm bands; the 4 cm band is suggested.

2. Route the high frequency converter outputs to a Baseband Converter. Set the Baseband Converter LO to 611 MHz and use a 2 MHz conversion bandwidth.

3. Using the power meter, check the high frequency converter power levels on the front panel SMA monitor connectors. The power level should be -40 dBm over 500 MHz bandwidth at standard system temperature.

4. Using the Baseband Converter overlays for this high frequency converter, jot down the values (i.e. counts) proportional to LCP and RCP total power.

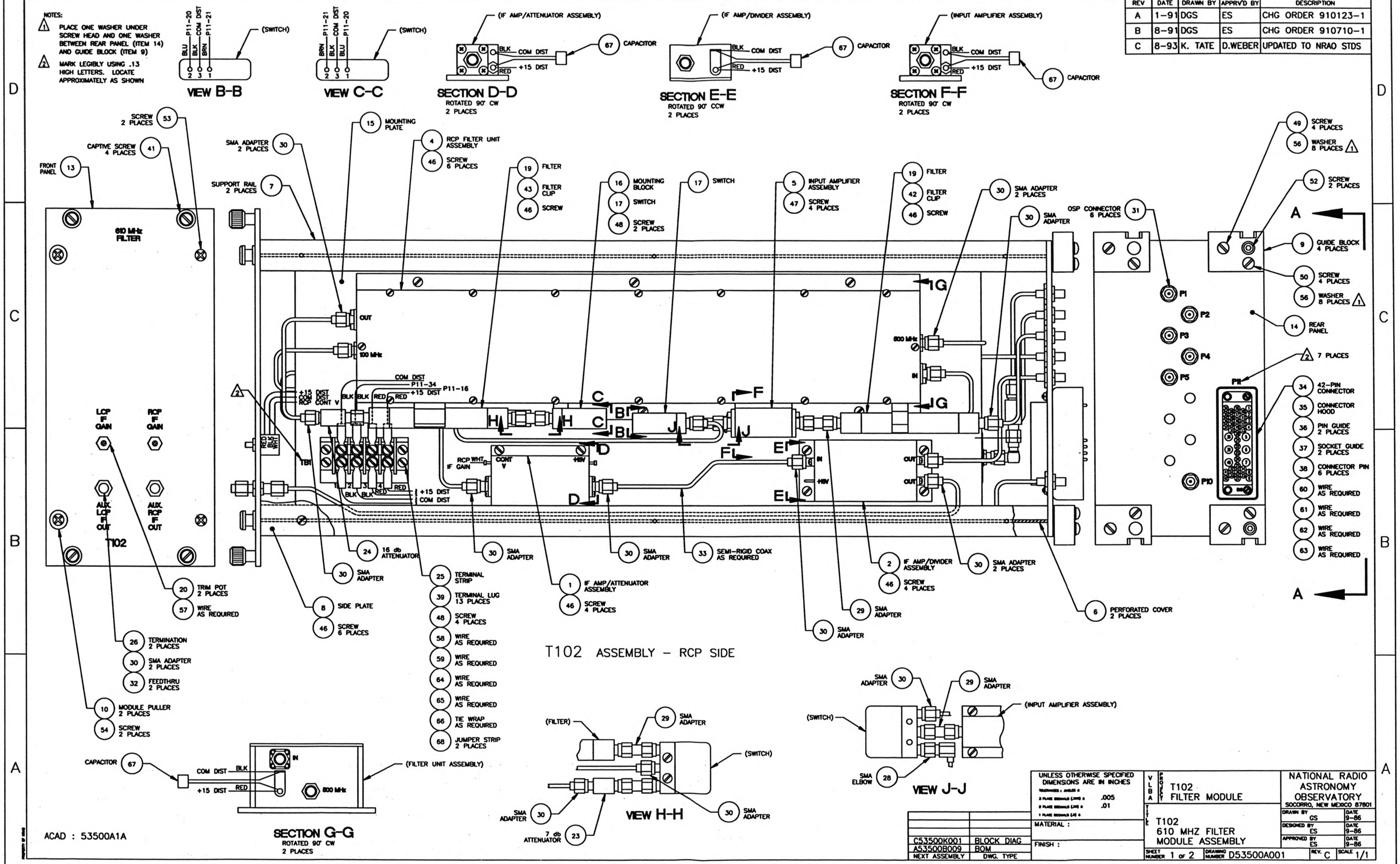
5. Set the receiving system to the 50 cm band, and without modifying the Baseband Converter's set up, adjust T102's front-panel gain potentiometers to produce a total power value identical (or close to) that obtained in Step 4 above. The gain adjustment error tolerance is ± 0.5 dB or up to 10% of the overlay value proportional to total power.

This procedure can be used to adjust the gains of other converters in bands where external RFI in the IF passband is a problem.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	1-91	DGS	ES	CHG ORDER 910123-1
B	8-91	DGS	ES	CHG ORDER 910710-1
C	8-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS

NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 14) AND GUIDE BLOCK (ITEM 9)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



ACAD : 53500A1A

C53500K001	BLOCK DIAG
A53500B009	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ± .01
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA

PROJECT T102 FILTER MODULE

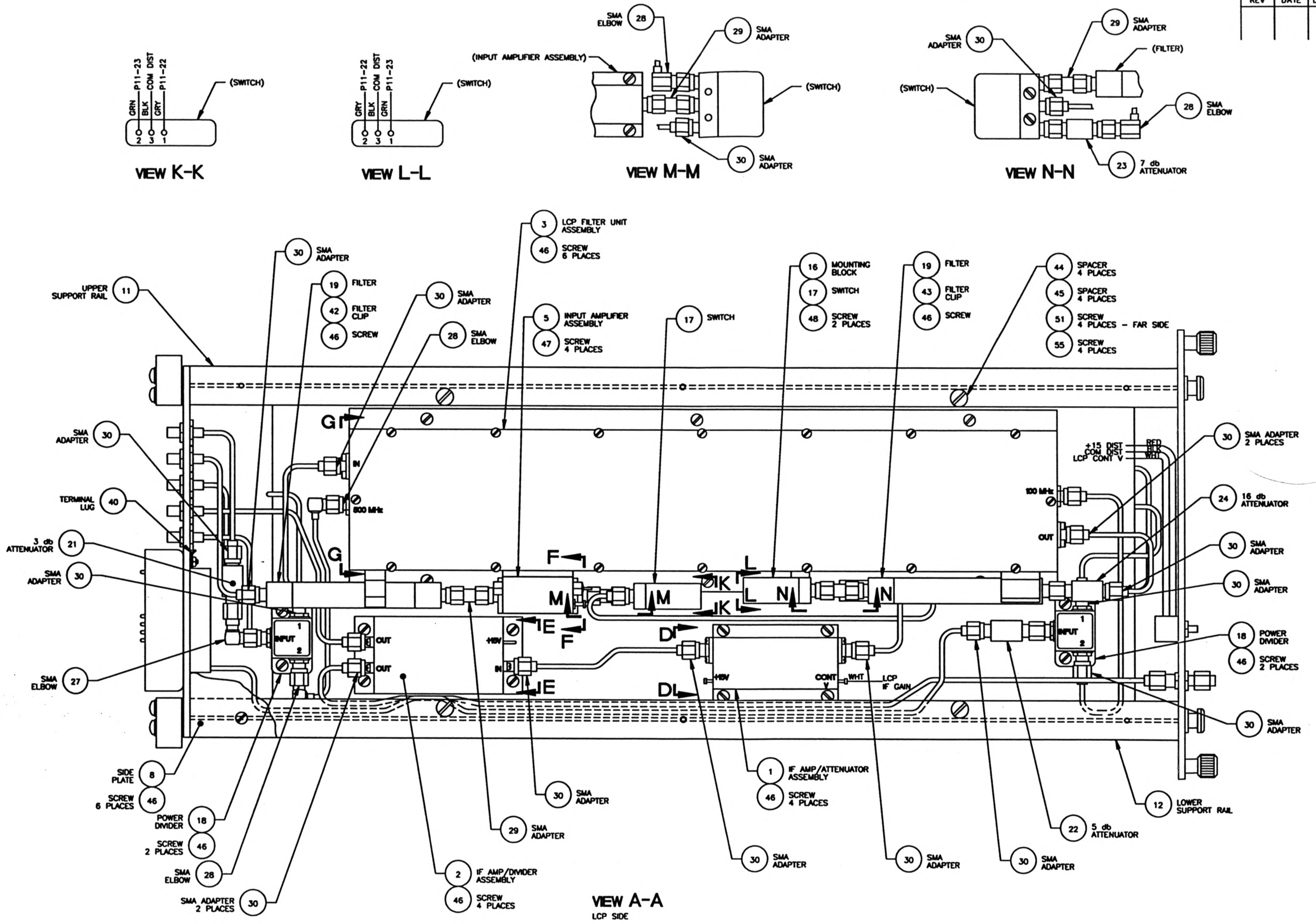
TITLE T102
610 MHZ FILTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY	GS	DATE 9-86
DESIGNED BY	ES	DATE 9-86
APPROVED BY	ES	DATE 9-86

SHEET NUMBER 1 OF 2 | DRAWING NUMBER D53500A001 | REV. C | SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



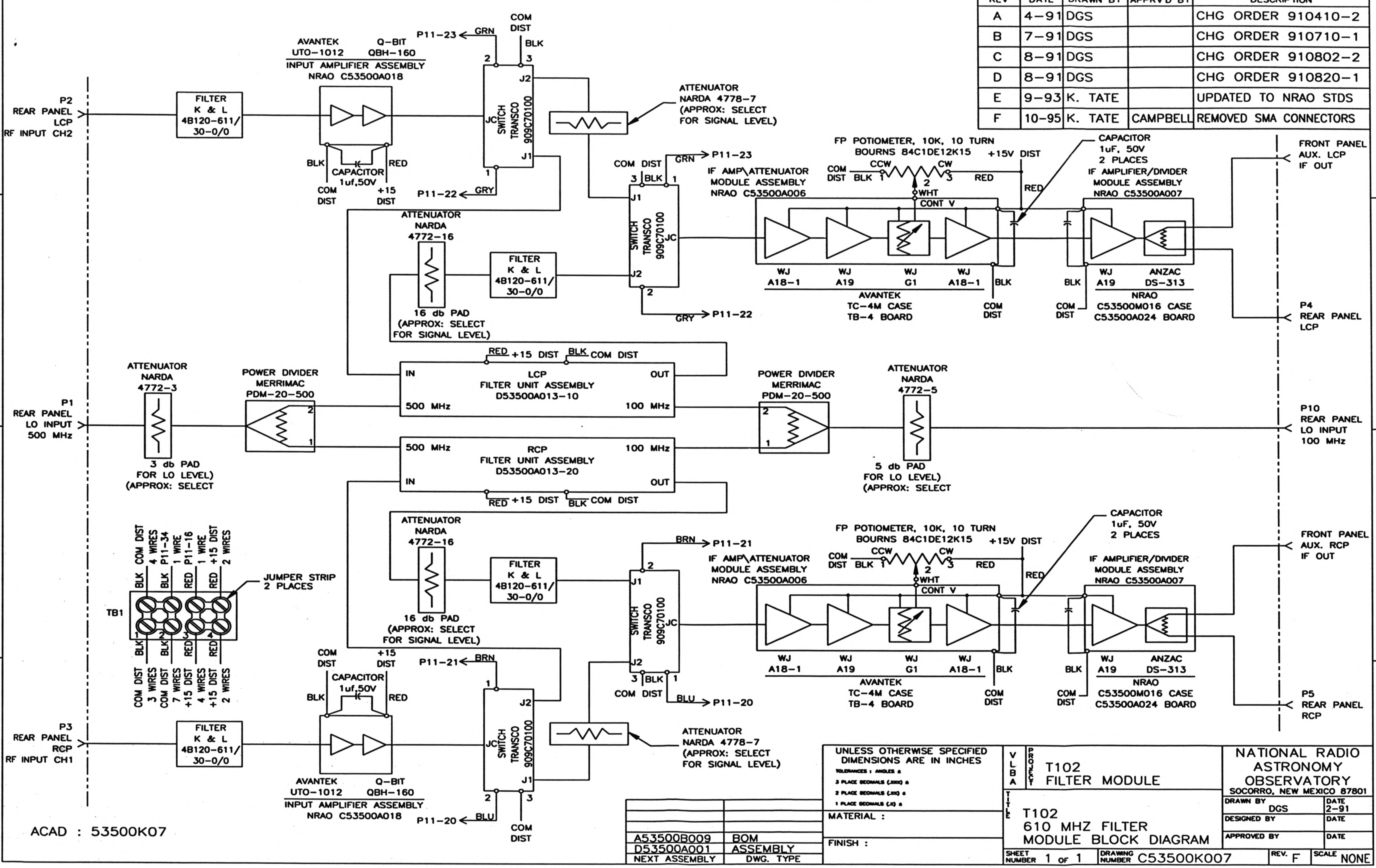
ACAD : 53500A1B

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES : ANGLES ± 3 PLACE DECIMALS (.XXX) ± .005 2 PLACE DECIMALS (.XX) ± .01 1 PLACE DECIMALS (.X) ±	VLBA PROJECT T102 FILTER MODULE
		MATERIAL :	TITLE T102 610 MHZ FILTER MODULE ASSEMBLY
C53500K007	BLOCK DIAG		
A53500B009	BOM	FINISH :	
NEXT ASSEMBLY	DWG. TYPE		SHEET NUMBER 2 OF 2

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY GS	DATE 9-86
DESIGNED BY ES	DATE 9-86
APPROVED BY ES	DATE 9-86

DRAWING NUMBER D53500A001 REV. C SCALE 1/1



REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	4-91	DGS		CHG ORDER 910410-2
B	7-91	DGS		CHG ORDER 910710-1
C	8-91	DGS		CHG ORDER 910802-2
D	8-91	DGS		CHG ORDER 910820-1
E	9-93	K. TATE		UPDATED TO NRAO STDS
F	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS

A53500B009	BOM
D53500A001	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA

PROJECT T102
FILTER MODULE

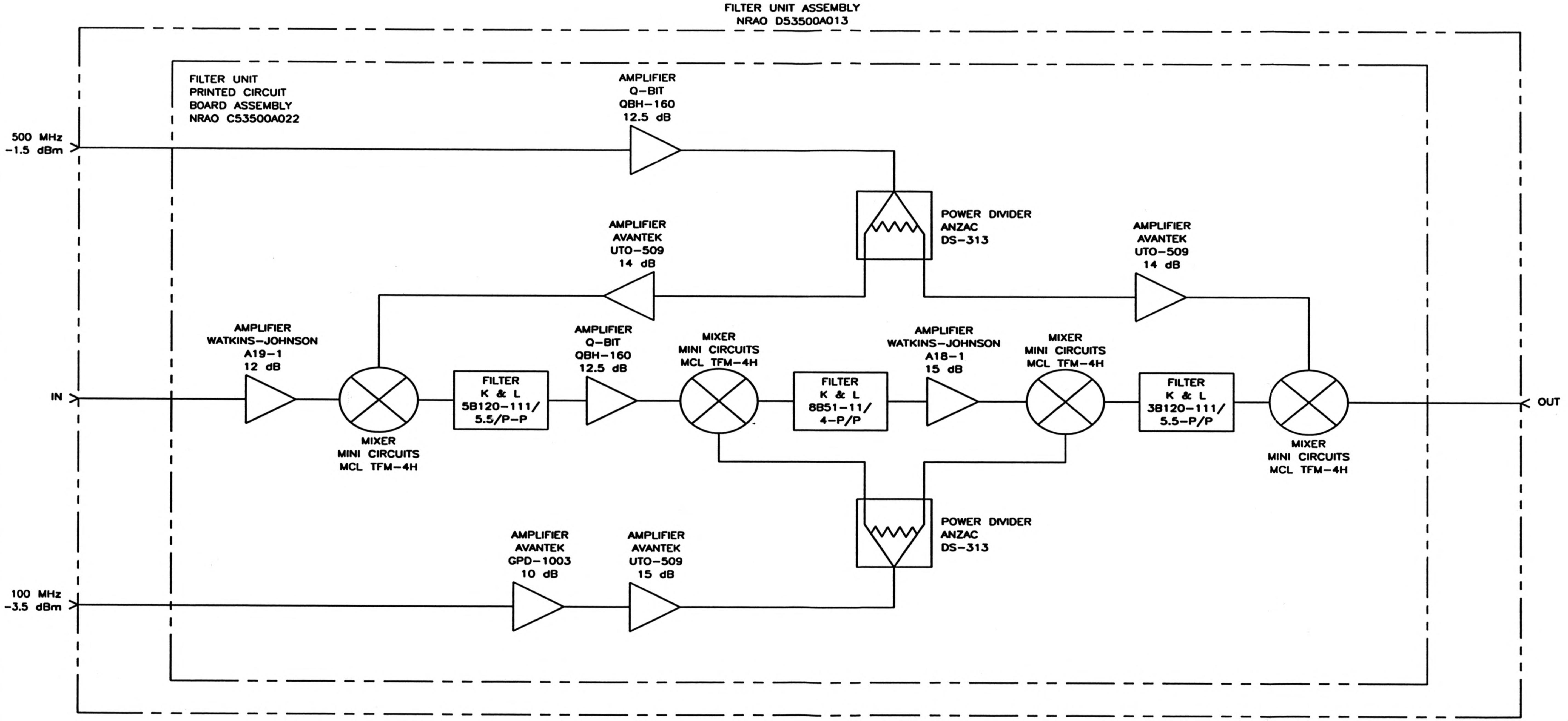
TITLE T102
610 MHZ FILTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY DGS
DATE 2-91
DESIGNED BY
DATE
APPROVED BY
DATE

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K007
REV. F
SCALE NONE

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	7-91	DGS	SCHLECHT	CHG ORDER 910710-2
C	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STDS
D	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS



ACAD : 53500K06

PROPERTY OF NRAO

C53500A022	PCB ASSY
D53500A013	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T102
FILTER MODULE

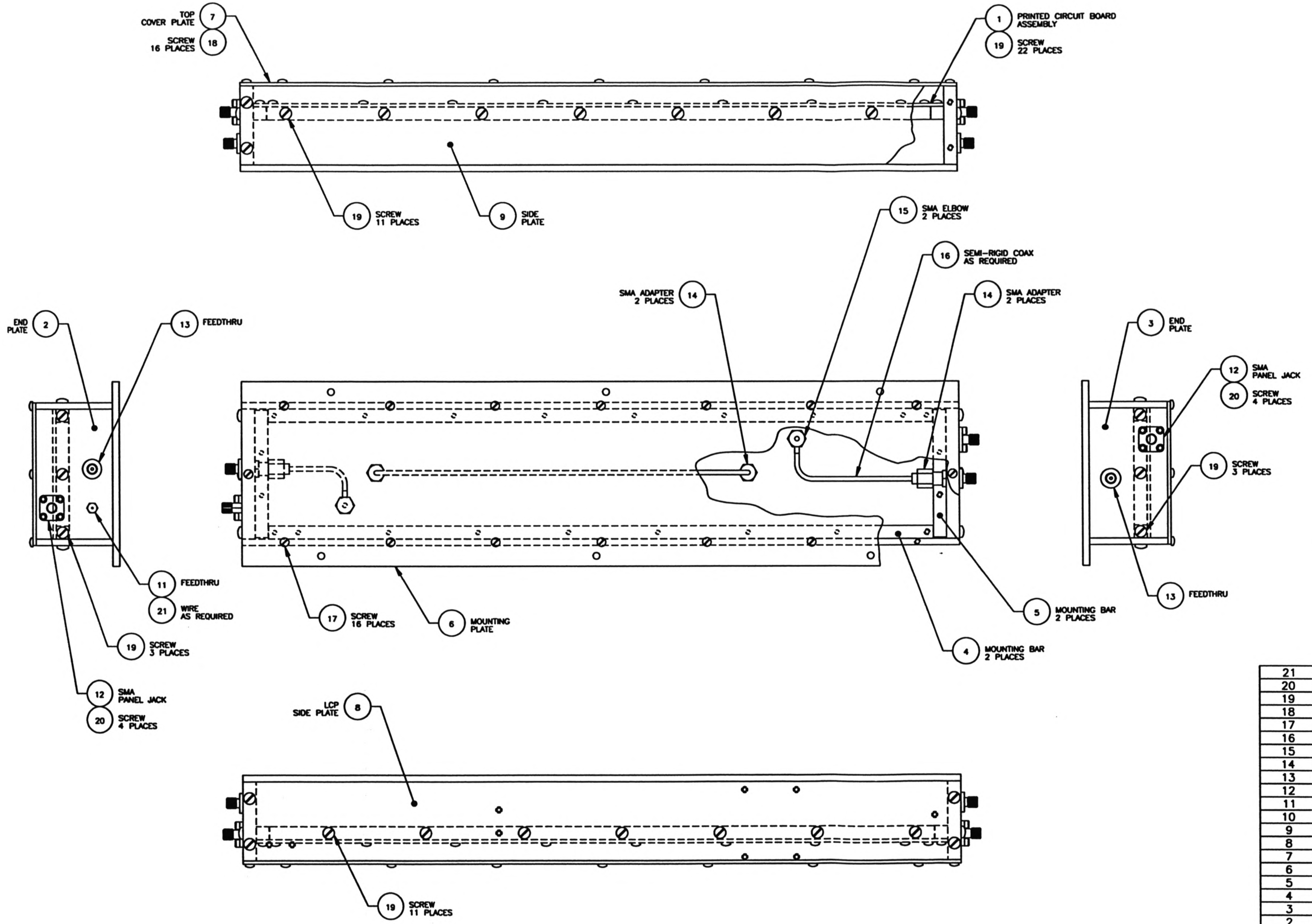
TITLE T102
610 MHZ FILTER MODULE
FILTER UNIT
BLOCK DIAGRAM

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K006
REV. D
SCALE NONE

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY SCHLECHT DATE 1-90
DESIGNED BY SCHLECHT DATE 1-90
APPROVED BY SCHLECHT DATE 1-90

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



-10 ASSEMBLY
LCP SIDE

ACAD : 3500A13A

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
21		ALPHA	7055	WIRE, RED #22	AR
20				SCREW, SOCKET HEAD, SS, 2-56UNC-2A x .25	16
19				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	100
18				SCREW, PAN HEAD, SS, 2-56UNC-2A x .25	32
17				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	32
16		PRECISION TUBE	AA50085	COAX, .085 SEMI-RIGID	AR
15		SOLITRON		ELBOW, SMA/.085	4
14		SOLITRON		ADAPTER, SMA/.085	8
13		OMNI-SPECTRA	2084-0000-00	FEEDTHRU, SMA	4
12		OMNI-SPECTRA	2052-1201-00	JACK, SMA PANEL	4
11		MURATA-ERIE	1250-402	FEEDTHRU	2
10		NRAO	C53500M051	PLATE, RCP SIDE	1
9		NRAO	C53500M020	PLATE, SIDE	2
8		NRAO	C53500M019	PLATE, LCP SIDE	1
7		NRAO	C53500M018	PLATE, TOP COVER	2
6		NRAO	C53500M017	PLATE, MOUNTING	2
5		NRAO	A53500M015	BAR, PCB MOUNTING	4
4		NRAO	C53500M014	BAR, PCB MOUNTING	4
3		NRAO	C53500M013-2	PLATE, END	2
2		NRAO	C53500M013-1	PLATE, END	2
1		NRAO	D53500A022	ASSEMBLY, PCB	2

C53500K006	BLOCK DIAG
D53500A001	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT
T102
FILTER MODULE

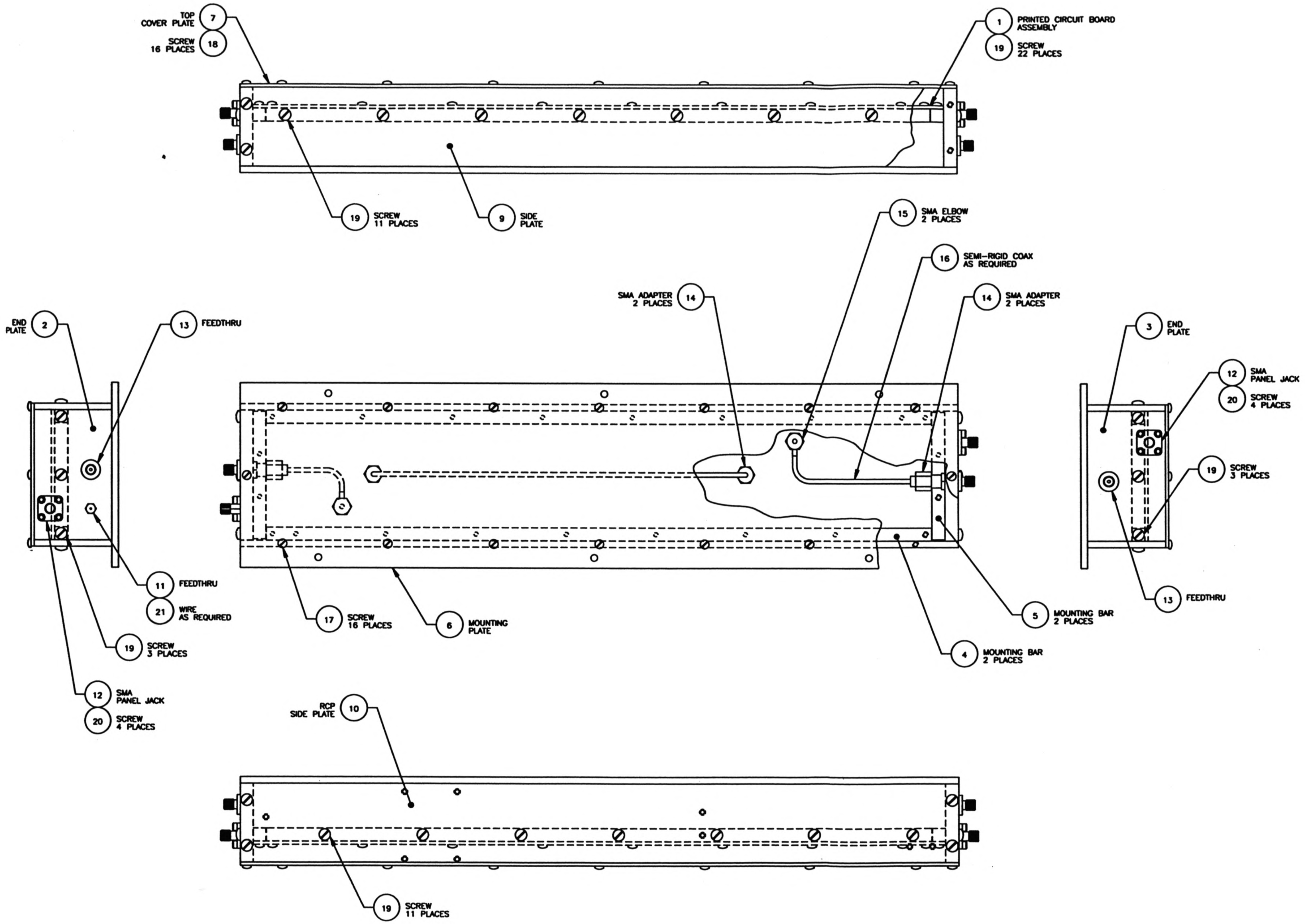
TITLE
T102
610 MHZ
FILTER MODULE
FILTER UNIT ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE
DATE 9-93
DESIGNED BY
DATE
APPROVED BY
DATE

SHEET NUMBER 1 OF 2
DRAWING NUMBER D53500A013
REV. –
SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



-20 ASSEMBLY
RCP SIDE

ACAD : 3500A13B

C53500K006	BLOCK DIAG
D53500A001	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T102 FILTER MODULE

TITLE
T102
610 MHZ
FILTER MODULE
FILTER UNIT ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE DATE 9-93
DESIGNED BY DATE
APPROVED BY DATE

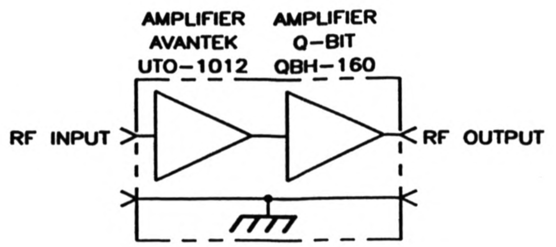
SHEET NUMBER 2 OF 2 DRAWING NUMBER D53500A013 REV. — SCALE 1/1

NOTES:

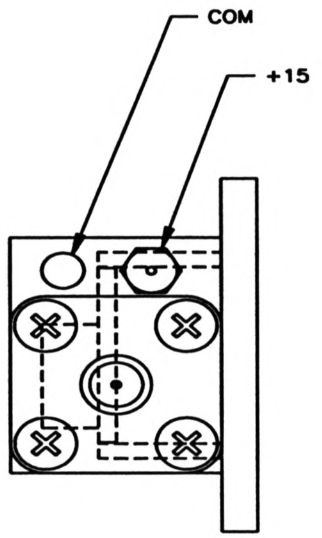
△1 ASSEMBLE CIRCUIT BOARD (ITEM 1) IN ENCLOSURE BOX (ITEM 2) USING APPROPRIATE AMPLIFIERS. DO NOT SOLDER AMPLIFIERS INTO PLACE UNTIL AFTER SCREWS (ITEM 7) ARE TIGHTENED ON CIRCUIT BOARD

△2 SOLDER LEADS TO CIRCUIT BOARD (ITEM 1). LOCATE APPROXIMATELY AS SHOWN

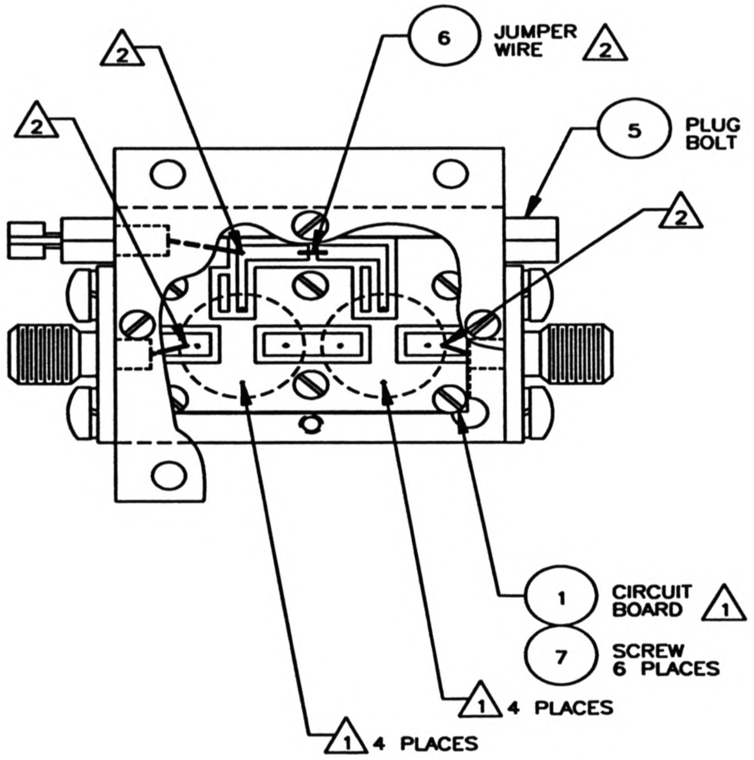
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-93	K. TATE	D.WEBER	REDRAWN ON ACAD

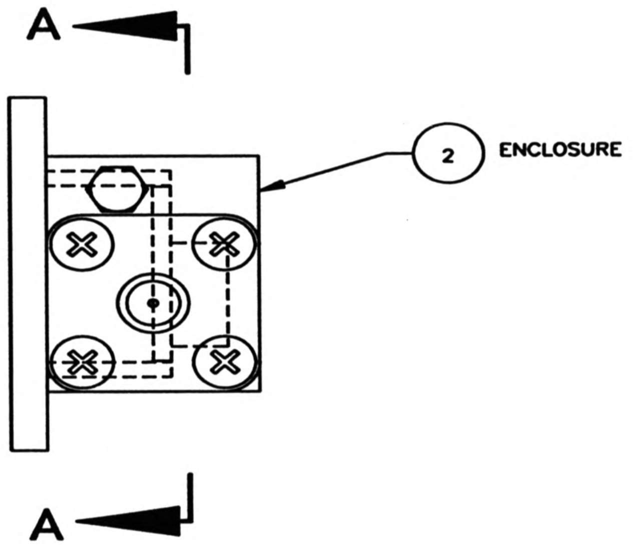


INPUT AMPLIFIER ASSEMBLY BLOCK DIAGRAM

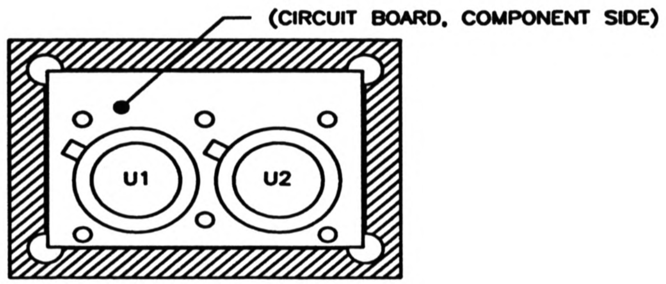


RF OUTPUT SIDE





RF INPUT SIDE



SECTION A-A

ACAD : 53500A18

7				SCREW, PAN HEAD, SS. 0-80UNF-2A x .25	6
6				WIRE, JUMPER	1
5		AVANTEK	C22-000401	BOLT, PLUG,12-32 HEX	1
4	U2	Q-BIT	QBH-160	AMPLIFIER	1
3	U1	AVANTEK	UTO-1012	AMPLIFIER	1
2		AVANTEK	TC-2M	BOX, ENCLOSURE	1
1		AVANTEK	TB-2	BOARD, CIRCUIT	1
ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY

A53500B009	BOM
D53500A001	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T102 FILTER MODULE

TITLE T102 610 MHZ
FILTER MODULE
INPUT AMPLIFIER
ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

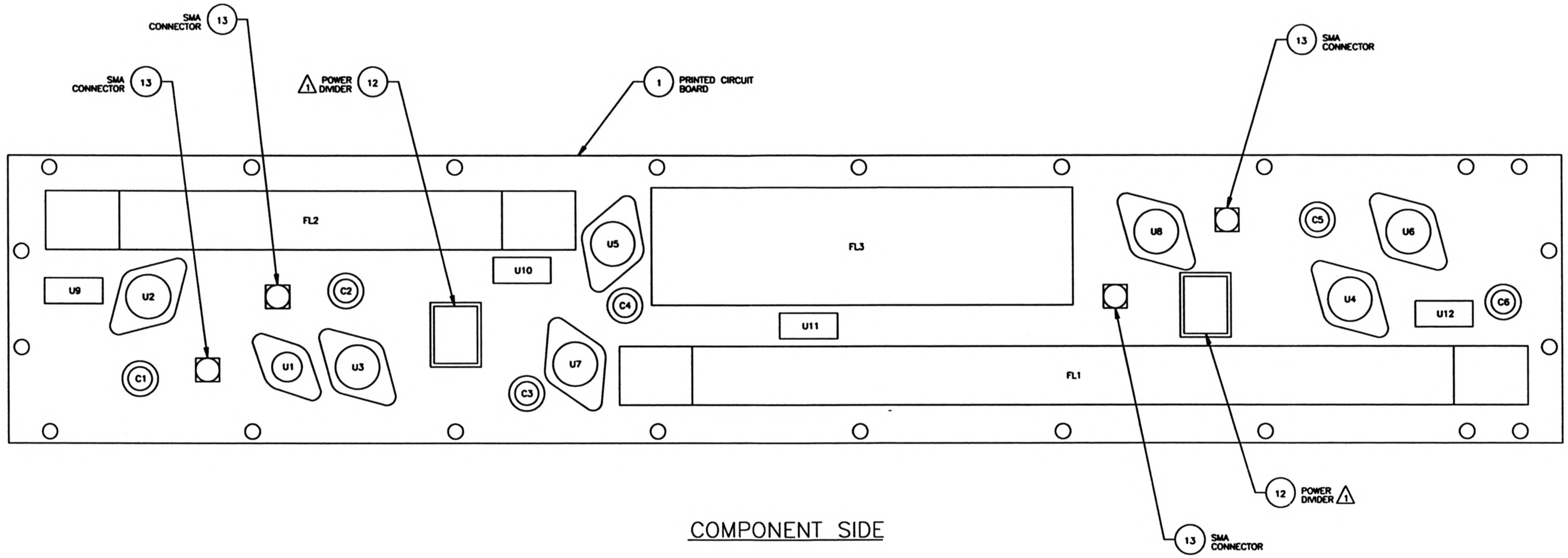
DRAWN BY K. TATE DATE 9-93
DESIGNED BY SCHLECHT DATE 8-90
APPROVED BY SCHLECHT DATE 8-90

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A018
REV. A
SCALE 2/1

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

NOTES:
1. MOUNT ON CIRCUIT SIDE OF BOARD



COMPONENT SIDE

13		OMNI-SPECTRA	2062-0000-00	CONNECTOR, SMA PCB	4
12		ANZAC	DS-313	DIVIDER, POWER	2
11	U9-U12	MINI CIRUCUITS	MCL TFM-4H	MIXER	4
10	U7, U8	Q-BIT	QBH-160	AMPLIFIER	2
9	U6	WATKINS-JOHNSON	A19-1	AMPLIFIER	1
8	U5	WATKINS-JOHNSON	A18-1	AMPLIFIER	1
7	U2-U4	AVANTEK	UTO-509	AMPLIFIER	3
6	U1	AVANTEK	GPD-1003	AMPLIFIER	1
5	FL3	K & L	8B51-11/4-P/P	FILTER	1
4	FL2	K & L	5B120-111/5.5-P/P	FILTER	1
3	FL1	K & L	3B120-111/5.5-P/P	FILTER	1
2	C1-C6	SPECTRUM	FA5C-102W	CAPACITOR, FEEDTHRU .001	6
1		NRAO	D53500Q003	BOARD, CIRCUIT	1
ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T102 FILTER MODULE

TITLE T102
610 MHZ FILTER
FILTER UNIT PCB
ASSEMBLY

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE DATE 9-93
DESIGNED BY DATE
APPROVED BY D. WEBER DATE 9-93

SHEET NUMBER 1 OF 1
DRAWING NUMBER D53500A022
REV. –
SCALE 2/1

C53500K006	BLOCK DIAG
D53500A013	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

ACAD : 53500A22

REVISIONS				
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
C	8-93	K. TATE	D. WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 8-93		
DESIGNED BY	DATE	C53500K007	BLOCK DIAG
		D53500A001	ASSEMBLY
APPROVED BY D. WEBER	DATE 8-93	NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T102 FILTER MODULE

TITLE T102 610 MHZ FILTER MODULE
ASSEMBLY BOM

DWG NO. A53500B009 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B009 REV C DATE 8-30-93 PAGE 2 OF 5

MODULE T102 NAME 610 MHZ FILTER DWG# D53500A001 SUB ASSY ______ DWG# ______

SCHEM. DWG# C53500K007 LOCATION ______ QUA/SYS. ______ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	D53500A013-10	ASSY, LCP FILTER UNIT	1
4		NRAO	D53500A013-20	ASSY, RCP FILTER UNIT	1
5		NRAO	A53500A018	ASSY, INPUT AMPLIFIER	2
6		NRAO	C53306M014-2	COVER, PERFORATED	2
7		NRAO	C53306M016	RAIL, SUPPORT	2
8		NRAO	C53306M017	PLATE, SIDE	2
9		NRAO	B53306M018	BLOCK, GUIDE	4
10		NRAO	A53306M038	PULLER, MODULE	2
11		NRAO	B53500M001	RAIL, UPPER	1
12		NRAO	B53500M002	RAIL, LOWER	1
13		NRAO	B53500M006	PANEL, FRONT	1
14		NRAO	B53500M004-2	PANEL, REAR	1
15		NRAO	D53500M027	PLATE, COMPONENT MOUNTING	1
16		NRAO	C53500M039	BLOCK, SWITCH MOUNTING	2
17		TRANSCO	82152-909C70100	SWITCH, SPDT	4
18		MERRIMAC	PDM-20-500	DIVIDER, POWER	2
19		K & L	4B120-611/30-0/0	FILTER	4
20		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B009 REV C DATE 8-30-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		NARDA	4772-3	ATTENUATOR, 3 db	1
22		NARDA	4772-5	ATTENUATOR, 5 db	1
23		NARDA	4778-7	ATTENUATOR, 7 db	2
24		NARDA	4772-16	ATTENUATOR, 16 db	2
25	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
26		SOLITRON	8018-6005	TERMINATION, 50Ω	2
27		SOLITRON	2993-6005	ELBOW, SMA MALE/MALE	1
28		SOLITRON		ELBOW, SMA MALE/.085 COAX	5
29		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	6
30		SOLITRON		ADAPTER, SMA MALE/.085 COAX	36
31	P1-P5,P10	OMNI-SPECTRA	2081-0000-00	CONNECTOR, OSP .085 MALE	6
32		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
33		PRECISION TUBE	AA50085	COAX, .085, SEMI-RIGID	AR
34	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
35		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
36		AMP	200833-2	PIN, GUIDE	2
37		AMP	203964-5	SOCKET, GUIDE	2
38		AMP	201578-1	PIN, 16 GA. CONNECTOR	6
39		ETC/MOLEX	AA-832-06	LUG, TERMINAL	13
40				LUG, TERMINAL	1
41		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B009 REV C DATE 8-30-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42		K & L	M12-A	CLIP, FILTER	2
43		K & L		CLIP, FILTER	2
44		H.H. SMITH	8367	SPACER, 8-32UNC-2B x 1.00	4
45		H.H. SMITH	8522	SPACER, 8-32UNC-2B x .38	4
46				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	48
47				SCREW, PAN HEAD, SS, 4-40UNC-2A x .38	8
48				SCREW, PAN HEAD, SS, 4-40UNC-2A x .75	8
49				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
50				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
51				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
52				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
53				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
54				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
55				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4
56				WASHER, EXT. TOOTH #6	16
57		ALPHA	7055	WIRE, WHT #22	AR

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B009 REV C DATE 8-30-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
58		ALPHA	7055	WIRE, BLK #22	AR
59		ALPHA	7055	WIRE, RED #22	AR
60		ALPHA	7055	WIRE, GRY #22	AR
61		ALPHA	7055	WIRE, GRN #22	AR
62		ALPHA	7055	WIRE, BLU #22	AR
63		ALPHA	7055	WIRE, BRN #22	AR
64		ALPHA	7056/19	WIRE, BLK #20	AR
65		ALPHA	7056/19	WIRE, RED #20	AR
66				WRAP, TIE	AR
67		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	8
68	TB1	TRW-CINCH	140J-1	STRIP, JUMPER	2
69					
70					
71					
72					
73					
74					
75					
76					
77					
78					

AVANTEK

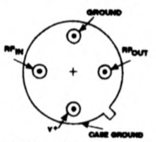
UTO/UTC 1012 Series
Thin-Film Cascadable Amplifier
5 to 1000 MHz

FEATURES

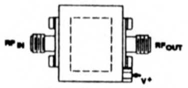
- Frequency Range: 5 to 1000 MHz
- Low Noise Figure: 2.5 dB (Typ)
- Medium Gain: 16.0 dB (Typ)
- Temperature Compensated

APPLICATIONS

- IF/RF Amplification



UTO—TO-8U, p. 16–48



UTC—TC-1, p. 16–42

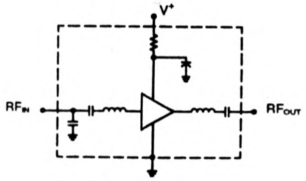
DESCRIPTION

The 1012 Series is a wideband, general-purpose thin-film bipolar RF amplifier using resistive feedback and active bias for stability over temperature and bias variations. Input and output blocking capacitors couple the RF through the amplifier while output inductance maintains a low VSWR. The 1012 Series amplifiers are available in either the TO-8 hermetic case or connectored TC-1 package.

ELECTRICAL SPECIFICATIONS (Measured in a 50-ohm system @ +15 VDC nominal unless otherwise noted)

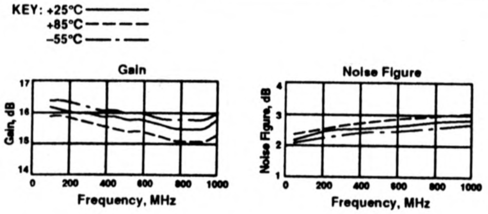
Symbol	Characteristic	Typical $T_c = 25°C$	Guaranteed Specifications $T_c = 0°$ to $50°C$	$T_c = -55°$ to $+85°C$	Unit
BW	Frequency Range	5-1000	5-1000	5-1000	MHz
GP	Small Signal Gain (Min.)	16.0	15.0	14.0	dB
—	Gain Flatness (Max.)	±0.5	±1.0	±1.0	dB
NF	Noise Figure (Max.)	2.5	4.0	4.5	dB
$P_{1\,dB}$	Power Output @ +1 dB Compression (Min.)	+5.0	+4.0	+3.0	dBm
—	Input VSWR (Max.)	<1.5:1	2.0:1	2.0:1	—
—	Output VSWR (Max.)	<1.3:1	2.0:1	2.0:1	—
IP_3	Two Tone 3rd Order Intercept Point	+17.0	—	—	dBm
IP_2	Two Tone 2nd Order Intercept Point	+23.0	—	—	dBm
HP_2	One Tone 2nd Harmonic Intercept Point	+30.0	—	—	dBm
I_D	DC Current	18	—	—	mA

SCHEMATIC



TYPICAL PERFORMANCE OVER TEMPERATURE

(@ +15 VDC unless otherwise noted)



MAXIMUM RATINGS

DC Voltage	17 Volts
Continuous RF Input Power	+13 dBm
Operating Case Temperature	–55°C to +125°C
Storage Temperature	–62°C to +150°C
"R" Series Burn-In Temperature	+125°C

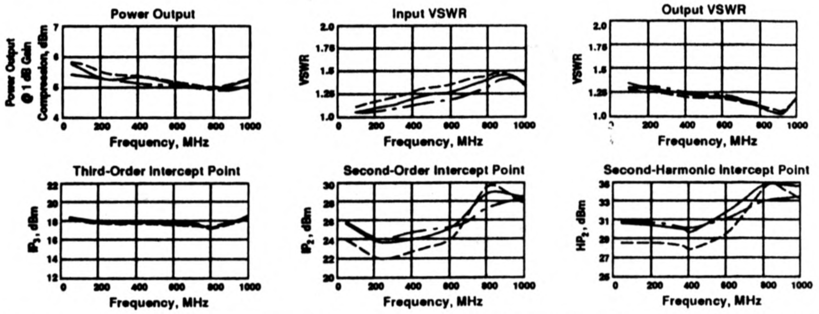
THERMAL CHARACTERISTICS*

θ_{JC}	105°C/W
Active Transistor Power Dissipation	120 mW
Junction Temperature Above Case Temperature	13°C
MTBF (MIL-HDBK-217E, A_{UF} @ 90°C)	1,253,000 Hrs.

*For further information, see High Reliability section, p. 17–2.

WEIGHT: (typical) UTO — 2.1 grams; UTC — 21.5 grams

TYPICAL PERFORMANCE OVER TEMPERATURE (continued)



AUTOMATIC NETWORK ANALYZER MEASUREMENTS (Typical production unit @ +25°C ambient)

NUMERICAL READINGS

BIAS = 15.00 VOLTS

FREQ MHz	VSWR IN	GAIN dB	PHASE DEG	PHASE DEV	GPDEL ns	VSWR OUT	ISOL dB
100.0	1.13	17.03	167.43	–.46	.00	1.20	22.33
150.0	1.13	17.09	161.48	–.77	.31	1.18	22.45
200.0	1.13	17.07	156.10	–.50	.30	1.18	22.27
250.0	1.14	16.96	150.74	–.21	.30	1.17	22.48
300.0	1.15	16.92	145.33	.01	.30	1.16	22.71
350.0	1.16	16.85	140.01	.34	.30	1.15	22.83
400.0	1.18	16.77	134.47	.44	.31	1.14	22.80
450.0	1.18	16.65	128.96	.57	.32	1.13	22.90
500.0	1.21	16.56	122.97	.22	.31	1.11	22.98
550.0	1.23	16.46	117.72	.61	.31	1.11	23.28
600.0	1.25	16.40	111.81	.36	.34	1.11	23.64
650.0	1.28	16.43	105.60	–.20	.32	1.11	23.65
700.0	1.31	16.47	100.30	.12	.30	1.13	23.99
750.0	1.36	16.46	94.95	.42	.30	1.15	24.23
800.0	1.41	16.43	89.51	.62	.31	1.18	24.53
850.0	1.48	16.44	83.70	.44	.32	1.22	24.86
900.0	1.56	16.46	77.85	.24	.34	1.26	25.12
950.0	1.66	16.48	71.46	–.50	.37	1.31	25.58
1000.0	1.80	16.56	64.54	–1.79	.39	1.37	26.02
1100.0	2.21	16.66	49.98	—	.46	1.53	27.19
1200.0	2.86	16.58	32.77	—	.46	1.75	29.35
1300.0	3.76	15.87	15.06	—	.54	2.02	31.86
1400.0	4.67	14.55	–3.57	—	.60	2.33	34.08
1500.0	5.17	12.72	–19.84	—	.37	2.51	32.48

S-PARAMETERS

BIAS = 15.00 VOLTS

FREQ	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	Mag	Ang	dB	Ang	dB	Ang	Mag	Ang
100.00	.026	–12.0	17.090	167.5	–22.180	–6.5	.092	170.5
150.00	.044	–32.5	17.084	162.0	–22.099	–6.8	.084	167.5
200.00	.053	–40.0	17.019	155.9	–22.274	–6.5	.084	163.5
250.00	.056	–45.1	16.964	149.8	–22.317	–10.2	.076	160.0
300.00	.063	–46.5	16.966	144.1	–22.559	–13.1	.074	156.3
350.00	.073	–49.2	16.942	138.5	–22.669	–14.3	.071	156.6
400.00	.083	–51.1	16.905	133.2	–22.774	–16.8	.066	156.4
450.00	.094	–52.9	16.796	127.8	–22.946	–20.0	.063	155.7
500.00	.106	–55.4	16.727	122.4	–23.142	–21.5	.059	161.0
550.00	.116	–57.0	16.677	117.0	–23.342	–23.5	.058	165.8
600.00	.128	–59.8	16.629	111.6	–23.378	–27.1	.056	175.4
650.00	.142	–61.9	16.580	106.2	–23.704	–28.8	.056	–175.4
700.00	.158	–64.5	16.568	100.8	–23.711	–31.0	.062	–167.8
750.00	.173	–67.2	16.551	95.2	–24.059	–33.2	.072	–160.4
800.00	.192	–71.0	16.516	89.4	–24.432	–35.6	.084	–153.9
850.00	.211	–75.9	16.532	83.3	–24.883	–38.3	.100	–150.7
900.00	.237	–80.5	16.560	77.4	–24.993	–40.4	.118	–149.5
950.00	.263	–86.0	16.573	70.9	–25.518	–41.7	.138	–149.5
1000.00	.295	–92.2	16.595	64.1	–25.979	–44.5	.160	–150.5
1100.00	.379	–107.1	16.633	49.1	–27.098	–49.3	.212	–154.6
1200.00	.479	–124.6	16.531	32.3	–29.122	–50.7	.277	–161.5
1300.00	.572	–144.6	15.908	13.6	–31.710	–44.2	.343	–172.6
1400.00	.642	–165.5	14.638	–3.7	–33.189	–26.2	.398	174.3
1500.00	.674	176.0	12.896	–17.6	–32.245	–5.5	.432	160.8

HYBRID RF AMPLIFIER QBH-160

Thin Film Hybrid Amplifiers

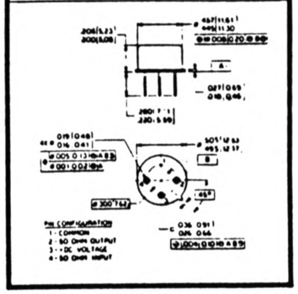
Q-bit Corporation's thin film amplifiers are computer designed for optimum VSWR and gain flatness, and built on stable TaN-TiW-Au sputtered substrates. Temperature compensated bias circuits, eutectic die bonding and all gold-to-gold interfaces help to give reliable performance over a broad temperature range.

Construction, Reliability and Screening.

Q-bit Corporation's hybird amplifier line utilizes both thick and thin film construction (depending on unit models) with an all-gold active chip bonding system. These units have been manufactured and environmentally tested for use in various military and space programs in the U.S. and internationally. Qualification and Conformance testing can be tailored to meet specific customer high reliability requirements.

Housing Outline — TO-8/3

Finish — Header: Gold Plated Kovar
Cap: Nickel
Weight — 2.0 grams



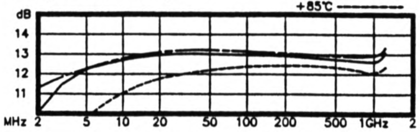
NOTE: Input and output pins are capacitance coupled. Maximum recommended offset current is ± 25 Vdc.

PARAMETERS	SPECIFICATION LIMITS*		UNITS	FREQUENCY
	+25°C	-55°C TO +85°C		20-1200 MHz
Small Signal Gain	12.5 ± .5	—	dB	
Gain Flatness	1.0	1.0	dB max p-p	
Gain vs. Temperature	—	+.6 / -1.6	dB max	
Noise Figure	8.0	8.5	dB max	
VSWR In/Out (50 Ohm system)	1.5:1	1.5:1	max	
Output 1 dB Compression	17	16	dBm min	
Output Intercept Point 3rd	30	29	dBm min	
Output Intercept Point 2nd	45	42	dBm min	
Reverse Isolation	22	21	dB min	
DC Power @ 15 Vdc ± 1%	140	150	mA max	
Gain vs. Vdc	.20	—	dB/volt max	

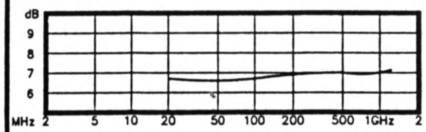
Q-BIT CORPORATION
2575 Pacific Avenue, N.E., Palm Bay, FL 32905
(407) 727-1838 TWX (510) 959-6257 FAX (407) 727-3729

TYPICAL

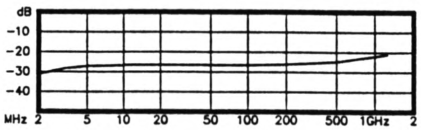
Gain/Gain vs Temp



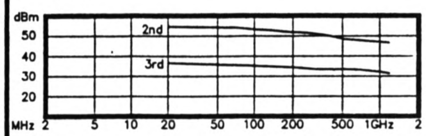
Noise Figure



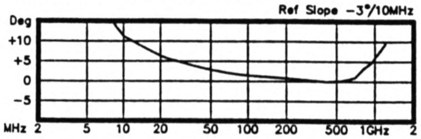
Reverse Isolation



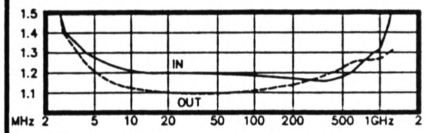
Intercept



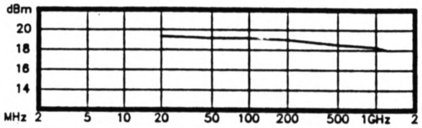
Deviation From Linear Phase



Input/Output VSWR



1 dB Compression



ABSOLUTE MAXIMUM RATINGS **

Power Supply Voltage:
Sustaining .... +16.5 Vdc
Pulse (Transient) .... +21 Vdc
Temperature:
Storage .... -65°C TO +150°C
Operating .... -55°C TO +125°C
Maximum Input Drive .... 1.2 VRMS
Thermal Rise, Junction to Case .... 35°C

H91-0160 A

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                          QBH-160 TYPICAL

   FREQUENCY     INPUT VSWR    GAIN                ISOLATION            OUTPUT VSWR
                   (S11)       FORWARD (S21)       REVERSE (S12)          (S22)
   MHZ            RATIO        dB       ANG        dB        ANG          RATIO

    20.000        1.2:1        12.8      0.6       -27        5.3         1.1:1
   100.000        1.2:1        12.9    -28.1       -26       -7.6         1.1:1
   200.000        1.2:1        12.8    -59.1       -26      -17.9         1.2:1
   300.000        1.2:1        12.8    -89.7       -26      -28.4         1.2:1
   400.000        1.2:1        12.8   -120.3       -26      -39.1         1.2:1
   500.000        1.2:1        12.7   -150.7       -25      -50.5         1.2:1
   600.000        1.2:1        12.7    179.5       -25      -62.5         1.3:1
   700.000        1.2:1        12.6    149.9       -25      -74.7         1.3:1
   800.000        1.3:1        12.5    122.2       -24      -87.0         1.3:1
   900.000        1.3:1        12.5     93.3       -24     -100.1         1.3:1
  1000.000        1.3:1        12.5     64.4       -23     -113.8         1.3:1
  1100.000        1.4:1        12.6     36.1       -23     -127.2         1.3:1
  1200.000        1.4:1        12.7      7.5       -23     -141.8         1.3:1

POWER: 15 Vdc 130 mA
                                                 3rd ORDER  33 dBm @ 600 MHz
NOISE FIGURE: 6.9 dB @  120 MHz    INTERCEPT:
                                                 2nd ORDER  46 dBm @ 600 MHz
              7.0 dB @ 1200 MHz
                                      1 dB COMPRESSION:  19 dBm @ 600 MHz
```

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*H91-0160 Revision A Feb. 1988
Parameter specifications are applicable to the revision level indicated. For latest revision level, please contact Q-bit Corporation

**Maximum operating temperature is defined as that temperature which, if exceeded for extended periods, could result in premature unit failure. This data is provided for user reliability information. This may or may not represent the maximum temperature for electrical parameter specifications.

AVANTEK

UTO/UTC/PPA 509 Series
Thin-Film Cascadable Amplifier
5 to 500 MHz

FEATURES

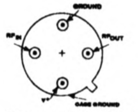
- Frequency Range: 5 to 500 MHz
- High Dynamic Range
- Output Power: +22.3 dBm (Typ)
- Noise Figure: 4.5 dB (Typ)
- Temperature Compensated
- Surface Mount Option
- Low Phase Noise

APPLICATIONS

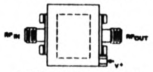
- IF/RF Amplification
- Output Stage
- Surface Mount Assembly

DESCRIPTION

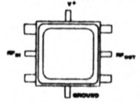
The 509 Series is a wideband single stage high power bipolar RF amplifier using thin-film construction with two Avantek transistors in parallel for better RF and thermal performance. Resistive feedback and active bias provide for temperature compensation and increased immunity to bias voltage variations. Blocking capacitors couple the RF through the amplifier. The 509 Series amplifiers are available in three packages: the surface mount PlanarPak PP-38 (.375 in. x .375 in.) case, the TO-8 hermetic case and the connectorized TC-1 case.



UTO—TO-8T, p. 16–48



UTC—TC-1, p. 16–42



PPA—PP-38, p. 16–35

ELECTRICAL SPECIFICATIONS (Measured in a 50-ohm system @ +15 VDC nominal unless otherwise noted)

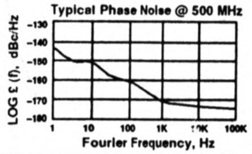
Symbol	Characteristic	Typical $T_c = 25°C$	Guaranteed Specifications $T_c = 0°$ to $50°C$	Guaranteed Specifications $T_c = -55°$ to $+85°C$	Unit
BW	Frequency Range	5-500	5-500	5-500	MHz
GP	Small Signal Gain (Min.)	14.3	13.0	12.0	dB
—	Gain Flatness (Max.)	±0.5	±0.7	±1.0	dB
NF	Noise Figure (Max.)	4.5	5.5	6.0	dB
P_{1dB}	Power Output @ +1 dB Compression (Min.)	+22.3	+20.0	+20.0	dBm
—	Input VSWR (Max.)	<1.4:1	2.0:1	2.0:1	—
—	Output VSWR (Max.)	<1.6:1	2.0:1	2.0:1	—
IP_3	Two Tone 3rd Order Intercept Point	+35.0	+30.0	+29.0	dBm
IP_2	Two Tone 2nd Order Intercept Point	+45.0	—	—	dBm
HP_2	One Tone 2nd Harmonic Intercept Point	+47.0	—	—	dBm
I_D	DC Current	90	—	—	mA
—	Phase Noise @ 500 MHz; 1KHz Offset	–170	—	—	dBc/Hz

TYPICAL PERFORMANCE OVER TEMPERATURE

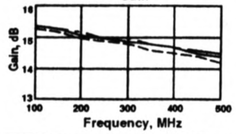
(@ +15 VDC unless otherwise noted)

KEY: +25°C ————
+85°C — — — —
–55°C —— - ——

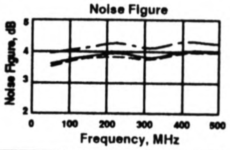
Typical Phase Noise @ 500 MHz



Gain



Noise Figure



MAXIMUM RATINGS

DC Voltage .... +17 Volts
Continuous RF Input Power .... +15 dBm
Operating Case Temperature .... –55°C to +115°C
Storage Temperature .... –62°C to +150°C
"R" Series Burn-In Temperature .... +115°C

THERMAL CHARACTERISTICS*

θ_{JC} .... 75°C/W
Active Transistor Power Dissipation .... 413 mW
Junction Temperature Above Case Temperature .... 31°C
MTBF (MIL-HDBK-217E, A_{UF} @ 90°C) .... 486,500 Hrs.

*For further information, see High Reliability section, p. 17–2.

WEIGHT: (typical) PPA — 0.5 grams; UTO — 2.1 grams; UTC — 21.5 grams

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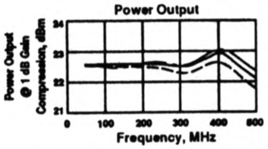
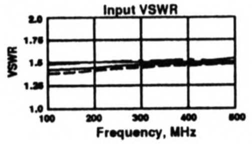
TYPICAL PERFORMANCE OVER TEMPERATURE (continued)

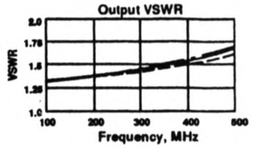
Power Output



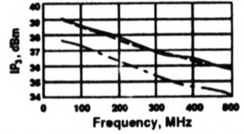
Input VSWR



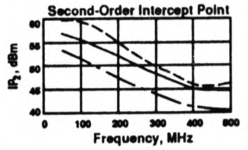
Output VSWR



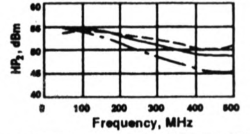
Third-Order Intercept Point



Second-Order Intercept Point



Second-Harmonic Intercept Point



AUTOMATIC NETWORK ANALYZER MEASUREMENTS (Typical production unit @ +25°C ambient)

NUMERICAL READINGS

BIAS = 15.00 VOLTS

FREQ MHz	VSWR IN	GAIN dB	PHASE DEG	PHASE DEV	GPDEL ns	VSWR OUT	ISOL dB
100.0	1.11	14.69	167.83	–.21	.00	1.06	18.73
150.0	1.12	14.70	161.60	–.36	.32	1.11	18.66
200.0	1.14	14.61	156.20	.32	.35	1.14	18.59
250.0	1.16	14.54	149.99	.19	.34	1.16	18.67
300.0	1.17	14.49	143.81	.09	.34	1.20	18.64
350.0	1.19	14.38	137.89	.25	.33	1.24	18.61
400.0	1.19	14.32	131.76	.20	.36	1.29	18.61
450.0	1.20	14.24	125.23	–.24	.36	1.34	18.58
500.0	1.21	14.22	119.13	–.26	.34	1.40	18.54
550.0	1.23	14.27	112.91	—	.36	1.46	18.40
600.0	1.24	14.23	106.42	—	.36	1.53	18.34
650.0	1.29	14.21	100.01	—	.39	1.58	18.31
700.0	1.37	14.17	92.65	—	.43	1.66	18.25
750.0	1.49	14.12	84.40	—	.46	1.74	18.27
800.0	1.64	14.04	75.54	—	.52	1.80	18.32
850.0	1.86	14.12	65.84	—	.66	1.84	18.38
900.0	2.27	14.02	55.59	—	.60	1.83	18.75
950.0	2.96	13.73	44.41	—	.58	1.75	19.15
1000.0	4.04	13.12	31.03	—	.70	1.63	20.02
1050.0	5.65	12.10	19.02	—	.84	1.49	21.02
1100.0	7.83	10.69	7.85	—	.84	1.35	22.26
1150.0	10.64	8.92	–1.24	—	.44	1.28	23.57
1200.0	12.36	7.07	–8.08	—	.31	1.21	24.30
1250.0	12.36	5.29	–12.57	—	.81	1.21	25.47
1300.0	12.31	3.62	–15.74	—	.13	1.23	26.15
1350.0	13.42	2.10	–17.32	—	.06	1.26	26.85
1400.0	13.75	.67	–18.71	—	.06	1.30	27.78
1450.0	13.02	–.78	–20.10	—	.04	1.33	28.30
1500.0	12.66	–2.03	–20.17	—	.00	1.35	28.52

LINEARIZATION RANGE: 100.0 to 500.0 MHz

S-PARAMETERS

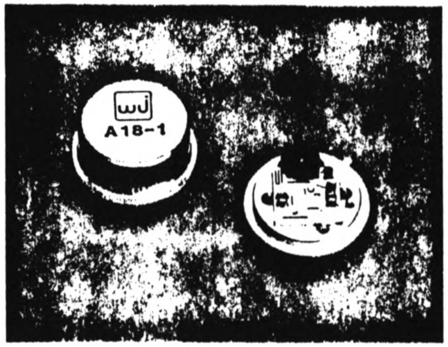
BIAS = 15.00 VOLTS

FREQ MHz	S_{11} Mag	S_{11} Ang	S_{21} dB	S_{21} Ang	S_{12} dB	S_{12} Ang	S_{22} Mag	S_{22} Ang
100.00	.053	–152.1	14.644	166.7	–18.644	–2.1	.044	–160.3
200.00	.065	–162.4	14.574	153.6	–18.711	–6.8	.064	–133.6
300.00	.078	–179.6	14.473	140.2	–18.704	–11.8	.091	–128.1
400.00	.087	159.4	14.295	126.8	–18.637	–17.4	.126	–128.4
500.00	.097	130.4	14.181	113.1	–18.580	–24.2	.163	–132.0
600.00	.111	98.6	14.192	99.4	–18.428	–31.7	.205	–138.9
700.00	.161	72.4	14.129	84.4	–18.270	–40.1	.246	–148.6
800.00	.242	48.4	14.047	66.0	–18.330	–50.3	.282	–162.5
900.00	.389	26.2	14.033	44.4	–18.731	–63.0	.293	179.5
1000.00	.608	–1.0	13.111	19.0	–19.939	–78.4	.239	157.2
1100.00	.776	–29.1	10.641	–5.7	–22.229	–88.3	.151	143.9
1200.00	.855	–51.6	7.060	–22.9	–24.374	–88.9	.098	158.7
1300.00	.857	–68.2	3.547	–31.6	–26.234	–88.4	.104	176.0
1400.00	.867	–79.3	.613	–35.6	–27.653	–90.8	.131	173.3
1500.00	.868	–87.1	–2.105	–38.2	–28.563	–90.7	.153	164.1
1600.00	.865	–92.8	–4.330	–40.6	–29.732	–93.3	.179	152.4
1700.00	.875	–97.4	–6.341	–41.4	–30.476	–94.3	.199	142.8
1800.00	.864	–101.4	–8.131	–43.6	–31.627	–92.8	.231	133.9
1900.00	.900	–105.7	–9.563	–43.8	–32.251	–93.6	.257	127.6
2000.00	.884	–108.7	–11.263	–43.7	–32.793	–94.3	.284	124.2

WJ-A18-1 / SMA18-1

10 to 1000 MHz
TO-8 CASCADABLE AMPLIFIER

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ HIGH DYNAMIC RANGE
- ◆ HIGH OUTPUT POWER: +16 dBm (TYP.)
- ◆ HIGH THIRD ORDER I.P.: +30 dBm (TYP.)
- ◆ LOW NOISE: 3.8 dB (TYP.)



Specifications*

Characteristics	Typical	Guaranteed 0° to 50°C	Guaranteed - 54° to +85°C
Frequency (Min.)	5-1100 MHz	10-1000 MHz	10-1000 MHz
Small Signal Gain (Min.)	14.7 dB	14 dB	13.5 dB
Gain Flatness (Max.)	< ±0.3 dB	±0.5 dB	±1.0 dB
Noise Figure (Max.)	3.8 dB	5.0 dB	5.5 dB
Power Output at 1 dB Compression (Min.)	+16 dBm	+15 dBm	+14.5 dBm
VSWR (Max.) Input/Output	< 1.5:1	1.8:1	2.0:1
DC Current (Max.) at 15 Volts	44 mA	46 mA	48 mA

*Measured in a 50-ohm system at +15 Vdc Nominal.

Notes:

1 WJ-CA18 is a standard WJ-A18 installed in a miniature SMA connector housing and guaranteed over 0 C to 50 C temperature range.

Typical Intermodulation Performance at 25°C

Second Order Harmonic Intercept Point	+45 dBm (Typ.)
Second Order Two Tone Intercept Point	+42 dBm (Typ.)
Third Order Two Tone Intercept Point	+30 dBm (Typ.)

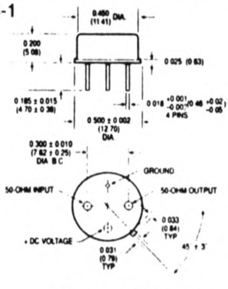
Absolute Maximum Ratings

Storage Temperature	-62°C to +125°C
Maximum Case Temperature	125°C
Maximum DC Voltage	+17 Volts
Maximum Continuous RF Input Power	+13 dBm
Maximum Short Term RF Input Power	50 Milliwatts (1 Minute Max.)
Maximum Peak Power	0.5 Watt (3 μsec Max.)
"S" Series Burn-in Temperature (Case)	125°C

Weight approximately 2.0 grams (0.07 oz.) max.

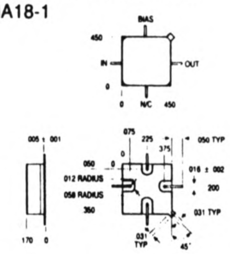
Outline Drawings

A18-1



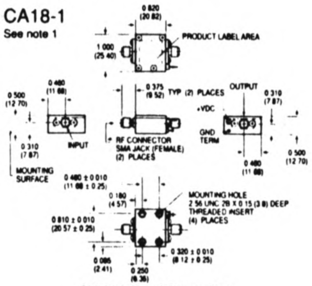
DIMENSIONS ARE IN INCHES (MILLIMETERS)
± .005 (.13) UNLESS OTHERWISE SPFCIFIED

SMA18-1



DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

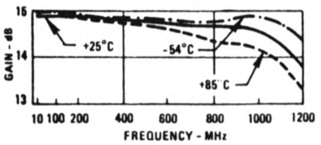
CA18-1
See note 1



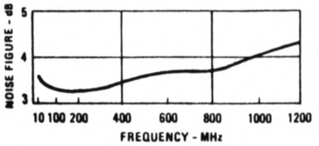
DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

Typical Performance at 25°C

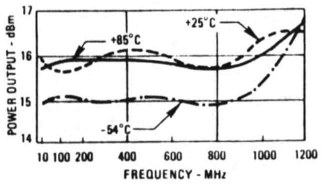
Gain



Noise Figure

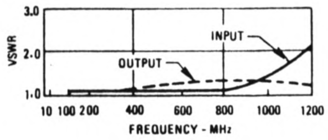


Power Output*

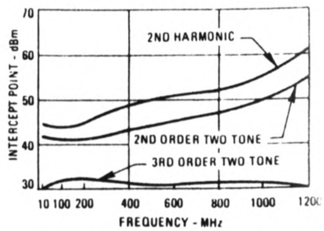


* at 1 dB Gain Compression

VSWR



Intercept Point



Typical Automatic Test Data

V_{CC} = 15.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1.2	14.8
2.0	1.1	1.2	14.8
5.0	1.1	1.1	14.9
10.0	1.0	1.0	14.9
50.0	1.0	1.0	14.8
100.0	1.1	1.0	14.7
200.0	1.1	1.0	14.6
300.0	1.1	1.1	14.6
400.0	1.2	1.1	14.8
500.0	1.2	1.2	15.0
600.0	1.2	1.2	15.1
700.0	1.2	1.3	15.2
800.0	1.1	1.3	15.3
900.0	1.1	1.4	15.4
1000.0	1.2	1.5	15.4
1100.0	1.6	1.6	15.0

Linear S-Parameters

Frequency MHz	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG
1.0	.078	-65	5.517	-174	107	8	.078	110
2.0	.068	-64	5.511	-175	107	7	071	110
5.0	.038	-61	5.543	-179	.109	3	.046	100
10.0	.016	-44	5.529	175	.110	-1	.022	73
50.0	.022	9	5.513	167	.111	-4	.015	42
100.0	.028	9	5.443	159	.111	-7	.014	12
200.0	.040	-5	5.377	147	.112	-11	.020	-28
300.0	.055	-28	5.361	132	.113	-18	.037	-74
400.0	.077	-51	5.495	116	117	-25	.066	-113
500.0	.075	-76	5.610	100	119	33	.089	-147
600.0	.075	-92	5.711	81	.121	-41	.101	-175
700.0	.077	-110	5.758	63	.124	-49	.117	158
800.0	.066	-141	5.836	44	.127	-58	.139	127
900.0	.035	143	5.916	24	.131	-68	.166	93
1000.0	.078	39	5.890	1	.134	-79	.196	55
1100.0	.216	-8	5.651	-24	134	-93	.223	12

V_{CC} = 5.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.4	1.3	13.2
2.0	1.4	1.3	13.2
5.0	1.3	1.3	13.2
10.0	1.3	1.3	13.3
50.0	1.3	1.3	13.2
100.0	1.3	1.3	13.1
200.0	1.3	1.3	13.0
300.0	1.3	1.3	13.0
400.0	1.4	1.4	13.1
500.0	1.3	1.5	13.2
600.0	1.3	1.5	13.3
700.0	1.3	1.5	13.4
800.0	1.3	1.6	13.3
900.0	1.4	1.6	13.2
1000.0	1.7	1.6	12.8
1100.0	2.2	1.6	12.0

Linear S-Parameters

Frequency MHz	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG
1.0	.158	-24	4.554	-174	.120	8	.122	50
2.0	.153	-23	4.581	-175	.121	7	.118	45
5.0	.139	-18	4.587	-179	.122	3	.115	26
10.0	.127	-18	4.607	174	.123	-1	.119	2
50.0	.133	-21	4.582	166	.123	-4	120	-14
100.0	.134	-35	4.537	158	.123	-7	120	-28
200.0	.140	-54	4.478	145	.124	-11	127	-46
300.0	.145	-79	4.446	129	.126	-18	143	-73
400.0	.150	-106	4.539	112	131	24	169	-103
500.0	.146	-137	4.582	95	135	-32	188	-132
600.0	.137	-168	4.632	75	.139	-41	.201	-161
700.0	.128	157	4.651	56	.144	-50	211	172
800.0	.128	112	4.624	35	.148	-60	224	141
900.0	.170	63	4.557	14	.153	-71	233	107
1000.0	.251	17	4.345	-9	152	-84	238	70
1100.0	.371	-22	3.970	-33	151	-96	225	29

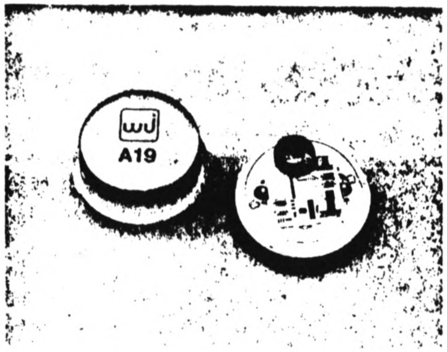
Thermal Data: V_{CC} = 15 Vdc

Thermal Resistance θ_{jc}	45°C/W
Transistor Power Dissipation P_d	0.407 W
Junction Temperature Rise Above Case T_{jc}	18°C

WJ-A19 / SMA19

10 TO 1000 MHZ
TO-8 CASCADABLE AMPLIFIER

- ◆ AVAILABLE IN SURFACE MOUNT
- ◆ HIGH OUTPUT POWER: +21 dBm (TYP.)
- ◆ HIGH THIRD ORDER I.P.: +34 dBm (TYP.)



Specifications*

Characteristics	Typical	Guaranteed	
		0° to 50°C	-54° to +85°C
Frequency (Min.)	5-1050 MHz	10-1000 MHz	10-1000 MHz
Small Signal Gain (Min.)	7.5 dB	6.0 dB	5.5 dB
Gain Flatness (Max.)	< ±0.3 dB	±1.0 dB	±1.3 dB
Noise Figure (Max.)	9.0 dB	10.5 dB	11.0 dB
Power Output at 1 dB Compression (Min.)	+21 dBm	+20 dBm	+19 dBm
VSWR (Max.) Input/Output	< 1.8:1	2.2:1	2.2:1
DC Current (Max.) at 15 Volts	100 mA	109 mA	114 mA

*Measured in a 50-ohm system at +15 Vdc Nominal.

Notes

1 WJ-CA19 is a standard WJ-A19 installed in a miniature SMA connector housing and guaranteed over 0°C to 50°C temperature range.

Typical Intermodulation Performance at 25°C

Second Order Harmonic Intercept Point ....+45 dBm (Typ.)
Second Order Two-Tone Intercept Point ....+40 dBm (Typ.)
Third Order Two-Tone Intercept Point ....+34 dBm (Typ.)

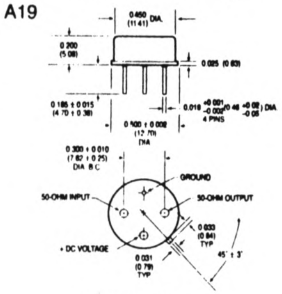
Absolute Maximum Ratings

Storage Temperature	-62°C to +125°C
Maximum Case Temperature	125°C
Maximum DC Voltage	+ 17 Volts
Maximum Continuous RF Input Power	+17 dBm
Maximum Short Term RF Input Power	100 Milliwatts (1 Minute Max.)
Maximum Peak Power	0.5 Watt (3 µsec Max.)
"S" Series Burn-In Temperature (Case)	125°C

Weight approximately 2.0 grams (0.07 oz.)

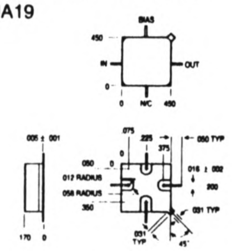
Outline Drawings

A19



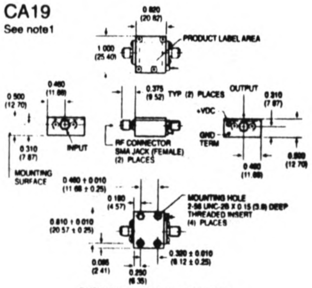
DIMENSIONS ARE IN INCHES (MILLIMETERS)
± .005 (.13) UNLESS OTHERWISE SPECIFIED

SMA19



DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

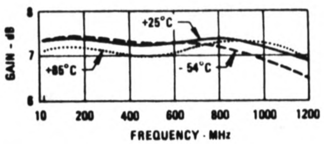
CA19
See note1



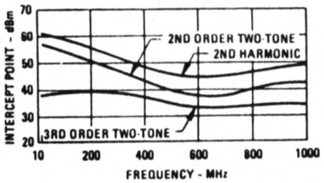
DIMENSIONS ARE IN INCHES (MILLIMETERS)
±.010 (.25) UNLESS OTHERWISE SPECIFIED

Typical Performance at 25°C

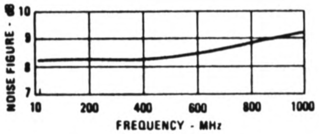
Gain



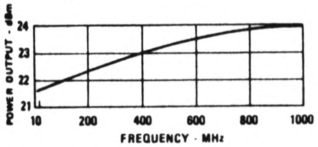
Intercept Point



Noise Figure

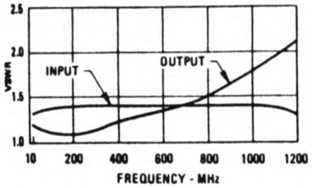


Power Output*



*at 1 dB Gain Compression

VSWR



Typical Automatic Test Data

V_{CC} = 15.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1 4	6.8
2 0	1.1	1 3	6.8
5.0	1 1	1 3	6.9
10.0	1.1	1 4	7.0
50.0	1.0	1.4	7 0
100.0	1.1	1 4	6.9
200.0	1.1	1 4	6.8
300.0	1 2	1.4	6.7
400.0	1.2	1.5	6.8
500.0	1.3	1.5	6.9
600.0	1.4	1 6	7.1
700.0	1.4	1 6	7 2
800 0	1 5	1 6	7 2
900.0	1.6	1.6	7.2
1000 0	1 7	1.6	7 2
1100.0	1.9	1 5	6 9

Linear S-Parameters

Frequency MHz	S11		S21		S12		S22	
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
1 0	079	-78	2 195	-169	165	3	151	35
2 0	068	-79	2 198	-170	165	3	.148	32
5 0	044	-78	2 216	-177	166	2	146	19
10 0	028	-86	2 227	176	.168	-0	.151	6
50.0	022	-88	2 226	167	168	-2	154	-2
100.0	035	-101	2 203	159	168	-4	157	-8
200 0	054	-118	2 181	147	170	-8	164	-17
300.0	075	-135	2 169	132	174	-10	.179	-30
400 0	.101	-165	2 199	115	180	-14	196	-47
500 0	131	180	2 218	99	185	-18	209	-65
600.0	155	156	2 264	83	191	-23	222	-83
700 0	174	133	2 284	66	199	-28	230	-102
800.0	.194	110	2 296	48	207	-34	.233	-122
900 0	232	95	2 269	32	220	-39	227	143
1000.0	269	68	2 262	13	.230	-46	217	-167
1100.0	301	39	2 221	-5	242	-53	200	169

V_{CC} = 12.0 V

Frequency MHz	VSWR IN	VSWR OUT	GAIN DB
1.0	1.2	1.4	6.8
2.0	1.2	1.4	6.8
5.0	1.1	1.3	6.8
10.0	1.1	1.4	6.9
50.0	1.0	1.4	6.9
100.0	1.1	1.4	6.8
200.0	1.1	1.4	6.7
300.0	1.2	1 4	6.7
400.0	1.2	1.5	6.8
500.0	1.3	1.5	6.9
600.0	1.4	1.5	7.0
700.0	1.4	1.6	7.1
800.0	1.5	1.6	7.1
900.0	1 6	1.5	7.1
1000.0	1.8	1.5	7.0
1100.0	1 9	1 4	6.8

Linear S-Parameters

Frequency MHz	S11		S21		S12		S22	
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG
1.0	074	-76	2 178	-169	.165	3	153	33
2.0	071	-77	2 180	-171	.165	3	.150	29
5.0	.040	-78	2 197	-177	166	1	.149	18
10.0	026	-95	2 207	176	.168	-0	.154	4
50.0	023	-92	2 208	167	168	-2	158	-3
100.0	.030	-103	2.187	159	.169	-4	.160	-10
200.0	053	-115	2 169	147	170	-6	.165	-19
300 0	.081	-135	2 153	131	175	-9	.178	33
400.0	102	-155	2 190	115	.181	-13	193	-51
500.0	133	180	2 203	99	.187	-18	.205	-69
600 0	158	155	2 246	82	.194	-22	.214	-87
700.0	179	133	2 276	65	.203	-27	.219	-107
800 0	.204	109	2.277	47	.213	-33	.219	-127
900.0	.243	84	2 263	31	227	-39	.212	-150
1000.0	278	57	2 246	12	.237	-46	.199	-175
1100 0	309	30	2.179	-6	249	53	.181	160

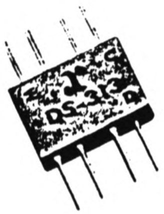
Thermal Data: V_{CC} = 15 Vdc

Thermal Resistance θ_{jc}	45°C/W
Transistor Power Dissipation P_d	0.944 W
Junction Temperature Rise Above Case T_{jc}	42°C

MODEL DS-313

TWO-WAY IN-PHASE POWER DIVIDER 10-2000 MHz

0.6 dB Typical Midband Loss
28 dB Typical Midband Isolation
1.2:1 Typical Midband VSWR



Guaranteed Specifications*

(From −55°C to +85°C)

Frequency Range		10-2000 MHz
Insertion Loss (Less coupling)	20-1000 MHz	1.1 dB Max
	10-1500 MHz	1.3 dB Max
	1500-2000 MHz	1.8 dB Max
Isolation	20-1000 MHz	23 dB Min
	10-1500 MHz	18 dB Min
	1500-2000 MHz	12 dB Min
Amplitude Balance	20-1000 MHz	0.3 dB Max
	10-1500 MHz	0.4 dB Max
	1500-2000 MHz	0.6 dB Max
Phase Balance	20-1000 MHz	4° Max
	10-1500 MHz	6° Max
	1500-2000 MHz	8° Max
VSWR (All Ports)	20-1000 MHz	1.5 Max
	10-1500 MHz	1.6 Max
	1500-2000 MHz	1.8 Max

Operating Characteristics

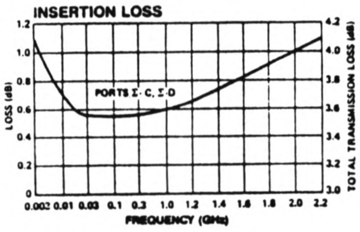
Impedance	50 Ohms Nominal
Maximum Power Rating or Input Power	250 mW Max
Internal Load Dissipation	50 mW Max
Package Type	Flatpack (FP-2) (See page 474 for physical dimensions.)

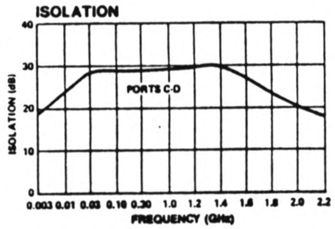
Environmental
These units are designed to meet the environmental and screening requirements of Table 1A, page 496 of the Adams-Russell catalog.

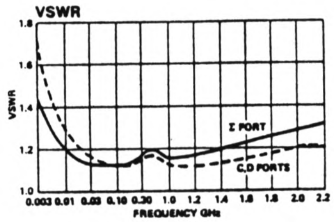
Pin Configuration	Σ; P1, Output 'C'; P4, Output 'D'; P8 Case and all other pins ground.

*All specifications apply with 50 ohm source and load impedance

Typical Performance







Ordering Information

Model No.	Part No.	Connectors	Unit Price (5-9 Units)
DS-313	8559	Pin	$67

Delivery is from stock.

ANZAC — Make the Connection . . . Adams Russell
COMPONENTS GROUP
80 Cambridge Street, Burlington, MA 01803 Fax (617) 273-1921

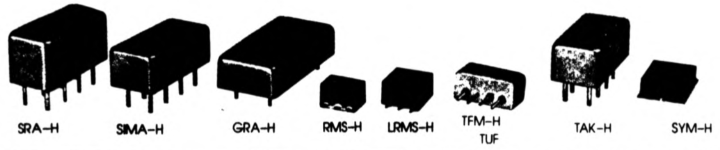
50 KHz to 1.2 GHz

Mini-Circuits

ULTRA-REL™ MIXERS

5-YR. GUARANTEE*

LEVEL 17S (+17 dBm LO, up to +14 dBm RF)



	MODEL NO.	FREQUENCY MHz		CONVERSION LOSS dB				LO–RF ISOLATION, dB						LO–IF ISOLATION, dB						PRICE $	DISTRIBUTOR	
		LO/RF f_L–f_U	IF	Mid-Band m $\bar{x}$	σ	Max.	Total Range Max.	L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	Qty. (1–9)	FACTORY	LOCAL
○□RMS–H case TT-100	RMS-1H	2–500	DC–500	6.25	034	7.0	8.5	55	44	44	25	33	20	50	34	45	25	37	22	10.95	●	●
	RMS-1WH	5–750	DC–750	7.00	11	8.5	8.8	55	40	43	22	28	20	52	30	38	22	29	20	11.95	●	●
	RMS-2H	5–1000	DC–900	6.98	054	8.5	9.3	55	40	39	22	33	20	52	30	45	22	30	17	11.95	●	●
	RMS-2UH	10–1000	10–750	7.10	083	8.5	9.6	50	40	38	30	30	23	50	30	40	25	34	22	14.45	●	●
	RMS-5H	10–1500	DC–900	6.36	05	8.0	9.8	65	40	36	20	22	15	50	30	30	18	17	7	17.95	●	●
○□LRMS–H case QQQ-130	LRMS-1H	2–500	DC–500	6.25	034	7.0	8.5	55	44	44	25	33	20	50	34	45	25	37	22	10.95	●	●
	LRMS-1WH	5–750	DC–750	7.00	11	8.5	8.8	55	40	43	22	28	20	52	30	38	22	29	20	11.95	●	●
	LRMS-2H	5–1000	DC–900	6.98	054	8.5	9.3	55	40	39	22	33	20	52	30	45	22	30	17	11.95	●	●
	LRMS-2UH	10–1000	10–750	7.10	083	8.5	9.6	50	40	38	30	30	23	50	30	40	25	34	22	14.45	●	●
	LRMS-5H	10–1500	DC–900	6.36	05	8.0	9.8	65	40	36	20	22	15	50	30	30	18	17	7	17.95	●	●
TFM–H case B02	TFM-1H	2–500	DC–500	6.14	11	7.5	8.5	50	45	40	30	30	20	45	40	35	25	25	20	25.95	●	●
	TFM-2H	5–1000	DC–1000	6.12	12	7.0	10	50	45	40	30	30	20	45	40	35	25	25	17	36.95	●	●
	TFM-3H	1–250	DC–250	4.58	11	7.0	8.5	50	45	40	30	28	23	45	40	35	25	26	20	25.95	●	●
case B13	TFM-4H	5–1200	DC–1200	5.24	05	8.0	9.0	50	40	35	25	30	20	50	40	35	20	30	20	39.45	●	●
TAK–H case A05	TAK-1H	2–500	DC–500	5.93	08	7.5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	21.45	●	●
	TAK-1WH	5–750	DC–750	5.71	08	7.5	9.0	50	40	40	30	30	25	45	35	35	25	30	20	25.95	●	●
	TAK-3H	05–300	DC–300	4.82	09	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	23.45	●	●
ZFM–H case K18	ZFM-1H	2–500	DC–500	6.14	11	7.5	8.5	50	45	40	30	30	25	45	35	35	25	25	20	64.95	●	
	ZFM-2H	5–1000	DC–1000	6.12	12	7.0	10	50	40	40	30	30	20	45	40	35	25	25	17	71.95	●	
	ZFM-3H	05–300	DC–300	5.18	11	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	64.95	●	
	ZFM-4H	5–1200	DC–1200	4.97	11	8.0	9.0	50	40	35	25	30	20	50	40	35	20	30	20	73.95	●	
ZLW–SH case M21	ZLW-1SH	2–500	DC–500	5.93	08	7.5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	62.95	●	
	ZLW-1WSH	5–750	DC–750	5.83	07	7.5	9.0	50	45	40	30	30	20	45	40	35	25	30	20	66.95	●	
	ZLW-3SH	05–300	DC–300	4.65	09	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	64.95	●	
ZAD–SH case M22	ZAD-1SH	2–500	DC–500	5.98	.08	7.5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	54.95	●	
	ZAD-1WSH	5–750	DC–750	5.64	08	7.5	9.0	50	45	40	30	30	20	45	40	35	25	30	20	56.95	●	
	ZAD-3SH	05–300	DC–300	5.08	09	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	55.95	●	
□TUF–H case B02	TUF-1H	2–600	DC–600	5.9	18	7.0	8.0	68	50	50	30	43	25	62	45	48	30	33	22	9.25	●	●
	TUF-2H	50–1000	DC–1000	6.2	22	7.5	9.0	58	40	47	30	42	25	58	35	44	25	28	18	10.20	●	●
	TUF-3H	0.15–400	DC–400	5.0	33	7.0	8.0	60	50	50	35	40	30	60	40	45	25	35	20	11.10	●	●
	TUF-5H	20–1500	DC–1000	7.5	17	8.5	9.0	62	55	50	40	38	25	40	25	29	18	20	8	14.45	●	●
	TUF-11AH	1400–1900	40–500	7.3	28	9.0	9.0	—	—	35	25	—	—	—	—	30	15	—	—	21.95	●	●
	TUF-860H	800–1050	DC–250	6.8	31	8.3	8.3	—	—	38	25	—	—	—	—	24	18	—	—	14.45	●	●

L=low range (f_L to 10 f_L) **M**=mid range (10 f_L to $f_U/2$) **U**=upper range ($f_U/2$ to f_U)

m=mid band (2f_L to $f_U/2$)

pin and coaxial connections see case style outline drawing

Series	TUF–H TFM–H	TAK–H		ZFM–H	ZLW-H ZLW–SH	ZAD-H ZAD–SH	RMS–H LRMS–H	SRA					GRA-H	SIMA-H	SYM-H
Models	all models	-1H -3H	-1WH	all models	all models	all models	all models	-1H -3H -6H▲	-1WH -2H	-11H	-173H Configuration 1	2	all models	-5H	all models
LO	4	8	8	1	1	1	1	8	8	8	3,4*	8	1	8	2
RF	1	1	1	2	3	3	4	1	1	1	1	1	6	1	1
IF	2	3,4*	3,4*	3	2	2	5	3,4*	3,4*	3	8	3,4*	4	3	3
GND◆	3	2,5,6,7	2,5,6,7	-	-	–	2,3,6	2,5,6,7	2,5,6,7	2,5,6,7	2,5,6,7	2,5,6,7	2,3,5	4	4,5,6
CASE GND	3	2	2,5,6,7	-	-	-	—	2	2,5,6,7	2,5,6,7	2,5,6,7	2,5,6,7	—	2,5,6,7	—
NOT USED										4					

*pins must be connected externally ◆Ground externally All measurements made with GND pin(s) grounded externally ▲Pin 2 is not case grounded

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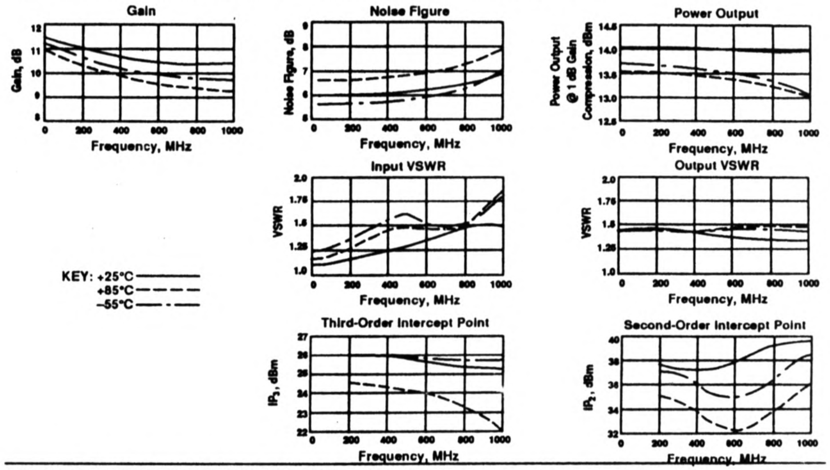
AVANTEK

GPD-1003/1063
Thin-Film Cascadable Amplifier Module
5 to 1000 MHz

TYPICAL PERFORMANCE OVER TEMPERATURE (@ +15 VDC unless otherwise noted)



AUTOMATIC NETWORK ANALYZER MEASUREMENTS (Typical production unit @ +25°C ambient)

NUMERICAL READINGS

BIAS = 15.00 VOLTS

FREQ MHz	VSWR IN	GAIN dB	PHASE DEG	PHASE DEV	GPDEL ns	VSWR OUT	ISOL dB
100.0	1.13	11.32	161.40	–.60	.00	1.46	22.29
200.0	1.17	11.18	141.34	–1.28	.54	1.43	22.12
300.0	1.23	11.14	122.54	–.68	.51	1.39	21.89
400.0	1.27	10.98	104.21	.36	.51	1.34	21.62
500.0	1.31	10.84	86.05	1.58	.53	1.29	21.29
600.0	1.36	10.72	66.56	1.47	.52	1.26	21.00
700.0	1.41	10.74	47.59	1.88	.57	1.26	21.02
800.0	1.53	10.67	26.70	.38	.56	1.22	19.34
900.0	1.50	10.75	6.66	–.23	.59	1.24	18.98
1000.0	1.54	10.88	–16.41	–3.94	.00	1.28	18.61

LINEARIZATION RANGE: 100.0 to 1000.0 MHz

S-PARAMETERS

BIAS = 15.00 VOLTS

FREQ	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	Mag	Ang	dB	Ang	dB	Ang	Mag	Ang
100.00	.053	–123.2	11.016	171.9	–21.498	11.5	.149	–9.5
200.00	.086	–119.4	11.120	167.0	–22.503	5.8	.125	–16.6
300.00	.082	–127.5	11.249	160.5	–20.865	25.2	.148	–22.0
400.00	.104	–130.2	10.924	154.6	–21.173	25.7	.139	–38.5
500.00	.113	–132.5	10.857	148.1	–21.142	33.8	.141	–49.3
600.00	.137	–146.1	10.755	141.8	–21.214	33.8	.136	–64.1
700.00	.144	–157.4	10.768	135.9	–20.690	39.1	.147	–77.9
800.00	.153	–169.4	10.778	127.8	–20.598	43.3	.156	–93.9
900.00	.186	169.2	10.973	120.2	–19.731	40.8	.157	–109.0
1000.00	.207	136.3	11.218	109.3	–18.887	36.1	.160	–128.3
1100.00	.293	88.5	11.458	95.4	–20.163	40.2	.165	–152.0
1200.00	.455	32.3	10.592	76.2	–19.339	31.5	.144	–175.6
1300.00	.646	–15.4	8.449	55.5	–19.985	24.1	.132	169.3
1400.00	.763	–50.0	5.442	43.9	–21.462	20.9	.133	154.4
1500.00	.820	–75.6	2.652	39.0	–22.083	25.1	.133	138.6
1800.00	.862	–94.2	.174	37.8	–22.710	30.6	.145	117.1
1700.00	.892	–109.5	–2.115	35.7	–24.469	22.8	.163	102.4

3.3 T103, 1.5 GHz CONVERTER MODULE

T103 Band Coverage and LO Frequencies

This section describes the T103 frequency converter that converts the L-Band Front-End signal to the standard 500 to 1000 MHz IF band. Since RF bandpass filters are installed in the Front-End, they are not included in the T103 RF circuitry; these filters have a 1550 MHz center frequency, 560 MHz bandwidth at the -3 dB points, and the band edges are 1.27 and 1.83 GHz, respectively.

Two LO frequencies, 2.1 and 2.4 GHz, each convert a portion of the Front-End spectrum to two standard 500 to 1000 MHz IF frequency bands. When the 2.1 GHz LO is mixed with the 1.27 to 1.83 GHz Front-End RF input, the mixer IF port spectrum is 270 to 830 MHz. The K&L 6B120-750/X550 IF filter passes the standard 500 to 1000 MHz portion and attenuates frequencies outside this passband. The converted portion of the Front-End RF spectrum is 1.27 to 1.6 GHz and the 1.6 to 1.83 GHz portion is attenuated by the IF filter.

When the 2.4 GHz LO is mixed with the 1.27 to 1.83 GHz Front-End input, the mixer IF port spectrum is 570 to 1130 MHz. The K&L 6B120-750/X550 IF filter passes the standard 500 to 1000 MHz portion and attenuates frequencies outside this passband. The converted portion of the Front-End RF spectrum is 1.6 to 1.83 GHz and the 1.27 to 1.4 and 1.83 to 1.9 GHz portions are attenuated by the IF filter.

Since the LO frequencies are higher than the RF frequencies, the IF signal spectrum is reversed relative to the RF band; the high end of the RF band is converted to the low end of the IF band, and vice versa. When testing the T103 it is important to remember this effect.

T103 Size and Location

T103 is a double-width module installed in Rack B, Bin C, Slots 8-9.

T103 Drawings and Data Sheets

The following T103 functional and assembly drawings are found at the end of this section.

C53500K001, Rev D - T103 1.5 GHz Converter Module Block Diagram
D53500A002, Rev C - T103 1.5 GHz Converter Module Assembly
A53500B001, Rev B - T103 1.5 GHz Converter Module Assembly BOM

A53500A012, Rev A - T103 1.5 GHz Converter Module LO Amplifier/Detector Assembly
A53500A008, Rev B - T103 1.5 GHz Converter Module LO Amp/Det PCB Assembly

Data sheets for the WJ M2-TC mixer, Avantek UTO-2013 and Avantek UTO-2321 amplifiers follow the drawings. A data sheet for the Virtech VF-1525 is not available. Data sheets for the KDI-Triangle D307M power divider and Narda 4772-X attenuator are included in the Appendix, Section 6.

T103 Differences from the General Converter Block Diagram

The differences between T103 Block Diagram and the general converter block diagram of Section 2.1 are the omission of the RF and LO bandpass filters and the use of an LO drive amplifier that contains an LO drive power detector. The LO Amp/Detector A53500A012 differs from the other converter's LO amplifiers in that it is an NRAO design rather than a commercial amplifier package.

T103 Specifications

Nominal Gain, dB	15	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	4.9	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	10,000	Noise Temp for 1% added Syst Noise, K	25,000	Nom LO Pwr input, dBm	2
Avg Noise Figure, dB	15.5	Noise Figure for 1% added Syst Noise, dB	19.4		
15 Volt Power Req't, mA	600				

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. When the 2.1 GHz LO frequency is used, the unwanted sideband is 3.37 to 3.93 GHz. Refer to Figure 5; the attenuation of the unwanted sideband lower edge frequency (3.37 GHz) is off the bottom of the plot, greatly in excess of 70 dB.

When the 2.4 GHz LO frequency is used, the unwanted sideband is 3.67 to 4.23 GHz. Again referring to Figure 5, the attenuation of this unwanted sideband lower edge frequency is off the bottom of the plot and is greatly in excess of 70 dB attenuation.

Image response bands are attenuated by the 1.5 GHz Front-End's 1550/X570 Bandpass filter which has a -3 dB passband of 1.27 to 1.83 GHz. Image response bands for the 2.1 and 2.4 GHz LO frequencies are 2.6 to 3.1 GHz and 2.9 to 3.4 GHz, respectively. The worst case image frequency is 2.6 GHz which is attenuated by this Bandpass filter.

Noise Temperature

The T103 noise temperature is a composite value that is a function of the noise temperatures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 10,000 K. A T103 noise temperature of 25,000 K would add 1 K to the system temperature.

Mixer

The WJ M2TC mixer is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO and RF frequencies of 10 to 2400 MHz, IF frequencies of 10 to 1000 MHz and a nominal LO drive of +13 dBm. In the 1.5 GHz frequency band, the typical conversion loss is 7.0 dB and the typical noise figure is 7.0 dB.

RCP-LCP Path Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths - the isolation between the two mixer LO ports and the transfer switch leakage. As shown in the table above, the module's specified RCP-LCP path isolation is 65 dB.

Since LO isolation filters are not used, the RCP-LCP path isolation is the 21 dB provided by the KDI-Engleman D307M power divider and the 40 dB (typical) between the mixer's LO ports and the RF-IF ports. The isolation of this shunt path is thus 100 dB.

The typical RCP-LCP path isolation of the RLC SRC-TC-R-d transfer switch at 1.5 GHz is about 90 dB.

VSWR's

The input VSWR, about 1.3:1, is the composite of the VSWR's of the transfer switch (1.1:1) and isolator (estimated to be 1.3:1). The output VSWR is the composite VSWR of the Amp/Divider, which is 1.5:1.

RF Input Circuitry

The losses in the RF input path are the insertion losses of the transfer switch 0.1 dB and the isolator 0.4 dB.

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

Refer to schematic diagram A53500S001 at the rear of this section. The amplifier consists of a cascade connection of Avantek UTO 2321 and Avantek UTO 2013 amplifiers and a diode power detector circuit. Both amplifiers have AC-coupled inputs and outputs. The input amplifier is a UTO 2321 that has a typical gain of 15 dB and a noise figure of 7. The input and output VSWR's are about 1.3 and 1.75, respectively, at the two LO frequencies. The UTO 2013 is the power stage with a typical gain of 15 and a noise figure of 7 dB. The input and output VSWR's are about 1.5 and 1.75, respectively. The power output is +12 dB at the 1 dB compression point. The LO amplifier gain is determined by the selection of the input attenuator, Narda series 4772-X. The appropriate attenuator value is determined in Test I, Adjustment of LO power and Converter Gain/Flatness. This test is described in Test I, Section 2.7.

The power detector circuit in the LO Amp/Detector subassembly is a square-law detector which has an output voltage that is proportional to the square of the diode current. The 0.1 pF capacitor AC-couples a portion of the amplifier output to the 75 nH shunt inductor and Back Diode, BD-4. The series resonant frequency of the LC combination is about 180 MHz. The inductor provides a DC return path for the diode output and has an impedance of about 1000 Ohms at the LO frequencies. The 12 pF capacitor and 3 K Ohm resistor are an RC filter for the half-wave diode output voltage. The Back Diode, BD-4, is a tunnel diode used in the nontunneling direction where it has a zero forward voltage drop.[1] The power detector output is connected via P11-1 to an analog multiplexer input in the B-Rack Interface, M102. The multiplexer address is 09H and the normal signal level is + 0.23 volts.

RF Switching

The T103 transfer switch S103A is an RLC SR-TC-R-D transfer switch; some T103's may use the Transco 710C70100 as an alternate unit. The transfer switch is driven by M102, address 12H, bit 0.

T103 Power Circuitry

All T103 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 1-4 where it is distributed to the amplifiers. The common returns for these devices are connected to a frame ground lug that is connected to P11-34 and P11-42. This ground is also the ground return for the +28 volt drive to the transfer switch. The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

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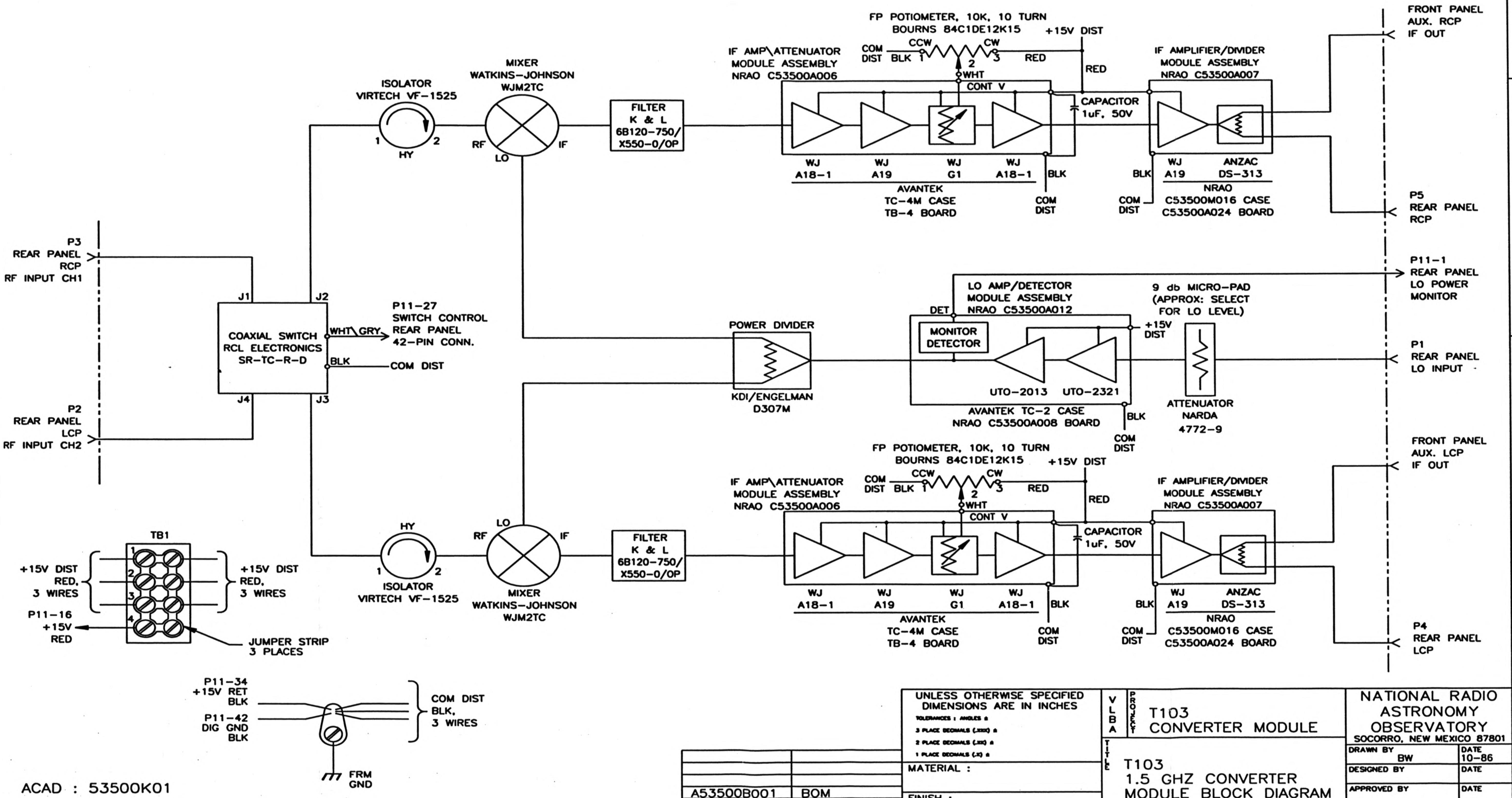
[1] The Art of Electronics, Horowitz and Hill, page 891.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-87	GM		REVISED AND REDRAWN
B	12-87	GM		REVISED CABLE LENGTHS
C	4-91	DGS		CHGD BOURNS POT
D	8-93	K. TATE		UPDATED TO NRAO STDS
E	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS



ACAD : 53500K01

A53500B001	BOM
D53500A002	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

VLBA PROJECT T103
CONVERTER MODULE

TITLE T103
1.5 GHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

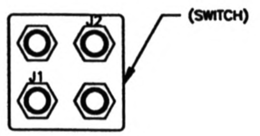
DRAWN BY BW DATE 10-86
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 1 DRAWING NUMBER C53500K001 REV. E SCALE NONE

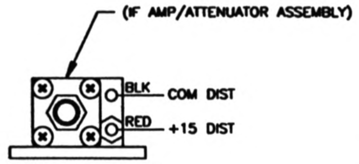
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	1-87	GM		MINOR REVISIONS
C	7-93	K. TATE		UPDATED TO NRAO STDS

NOTES:

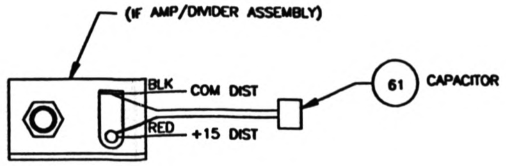
1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 12) AND GUIDE BLOCK (ITEM 7)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



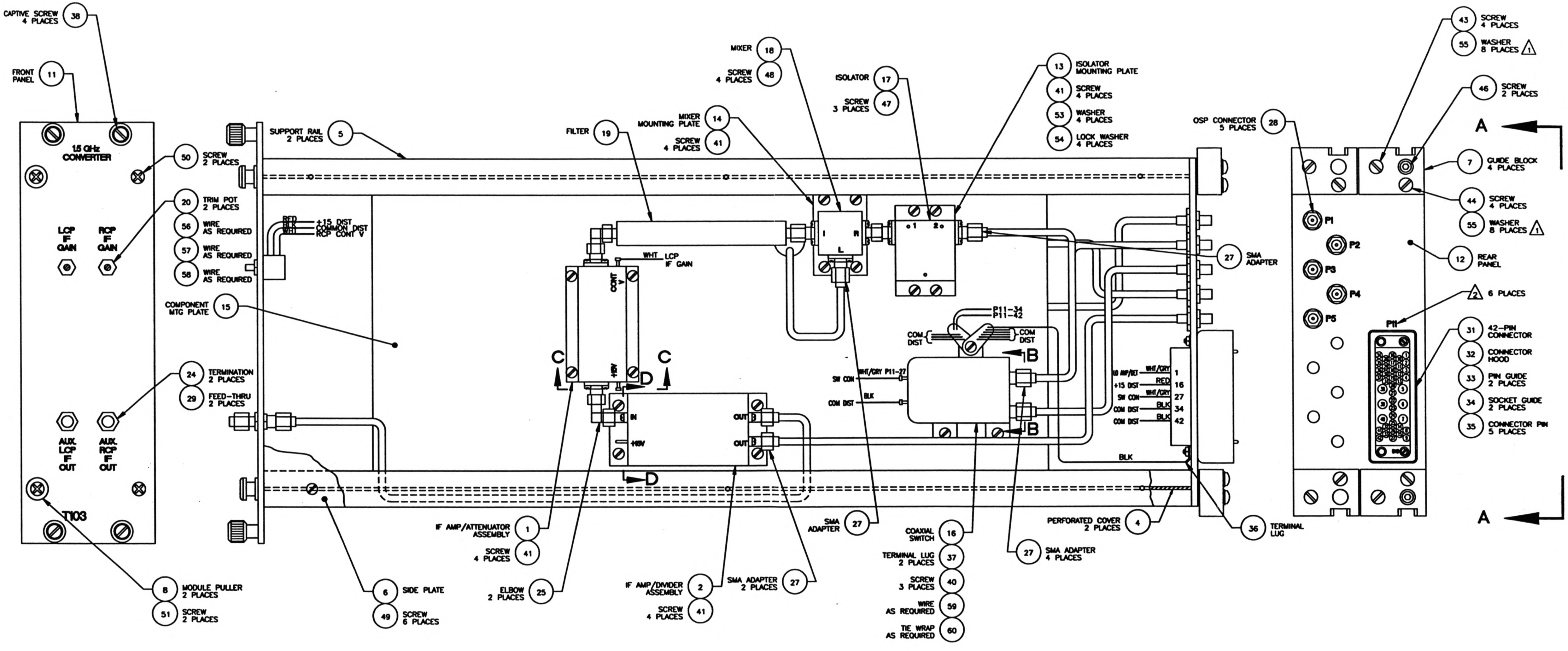
SECTION B-B
ROTATED 90° CW



SECTION C-C
2 PLACES



SECTION D-D
ROTATED 90° CW
2 PLACES



T103 ASSEMBLY - RCP SIDE

ACAD : 53500A2A

C53500K001	BLOCK DIAG
A53500B001	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ± .01
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T103
CONVERTER MODULE

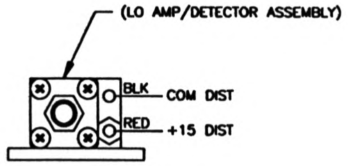
TITLE T103
1.5 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

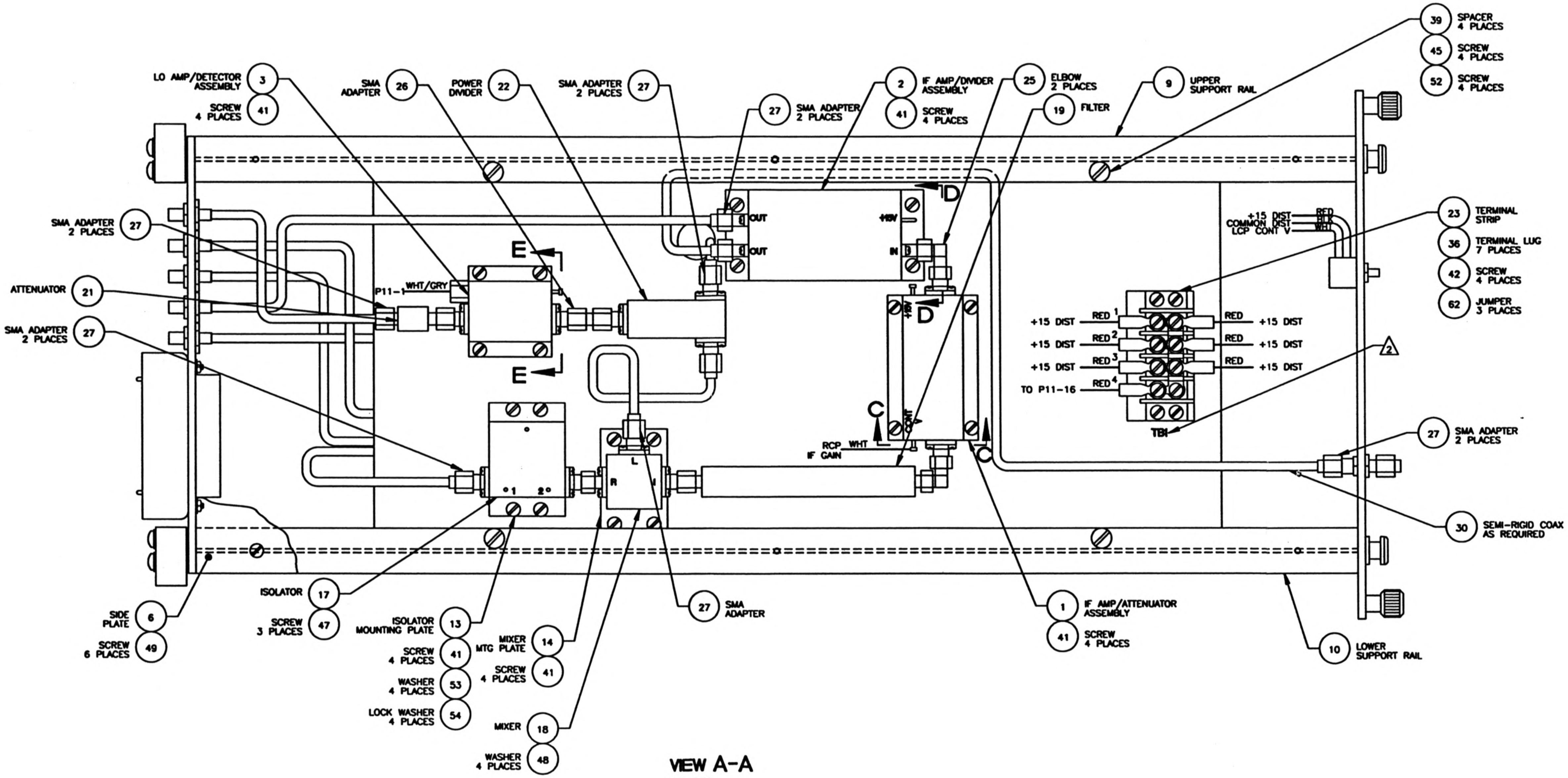
DRAWN BY G. MORRIS DATE 1/88
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 2 DRAWING NUMBER D53500A002 REV. C SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



SECTION E-E



VIEW A-A
LCP SIDE

ACAD : 53500A2B

C53500K001	BLOCK DIAG
A53500B001	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ± .01
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

VLBA
PROJECT T103
CONVERTER MODULE

TITLE T103
1.5 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

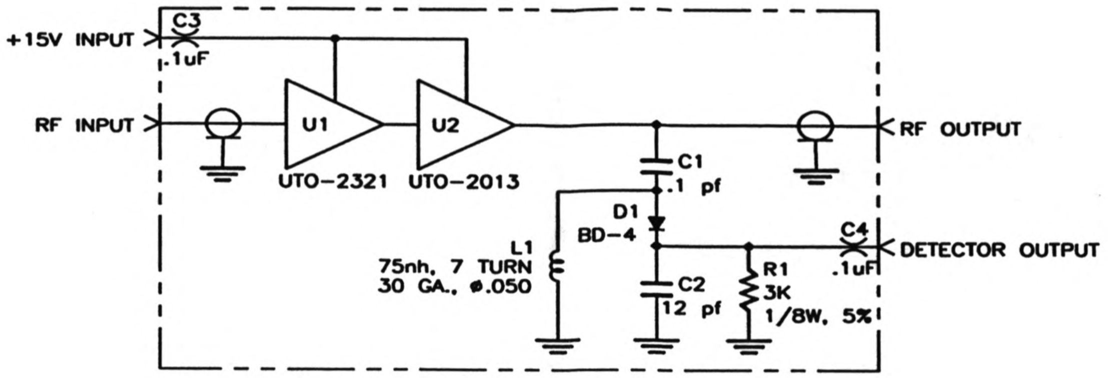
DRAWN BY G. MORRIS DATE 1/88
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 2 OF 2
DRAWING NUMBER D53500A002
REV. C
SCALE 1/1

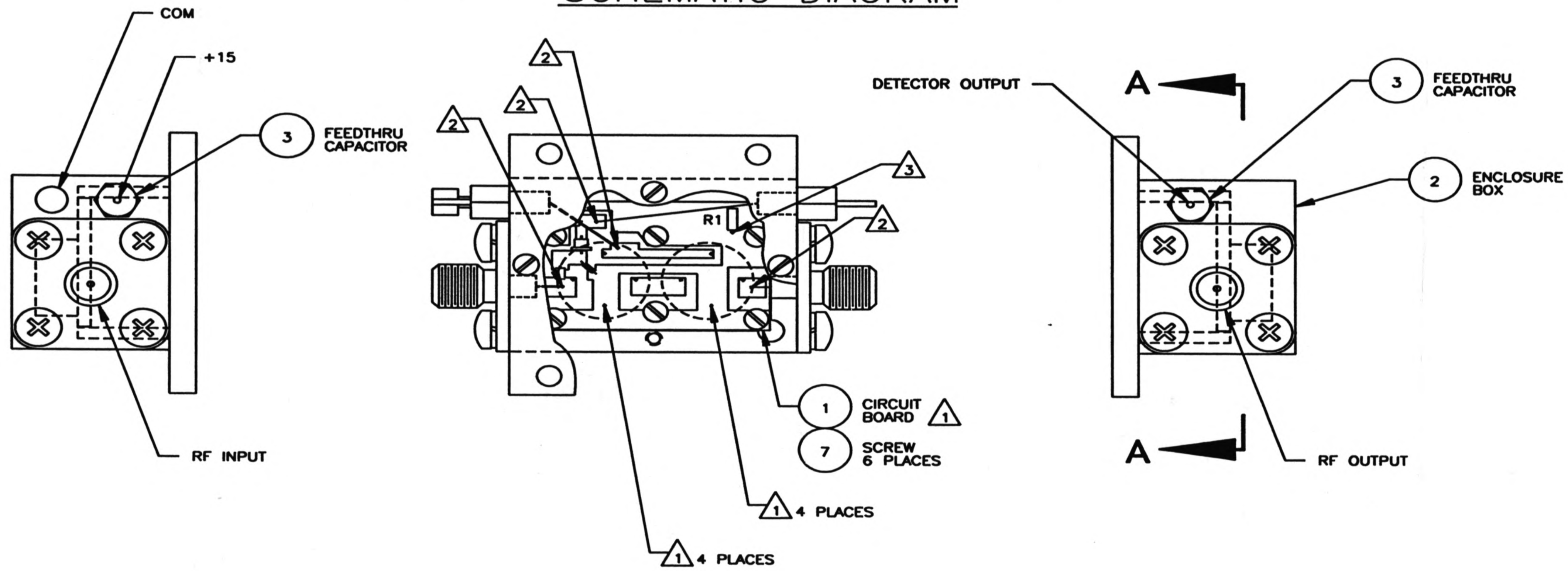
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-93	K. TATE	D.WEBER	REDRAWN ON ACAD

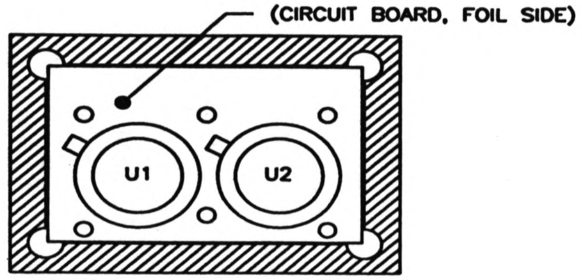
NOTES:

1. ASSEMBLE CIRCUIT BOARD (ITEM 1) IN ENCLOSURE BOX (ITEM 2) USING APPROPRIATE AMPLIFIERS. DO NOT SOLDER AMPLIFIERS INTO PLACE UNTIL AFTER SCREWS (ITEM 7) ARE TIGHTENED ON CIRCUIT BOARD
2. SOLDER LEADS TO CIRCUIT BOARD (ITEM 1). LOCATE APPROXIMATELY AS SHOWN
3. SOLDER R1 RESISTOR (ITEM 4) TO CIRCUIT BOARD (ITEM) AND C4 FEEDTHRU CAPACITOR LEAD (ITEM 3). LOCATE APPROXIMATELY AS SHOWN



LO AMPLIFIER/DETECTOR ASSEMBLY
SCHEMATIC DIAGRAM





SECTION A-A

ACAD : 53500A18

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
7				SCREW, PAN HEAD, SS, 0-80UNF-2A x .25	6
6	U2	AVANTEK	UTO-2013	AMPLIFIER	1
5	U1	AVANTEK	UTO-2321	AMPLIFIER	1
4	R1			RESISTOR, 3K,1/8W,5%	1
3	C3, C4	SPECTRUM CONTROL	51-719-021	CAPACITOR, FEEDTHRU .1uf	2
2		AVANTEK	TC-2M	BOX, ENCLOSURE	1
1		NRAO	C53500A008	BOARD, CIRCUIT	1

NEXT ASSEMBLY	DWG. TYPE
A53500B001	BOM
D53500A002	ASSEMBLY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T103 CONVERTER MODULE

TITLE T103
CONVERTER MODULE
LO AMPLIFIER/DETECTOR
ASSEMBLY

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

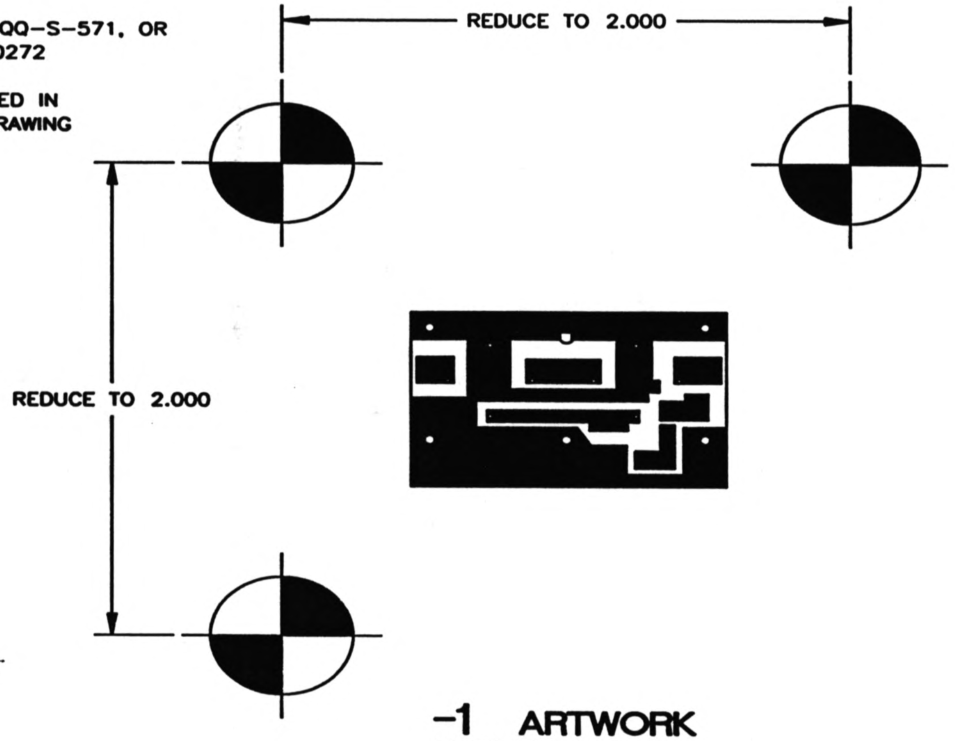
DRAWN BY K. TATE DATE 10-93
DESIGNED BY SCHLECHT DATE 8-90
APPROVED BY SCHLECHT DATE 8-90

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A012
REV. A
SCALE 2/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-93	K. TATE	D.WEBER	REDRAWN ON ACAD

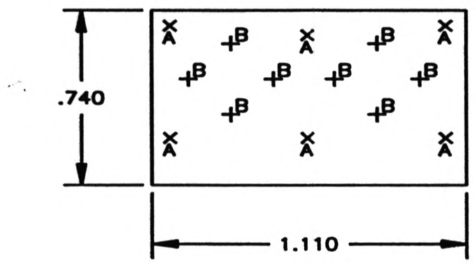
NOTES:

1. MATERIAL: G10 GLASS EPOXY, .063 THICK
2. REMOVE ALL BURRS AND SHARP EDGES
3. ALL HOLES TO BE PLATED THROUGH
4. ELECTROLITICALLY DEPOSIT 2 OZ. OF COPPER TO BOTH SIDES OF BOARD AND INSIDE WALL OF ALL HOLES
5. PLATING:
   60/40 SOLDER PLATE PER QQ-S-571, OR ELECTRO-TIN PER MIL-T-10272
6. THIS DRAWING MUST BE USED IN CONJUNCTION WITH NRAO DRAWING NUMBER C53500A012

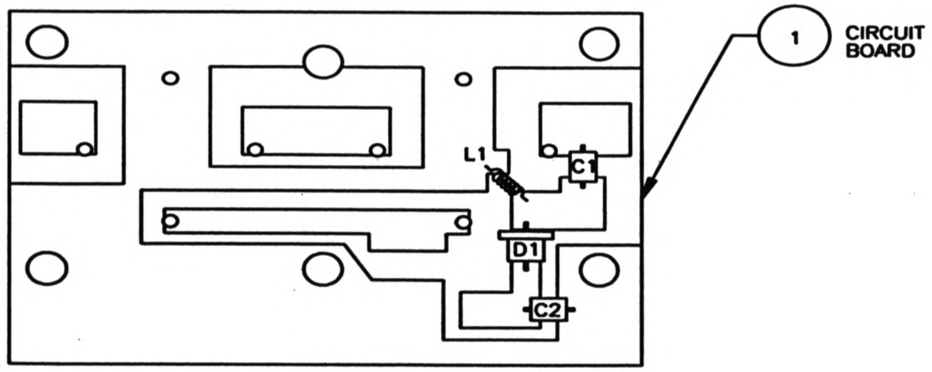


-1 ARTWORK
COMPONENT SIDE

DRILL CHART		
HOLE	FINISHED SIZE	QTY
A	ø.067	6
B	ø.025	8



-1 DRILL DRAWING △1
COMPONENT SIDE



-10 ASSEMBLY
COMPONENT SIDE
SCALE: 4/1

ACAD : 53500A08

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
5	L1			INDUCTOR, 75nh, 7 TURN	1
4	D1	GE	BD-4	BACK DIODE, DETECTOR	1
3	C2	ATC	100-A-120-M-P-15X	CAPACITOR,CHIP,12pf	1
2	C1	ATC	100-A-0R1-B-P-150X	CAPACITOR,CHIP,.1pf	1
1		NRAO	-1	BOARD, CIRCUIT	1

C53500A012	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

PROJECT: VLBA
T103
CONVERTER MODULE

TITLE:
T103 1.5 GHZ
CONVERTER MODULE
LO AMP/DETECTOR
PCB ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY MORRIS DATE 4-87
DESIGNED BY SCHLECHT DATE 4-87
APPROVED BY SCHLECHT DATE 4-87

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500A008
REV. B
SCALE 2/1

REVISIONS				
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	7-93	K. TATE		UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 7-93			
DESIGNED BY	DATE		C53500K001	BLOCK DIAG
APPROVED BY	DATE		D53500A002	ASSEMBLY
			NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

VLBA

PROJECT T103 CONVERTER MODULE

TITLE T103 1.5 GHZ CONVERTER MODULE ASSEMBLY BOM

DWG NO. A53500B001 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B001 REV B DATE 7-19-93 PAGE 2 OF 5

MODULE T103 NAME 1.5 GHZ CONVERTER DWG# D53500A002 SUB ASSY ____ DWG# ____

SCHEM. DWG# C53500K001 LOCATION ____ QUA/SYS. ____ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53500A012	ASSY, LO AMP/DETECTOR	1
4		NRAO	C53306M014-1	COVER, PERFORATED	2
5		NRAO	C53306M016	RAIL, SUPPORT	2
6		NRAO	C53306M017	PLATE, SIDE	2
7		NRAO	B53306M018	BLOCK, GUIDE	4
8		NRAO	A53306M035	PULLER, MODULE	2
9		NRAO	B53500M001	RAIL, UPPER	1
10		NRAO	B53500M002	RAIL, LOWER	1
11		NRAO	B53500M003	PANEL, FRONT	1
12		NRAO	B53500M004-1	PANEL, REAR	1
13		NRAO	A53500M008-1	PLATE, ISOLATOR MOUNTING	2
14		NRAO	A53500M011-1	PLATE, MIXER MOUNTING	2
15		NRAO	D53500M023	PLATE, COMPONENT MOUNTING	1
16		RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
17		DITOM	DF-1170	ISOLATOR	2
18		WATKINS-JOHNSON	WJM2TC	MIXER	2
19		K & L	6B120-750/X550-0/OP	FILTER	2
20		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B001 REV B DATE 7-19-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		NARDA	4772-9	ATTENUATOR	1
22		KDI/ENGLEMAN	D307M	DIVIDER, POWER	1
23	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
24		SOLITRON	8018-6005	TERMINATION, 50Ω	2
25		SOLITRON	2993-6005	ELBOW, SMA MALE/MALE	4
26		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	1
27		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 TUBE	17
28	P1 - P5	OMNI-SPECTRA	4503-7941-00	CONNECTOR, OSP .141 MALE	5
29		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
30		PRECISION TUBE	AA50141	COAX, .141. SEMI-RIGID	AR
31	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
32		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
33		AMP	200833-2	PIN, GUIDE	2
34		AMP	203964-5	SOCKET, GUIDE	2
35		AMP	201578-1	PIN, 16 GA. CONNECTOR	5
36		ETC/MOLEX	AA-832-06	LUG, TERMINAL	8
37				LUG, TERMINAL	2
38		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
39		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4
40				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	3
41				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	36

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B001 REV B DATE 7-19-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42				SCREW, PAN HEAD, SS, 4-40UNC-2A x .38	4
43				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
44				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
45				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
46				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
47				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	6
48				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .38	8
49				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	12
50				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
51				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
52				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4
53				WASHER, FLAT #4	8
54				WASHER, LOCK #4	8
55				WASHER, EXT. TOOTH #6	16
56		ALPHA	7055	WIRE, WHT #22	AR
57		ALPHA	7055	WIRE, BLK #22	AR

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B001 REV B DATE 7-19-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
58		ALPHA	7055	WIRE, RED #22	AR
59		ALPHA	7055	WIRE, BLK/GRY #22	AR
60				WRAP, TIE	AR
61		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	2
62	TB1	TRW-CINCH	140J-1	STRIP, JUMPER	3
63					
64					
65					
66					
67					
68					
69					
70					
71					
72					
73					
74					
75					
76					
77					
78					

AVANTEK

UTO/UTC/PPA 2013 Series
Thin-Film Cascadable Amplifier
500 to 2000 MHz

FEATURES

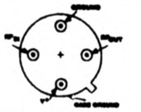
- Frequency Range: 500 to 2000 MHz
- High Dynamic Range
- High Output Power: +21.0 dBm (Typ)
- GaAs FET Technology
- Temperature Compensated
- Surface Mount Option

APPLICATIONS

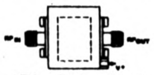
- System Front End
- Output Stage
- Surface Mount Assembly

DESCRIPTION

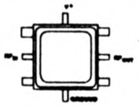
The 2013 Series is a thin-film high power GaAs FET RF amplifier using active bias and resistive feedback for stability over temperature and bias voltage variations. Input/output blocking capacitors couple RF through the amplifier, while a low VSWR is maintained through inductive tuning. The 2013 Series amplifiers are available in three packages: the surface mount Planar-Pak PP-38 (.375 in. x .375 in.) case, the TO-8 hermetic case and the connectorized TC- 1 case.



UTO — TO-8U, p. 16–48



UTC — TC-1, p. 16–42



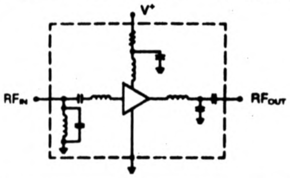
PPA — PP-38, p. 16–35

ELECTRICAL SPECIFICATIONS[1] (Measured in a 50-ohm system @ +15 VDC nominal unless otherwise noted)

Symbol	Characteristic	Typical T_c = 25°C	Guaranteed Specifications		Unit
			T_c = 0° to 50°C	T_c = −55° to +85°C	
BW	Frequency Range	500-2000	500-2000	500-2000	MHz
GP	Small Signal Gain (Min.)	10.0	9.0 Min.	8.5 Min.	dB
—	Gain Flatness (Max.)	±0.5	±1.0	±1.0	dB
NF	Noise Figure (Max.)	4.5	5.5	6.0	dB
P_{1dB}	Power Output @ +1 dB Compression (Min.)	+21.0	+19.0	+18.0	dBm
—	Input VSWR (Max.)	<1.7:1	2.0:1	2.0:1	—
—	Output VSWR (Max.)	<1.6:1	2.0:1	2.0:1	—
IP_3	Two Tone 3rd Order Intercept Point	+33.0	—	—	dBm
IP_2	Two Tone 2nd Order Intercept Point	+45.0	—	—	dBm
HP_2	One Tone 2nd Harmonic Intercept Point	+50.0	—	—	dBm
I_D	DC Current	100	—	—	mA

NOTE: RF input pin is at DC ground — no input blocking capacitor.

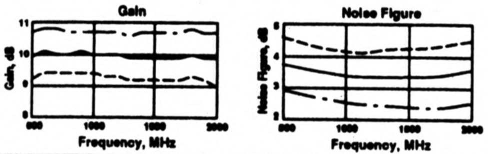
SCHEMATIC



TYPICAL PERFORMANCE OVER TEMPERATURE

(@ +15 VDC unless otherwise noted)

KEY: +25°C ———— +85°C – – – – −55°C —·—



MAXIMUM RATINGS

DC Voltage .... 17 Volts
Continuous RF Input Power .... +17 dBm
Operating Case Temperature .... −55°C to +100°C
Storage Temperature .... −62°C to +150°C
"R" Series Burn-In Temperature .... +100°C

THERMAL CHARACTERISTICS*

θ_{JC} .... 60°C/W
Active Transistor Power Dissipation .... 900 mW
Junction Temperature Above Case Temperature .... 54°C
MTBF (MIL-HDBK-217E, A_{UF} @ 90°C) .... 361,600 Hrs.

*For further information, see High Reliability section, p. 17–2.

WEIGHT: (typical) PPA — 0.5 grams; UTO — 2.1 grams; UTC — 21.5 grams

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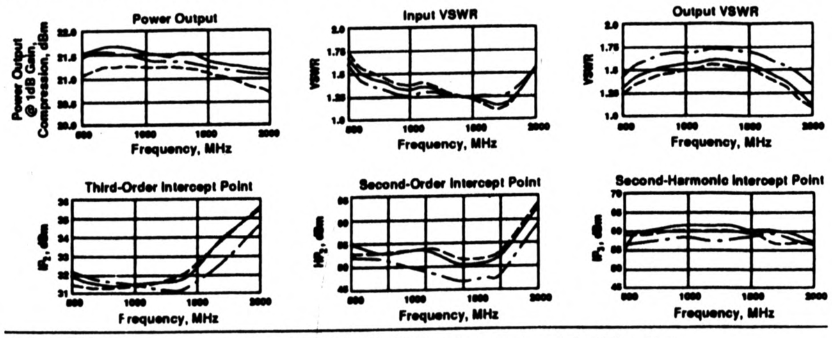
TYPICAL PERFORMANCE OVER TEMPERATURE (continued)



AUTOMATIC NETWORK ANALYZER MEASUREMENTS (Typical production unit @ +25°C ambient)

NUMERICAL READINGS

BIAS = 15.00 VOLTS

FREQ MHz	VSWR IN	GAIN dB	PHASE DEG	PHASE DEV	GPDEL ns	VSWR OUT	ISOL dB
400.0	1.56	9.64	−160.92	—	.92	1.39	15.90
500.0	1.28	9.91	170.86	10.06	.69	1.36	16.01
600.0	1.15	10.02	148.57	3.28	.57	1.36	16.14
700.0	1.08	10.03	128.97	−.80	.52	1.42	16.35
800.0	1.09	10.04	111.27	−2.97	.47	1.44	16.53
900.0	1.11	10.13	94.80	−3.92	.43	1.46	16.66
1000.0	1.11	10.20	80.09	−3.11	.40	1.44	16.90
1100.0	1.07	10.20	65.49	−2.18	.42	1.39	17.03
1200.0	1.06	10.18	50.46	−1.70	.41	1.34	17.07
1300.0	1.07	10.15	35.55	−1.08	.42	1.32	17.01
1400.0	1.07	10.19	20.43	−.68	.41	1.32	17.02
1500.0	1.04	10.19	5.46	−.13	.43	1.38	17.00
1600.0	1.06	10.30	−9.46	.45	.39	1.51	17.05
1700.0	1.14	10.23	−23.97	1.46	.42	1.66	17.16
1800.0	1.24	10.16	−38.70	2.24	.43	1.74	17.32
1900.0	1.32	10.12	−55.02	1.45	.45	1.72	17.35
2000.0	1.40	10.21	−71.49	.51	.46	1.68	17.43
2100.0	1.44	10.29	−86.92	—	.52	1.66	17.28

LINEARIZATION RANGE: 500.0 to 2000.0 MHz

S-PARAMETERS

BIAS = 15.00 VOLTS

FREQ MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	Mag	Ang	dB	Ang	dB	Ang	Mag	Ang
500.00	.199	32.7	10.097	178.2	−17.068	−14.6	.130	−72.6
600.00	.125	19.7	10.257	154.3	−16.580	−29.8	.111	−108.7
700.00	.089	−14.2	10.299	135.3	−16.848	−48.7	.094	−154.8
800.00	.053	−69.5	10.288	117.2	−17.316	−61.4	.093	166.5
900.00	.078	−111.6	10.385	100.5	−17.040	−77.9	.120	145.9
1000.00	.089	−111.9	10.375	86.4	−17.402	−91.4	.114	139.3
1100.00	.103	−109.0	10.296	71.4	−18.034	−105.3	.094	146.7
1200.00	.115	−116.0	10.205	56.0	−17.977	−119.2	.071	146.7
1300.00	.116	−120.1	10.078	40.9	−17.626	−131.8	.048	172.7
1400.00	.111	−135.0	10.045	26.8	−17.864	−143.2	.040	−171.3
1500.00	.098	−144.1	10.015	12.8	−18.129	−156.0	.025	−170.5
1600.00	.071	179.8	10.189	−.1	−17.931	−170.3	.018	115.7
1700.00	.068	134.5	10.142	−14.9	−17.947	177.3	.019	64.0
1800.00	.072	93.3	10.156	−30.8	−18.386	158.1	.013	−38.3
1900.00	.095	66.8	10.091	−47.6	−18.220	145.4	.032	−54.2
2000.00	.110	46.5	9.907	−63.4	−18.194	132.1	.068	−86.7

AVANTEK

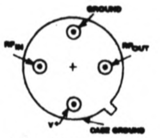
UTO/UTC 2321 Series
Thin-Film Cascadable Amplifier
1700 to 2300 MHz

FEATURES

- Frequency Range: 1700 to 2300 MHz
- Medium Gain: 15.0 dB (Typ)
- Medium Output Power: +12.0 dBm (Typ)
- Temperature Compensated

APPLICATIONS

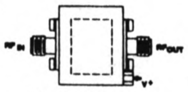
- RF/IF Amplification
- Telemetry
- Military Communications



UTO—TO-8U, p. 16–48

DESCRIPTION

The 2321 Series is a two-stage thin-film bipolar RF amplifier using resistive feedback and active bias for temperature compensation and increased immunity to bias voltage variations. Input/output blocking capacitors couple RF through the amplifier, while a low VSWR is maintained through inductive tuning. The 2321 Series amplifiers are available in either the TO-8 hermetic case or connectored TC-1 package.

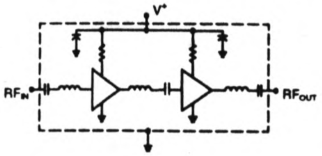


UTC—TC-1, p. 16–42

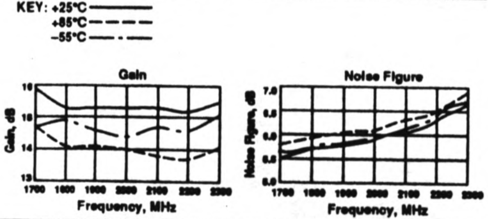
ELECTRICAL SPECIFICATIONS (Measured in a 50-ohm system @ +15 VDC nominal unless otherwise noted)

Symbol	Characteristic	Typical $T_o = 25°C$	Guaranteed Specifications		Unit
			$T_o = 0°$ to $50°C$	$T_o = -55°$ to $+85°C$	
BW	Frequency Range	1700-2300	1700-2300	1700-2300	MHz
GP	Small Signal Gain (Min.)	15.0	14.0	13.0	dB
—	Gain Flatness (Max.)	±0.5	±1.0	±1.0	dB
NF	Noise Figure (Max.)	7.0	8.0	8.5	dB
P_{1dB}	Power Output @ +1 dB Compression (Min.)	+12.0	+10.0	+9.0	dBm
—	Input VSWR (Max.)	<1.8:1	2.0:1	2.0:1	—
—	Output VSWR (Max.)	<1.6:1	2.0:1	2.0:1	—
IP_3	Two Tone 3rd Order Intercept Point	+20.0	—	—	dBm
IP_2	Two Tone 2nd Order Intercept Point	+35.0	—	—	dBm
HP_2	One Tone 2nd Harmonic Intercept Point	+41.0	—	—	dBm
I_D	DC Current	70	—	—	mA

SCHEMATIC



TYPICAL PERFORMANCE OVER TEMPERATURE
(@ +15 VDC unless otherwise noted)



MAXIMUM RATINGS

DC Voltage .... +17 Volts
Continuous RF Input Power .... +18 dBm
Operating Case Temperature .... –55°C to +115°C
Storage Temperature .... –62°C to +150°C
"R" Series Burn-In Temperature .... +115°C

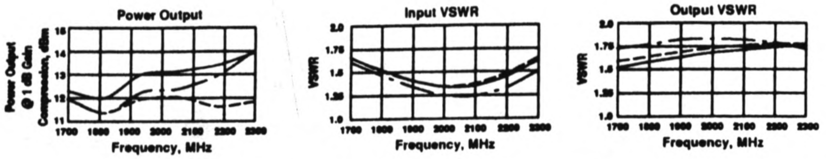
THERMAL CHARACTERISTICS*

θ_{JC} .... 105/75°C/W
Active Transistor Power Dissipation .... 180/450 mW
Junction Temperature Above Case Temperature .... 19/34°C
MTBF (MIL-HDBK-217E, A_{UF} @ 90°C) .... 366,000 Hrs.

*For further information, see High Reliability section, p. 17–2.

WEIGHT: (typical) UTO — 2.1 grams; UTC — 21.5 grams

TYPICAL PERFORMANCE OVER TEMPERATURE (continued)



AUTOMATIC NETWORK ANALYZER MEASUREMENTS (Typical production unit @ +25°C ambient)

NUMERICAL READINGS

BIAS = 15.00 VOLTS

FREQ MHz	VSWR IN	GAIN dB	PHASE DEG	PHASE DEV	GPDEL ns	VSWR OUT	ISOL dB
500.0	2.53	14.27	54.15	—	1.01	3.86	42.19
600.0	2.05	15.40	20.93	—	.86	3.00	40.12
700.0	2.01	15.93	–7.33	—	.73	2.46	39.51
800.0	2.08	16.27	–31.37	—	.62	2.06	38.85
900.0	2.21	16.21	–52.07	—	.54	1.76	38.36
1000.0	2.27	16.06	–69.93	—	.48	1.53	38.49
1100.0	2.30	15.76	–85.55	—	.44	1.35	38.20
1200.0	2.29	15.60	–101.64	—	.40	1.24	37.76
1300.0	2.19	15.32	–115.02	—	.37	1.18	37.69
1400.0	2.13	15.01	–128.55	—	.37	1.19	38.03
1500.0	2.00	14.80	–141.86	—	.38	1.25	37.94
1600.0	1.88	14.76	–155.69	—	.37	1.34	37.77
1700.0	1.72	14.80	–168.27	–1.95	.34	1.43	37.71
1800.0	1.58	14.62	179.58	.04	.35	1.57	36.65
1900.0	1.49	15.00	166.56	1.17	.37	1.56	38.68
2000.0	1.40	15.05	152.69	1.46	.39	1.64	38.57
2100.0	1.41	14.98	138.50	1.43	.42	1.67	38.64
2200.0	1.56	15.10	122.45	–.45	.44	1.67	38.95
2300.0	1.82	15.12	107.05	–1.70	.47	1.66	39.53
2400.0	2.21	14.67	88.70	—	.52	1.61	39.45
2500.0	2.66	13.97	69.28	—	.50	1.55	39.21
2600.0	3.09	13.37	52.57	—	.48	1.48	40.23
2700.0	3.56	12.22	34.59	—	.48	1.43	40.52
2800.0	4.06	10.99	17.92	—	.46	1.43	40.94
2900.0	4.70	9.38	1.18	—	.44	1.49	40.95
3000.0	5.33	7.77	–13.79	—	.00	1.60	40.96

LINEARIZATION RANGE: 1700 to 2300 MHz

S-PARAMETERS

BIAS = 15.00 VOLTS

FREQ MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	Mag	Ang	dB	Ang	dB	Ang	Mag	Ang
500.00	.437	–73.5	13.952	53.4	–42.019	134.1	.580	–72.0
600.00	.345	–67.1	15.169	21.3	–40.348	119.9	.490	–82.5
700.00	.326	–60.8	15.698	–6.4	–39.169	110.8	.410	–91.8
800.00	.363	–57.9	16.075	–30.5	–38.765	107.2	.328	–99.6
900.00	.371	–59.1	16.066	–50.9	–38.267	103.3	.246	–106.8
1000.00	.398	–67.1	15.963	–68.5	–38.026	99.8	.179	–112.1
1100.00	.411	–71.3	15.653	–85.2	–38.166	98.3	.123	–111.9
1200.00	.400	–78.6	15.569	–100.2	–37.669	98.9	.080	–99.9
1300.00	.400	–84.8	15.309	–113.8	–37.939	96.8	.062	–68.1
1400.00	.378	–91.3	15.062	–127.4	–37.710	95.8	.075	–40.3
1500.00	.363	–98.9	14.850	–141.0	–37.955	96.6	.103	–32.4
1600.00	.332	–104.7	14.837	–154.9	–37.930	97.0	.136	–31.2
1700.00	.290	–115.0	14.881	–167.8	–37.876	97.1	.165	–33.2
1800.00	.248	–119.4	14.601	–179.9	–38.664	95.3	.202	–43.6
1900.00	.207	–141.5	15.025	166.9	–38.709	91.2	.197	–44.0
2000.00	.169	–169.3	15.065	152.9	–38.586	91.4	.222	–50.7
2100.00	.148	152.0	15.016	138.7	–38.698	89.0	.229	–54.8
2200.00	.186	113.9	15.133	122.9	–38.997	87.7	.226	–59.9
2300.00	.259	85.4	15.155	107.5	–39.194	83.2	.225	–64.5
2400.00	.356	68.3	14.712	89.1	–39.515	81.7	.211	–67.6
2500.00	.440	54.2	14.071	69.7	–39.410	72.8	.192	–68.9
2600.00	.511	43.3	13.453	52.9	–40.173	69.1	.168	–68.4
2700.00	.566	34.5	12.331	34.8	–40.402	62.8	.149	–59.0
2800.00	.621	27.6	11.064	17.8	–40.704	62.7	.150	–47.2
2900.00	.665	23.1	9.439	1.2	–40.619	58.0	.172	–37.2
3000.00	.704	18.6	7.761	–14.1	–40.887	56.3	.204	–33.2

WJ - M2T/M2TC

TRIPLE-BALANCED MIXER

- ◆ LO } 10 TO 2400 MHz
  RF
- ◆ IF 10 TO 1000 MHz
- ◆ LO DRIVE +13 dBm (nominal)
- ◆ HIGH INTERCEPT +22 dBm (TYP.)
- ◆ HIGH ISOLATION 40 dB (TYP.)

*MIL–M–28837 Screening Available (See "QPL Mixers" Section)

Guaranteed Specifications[1,2]

Characteristics	Min.	Typ.	Max.	Test Conditions
SSB Conversion Loss				f_R & f_L 10 to 2400 MHz
		7.5 dB	9.5 dB	f_I = 50 to 1000 MHz
and		9.0 dB	10.0 dB	f_I =10 to 1000 MHz
SSB Noise Figure				f_R & f_L 500 to 1500 MHz
		7.0 dB	8.5 dB	f_I =10 to 1000 MHz
Isolation				
f_L at R	35 dB	40 dB		f_L 10 to 1200 MHz
f_L at I	35 dB	40 dB		
f_L at R	30 dB	40 dB		f_L 1200 to 2400 MHz
f_L at I	30 dB	40 dB		
Conversion Compression		1.0 dB		f_R Level = +11 dBm f_L Level = +13 dBm
Third Order Intercept Point		+22 dBm		f_L Level = +16 dBm f_{R_1}, f_{R_2} Level = 0 dBm

Notes

1. Measured in a 50-ohm system with nominal LO drive and downconverter application only, unless otherwise specified.
2. Guaranteed conversion loss values for M2TC are 0.5 dB worse than values listed and guaranteed over 0°C to 50°C temperature range only.

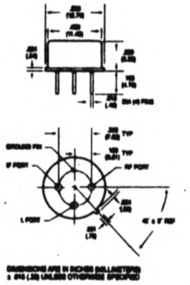
Absolute Maximum Ratings

Operating Temperature .... -54°C to +100°C
Storage Temperature .... -65°C to +100°C
Peak Input Power .... +25 dBm at +25°C, derate at +4 dBm/°C
Peak Input Current at +25°C .... 75 mA DC

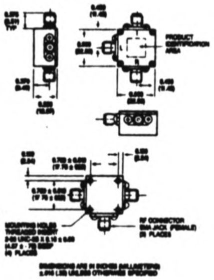
Weight M2T: 2 grams (0.07 oz.) max.
M2TC: 22 grams (0.78 oz.) max.

Outline Drawings

M2T

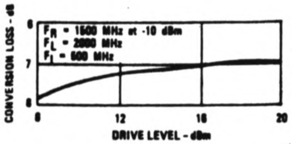


M2TC

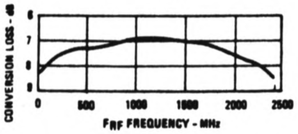


Typical Performance at 25°C

Conversion Loss

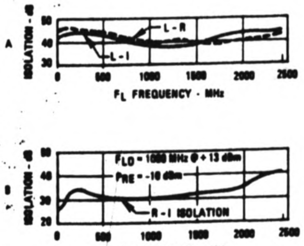


Conversion Loss vs. Drive Level: The minimum recommended drive level is +11 dBm. The maximum recommended drive level is +20 dBm.



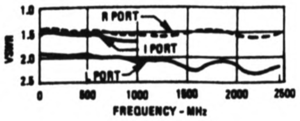
Conversion Loss vs. Input Frequency: Conversion loss of the mixer when used in an SSB system. The frequency ordinate refers to the R-port (f_R) with f_I equal to 100 MHz. Data plotted with f_L level of +13 dBm.

Isolation



Isolation vs. Frequency: A) Level of the f_L signal fed through the R- and I-ports with respect to the level of the f_L signal at the L-port. Data plotted with f_L level of +13 dBm. B) Level of the f_R signal fed through to the I-Iport with respect to the level of the f_R signal at the R-port.

VSWR



$P_{RF} = P_{IF} = -10$ dBm
$P_{LO} = +13$ dBm
$f_{LO} = 500$ MHz

VSWR vs. Frequency: VSWR of the L-I- and R-ports in a 50-ohm system with f_L at +13 dBm. Some variation in the R-port VSWR wil occur as a function of the L-port frequency. Both R-port and I-port VSWR are plotted for f_L at 500 MHz. Also shown is the L-port VSWR.

Two-Tone Intermodulation Performance

$f_{RF1} = 1100$ MHz $f_{RF2} = 1110$ MHz
$P_{RF1} = P_{RF2} = 0$ dBm
$f_{LO} = 1600$ MHz $P_{LO} = +16$ dBm
$f_I = 500$ MHz @ 10 dB/div

Two-Tone Intermodulation Performance: The photo displays typical relative suppresion of 3rd order two-tone measurement, with $P_{FR}1$ equal to P_{FR2} at 0 dBm.

3.4 T104, 2.3 GHz CONVERTER MODULE

T104 Band Coverage and LO Frequencies

This section describes the T104 frequency converter that converts the S-Band 2.3 GHz (13 cm) Front-End signal to the standard 500 to 1000 MHz IF band. Since RF bandpass filters are installed in the Front-End, they are not included in the T104 RF circuitry; these filters have a 2400 MHz center frequency, 800 MHz bandwidth at the -3 dB points, and the band edges are 2.0 and 2.8 GHz, respectively.

This band uses LO frequencies of 2.9 and 3.1 GHz; 3.4 GHz may also be used although it is not specified in the LO frequency table in Section 6.

When the 2.9 GHz LO is mixed with the 2.0 to 2.8 GHz Front-End RF input, the mixer IF port spectrum is 100 to 900 MHz. The K&L 6B120-750/X550 filter passes the standard 500 to 1000 MHz portion and attenuates frequencies outside this passband. The converted portion of the Front-End RF spectrum is 2.0 to 2.4 GHz and the 2.4 to 2.8 GHz portion is attenuated by the IF filter.

When the other LO frequencies are used, the following tabulation shows the mixer IF port spectrum, converted and attenuated bands. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The Mixer IF port frequencies are in MHz, converted and attenuated in GHz.

LO Freq	Mixer IF Port	Converted	Attenuated
2.9	100 to 900	2.0 to 2.4	2.4 to 2.8
3.1	300 to 1100	2.1 to 2.6	2.0 to 2.1 2.6 to 2.8
3.4	600 to 1000	2.4 to 2.8	2.0 to 2.4

Since the LO frequencies are higher than the RF frequencies, the IF signal spectrum is reversed relative to the RF band; the high end of the RF band is converted to the low end of the IF band, and vice versa. When testing the T104 it is important to remember this effect.

T104 Size and Location

T104 is a double-width module installed in Rack B, Bin C, Slots 1-2.

T104 Drawings and Data Sheets

The following T104 functional and assembly drawings are found at the end of this section.

C53500K008, Rev D	- T104 2.3 GHz Converter Module Block Diagram
D53500A016, Rev B	- T104 2.3 GHz Converter Module Assembly
A53500B010, Rev B	- T104 2.3 GHz Converter Module Assembly BOM

Data sheets for the VARIL DBM-1150H mixer, and Miteq AMF-2B-2830-18P amplifier follow the drawings. Data sheets for the Ditom D3I-2040, KDI-Triangle D307M power divider and Narda 4772-X attenuator are included in the Appendix, Section 6.

T104 Difference from the General Converter Block Diagram

The difference between the T104 Block Diagram and the general converter block diagram of Section 2.1 is the omission of the RF bandpass filters.

T104 Specifications

Nominal Gain, dB	14	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+4	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	10,000	Noise Temp for 1% added Syst Noise, K	20,000	Nom LO Pwr input, dBm	+2
Avg Noise Figure, dB	15.2	Noise Figure for 1% added Syst Noise, dB	18.4		
15 Volt Power Req't, mA	650				

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. Image response bands are attenuated by the 2.3 GHz Front-End's 2400/800 Bandpass filter, which has -3 dB frequencies of 2.0 and 2.8 GHz. The following tabulation shows the LO frequency, unwanted (UWSB) and image sidebands in GHz and the attenuation of these bands in dB.

LO Freq	UWSB	UWSB Attn	Image
2.9	4.9 to 5.7	»70	3.4 to 3.9
3.1	5.1 to 5.9	»70	3.6 to 4.1
3.4	5.4 to 6.2	»70	3.9 to 4.4

The worst case image frequency for these three LO's is 3.4 GHz, which is attenuated by the Front-End's 2400/800 Bandpass filter.

Noise Temperature

The T104 noise temperature is a composite value that is a function of the noise temperatures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 10,000 K. A T104 noise temperature of 20,000 K would add 1 K to the system temperature.

Mixer

The VARI-L DBM 1150H mixer is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO and RF frequencies of 1.6 to 3.2 GHz, IF frequencies of DC to 1000 MHz and a nominal LO drive of +13 dBm. In the 2.3 GHz frequency band, the typical conversion loss is 7.0 dB and the typical noise figure is 7.0 dB.

RCP-LCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths - the isolation between the two mixer LO ports and the transfer switch leakage. A K&L 3B250-3000/600 bandpass filter (next page) in the LO drive path provides additional out-of-band isolation to the mixer LO port paths. As shown in the table above, the module's RCP-LCP path isolation specification is 65 dB.

The VARI-L DBM-1150H mixer LO to RF isolation is 30 dB and the LO to IF isolation is 15 dB. The KDI/Englemen D307M power divider port-to-port isolation is 21 dB. At the 3.1 GHz LO frequency, the isolation of this shunt path is the sum of the two mixer LO port's to RF port isolation and the divider's isolation; this is 72 dB. Outside the 600 MHz filter bandpass, the isolation is increased by the filter's attenuation. At the lowest RF frequency (2.0 GHz) the filter attenuation is about 35 dB and at the highest RF frequency (2.8 GHz), the attenuation is about 10 dB. The resultant mixer LO port to mixer LO port isolation for RF frequencies is roughly 90 dB. For frequencies in the 500 to 1000 MHz IF band, the filter's attenuation is about 36 dB; the resultant mixer LO port to mixer LO port isolation is about 100 dB.

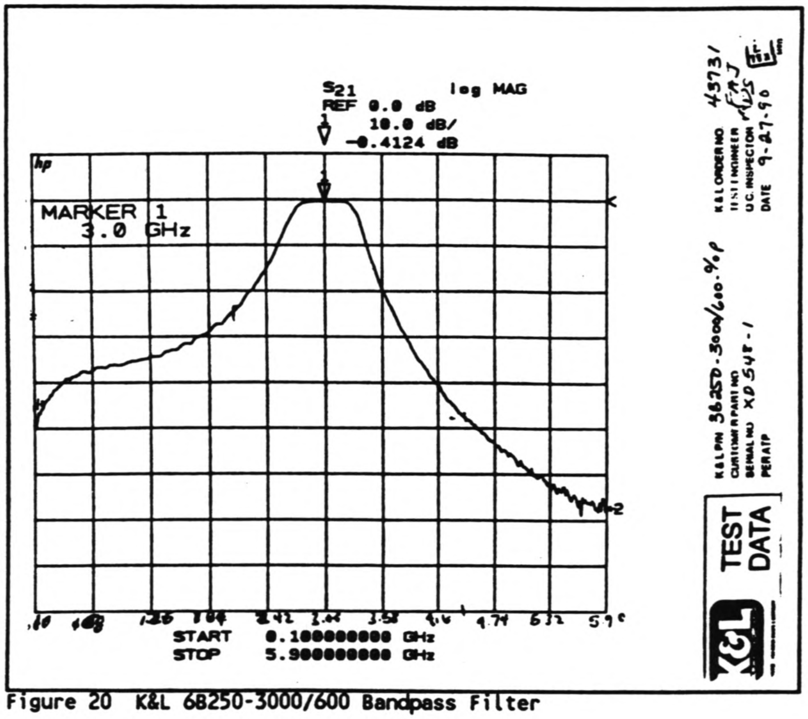


Figure 20 K&L 6B250-3000/600 Bandpass Filter

The typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch at 2.3 GHz is about 85 dB.

VSWR's

The input VSWR, about 1.3:1 is the composite of the VSWR's of the transfer switch (1.15:1) and isolator (1.25:1). The output VSWR is the composite VSWR of the Amp/Divider which is 1.5:1.

RF Input Circuitry Losses

The losses in the RF input path are the insertion losses of the transfer switch (0.1 dB) and the isolator (0.4 dB).

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 IF bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

The LO drive amplifier is a MITEQ AMF-2B-2830-18P amplifier that is a special order adaption of the AMF-2B amplifier series for NRAO. The amplifier is characterized over the T104 2.8 to 3.0 Ghz LO frequency range. The gain is 15 dB and is flat over this band within ± 0.5 dB; the noise figure is about 3.3; maximum input and output VSWR is 1.9 and the 1 dB compression point is about 18.5 dB. During module alignment, the amplifier gain is adjusted to produce a +13 dBm drive to the DBM-1150H mixers. The gain is determined by the selection of the appropriate NARDA 4772-X pad. The LO amplifier gain adjustment procedure is described in Test I, LO Powr, Gain and Flatness, Section 2.7.

The LO isolation filter is a K&L 3B250-3000/600; the attenuation plot is shown in Figure 20.

RF Switching

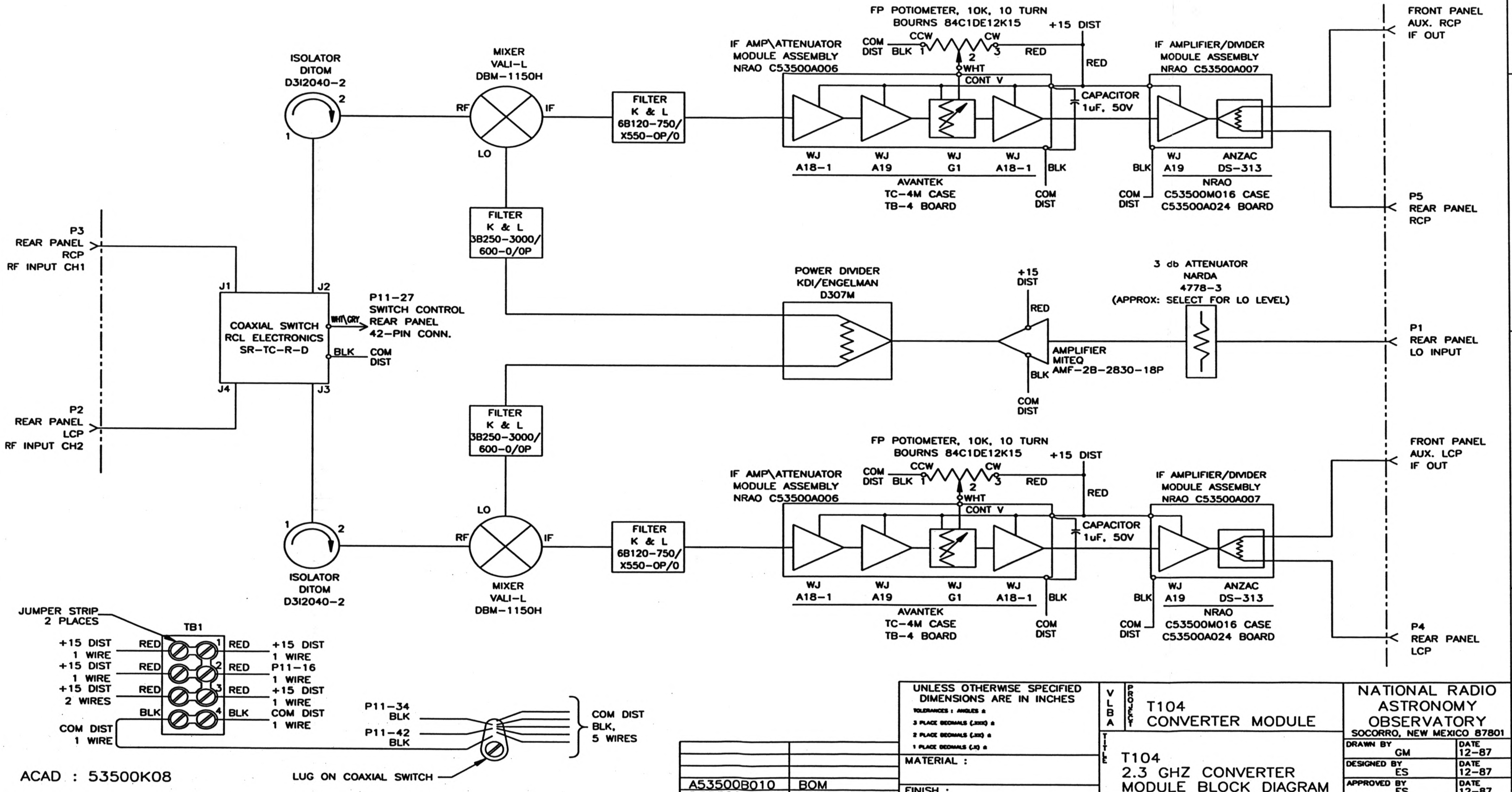
The T104 transfer switch, S104A is an an RLC SR-TC-R-D transfer switch; some T104's may use the Transco 710C70100 as an alternate unit. The transfer switch is driven by M102, address 13H, bit 0.

T104 Power Circuitry

All T104 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 1-4 where it is distributed to the amplifiers. The common returns for these devices are connected to a frame ground lug that is connected to P11-34 and P11-42. This ground is also the ground return for the +28 volt drive to the transfer switch.

The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	12-87	CM	ES	ADDED CABLES LENGTHS
B	10-90	DGS	ES	CHG ORDER 901023-1
C	4-91	DGS	ES	CHG ORDER 910410-4
D	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
E	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS



ACAD : 53500K08

A53500B010	BOM
D53500A016	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T104
CONVERTER MODULE

TITLE T104
2.3 GHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

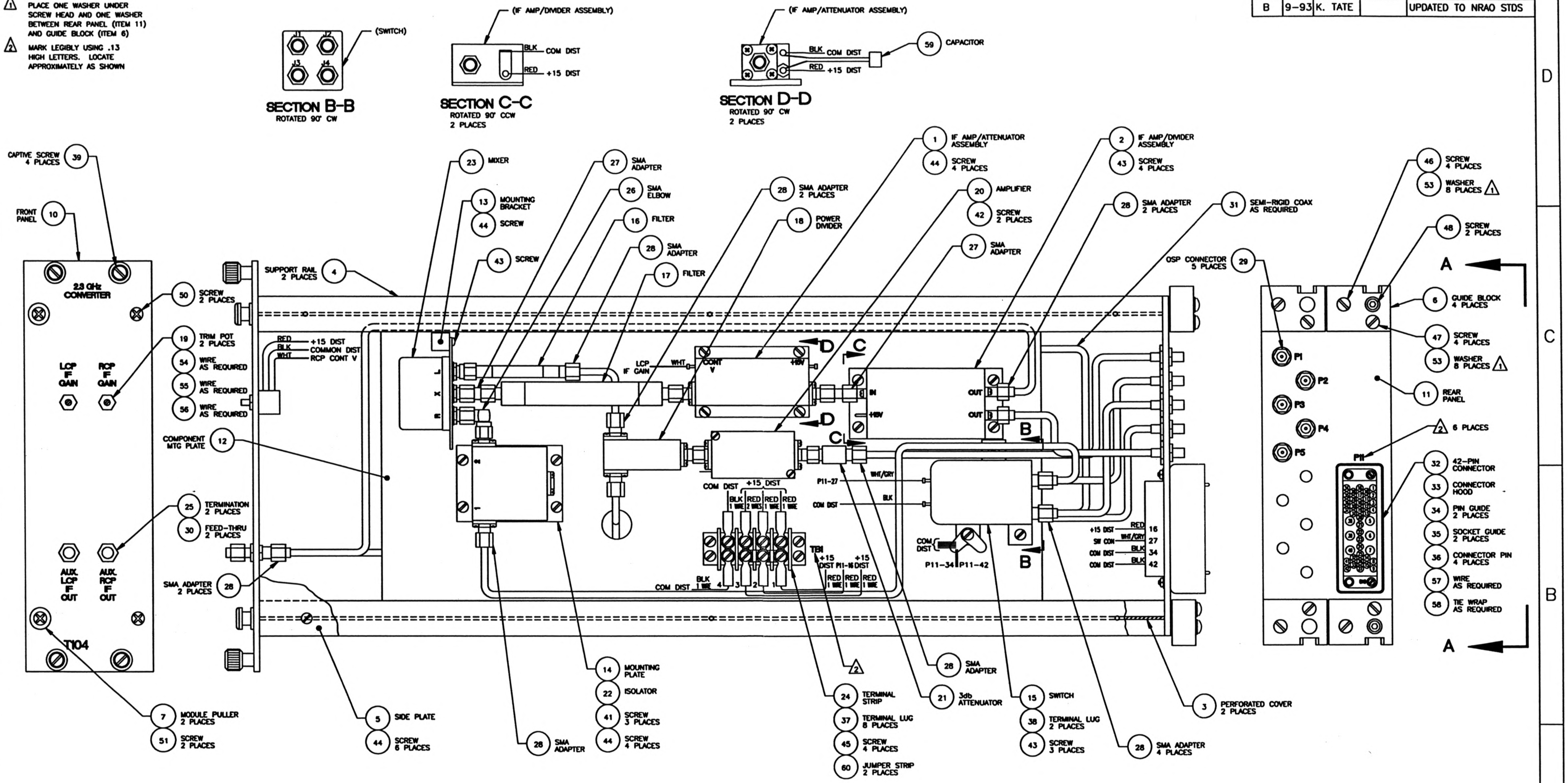
DRAWN BY GM DATE 12-87
DESIGNED BY ES DATE 12-87
APPROVED BY ES DATE 12-87

SHEET NUMBER 1 OF 1 DRAWING NUMBER C53500K008 REV. E SCALE NONE

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-90	DGS		CHG ORDER #901022-1
B	9-93	K. TATE		UPDATED TO NRAO STDS

NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 11) AND GUIDE BLOCK (ITEM 6)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



T104 ASSEMBLY – RCP SIDE

ACAD : 3500A16A

C53500K008	BLOCK DIAG
A53500B010	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T104 CONVERTER MODULE

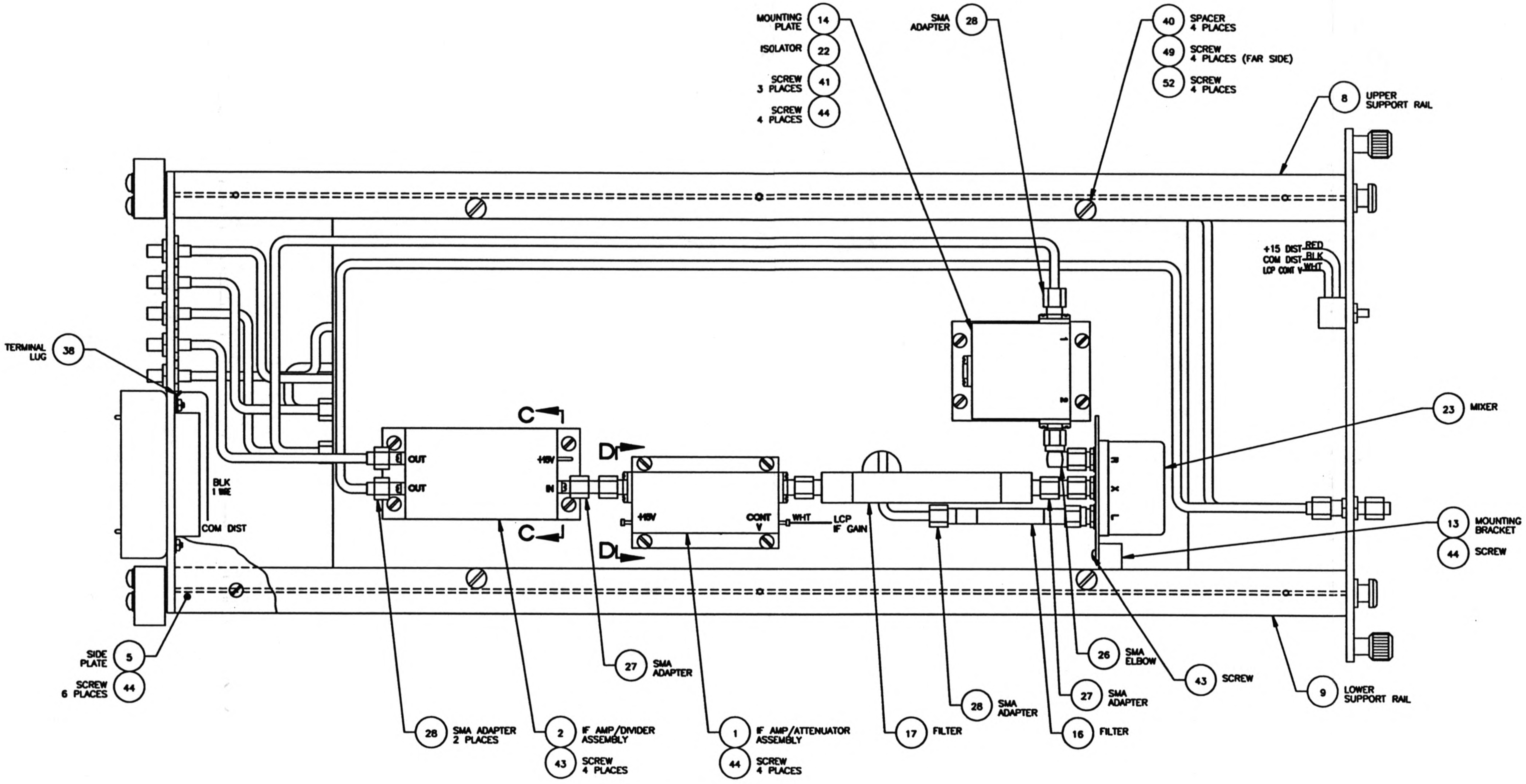
TITLE T104
2.3 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY GM DATE 1-88
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 2
DRAWING NUMBER D53500A016
REV. B
SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



VIEW A-A

LCP SIDE

ACAD : 3500A16B

C53500K008	BLOCK DIAG
A53500B010	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T104
CONVERTER MODULE

TITLE T104
2.3 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY GM DATE 1-88
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 2 OF 2 DRAWING NUMBER D53500A016 REV. B SCALE 1/1

REVISIONS				
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	9-93	K. TATE		UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 9-93		
DESIGNED BY	DATE	C53500K008	BLOCK DIAG
APPROVED BY	DATE	D53500A016	ASSEMBLY
		NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T104 CONVERTER MODULE

TITLE T104 2.3 GHZ CONVERTER MODULE
ASSEMBLY BOM

DWG NO. A53500B010 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B010 REV B DATE 9-14-93 PAGE 2 OF 5

MODULE T104 NAME 2.3 GHZ CONVERTER DWG# D53500A016 SUB ASSY ________ DWG# ________

SCHEM. DWG# C53500K008 LOCATION ________ QUA/SYS. ________ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53306M014-1	COVER, PERFORATED	2
4		NRAO	C53306M016	RAIL, SUPPORT	2
5		NRAO	C53306M017	PLATE, SIDE	2
6		NRAO	B53306M018	BLOCK, GUIDE	4
7		NRAO	A53306M038	PULLER, MODULE	2
8		NRAO	B53500M001	RAIL, UPPER	1
9		NRAO	B53500M002	RAIL, LOWER	1
10		NRAO	B53500M003	PANEL, FRONT	1
11		NRAO	B53500M004-1	PANEL, REAR	1
12		NRAO	D53500M034	PLATE, COMPONENT MOUNTING	1
13		NRAO	B53500M035	BRACKET, MIXER MOUNTING	2
14		NRAO	B53500M036	PLATE, ISOLATOR MOUNTING	2
15		RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
16		K & L	38250-3000/600-0-0P	FILTER	2
17		K & L	6B120-750/X550-0-0P	FILTER	2
18		KDI/ENGELMAN	D307M	DIVIDER, POWER	1
19		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2
20		MITEQ	AMF-28-2830-18P	AMPLIFIER	1

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B010 REV B DATE 9-14-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		NARDA	4778-3	ATTENUATOR, 3db	1
22		DITOM	D3I2040-2	ISOLATOR	2
23		VARI-L	DBM1150H	MIXER	2
24	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
25		SOLITRON	8018-6005	TERMINATION, 50Ω	2
26		SOLITRON	2993-6005	ELBOW, SMA MALE/MALE	2
27		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	4
28		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 TUBE	16
29	P1 - P5	OMNI-SPECTRA	4503-7941-00	CONNECTOR, OSP .141 MALE	5
30		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
31		PRECISION TUBE	AA50141	COAX, .141. SEMI-RIGID	AR
32	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
33		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
34		AMP	200833-2	PIN, GUIDE	2
35		AMP	203964-5	SOCKET, GUIDE	2
36		AMP	201578-1	PIN, 16 GA. CONNECTOR	4
37		ETC/MOLEX	AA-832-06	LUG, TERMINAL	8
38				LUG, TERMINAL	3
39		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B010 REV B DATE 9-14-93 PAGE 4 OF 5

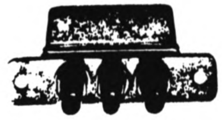
ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
40		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44 BOTH ENDS	4
41				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	6
42				SCREW, PAN HEAD, SS, 2-56UNC-2A x .50	2
43				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	13
44				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	30
45				SCREW, PAN HEAD, SS, 4-40UNC-2A x .38	4
46				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
47				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
48				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
49				SCREW, PAN HEAD, SS, 8-32UNC-2A x .25	4
50				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
51				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
52				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4
53				WASHER, EXT. TOOTH #6	16

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B010 REV B DATE 9-14-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
54		ALPHA	7055	WIRE, WHT #22	AR
55		ALPHA	7055	WIRE, BLK #22	AR
56		ALPHA	7055	WIRE, RED #22	AR
57		ALPHA	7055	WIRE, BLK/GRY #22	AR
58				WRAP, TIE	AR
59		SPRAGUE	2C20Z50105M050B	CAPACITOR, 1µf, 50V	2
60	TB1	TRW CINCH	140J-1	STRIP, JUMPER	2
61					
62					
63					
64					
65					
66					
67					
68					
69					
70					
71					
72					
73					
74					
75					

DBM-1150H
Microwave Double Balanced Mixer
1.6-3.2 GHz



DESCRIPTION

DBM-1150H is a high drive member of the 1100 series mixers. A nominal +13 LO yields a +16 dBm third order intercept point. This Vari-L mixer also exhibits excellent conversion loss from 1.6 to 3.2 GHz which improves system performance. Other features typical of the 1100 series are good port to port isolation and wide IF response from DC.

The rugged transmission line transformers and a quad of precisely matched Schottky diodes are sealed in a sturdy package with a mounting bracket, simplifying mechanical installation.

Each DBM-1150H is individually tested to Vari-L's demanding quality and performance specifications.

LIMITED WARRANTY

Vari-L Company, Inc. warrants its products against defects in parts and workmanship for a period of one year.

GUARANTEED MINIMUM PERFORMANCE DATA

TEST CONDITION:

LO +13 dBm (High side LO)
RF −10 dBm
IF 100 MHz

NOTE:

Specifications below, guaranteed with IF from DC to 0.7 GHz. For higher IF frequencies, consult IF response curve for typical rolloff.

OVERALL FREQUENCY RANGE IN GHz:

L	R	X
1.6-3.2	1.6-3.2	DC-1.0

FREQUENCY BANDS IN GHz:

	1.6-3.2
Conversion Loss	7.0
L-R Isolation	30
L-X Isolation	15
R-X Isolation	10

ABSOLUTE MAXIMUM RATINGS:

Operating Temp. −54 to +100°C
X-port Input Current 50 mA
Total Input Power 200 mW @ +25°C
Derate linearly to 50 mW @ 100°C

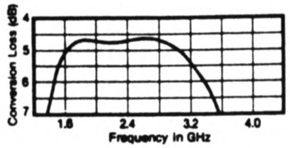
DC POLARITY:

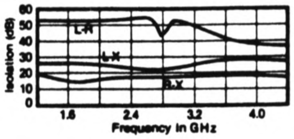
Positive with L and R port signals in-phase

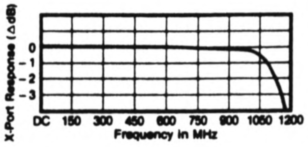
DBM-1150H
Microwave Double Balanced Mixer
1.6-3.2 GHz

TYPICAL PERFORMANCE

Impedance: All ports 50 ohms
1 dB Compression Point: +7 dBm
1 dB Desensitization Point: +4 dBm
3rd Order Intercept Point: +16 dBm
Noise Figure is within 1 dB of conversion loss
LO Power Range: +10 to +20 dBm







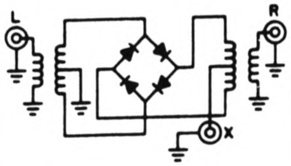
ENVIRONMENTAL CONDITIONS

GUARANTEED ENVIRONMENTAL PERFORMANCE:

All units are designed to meet their specifications over −54°C to +100°C and after exposure to any or all of the following tests per MIL-STD-202E.

Exposure	Method	Test Condition
Thermal Shock	107D	B
Altitude	105C	G
H.F. Vibration	204C	D
Mechanical Shock	213B	C
Random Vibration (15 minutes per axis)	214	IIF

FUNCTIONAL SCHEMATIC



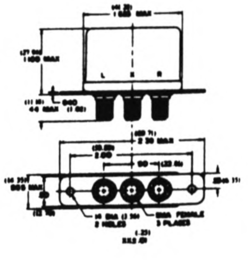
PACKAGE

MATERIAL:

Header and Plate: CRS per QQ-S-698
Cover: Terne Coated Steel per Federal Standard Specifications QQ-T-191b, Class 1, Type 2, Grade B
Base material conforms to QQ-S-698
Connector Body: Stainless Steel per QQ-S-764, Class 303, Cond. A
Contacts: Beryllium Copper per QQ-C-530, Half hard
Dielectric: Polytetrafluorethylene per MIL-P-19468
Federal Specification L-P-403

FINISH:

Header, Plate, and Cover: bright nickel per QQ-N-290A, Class 1, Grade F, Form SB over copper per MIL-C-14550A, Class 3
Connector: Per paragraph 4.6.11. of MIL-C-39012
Pin: Gold per MIL-G-45204, Type 1, Grade C, Class 2



Wideband Medium Power Amplifiers

MITEG

Model Number	Freq. (GHz)	Gain (Min.) (dB)	Gain Var. (Max.) (±dB)	Noise Figure (Max.) (dB)	VSWR (Max.)		Dynamic Range 1 dB Gain Comp. Output (Min., dBm)	Nom. DC Power (+15V, mA)	Outline
					Input	Output			
Standard Housings									
2-4 GHz									
AMF-1B-2040-17P	2-4	10	1.0	5.0	2:1	2:1	+17	90	8
AMF-2B-2040-17P	2-4	20	1.0	4.0	2:1	2:1	+17	140	9
AMF-3B-2040-17P	2-4	30	1.0	3.5	2:1	2:1	+17	180	10
AMF-4B-2040-17P	2-4	40	1.5	3.5	2:1	2:1	+17	220	11
AMF-1B-2040-20P	2-4	10	1.0	6.0	2:1	2:1	+20	130	8
AMF-2B-2040-20P	2-4	20	1.0	5.0	2:1	2:1	+20	210	9
AMF-3B-2040-20P	2-4	30	1.0	4.0	2:1	2:1	+20	260	10
AMF-4B-2040-20P	2-4	40	1.5	4.0	2:1	2:1	+20	300	11
AMF-1B-2040-23P	2-4	10	1.0	8.0	2:1	2:1	+23	190	96
AMF-2B-2040-23P	2-4	20	1.0	8.0	2:1	2:1	+23	310	97
AMF-3B-2040-23P	2-4	30	1.5	6.0	2:1	2:1	+23	390	98
AMF-4B-2040-23P	2-4	40	1.5	6.0	2:1	2:1	+23	440	99
AMF-1B-2040-25P	2-4	8	1.0	8.0	2:1	2:1	+25	300	96
AMF-2B-2040-25P	2-4	17	1.0	8.0	2:1	2:1	+25	480	97
AMF-3B-2040-25P	2-4	27	1.5	6.0	2:1	2:1	+25	600	98
AMF-4B-2040-25P	2-4	37	1.5	6.0	2:1	2:1	+25	680	99
AMF-1B-2040-27P	2-4	7	1.0	8.0	2:1	2:1	+27	600	96
AMF-2B-2040-27P	2-4	15	1.0	8.0	2:1	2:1	+27	900	97
AMF-3B-2040-27P	2-4	24	1.5	6.0	2:1	2:1	+27	1080	98
AMF-4B-2040-27P	2-4	33	1.5	6.0	2:1	2:1	+27	1200	99
4-8 GHz									
AMF-2B-4080-17P	4-8	16	1.0	6.0	2:1	2:1	+17	90	14
AMF-3B-4080-17P	4-8	24	1.0	5.0	2:1	2:1	+17	140	15
AMF-4B-4080-17P	4-8	32	1.5	5.0	2:1	2:1	+17	180	16
AMF-5B-4080-17P	4-8	40	1.5	5.0	2:1	2:1	+17	220	17
AMF-2B-4080-20P	4-8	15	1.0	7.0	2:1	2:1	+20	130	14
AMF-3B-4080-20P	4-8	23	1.0	6.0	2:1	2:1	+20	210	15
AMF-4B-4080-20P	4-8	31	1.5	6.0	2:1	2:1	+20	260	16
AMF-5B-4080-20P	4-8	39	1.5	6.0	2:1	2:1	+20	300	17

3.5 T105, 4.8 GHz CONVERTER MODULE

T105 Band Coverage and LO Frequencies

This section describes the T105 frequency converter that converts the C-Band Front-End signal to the standard 500 to 1000 MHz IF band. Since RF bandpass filters are installed in the Front-End, they are not included in the T105 RF circuitry. These filters have a 4850 MHz center frequency, 700 MHz bandwidth at the -3 dB points, and the band edges are 4.5 and 5.2 GHz, respectively.

T105 uses LO frequencies of 3.9, 4.1, 5.6 and 5.9 GHz. The following tabulation shows the mixer IF port spectrum, converted and attenuated bands. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The IF port frequencies are in MHz, the others in GHz.

LO Freq	Mixer IF Port	Converted	Attenuated
3.9	600 to 1300	4.5 to 4.9	4.4 to 4.5 4.9 to 5.2
4.1	400 to 1100	4.6 to 5.1	4.5 to 5.1 5.1 to 5.2
5.6	600 to 1100	4.6 to 5.2	4.5 to 5.0 5.1 to 5.2
5.9	700 to 1400	5.0 to 5.2	4.5 to 5.0

Since the 5.6 and 5.9 GHz LO frequencies are higher than the RF frequencies, the IF signal spectrum is reversed relative to the RF band. The high end of the RF band is converted to the low end of the IF band, and vice versa. It is important to remember this effect when testing the T105 with this LO frequency.

T105 Size and Location

T105 is a double-width module installed in Rack B, Bin C, Slots 4-5.

T105 Drawings and Data Sheets

The following T105 functional and assembly drawings are found at the end of this section.

C53500K002, Rev D - T105 4.8 Converter Module Block Diagram
D53500A003, Rev C - T105 4.8 GHz Converter Module Assembly
A53500B002, Rev B - T105 4.8 GHz Converter Module Assembly BOM

Data sheets for the Avantek DBX-72M mixer and Miteq AMF-2B-4156 amplifier follow the drawings. Data sheets for the KDI-Triangle power divider, Ditom D3I-4080 isolator and Narda 4772-X attenuator are included in the Appendix, Section 6.

T105 Differences from the General Converter Block Diagram

There are no differences between the T105 Block Diagram and the general converter block diagram of Section 2.1.

T105 Specifications

Nominal Gain, dB	14	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+3.9	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	9,000	Noise Temp for 1% added Syst Noise, K	25,000	Nom LO Pwr input, dBm	+1
Avg Noise Figure, dB	15.2	Noise Figure for 1% added Syst Noise, dB	19.4		
15 Volt Power Req't, mA	680				

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. Image response bands are attenuated by the 4.8 GHz Front-End's 4850/700 bandpass filter, which has a -3 dB passband of 4.5 to 5.2 GHz. The following tabulation shows the LO frequency, unwanted (UWSB) and image sidebands in GHz.

LO Freq	UWSB	UWSB Attn	Image
3.9	8.4 to 9.1	»70	2.9 to 3.3
4.1	8.6 to 9.3	»70	3.1 to 3.6
5.6	10.1 to 10.8	»70	6.1 to 6.6
5.9	10.4 to 11.1	»70	6.4 to 6.9

The worst case image frequency for these three LO's is 4.1 GHz which is attenuated by the Front-End's 4850/700 Bandpass filter.

Noise Temperature

The T105 noise temperature is a composite value that is a function of the noise temperatures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperaturs of the LCP and RCP channels is 9,000 K. A T105 noise temperature of 25,000 K would add 1 K to the system temperature.

Mixer

The AVANTEK DBX-72M-1 is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO and RF frequencies of 2.0 to 7.0 GHz, IF frequencies of DC to 1500 MHz and a nominal LO drive of +10 dBm. In the 4.8 GHz frequency band, the typical conversion loss is 6.5 dB and the typical noise figure is 6.5 dB. Typical mixer port isolations are: LO-IF, 25 dB; LO-RF, 35 dB and RF-IF, 20 dB.

LCP-RCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths: the isolation between the two mixer LO ports and the transfer switch leakage. A K&L 3B250-4100/1300 bandpass filter (next page) in the LO path provides additional out-of-band isolation to the mixer LO port paths. As shown in the table above, the module's RCP-LCP path isolation specification is 65 dB.

The AVANTEK DBX-72M-1 mixer LO to RF isolation is 35 dB and the LO to IF isolation is also 35 dB. The KDI/Englemen D307M power divider port-to-port isolation is 21 dB. At the 4.1 and 5.6 GHz LO frequencies, the isolation of this shunt path is the sum of the two mixer LO port's to RF port isolation and the divider's isolation; this is 91 dB. The filter's attenuation is about 0.25 dB for frequencies in the 1300 MHz passband; the isolation is increased by the filter's attenuation. At the lowest Front-End frequency of 4.5 GHz, the filter attenuation is negligible and at the highest Front-End frequency of 5.2 GHz, the attenuation is about 12 dB. The resultant mixer LO port to mixer LO port isolation for RF frequencies outside the Front-End band is roughly 110 dB.

The typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch at 4.8 GHz is about 83 dB.

VSWR's

The input VSWR, about 1.25:1, is the composite of the VSWR's of the transfer switch (1.25:1) and isolator (1.18:1) The output VSWR is the composite VSWR of the Amp/Divider which is about 1.5:1.

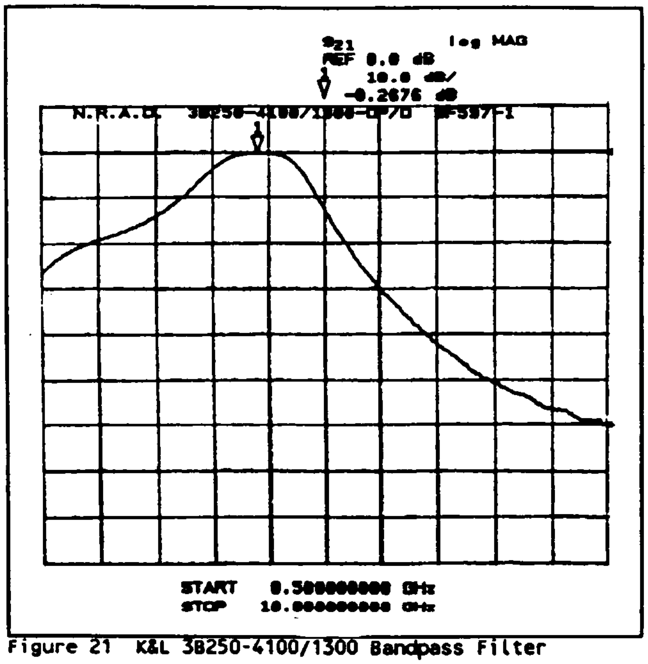


Figure 21 K&L 3B250-4100/1300 Bandpass Filter

RF Path Losses

The losses in the RF input path are the insertion losses of the transfer switch, 0.1 dB and the isolator 0.4 dB.

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

The LO Drive Amplifier is a MITEQ AMF-2B-4156-18P amplifier that is a special-order adaption of the AMF-2B amplifier series for NRAO; the amplifier is characterized over the T105 4.1 to 5.6 Ghz LO frequency range. The gain is 15 dB and is flat over this band within ± 0.5 dB; the noise figure is about 3.3; maximum input and output VSWR is 1.9:1 and the 1 dB compression point is about 18.5 dB. During module alignment, the amplifier gain is adjusted to produce a +10 dBm drive to the AVANTEK DBX-72M-1 mixers. The gain is determined by the selection of the appropriate NARDA 4772-X pad. The LO amplifier gain procedure is described in Test I, LO Powr, Gain and Flatness, Section 2.7.

The LO isolation filter is a K&L 3B250-4100/1300; the attenuation curve is shown in Figure 21.

RF Switching

The T105 transfer switch S105A is an RLC SR-TC-R-D transfer switch; some T105's may use the Transco 710C701UU as an alternate unit. The transfer switch is driven by M102, address 14H, bit 0.

T105 Power Circuitry

All T105 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 1-4 where it is distributed to the amplifiers. The common returns for these devices are connected to a frame ground lug connected to P11-34 and P11-42. This ground is also the ground return for the +28 volt drive to the transfer switch.

The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

REVISIONS

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY	DATE
K. TATE	9-93
DESIGNED BY	DATE
APPROVED BY	DATE

C53500K002	BLOCK DIAG
D53500A003	ASSEMBLY
NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

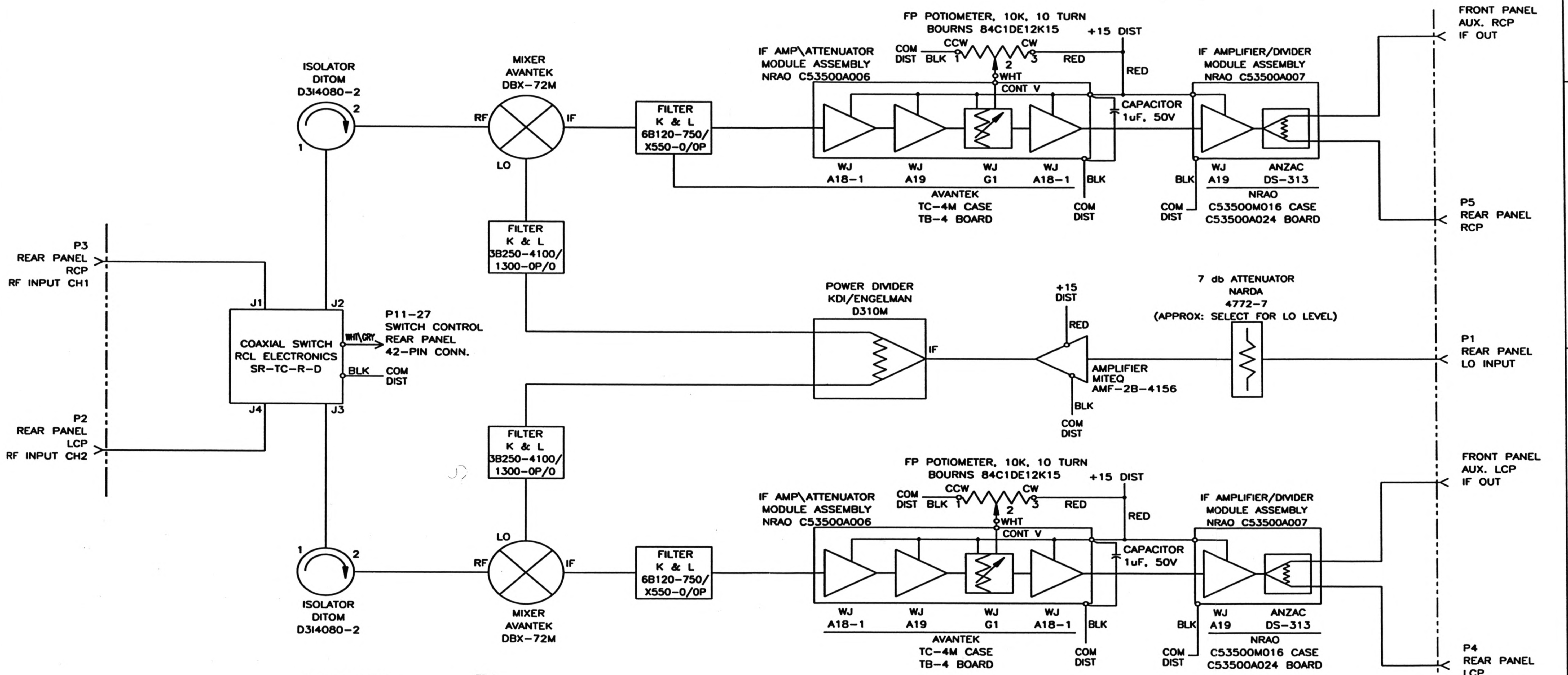
VLBA

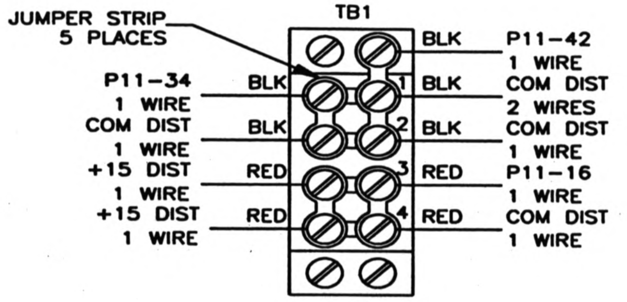
PROJECT T105 CONVERTER MODULE

TITLE T105 4.8 GHZ CONVERTER MODULE ASSEMBLY BOM

DWG NO. A53500B002 SHEET 1 OF 5

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-87	GM	ES	REVISED AND REDRAWN
B	12-87	GM	ES	REVISED CABLE LENGTHS
C	4-91	DGS	ES	CHG ORDER 910410-1
D	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
E	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS





ACAD : 53500K02

A53500B002	BOM
D53500A003	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T105 CONVERTER MODULE

TITLE T105
4.8 GHZ CONVERTER
MODULE BLOCK DIAGRAM

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K002
REV. E
SCALE NONE

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

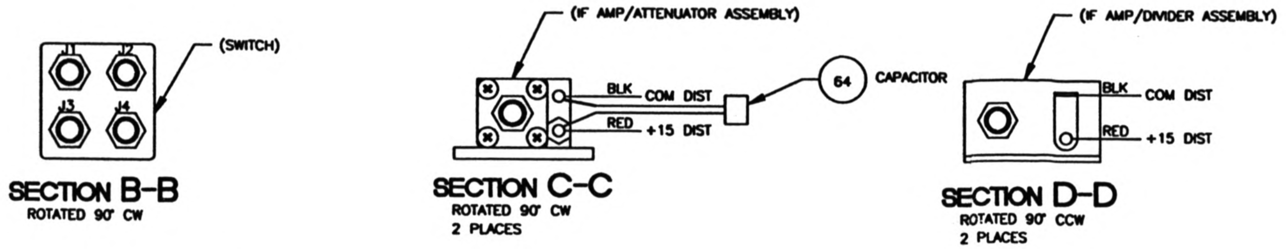
DRAWN BY BW — DATE 10-86
DESIGNED BY ES — DATE 10-86
APPROVED BY ES — DATE 10-86

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	1-87	GM		MINOR REVISIONS
C	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS

NOTES:

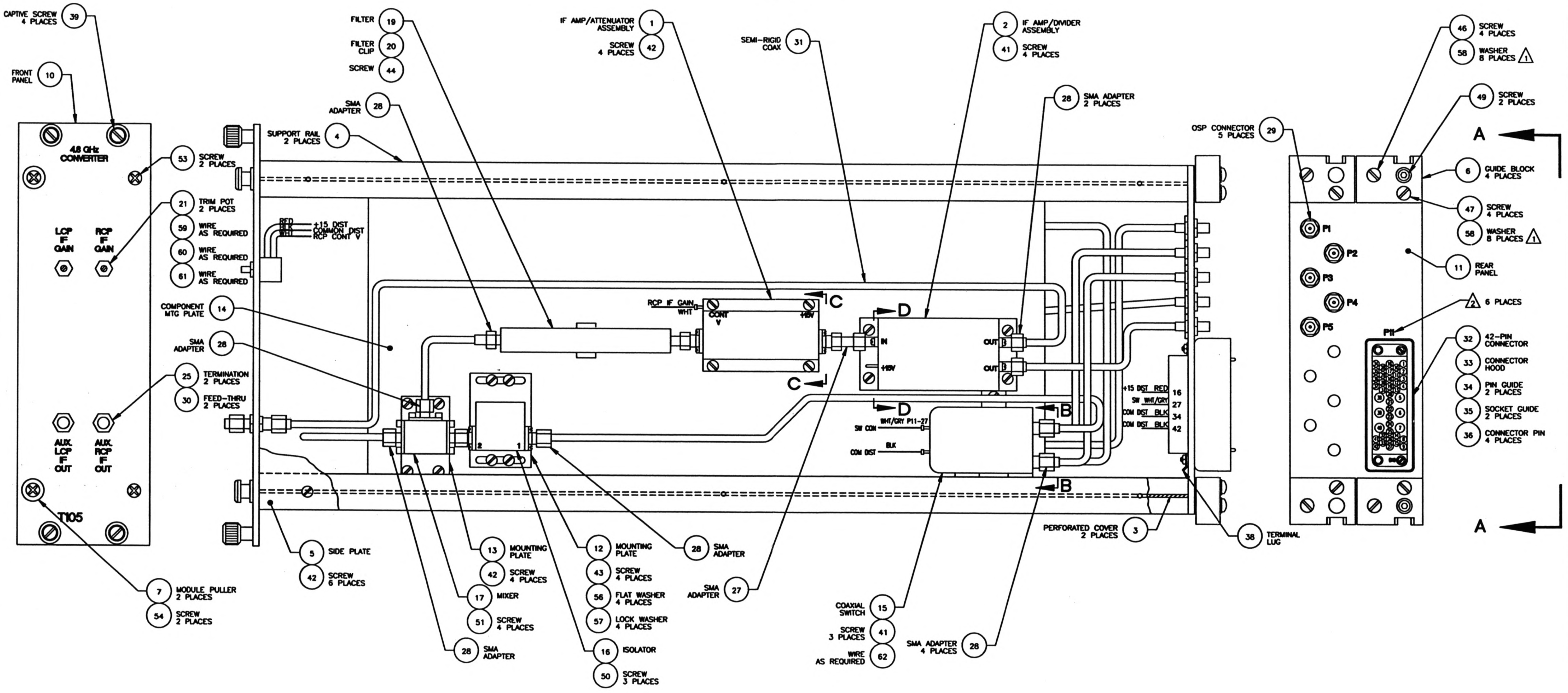
1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 11) AND GUIDE BLOCK (ITEM 6)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



SECTION B-B
ROTATED 90° CW

SECTION C-C
ROTATED 90° CW
2 PLACES

SECTION D-D
ROTATED 90° CCW
2 PLACES



T105 ASSEMBLY - RCP SIDE

ACAD : 53500A3A

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

NEXT ASSEMBLY	DWG. TYPE
C53500K002	BLOCK DIAG
A53500B002	BOM

VLBA PROJECT T105 CONVERTER MODULE

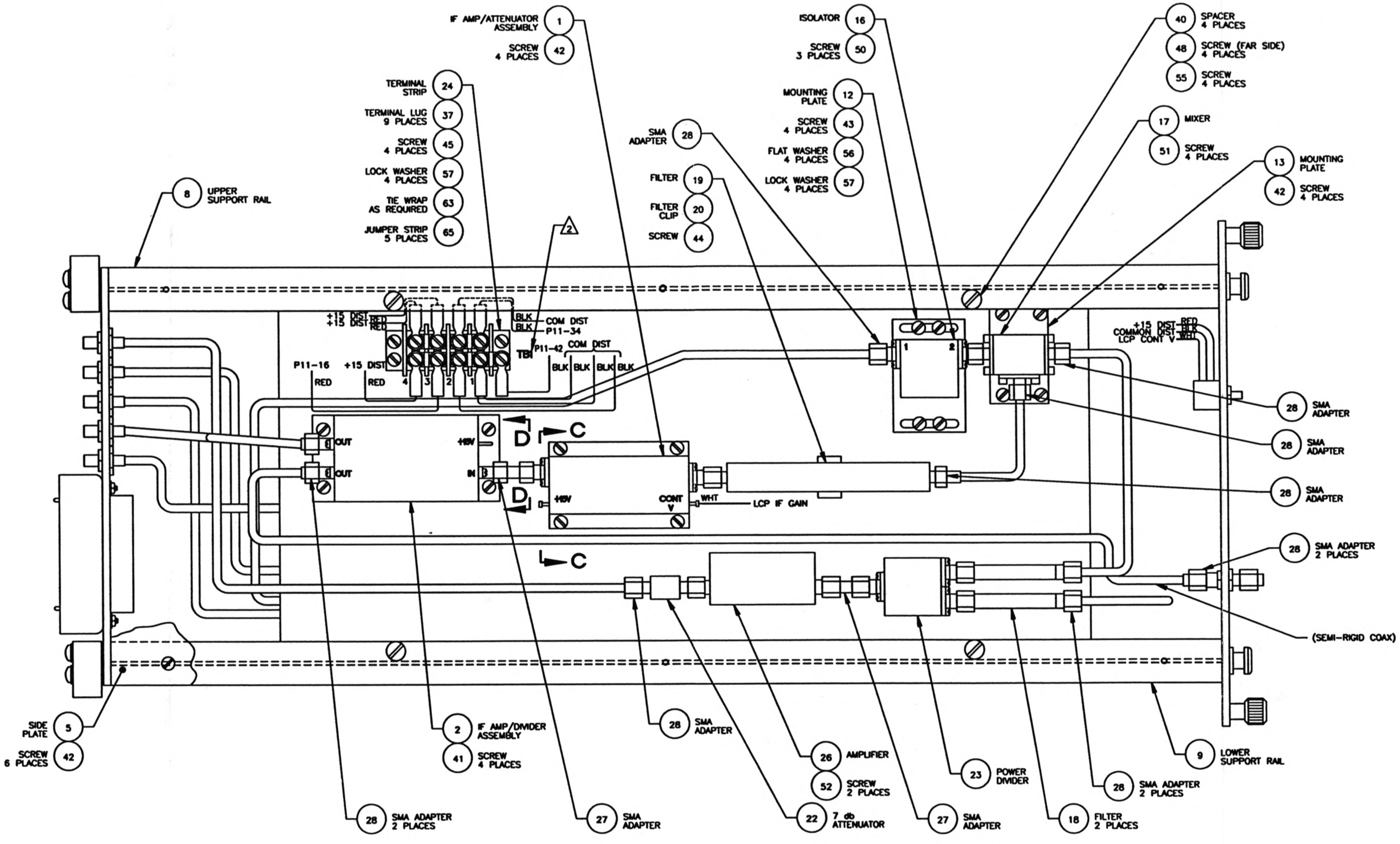
TITLE T105 4.8 GHZ CONVERTER MODULE ASSEMBLY

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY G. MORRIS DATE 1/87
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 2 DRAWING NUMBER D53500A003 REV. C SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



VIEW A-A

LCP SIDE

ACAD : 53500A3B

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

C53500K002	BLOCK DIAG
A53500B002	BOM
NEXT ASSEMBLY	DWG. TYPE

VLBA PROJECT T105
CONVERTER MODULE

TITLE T105
4.8 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY G. MORRIS DATE 1/87
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 2 OF 2
DRAWING NUMBER D53500A003
REV. C
SCALE 1/1

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B002 REV B DATE 9-20-93 PAGE 2 OF 5

MODULE T105 NAME 4.8 GHZ CONVERTER DWG# D53500A003 SUB ASSY ____ DWG# ____

SCHEM. DWG# C53500K002 LOCATION ____ QUA/SYS. ____ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53306M014-1	COVER, PERFORATED	2
4		NRAO	C53306M016	RAIL, SUPPORT	2
5		NRAO	C53306M017	PLATE, SIDE	2
6		NRAO	B53306M018	BLOCK, GUIDE	4
7		NRAO	A53306M038	PULLER, MODULE	2
8		NRAO	B53500M001	RAIL, UPPER	1
9		NRAO	B53500M002	RAIL, LOWER	1
10		NRAO	B53500M003	PANEL, FRONT	1
11		NRAO	B53500M004-1	PANEL, REAR	1
12		NRAO	A53500M008-2	PLATE, ISOLATOR MOUNTING	2
13		NRAO	A53500M009	PLATE, MIXER MOUNTING	2
14		NRAO	D53500M024	PLATE, COMPONENT MOUNTING	1
15		RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
16		DITOM	DI4080-2	ISOLATOR	2
17		AVANTEK	DBX-72M	MIXER	2
18		K & L	3B250-4100/1300-00/0	FILTER	2
19		K & L	6B120-750/X550-0/OP	FILTER	2
20		K & L	M12-A	CLIP, FILTER	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B002 REV B DATE 9-20-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2
22		NARDA	4772-7	ATTENUATOR, 7 db	1
23		KDI/ENGLEMAN	D310M	DIVIDER, POWER	1
24	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
25		SOLITRON	8018-6005	TERMINATION, 50Ω	2
26		MITEQ	AMF-2B-4156	AMPLIFIER	1
27		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	3
28		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 TUBE	21
29	P1 - P5	OMNI-SPECTRA	4503-7941-00	CONNECTOR, OSP .141 MALE	5
30		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
31		PRECISION TUBE	AA50141	COAX, .141. SEMI-RIGID	AR
32	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
33		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
34		AMP	200833-2	PIN, GUIDE	2
35		AMP	203964-5	SOCKET, GUIDE	2
36		AMP	201578-1	PIN, 16 GA. CONNECTOR	4
37		ETC/MOLEX	AA-832-06	LUG, TERMINAL	9
38				LUG, TERMINAL	1
39		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
40		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4
41				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	11

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B002 REV B DATE 9-20-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	28
43				SCREW, PAN HEAD, SS, 4-40UNC-2A x .31	8
44				SCREW, PAN HEAD, SS, 6-32UNC-2A x .25	2
45				SCREW, PAN HEAD, SS, 6-32UNC-2A x .38	4
46				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
47				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
48				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
49				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
50				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	6
51				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .38	8
52				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	2
53				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
54				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
55				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B002 REV B DATE 9-20-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
56				WASHER, FLAT #4	8
57				WASHER, LOCK #4	12
58				WASHER, EXT. TOOTH #6	16
59		ALPHA	7055	WIRE, WHT #22	AR
60		ALPHA	7055	WIRE, BLK #22	AR
61		ALPHA	7055	WIRE, RED #22	AR
62		ALPHA	7055	WIRE, BLK/GRY #22	AR
63				WRAP, TIE	AR
64		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	2
65	TB1	TRW-CINCH	140J-1	STRIP, JUMPER	5
66					
67					
68					
69					
70					
71					
72					
73					
74					
75					
76					

AVANTEK

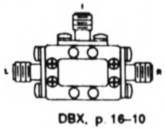
DBX–72L/M/H
DBY–72L/M/H
Duroid Mixer
2 to 7 GHz Double Balanced

FEATURES

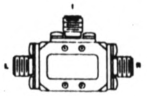
- Single Schottky Diode Quad
- 5.5 dB Conversion Loss
- 35 dB Isolation
- Low VSWR

APPLICATIONS

- Ideal for 2 to 6 GHz and 3.7 to 4.2 GHz Downconversion
- Threat Warning Systems
- Self Protection Jammers
- Wideband Heterodyned Receivers



DBX, p. 16–10



DBY, p. 16–11

DESCRIPTION

The DBX/DBY Series uses precisely matched Schottky-barrier diodes and a "quasi-planar" physical construction for excellent overall symmetry. Construction techniques result in high LO to RF isolation, extremely low single tone intermodulation distortion and very good amplitude and phase match characteristics.

ELECTRICAL SPECIFICATIONS (Measured in a 50-ohm system)

Symbol	Characteristic	Operating Frequencies GHz			Power Level			Specifications		Unit
		f_{LO}	f_{RF}	f_{IF}	LO Port dBm (typ)	Model Suffix	RF Port dBm	Typical $T_c = 25°C$	Guaranteed $T_c = -55°$ to $+100°C$	
BW	Operating Frequency Range	2.0–7.0	2.0–7.0	DC–1.5						GHz
CL	SSB Conversion Loss	2.0–7.0 2.0–7.0 2.0–7.0	2.0–7.0 2.0–7.0 2.0–7.0	DC–0.5 DC-1.2 DC–1.5				5.5 6.5 7.5	7.5 8.6 9.5	dB max
NF	SSB Noise Figure	2.0–7.0 2.0–7.0 2.0–7.0	2.0–7.0 2.0–7.0 2.0–7.0	0.03–0.5 0.03–1.2 0.03–1.5				5.5 6.5 7.5	7.5 8.5 9.5	dB max
ISOL	Isolation Port-to-Port L–R L–R R–L R–I L–I	2.0–3.0 3.0–7.0 — — 2.0–7.0	— — 2.0–7.0 2.0–7.0 —	— — — — —				25 35 35 20 25	20 25 — — 20	dB min
—	VSWR (50 ohm) L R R R I	2.0–7.0 4.0–7.0 2.0–3.0 3.0–4.0 —	— — — — —	— — — — ≤1.5				1.7:1 1.5:1 3.0:1 2.0:1 1.5:1		max
CC	Conversion Compression Point (1 dB)	2.0–7.0 2.0–7.0 2.0–7.0	2.0–7.0 2.0–7.0 2.0–7.0	≤1.5 ≤1.5 ≤1.5	≥+ 7 ≥+10 ≥+17	L M H		+ 2 + 6 +12		dBm typ
IP_3	Third-Order Two-Tone Intercept Point	2.0–7.0 2.0–7.0 2.0–7.0 2.0–7.0	2.0–7.0 2.0–7.0 2.0–7.0 2.0–7.0	≤1.5 ≤1.5 ≤1.5 ≤1.5	≥+ 7 ≥+10 ≥+17 ≥+20	L L M H	— — — —	+ 9 +10 +12 +22	— — — —	dBm typ
—	LO Port Drive Level (typical)	2.0–7.0 2.0–7.0 2.0–7.0	2.0–7.0 2.0–7.0 2.0–7.0	DC–1.5 DC–1.5 DC–1.5	+ 7→+13 +10→+17 +17→+24	L M H				dBm

NOTE Specifications guaranteed at LO Power of +7 dBm for " model, +10 dBm for "M" model, and +17 dBm for "H" model.

MAXIMUM RATINGS

Peak Input Current @ 25°C	100 mA DC
Pin Temperature	260°C for 10 seconds
Operating Case Temperature	–55°C to +100°C
Storage Temperature	–65°C to +100°C
Continuous RF Input Power	200 mW @ +25°C 100 mW @ +100°C

WEIGHT: (typical) DBX — 22 grams; DBY — 16 grams (with connectors)

TYPICAL PERFORMANCE AT 25° C

Typical Single Tone Intermodulation Harmonic Suppression at 25°C (dB below desired output)

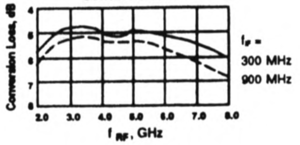
Harmonics of f_{RF}				
4	>70	>70	>70	>70
3	65	>70	55	>70
2	50	55	50	58
1	0	25	18	40
	1	2	3	4

Harmonics of f_{LO}

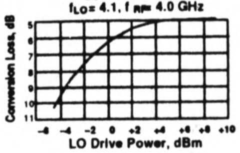
Typical Harmonic Intermodulation Suppression for mixer generated harmonics of the input signals. Suppression numbers are for a f_{RF} signal level at –10 dBm and f_{LO} signal level of:

L Suffix	+7 dBm
M Suffix	+10 dBm
H Suffix	+17 dBm

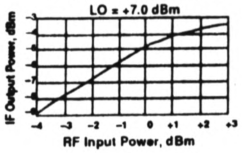
Conversion Loss



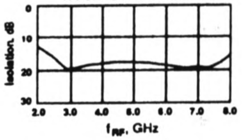
Conversion Loss
fLO= 4.1, f RF= 4.0 GHz



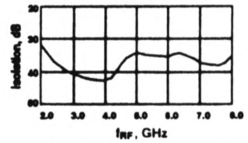
IF Output vs. RF Input Level
LO = +7.0 dBm



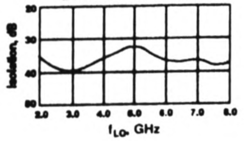
R Port to I Port Isolation



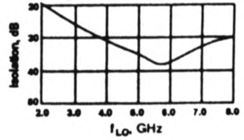
R Port to L Port Isolation



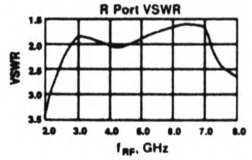
L Port to R Port Isolation



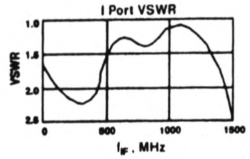
L Port to I Port Isolation



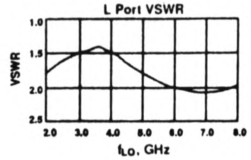
R Port VSWR



I Port VSWR



L Port VSWR



Wideband Medium Power Amplifiers

MITEQ

Model Number	Freq. (GHz)	Gain (Min.) (dB)	Gain Var. (Max.) (±dB)	Noise Figure (Max.) (dB)	VSWR (Max.)		Dynamic Range 1 dB Gain Comp. Output (Min., dBm)	Nom. DC Power (+15V, mA)	Outline
					Input	Output			
Standard Housings									
2-4 GHz									
AMF-1B-2040-17P	2-4	10	1.0	5.0	2:1	2:1	+17	90	8
AMF-2B-2040-17P	2-4	20	1.0	4.0	2:1	2:1	+17	140	9
AMF-3B-2040-17P	2-4	30	1.0	3.5	2:1	2:1	+17	180	10
AMF-4B-2040-17P	2-4	40	1.5	3.5	2:1	2:1	+17	220	11
AMF-1B-2040-20P	2-4	10	1.0	6.0	2:1	2:1	+20	130	8
AMF-2B-2040-20P	2-4	20	1.0	5.0	2:1	2:1	+20	210	9
AMF-3B-2040-20P	2-4	30	1.0	4.0	2:1	2:1	+20	260	10
AMF-4B-2040-20P	2-4	40	1.5	4.0	2:1	2:1	+20	300	11
AMF-1B-2040-23P	2-4	10	1.0	8.0	2:1	2:1	+23	190	96
AMF-2B-2040-23P	2-4	20	1.0	8.0	2:1	2:1	+23	310	97
AMF-3B-2040-23P	2-4	30	1.5	6.0	2:1	2:1	+23	390	98
AMF-4B-2040-23P	2-4	40	1.5	6.0	2:1	2:1	+23	440	99
AMF-1B-2040-25P	2-4	8	1.0	8.0	2:1	2:1	+25	300	96
AMF-2B-2040-25P	2-4	17	1.0	8.0	2:1	2:1	+25	480	97
AMF-3B-2040-25P	2-4	27	1.5	6.0	2:1	2:1	+25	600	98
AMF-4B-2040-25P	2-4	37	1.5	6.0	2:1	2:1	+25	680	99
AMF-1B-2040-27P	2-4	7	1.0	8.0	2:1	2:1	+27	600	96
AMF-2B-2040-27P	2-4	15	1.0	8.0	2:1	2:1	+27	900	97
AMF-3B-2040-27P	2-4	24	1.5	6.0	2:1	2:1	+27	1080	98
AMF-4B-2040-27P	2-4	33	1.5	6.0	2:1	2:1	+27	1200	99
4-8 GHz									
AMF-2B-4080-17P	4-8	16	1.0	6.0	2:1	2:1	+17	90	14
AMF-3B-4080-17P	4-8	24	1.0	5.0	2:1	2:1	+17	140	15
AMF-4B-4080-17P	4-8	32	1.5	5.0	2:1	2:1	+17	180	16
AMF-5B-4080-17P	4-8	40	1.5	5.0	2:1	2:1	+17	220	17
AMF-2B-4080-20P	4-8	15	1.0	7.0	2:1	2:1	+20	130	14
AMF-3B-4080-20P	4-8	23	1.0	6.0	2:1	2:1	+20	210	15
AMF-4B-4080-20P	4-8	31	1.5	6.0	2:1	2:1	+20	260	16
AMF-5B-4080-20P	4-8	39	1.5	6.0	2:1	2:1	+20	300	17

3.6 T106, 8.4/23 GHz CONVERTER MODULE

T106 Modes, LO Frequencies and Band Coverage

This section describes T106, the 8.4/23 GHz converter. T106 is more complicated than most of the other converters because it operates in three modes as a function of the state of four switches and the frequencies of two separate LO signals. The 8.4 GHz and 23 GHz Front-End's output signals are both in the neighborhood of 8 GHz, which permits a single set of conversion circuitry to convert the two Front-End signals to the standard 500 to 1000 MHz IF signals. Although T106's three-mode operation is the reason for the complexity, the modes are implemented with simple RF signal selection circuitry and the frequency conversion function is identical to that of the other converters.

The 8.4 GHz Front-End does not have bandpass filters. This function is incorporated in the 8.4 GHz RF circuitry which has K&L 6FV-8400/X960 bandpass filters with an 8400 MHz center frequency and a 1 dB bandwidth of 960 MHz. As is the case with the other VLBA K&L filters, the X supplemental code indicates that the bandwidth is defined at the -1 dB points. The 8.4 GHz signal spectrum is 7.92 to 8.88 GHz.

The first mode is conversion of the 8.4 GHz Front-End RCP and LCP outputs. A single LO signal is used and the conversion function is identical to the other converters because it produces the standard 500 MHz bandwidth RCP IF and LCP IF signals. This mode uses LO frequencies of 7.4, 7.6, 9.1 and 9.4 GHz. The following tabulation shows the mixer IF port spectrum, converted and attenuated bands. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The IF port frequencies are in MHz, the others in GHz.

LO Freq	Mixer IF Port	Converted	Attenuated
7.4	520 to 1400	7.92 to 8.4	8.4 to 8.8
7.6	320 to 1200	8.1 to 8.6	7.92 to 8.1 8.6 to 8.8
9.1	300 to 1180	8.1 to 8.6	7.92 to 8.1 8.1 to 8.8
9.4	600 to 1480	8.4 to 8.8	7.92 to 8.4

The IF spectrum is reversed when the 9.1 and 9.4 GHz LO frequencies are used.

The second mode is conversion of the RCP (only) output of the 8.4 GHz Front-End using two separate LO signals. This mode permits simultaneous conversion of the full 1 GHz RCP signal bandwidth from the 8.4 GHz Front-End. This mode produces two standard 500 MHz bandwidth RCP IF signals, one for each half of the RF input spectrum. LO frequencies used in this mode are 7.4 and 9.4 GHz (only). The table above shows the IF port spectrum, converted and attenuated bands for these two LO frequencies.

The third mode is conversion of a first IF signal from the 23 GHz Front-End to the Standard 500 MHz bandwidth RCP and LCP IF signals. Refer to the LO Frequency table in Section 6 which shows the first and second (T106) LO frequencies and the 23 GHz Front-End band coverage. A single T106 LO signal (Synthesizer #1) is used and the conversion function is also identical to the other converters. A mixer in the 23 GHz Front-End converts the 23 GHz signal to a first IF signal that is filtered by a 9750/X900 bandpass filter and output to T106. The first IF spectrum at the -1 dB frequencies is 9.3 to 10.2 GHz. Synthesizer #3 provides the LO signal for this conversion. Since these filters are in the Front-End, T106's RF circuitry does not contain bandpass filters for the first IF signal. Two T106 LO frequencies are used in this mode, 8.9 and 9.1 GHz. In conjunction with the appropriate T106 LO frequencies, Synthesizer #3 is adjusted in 200 and 300 MHz steps to cover the 23 GHz Front-End's output spectrum.

The mode 3 second LO (T106) frequencies, mixer IF port spectrum, converted and attenuated bands are tabulated below. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The mixer IF port frequencies are in MHz, the converted and attenuated in GHz.

T106 LO Freq	Mixer IF Port	Converted	Attenuated
8.9	400 to 1300	9.4 to 9.9	9.3 to 9.4 9.9 to 10.2
9.1	200 to 1100	9.6 to 10.1	9.3 to 9.6 9.6 to 10.2

T106 Size and Location

T106 is a double-width module located in Rack B, Bin A, Slots 4-5.

T106 Drawings and Data Sheets

The following T106 functional and assembly drawings are found at the end of this section.

C53500K009, Rev E - T106 8.4/23 GHz Converter Module Block Diagram
D53500A010, Rev F - T106 8.4/23 GHz Converter Module Assembly
A53500B005, Rev B - T106 8.4/23 GHz Converter Module Assembly BOM

C53500A009, Rev B - T106 8.4/23 GHz Converter Module IF Gain Relay Assembly
C53500A023, Rev B - T106 8.4/23 GHz Converter Module IF Gain Relay PCB Assembly

Data sheets for the Wj M77C mixer, Transco 909C70100 selector switch and Miteq AMF-2B-7494-15P amplifier follwo the drawings. Data sheets for the Ditom D3I-7011 isolator, Triangle YL-56 power divider and Narda 4772-X attenuator are included in the Appendix, Section 6.

T106 Specifications

Nominal Gain, dB	14	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+6	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	17,000	Noise Temp for 1% added Syst Noise, K	25,000	Nom LO Pwr input, dBm	+2
Avg Noise Figure, dB	17.7	Noise Figure for 1% added Syst Noise, dB	19.4		
15 Volt Power Req't, mA	750				

T106 Differences From the General Converter Block Diagram

T106 differs from the general converter block diagram of Section 2.1 as follows: 1) Two SPDT selector switches (S106A and S016B) select either the RF output of the 8.4 GHz Front-End or the first IF output of the 23 GHz Front-End. 2) T106 does not have an RCP-LCP transfer switch to interchange the selected RCP and LCP RF inputs for test purposes. 3) A selector switch (S106D) permits selection of the LCP inputs (8.4 GHz or 23 GHz first IF) or the RCP inputs (8.4 GHz or 23 GHz first IF) for conversion by the LCP mixer. 4) A second LO drive circuit is provided to drive the LCP mixer when the RCP-only signals are selected for conversion. The single-dual LO signals are selected by S106E. 5) In conjunction with the opreration of the 8.4 GHz/23 GHz first IF selector switches, a DPDT IF Gain Relay Assembly switches the Amp/Attenuator control voltages between the outputs of two sets of front panel gain potentiometers. 6) 8.4 GHz bandpass filters are not included in the RF circuitry because these filters are installed in the 8.4 GHz Front-End.

Although VLBA Technical Report No. 15 (Rev A) does not mention a possible fourth mode, dual LO, RCP (only) conversion of the 23 GHz Front-End's first IF output is possible. This mode is established by setting the switches to the proper state and providing a second LO signal of the appropriate frequency.

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. In mode 1, Image bands are attenuated by T106's K&L 6FV-8400/X960 bandpass filters. In mode 3, the image band is attenated by the 23 GHz Front-End's 9750/X900 bandpass filters. The following tabulation shows the LO frequency, unwanted (UWSB) and image sidebands in GHz.

MODES 1 and 2

T106 LO Freq	UWSB	UWSB Attn	Image
7.4	15.32 to 16.2	»70	6.4 to 6.9
7.6	15.52 to 16.4	»70	6.6 to 7.1
9.1	17.02 to 17.9	»70	9.6 to 10.1
9.4	17.32 to 18.2	»70	9.9 to 10.4

MODE 3

T106 LO Freq	UWSB	UWSB Attn	Image
8.9	18.2 to 19.1	»70	7.9 to 8.4
9.1	18.4 to 19.3	»70	8.1 to 8.6

In mode 1, the worst case unwanted sidebands result from the use of the 7.4 and 7.9 GHz LO frequencies. Refer to Figure 5; the attenuation of these unwanted sideband frequencies is off the bottom of the plot, greatly in excess of 70 dB.

In mode 2, the unwanted sidebands are the same as mode 1, consequently the unwanted sideband attenuation is identical to Mode 1.

In mode 3 the 23 GHz Front-End's first IF band is 9.4 to 9.9 GHz. The IF filter attenuation for these unwanted sidebands is greatly in excess of 70 dB.

Noise Temperature

The T106 noise temperature is a composite value that is a function of the noise temperatures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 17,000 K. A T160 noise temperature of 25,000 K would add 1 K to the system temperature.

Mixer

The WJ M77C is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO frequencies of 7.0 to 15.0 GHz, RF frequencies of 8.0 to 12.5 GHz, IF frequencies of DC to 2500 MHz and a nominal LO drive of +10 dBm. At the 8.4 GHz conversion frequency, the typical conversion loss is 5.0 dB and the typical noise figure is 7.0 dB.

RCP-LCP Isolation

Despite T106's more complex switching structure, the RCP-LCP isolation is a function of the isolation properties of two shunt paths: the isolation between the two mixer LO ports and the RCP-LCP selector switch leakage. K&L 2FV-8400/2400 bandpass filters (attenuation curve on page 76) in the LO path provides additional out-of-band isolation to the mixer LO ports. Although there is no RCP-LCP transfer switch, the RCP-LCP selector switch leakage is a shunt leakage path. Both these paths are a bit more complicated than the corresponding paths in the other mixers. From the table above, the module's specified RCP-LCP path isolation is 65 dB.

At 8.4 GHz, the typical RCP-LCP path isolation of the RLC SRC-TC-R-D selector switch is about 78 dB. The Triangle YL-56 power divider adds 19 dB of port-to-port isolation to this shunt path so the resultant isolation is about 97 dB.

The WJ M77C mixer's typical LO to RF isolation is 35 dB and the LO to IF isolation is also 35 dB. The Triangle YL-56 power divider port-to-port isolation is 19 dB. Over the 7.4 to 10.4 GHz range of LO frequencies, the isolation of this shunt path is the sum of the two mixer LO port's to RF port isolation and the divider's isolation; this is 89 dB. The filter's insertion loss is about 0.25 dB for frequencies in the 2500 MHz passband; for frequencies outside the passband, the isolation is increased by the filter's attenuation. At frequencies of 5900 and 10900 (± 1 bandwidth from center frequency) the filter's attenuation is 15 dB and 22 dB, respectively. At these two frequencies the isolation increases to 104 and 111 dB, respectively.

Isolation Between the 8.4 Ghz and 23 GHz Front-End Inputs

Two Transco 909C70100 SPDT coaxial selector switches (S106A and S106B)select the outputs of either the 8.4 GHz Front-End or the first IF output of the 23 GHz Front-End for conversion. Since the frequencies of these two signals are similar, switch isolation is an important consideration because the coupling between the unselected signals and selected signals should be very small. At 8 GHz the switch's isolation between inputs is typically 90 dB.

VSWR's

In modes 1 and 2, (8.4 GHz) the input VSWR, about 1.5:1, is the composite of the DITOM D3I-7011 isolator (1.18:1), the K&L 6FV-8400/X960 bandpass filter (1.5:1) and the Transco 909C70100 selector switch (1.1:1).

In mode 3, the (23 GHz mode) the input VSWR, about 1.2:1 is the composite of the DITOM D3I-7011 isolator (1.18:1) and the Transco 909C70100 selector switch (1.1:1).

The output VSWR, about 1.5:1 is the composite VSWR of the Amp/Divider which is 1.5:1. 12/10

RF Input Circuitry

Since T106 has inputs from two Front-Ends that are selected by Transco 909C70100 switches and an RCP-LCP selector switch (an RLC SR-TC-R-D), it differs from the RF circuitry of the general converter block diagram of Section 2.1. In addition, the RCP and LCP RF circuits are not identical as in the generic converter. In contrast to 8.4 GHz inputs, the 23 GHz first IF inputs to the selector switches do not have isolators or bandpass filters. The selector switch outputs have a second DITOM D3I 17011 isolator to minimize reflections back to the 23 GHz Front-Ends in mode 3 (i.e. when the 23 GHz first IF is selected).

The bandwidth of the input from the 8.4 GHz Front-End is determined by the K&L 6FV-844/X960 bandpass filter. The center frequency is 8.4 GHz, the 1 dB bandwidth is 960 MHz and the center-frequency insertion loss is 0.25 dB. The next page has a plot of the filter's attenuation.

The Triangle Microwave YL-56 two way power divider evenly divides the RCP signal into two components that drive the mixers. The divider's LCP output is input to the LCP mixer in mode 2 via the RCP-LCP selector switch. The YL-56 outputs are 3 dB below the splitter input so a 3 dB attenuator (Narda 4778-3) reduces the LCP RF signal level from the LCP selector switch to equalize the two path losses in mode 1. The insertion loss of the

YL-56 is 0.6 dB. The 50 Ohm termination on J3 of the RCP-LCP selector switch terminates the power divider's LCP output in mode 1.

At this point in mode 1, the 8.4 GHz inputs to the Watkins-Johnsom M77C have been reduced from T106's input levels by the insertion losses of the two isolators (0.35 dB each), the 8.4 GHz filter (0.25 dB), the selector switch (0.15 dB), the RCP-LCP selector switch (0.1 dB) and the divider (0.6 dB). The power level is further reduced by the LCP path attenuator (3 dB) and the RCP path power divider (3 dB). The values cited are all typical and the total attenuation in this mode is about 4.8 dB. The mode 2 RF circuit losses to the mixier are identical to those of mode 1 while the mode 3 (23 GHz) losses to the mixer are about 4.2 dB because one isolator and the filter have been omitted from the path.

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

A DPDT IF Gain Relay Assembly C53500A009 selects either the 8.4 GHz (modes 1 and 2) or the 23 GHz (mode 3) front panel gain control potentiometers for control of the Amp/Attenuator gain. The 28 volt relay assembly is driven by L107, address 0A, bit 6 via P11-24. The IF Relay Assembly drawing is included in Section 2.5.

LO Drive Circuitry

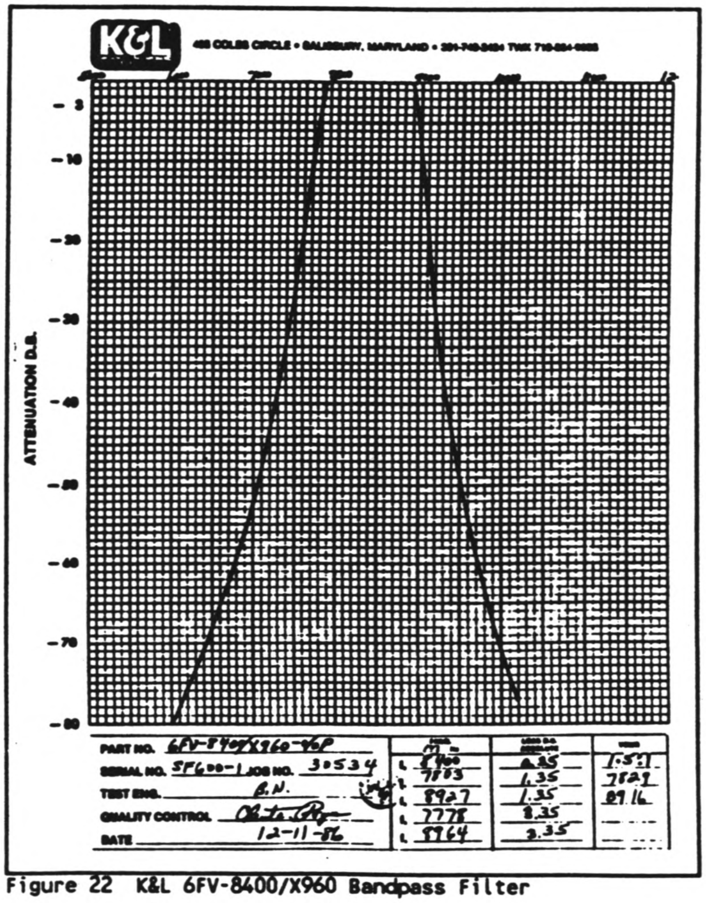
The LO drive circuitry also differs from that of the general converter of Section 2.1 because it has a second LO drive amplifier to drive the LCP mixer through an RLC SR-TC-R-D LO selector switch. This second LO drive is used in mode 2.

In modes 1 and 3, the J10 LO input drives the mixer's LO ports via a MITEQ AMF-2B-7494 amplifier, a Triangle Microwave YL-56 two-way power divider, the J3-J4 contacts of the LO selector switch and the K&L 2FV-8400/2500 bandpass filters.

In mode 2, the J9 LO input drives the LCP mixer's LO port via the second MITEQ AMF-2B-7494 amplifier, the J2-J4 contacts of the LO selector switch and the LCP 8400/2500 bandpass filter.

The 50 Ohm termination on the LO selector switch J1 terminates the second LO amplifier in mode 1 and terminates the LCP port of the LO power divider in mode 2.

The LO amplifiers are MITEQ AMF-2B-7494-15P amplifiers, identical to those used in T110. During the T106 design process, bench tests showed that this amplifier could also be used in T106 without degradation of performance so it was used in T106. This improves commonality between modules.



PART NO. 6FV-8400/X960-46P
SERIAL NO. SF600-1 JOB NO. 30534
TEST ENG. B.N.
QUALITY CONTROL
DATE 12-11-86

8400	.35	1.5:1
7883	1.35	7829
8927	1.35	89.16
7778	3.35	
8964	3.35	

Figure 22 K&L 6FV-8400/X960 Bandpass Filter

These amplifiers are a special order adaption of the AMF-2B amplifier series for NRAO. The amplifier is characterized over the 7.4 to 9.4 Ghz LO frequency range but operates satisfactorily at the 10.4 GHz frequency LO frequency of mode 3. The gain is 15 dB and is flat over this band within ± 0.5 dB; the noise figure is about 3.3; maximum input and output VSWR is 1.9 and the 1 dB compression point is about 18.5 dB. During module alignment, the amplifier gain is adjusted to produce a +10 dBm drive to the WJ M77C mixers. The gain is determined by the selection of the appropriate NARDA 4772-X pad. The LO amplifier gain procedure is described in Test I, LO Powr, Gain and Flatness, Section 2.7. A MITEQ test data sheet for this amplifier is included at the rear of this section.

The LO drive circuitry has K&L 2FV-8400/2500 bandpass filters in series with the drive to each mixer LO port. These filters have a center frequency of 8400 MHz, a 3 dB bandwidth of 2500 MHz and an insertion loss of 0.24 dB at the center frequency. Figure 23 shows the filter attenuation characteristics.

RF Switching

Two Transco 909C70100 SPDT selector switches (S106A and S016B) are used to select either Front-End input. At 8 GHz typical values are: VSWR - 1.1:1, insertion loss - 0.15 dB and the isolation is 90 dB. This switch is described in Section 2.5. A +28 volt input to terminal 1 (P11-24) will select the 23 GHz Front-End signal and a +28 volt input to terminal 2 (P11-25) will select the 8.4 GHz Front-End signal. The switch coil common is connected to the module common distribution.

This pair of switches is driven by L107, address 1DH, bits 0 and 1. Section 2.5 has data sheet for the Transco 909C70100 selector switch.

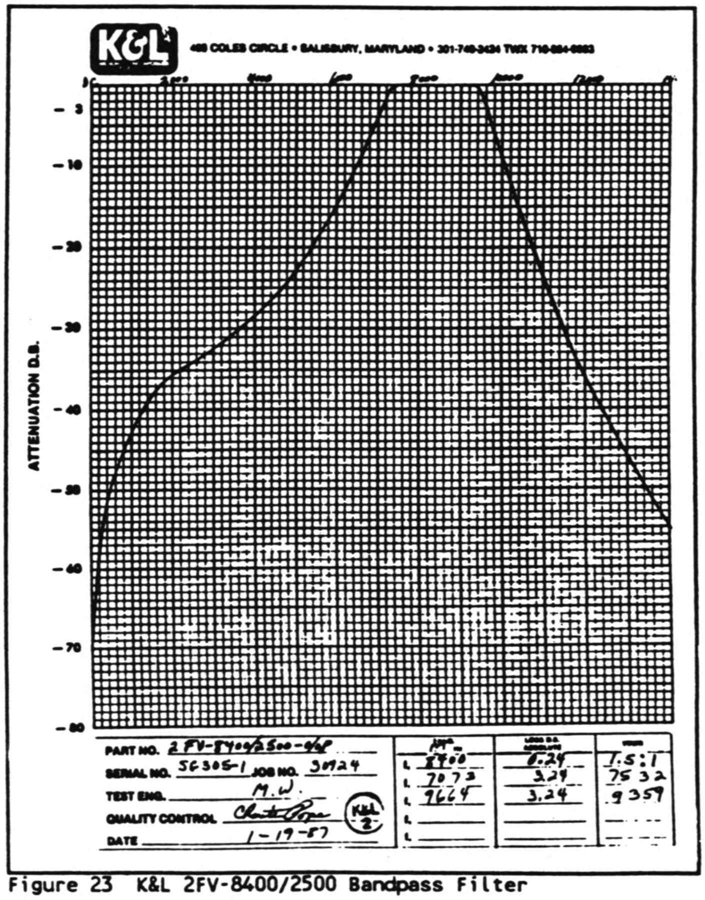
Two RLC SR-TC-R-D selector switches (the RLC data sheet calls the switch a transfer switch) are used as selector switches. This switch is typically used as a transfer switch but it can also be used as a selector switch as is the case in T106. This switch is a failsafe switch. The NC contacts are closed when the coil is not energized; applying +28 volts energizes the coil and closes the NO contacts.

The first switch, S106D, selects either the LCP signal from the 8.4/23 GHz selector switch (mode 3 is the 23 GHz case) or the RCP signal from the RCP selector switch (this case is mode 1) for input to the LCP mixer. This switch is connected to P11-27 (the standard transfer switch pin) and is driven by M102, address 15H, bit 0.

The second RLC SR-TC-R-D switch, S106E, is connected to P11-23 and is driven by L107, address 1EH, bit 0.

T106 does not have an RCP-LCP transfer switch.

Transco switch 710C70100 may be used as an alternate to the RLC switch. Section 2.5 has data sheets for the two switches.



PART NO. 2FV-8400/2500-4/P
SERIAL NO. 5G305-1 JOB NO. 30724
TEST ENG. M.W.
QUALITY CONTROL
DATE 1-19-87

8400	0.24	1.5:1
7073	3.24	7532
9664	3.24	9359

Figure 23 K&L 2FV-8400/2500 Bandpass Filter

T106 Power Circuitry

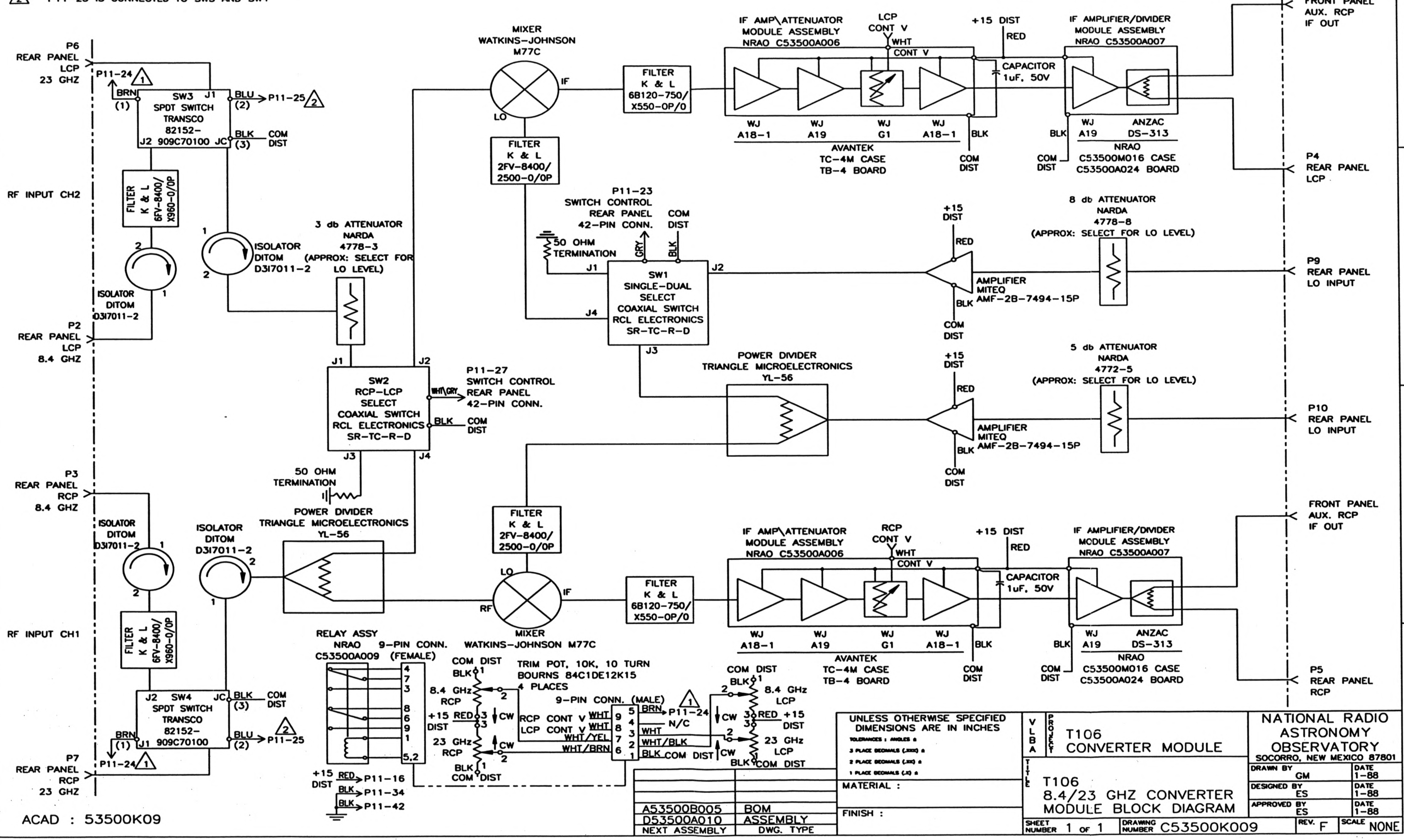
All T106 active components are powered by +15 volts. +15 volts from P11-16 is connected in a +15 distribution string to the amplifiers. The common returns for these devices are connected to a frame ground lug connected to P11-34 and P11-42. This ground is also the ground return for the +28 volt drive to the transfer switch.

The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
E	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
F	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS

NOTES:

1. P11-24 IS CONNECTED TO SW3, SW4, AND RELAY MODULE ASSY
2. P11-25 IS CONNECTED TO SW3 AND SW4



A53500B005	BOM
D53500A010	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA

PROJECT T106
CONVERTER MODULE

TITLE T106
8.4/23 GHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY GM	DATE 1-88
DESIGNED BY ES	DATE 1-88
APPROVED BY ES	DATE 1-88

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K009
REV. F
SCALE NONE

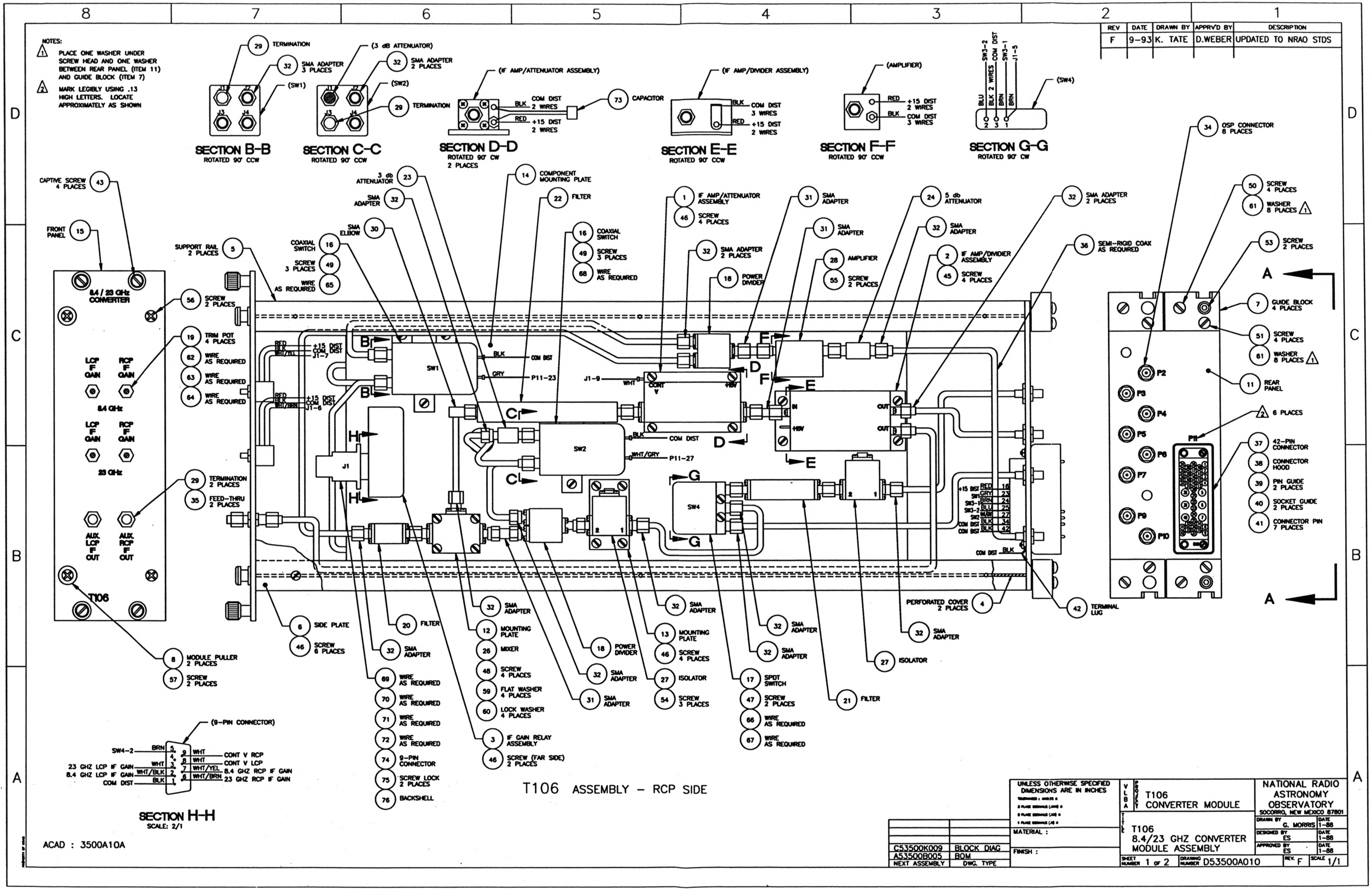
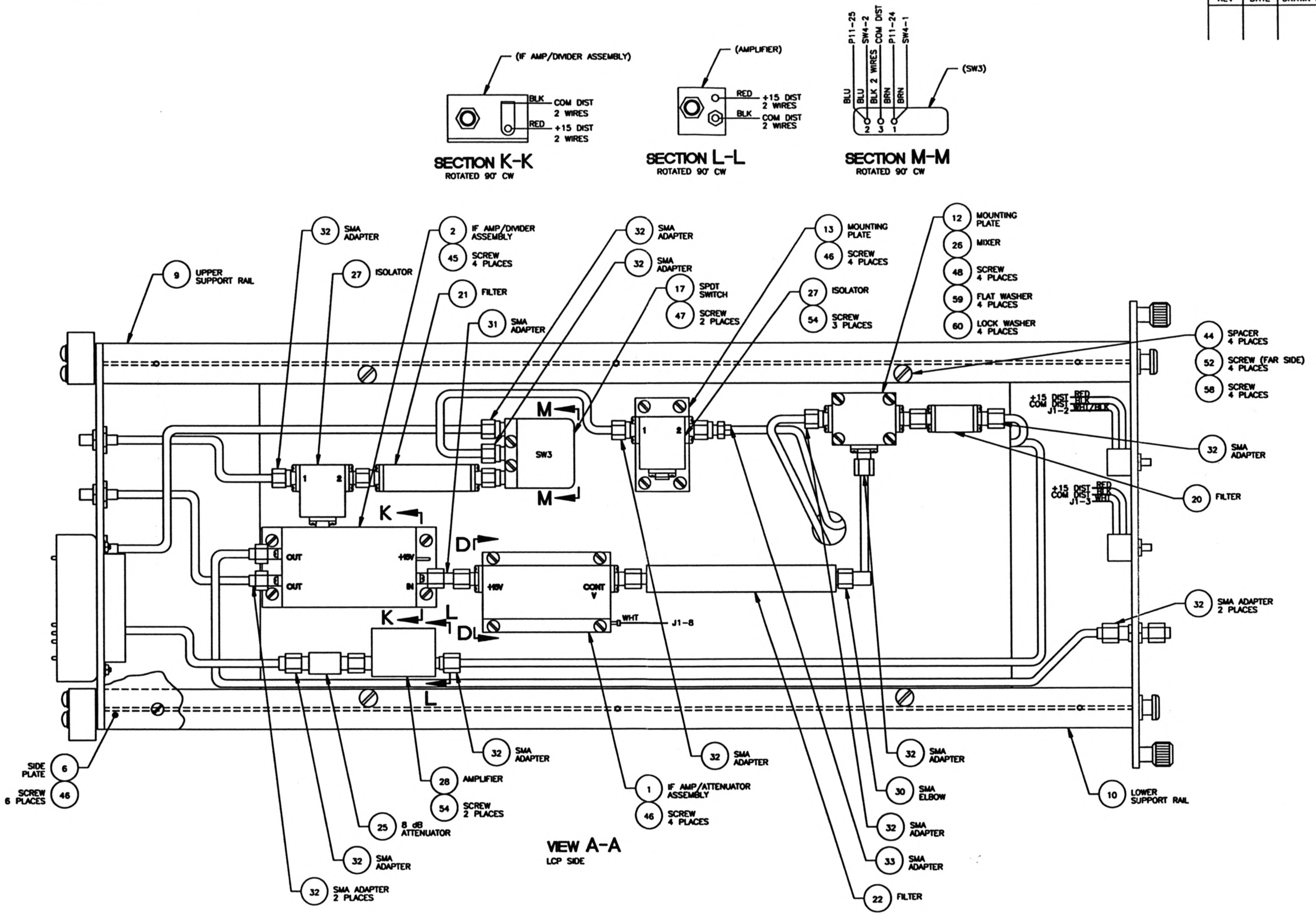

NOTES:
1 PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 11) AND GUIDE BLOCK (ITEM 7)
2 MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN
REV | DATE | DRAWN BY | APPRV'D BY | DESCRIPTION
F | 9-93 | K. TATE | D.WEBER | UPDATED TO NRAO STDS
29 TERMINATION
32 SMA ADAPTER 3 PLACES
(SW1)
J1 J2 J3 J4
SECTION B-B ROTATED 90° CCW
(3 dB ATTENUATOR)
32 SMA ADAPTER 2 PLACES
(SW2)
29 TERMINATION
SECTION C-C ROTATED 90° CCW
(IF AMP/ATTENUATOR ASSEMBLY)
BLK COM DIST 2 WIRES
RED +15 DIST 2 WIRES
73 CAPACITOR
SECTION D-D ROTATED 90° CW 2 PLACES
(IF AMP/DIVIDER ASSEMBLY)
BLK COM DIST 3 WIRES
RED +15 DIST 2 WIRES
SECTION E-E ROTATED 90° CCW
(AMPLIFIER)
RED +15 DIST 2 WIRES
BLK COM DIST 3 WIRES
SECTION F-F ROTATED 90° CCW
SW3-2 BLK 2 WIRES COM DIST SW3-1 J1-5
BLU BRN BRN
2 3 1
(SW4)
SECTION G-G ROTATED 90° CW
34 OSP CONNECTOR 8 PLACES
43 CAPTIVE SCREW 4 PLACES
15 FRONT PANEL
5 SUPPORT RAIL 2 PLACES
23 3 db ATTENUATOR
32 SMA ADAPTER
30 SMA ELBOW
16 COAXIAL SWITCH
49 SCREW 3 PLACES
65 WIRE AS REQUIRED
14 COMPONENT MOUNTING PLATE
22 FILTER
16 COAXIAL SWITCH
49 SCREW 3 PLACES
68 WIRE AS REQUIRED
1 IF AMP/ATTENUATOR ASSEMBLY
46 SCREW 4 PLACES
32 SMA ADAPTER 2 PLACES
18 POWER DIVIDER
31 SMA ADAPTER
31 SMA ADAPTER
28 AMPLIFIER
55 SCREW 2 PLACES
24 5 db ATTENUATOR
32 SMA ADAPTER
2 IF AMP/DIVIDER ASSEMBLY
45 SCREW 4 PLACES
32 SMA ADAPTER 2 PLACES
36 SEMI-RIGID COAX AS REQUIRED
50 SCREW 4 PLACES
61 WASHER 8 PLACES 1
53 SCREW 2 PLACES
A A
7 GUIDE BLOCK 4 PLACES
51 SCREW 4 PLACES
61 WASHER 8 PLACES 1
11 REAR PANEL
2 6 PLACES
P2 P3 P4 P5 P6 P7 P9 P10 P11
37 42-PIN CONNECTOR
38 CONNECTOR HOOD
39 PIN GUIDE 2 PLACES
40 SOCKET GUIDE 2 PLACES
41 CONNECTOR PIN 7 PLACES
8.4 / 23 GHz CONVERTER
LCP IF GAIN
RCP IF GAIN
8.4 GHz
23 GHz
AUX. LCP IF OUT
AUX. RCP IF OUT
T106
56 SCREW 2 PLACES
19 TRIM POT 4 PLACES
62 WIRE AS REQUIRED
63 WIRE AS REQUIRED
64 WIRE AS REQUIRED
29 TERMINATION 2 PLACES
35 FEED-THRU 2 PLACES
RED +15 DIST
BLK COM DIST
WHT/YEL J1-7
RED +15 DIST
BLK COM DIST
WHT/BRN J1-6
SW1
BLK COM DIST
GRY P11-23
J1-9 WHT CONT V +15V
SW2
BLK COM DIST
WHT/GRY P11-27
IN OUT OUT +15V
J1
H H
B B C C D D E E F F G G
SW4
+15 DIST RED 16
SW1 GRY 23
SW3-1 BRN 24
SW3-2 BLU 25
SW2 WH/GRY 27
COM DIST BLK 34
COM DIST BLK 42
COM DIST BLK
4 PERFORATED COVER 2 PLACES
42 TERMINAL LUG
8 MODULE PULLER 2 PLACES
57 SCREW 2 PLACES
6 SIDE PLATE
46 SCREW 6 PLACES
20 FILTER
32 SMA ADAPTER
32 SMA ADAPTER
12 MOUNTING PLATE
26 MIXER
48 SCREW 4 PLACES
59 FLAT WASHER 4 PLACES
60 LOCK WASHER 4 PLACES
18 POWER DIVIDER
32 SMA ADAPTER
31 SMA ADAPTER
32 SMA ADAPTER
13 MOUNTING PLATE
46 SCREW 4 PLACES
27 ISOLATOR
54 SCREW 3 PLACES
32 SMA ADAPTER
32 SMA ADAPTER
17 SPDT SWITCH
47 SCREW 2 PLACES
66 WIRE AS REQUIRED
67 WIRE AS REQUIRED
21 FILTER
32 SMA ADAPTER
27 ISOLATOR
69 WIRE AS REQUIRED
70 WIRE AS REQUIRED
71 WIRE AS REQUIRED
72 WIRE AS REQUIRED
74 9-PIN CONNECTOR
75 SCREW LOCK 2 PLACES
76 BACKSHELL
3 IF GAIN RELAY ASSEMBLY
46 SCREW (FAR SIDE) 2 PLACES
(9-PIN CONNECTOR)
SW4-2 BRN 5 9 WHT CONT V RCP
4 8 WHT CONT V LCP
23 GHZ LCP IF GAIN WHT 3 7 WHT/YEL 8.4 GHZ RCP IF GAIN
8.4 GHZ LCP IF GAIN WHT/BLK 2 6 WHT/BRN 23 GHZ RCP IF GAIN
COM DIST BLK 1
SECTION H-H SCALE: 2/1
ACAD : 3500A10A
T106 ASSEMBLY - RCP SIDE
C53500K009 BLOCK DIAG
A53500B005 BOM
NEXT ASSEMBLY DWG. TYPE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
MATERIAL :
FINISH :
VLBA PROJECT T106 CONVERTER MODULE
TITLE T106 8.4/23 GHZ CONVERTER MODULE ASSEMBLY
NATIONAL RADIO ASTRONOMY OBSERVATORY SOCORRO, NEW MEXICO 87801
DRAWN BY G. MORRIS DATE 1-88
DESIGNED BY ES DATE 1-88
APPROVED BY ES DATE 1-88
SHEET NUMBER 1 of 2 DRAWING NUMBER D53500A010 REV. F SCALE 1/1
8 7 6 5 4 3 2 1
D C B A

Figure 1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



VIEW A-A
LCP SIDE

ACAD : 3500A10B

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

MATERIAL :

FINISH :

C53500K009	BLOCK DIAG
A53500B005	BOM
NEXT ASSEMBLY	DWG. TYPE

VLBA
PROJECT T106
CONVERTER MODULE

TITLE T106
8.4/23 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY G. MORRIS	DATE 1-88
DESIGNED BY ES	DATE 1-88
APPROVED BY ES	DATE 1-88

SHEET NUMBER 2 OF 2 DRAWING NUMBER D53500A010 REV. F SCALE 1/1

REVISIONS

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	9-93	K. TATE	D. WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 9-93
DESIGNED BY	DATE
APPROVED BY D. WEBER	DATE 9-93

C53500K009	BLOCK DIAG
D53500A010	ASSEMBLY
NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T106 CONVERTER MODULE

TITLE T106 8.4/23 GHZ CONVERTER MODULE
ASSEMBLY BOM

DWG NO. A53500B005 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B005 REV B DATE 9-22-93 PAGE 2 OF 5

MODULE T106 NAME 8.4/23 GHZ CONVERTER DWG# D53500A010 SUB ASSY ________ DWG# ________

SCHEM. DWG# C53500K009 LOCATION ________ QUA/SYS. ________ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53500A009	ASSY, IF GAIN RELAY	1
4		NRAO	C53306M014-1	COVER, PERFORATED	2
5		NRAO	C53306M016	RAIL, SUPPORT	2
6		NRAO	C53306M017	PLATE, SIDE	2
7		NRAO	B53306M018	BLOCK, GUIDE	4
8		NRAO	A53306M038	PULLER, MODULE	2
9		NRAO	B53500M001	RAIL, UPPER	1
10		NRAO	B53500M002	RAIL, LOWER	1
11		NRAO	B53500M004-1	PANEL, REAR	1
12		NRAO	B53500M029	PLATE, MIXER MOUNTING	2
13		NRAO	B53500M030	PLATE, ISOLATOR MOUNTING	2
14		NRAO	D53500M031	PLATE, COMPONENT MOUNTING	1
15		NRAO	C53500M033	PANEL, FRONT	1
16	SW1, SW2	RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	2
17	SW3, SW4	TRANSCO	82152-909C70100	SWITCH, SPDT	2
18		TRIANGLE MICROELECTRONICS	YL-56	DIVIDER, POWER	2
19		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	4
20		K & L	2FV-8400/2500-0/0P	FILTER	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B005 REV B DATE 9-22-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		K & L	6FV-8400/X960-0/0P	FILTER	2
22		K & L	6B120-750/X550-0/0P	FILTER	2
23		NARDA	4778-3	ATTENUATOR, 3 db	1
24		NARDA	4778-5	ATTENUATOR, 5 db	1
25		NARDA	4778-8	ATTENUATOR, 8 db	1
26		WATKINS-JOHNSON	M77C	MIXER	2
27		DITOM	D3I7011-2	ISOLATOR	4
28		MITEQ	AMF-2B-7494-15B	AMPLIFIER	2
29		SOLITRON	8018-6005	TERMINATION, 50Ω	4
30		SOLITRON	2912-6001	ELBOW, SMA MALE/.141 COAX	2
31		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	4
32		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 COAX	31
33		SOLITRON	2002-5015-00	ADAPTER, SMA FEM./.141 COAX	1
34	P1-P7, P9-P10	OMNI-SPECTRA	2081-0000-00	CONNECTOR, OSP .141 MALE	8
35		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
36		PRECISION TUBE	AA50141	COAX, .141, SEMI-RIGID	AR
37	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
38		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
39		AMP	200833-2	PIN, GUIDE	2
40		AMP	203964-5	SOCKET, GUIDE	2
41		AMP	201578-1	PIN, 16 GA. CONNECTOR	7

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B005 REV B DATE 9-22-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42				LUG, TERMINAL	1
43		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
44		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4
45				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	8
46				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	30
47				SCREW, PAN HEAD, SS, 4-40UNC-2A x .63	4
48				SCREW, PAN HEAD, SS, 4-40UNC-2A x .75	8
49				SCREW, PAN HEAD, SS, 6-32UNC-2A x .25	6
50				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
51				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
52				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
53				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
54				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	6
55				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	4
56				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B005 REV B DATE 9-22-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
57				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
58				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .75	4
59				WASHER, FLAT #4	8
60				WASHER, LOCK #4	8
61				WASHER, EXT. TOOTH #6	16
62		ALPHA	7055	WIRE, WHT #22	AR
63		ALPHA	7055	WIRE, BLK #22	AR
64		ALPHA	7055	WIRE, RED #22	AR
65		ALPHA	7055	WIRE, GRY #22	AR
66		ALPHA	7055	WIRE, BLU #22	AR
67		ALPHA	7055	WIRE, BRN #22	AR
68		ALPHA	7055	WIRE, WHT/GRY #22	AR
69		ALPHA	7055	WIRE, WHT/BLK #22	AR
70		ALPHA	7055	WIRE, WHT/BRN #22	AR
71		ALPHA	7055	WIRE, WHT/YEL #22	AR
72				WRAP, TIE	AR
73		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	2
74	J1	TRW CINCH	DE-9P	CONNECTOR, 9-PIN D-SUB	1
75		AMPHENOL	17-D20418-2X	SCREW LOCK, MALE	2
76		TRW CINCH		BACKSHELL	1

WJ-M77/M77C
WJ-MY77/MY77C

DOUBLE-BALANCED MIXER

- ◆ LO 7.0 TO 15.0 GHz
- ◆ RF 8.0 TO 12.5 GHz
- ◆ IF DC TO 2500 MHz
- ◆ LO DRIVE +10 dBm (nominal)
- ◆ LOW NOISE FIGURE

*MIL–M–28837 Screening Available (See "QPL Mixers" Section)

Guaranteed Specifications [1]

Characteristics	Min.	Typ.	Max.	Test Conditions
SSB Conversion Loss and SSB Noise Figure		5.0 dB	7.0 dB	f_R 8 to 12.5 GHz f_L 7 to 13.5 GHz f_I 30 to 1000 MHz
		5.5 dB	7.5 dB	f_R 8 to 12.5 GHz f_L 7 to 14.5 GHz f_I 1000 to 2000 MHz
		6.0 dB	8.0 dB	f_R 8 to 12.5 GHz f_L 7 to 15.0 GHz f_I 2000 to 2500 MHz
Isolation				
L to R	20 dB	35 dB		f_L 7 to 15 GHz
L to I	20 dB	35 dB		f_L 8 to 12 GHz
	15 dB	30 dB		f_L 7 to 14 GHz
	10 dB	20 dB		f_L 14 to 15 GHz
Conversion Compression			1.0 dB	f_R level +4 dBm f_L level +10 dBm
Third Order Input Intercept Point		+15 dBm		f_{R_1} = 10.00 GHz; f_{R_2} = 10.01 GHz both at -6 dBm f_L = 11.0 GHz at +10 dBm
Single Tone IM Suppression				f_R 8 to 12.5 GHz at -10 dBm
f_L f_R				
2 x 2		60 dB		
2 x 3		70 dB		
3 x 2		37 dB		
3 x 3		59 dB		
3 x 4		> 70 dB		
4 x 3		> 70 dB		
4 x 4		> 70 dB		

Notes: 1. Measured in a 50-ohm system with nominal LO drive and dovvnconverter application only,unless otherwise specified. The I-Port frequency range extends to DC for phase detection, pulse modulation, or attenuator applications, I-Port VSWR degrades from a 50-ohm system at low IF frequencies.

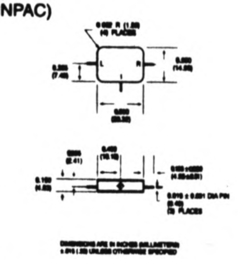
Absolute Maximum Ratings

Operating Temperature .... -54°C to +100°C
Storage Temperature .... -65°C to +100°C
Peak Input Power .... +23 dBm max. at +25°C, +20 dBm max. at +100°C
Peak Input Current at 25°C .... 100 mA DC

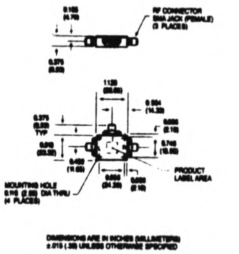
Weight	M77:	9 grams (0.32 oz.) max.	MY77:	7.9 grams (0.28 oz.) max.
	M77C:	36 grams (1.27 oz.) max.	MY77C:	20.0 grams (0.70 oz.) max.

Outline Drawings

M77
(MINPAC)

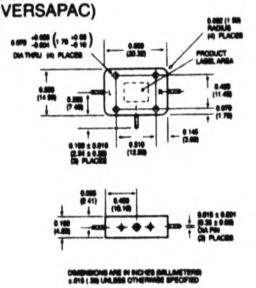


M77C
(CONNECTORIZED)

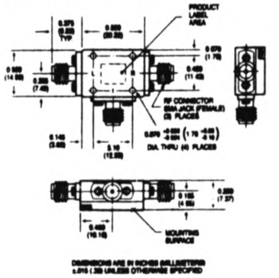


Outline Drawings

MY77
(VERSAPAC)

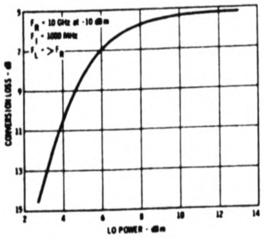


MY77C
(CONNECTORIZED)

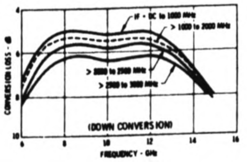


Typical Performance at 25°C*

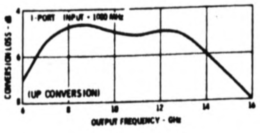
Conversion Loss Vs. LO Drive



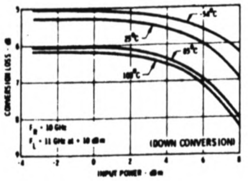
Conversion Loss vs. Frequency



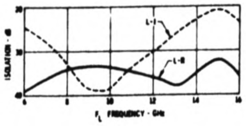
Conversion Loss vs. Output Frequency



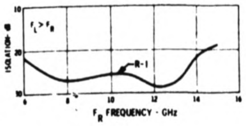
Conversion Loss vs. RF Input Power



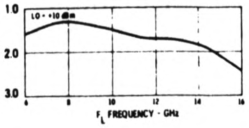
Isolation vs. Frequency



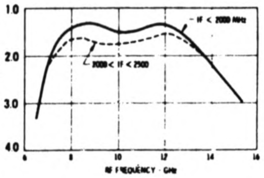
Isolation vs. Frequency



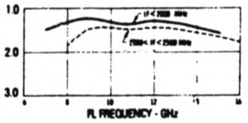
L-Port VSWR vs. Frequency



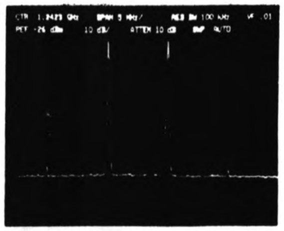
R-Port VSWR vs. Frequency



I-Port VSWR vs. f_L



Typical Two-Tone Performance



Typical Two-Tone Performance: f_I = 1250 MHz, f_R = 10.25 GHz ± 1 MHz f_R @ -10 dBm, $f_L > f_R$, f_L = 11.5 GHz @ +10 dBm. Vertical scale = 10 dB/cm.

*Typical performance applies to the MINPAC™ model and does not necessarily reflect the performance of the VERSAPAC® model.

MITEQ

Project No.: 17166

File No.:

TEST DATA

Model No.: AMF-2B-7494-15P

Serial No.: 107864

Frequency: 7.4 - 9.4 GHz

Purchase Order No.:

Specification :

Frequency (GHz)	7.4-9.4 GHz	Output Power (dBm) at 1 dB Compression	+15 dBm min.
Gain (dB)	15 dB min.	Voltage	+15 VDC
Gain Flatness (dB)	± 0.5 db max.	I1 Measured Current (ma)	115 mA
VSWR Input	2:1 max.	Noise Figure (dB)	No SPEC
VSWR Output	2:1 max.		

Test Data:

Frequency (GHz)	Gain (dB)	VSWR In	VSWR Out	Noise Figure (dB)	Output Power (dBm) at 1 dB Compression
7.4	SEE ATTACHED GRAPH	1.89:1 max.	1.75:1 max.	3.11	+ 17.6
7.9		↓	↓	3.29	+ 18.2
8.4				3.51	+ 18.4
8.9				3.37	+ 19.2
9.4				3.24	+ 16.8

Tested By:

Date: 5/22/87

MITEQ INC • 125 Ricefield Lane • Hauppauge, New York 11788-2086 • Tel. (516) 543-8873

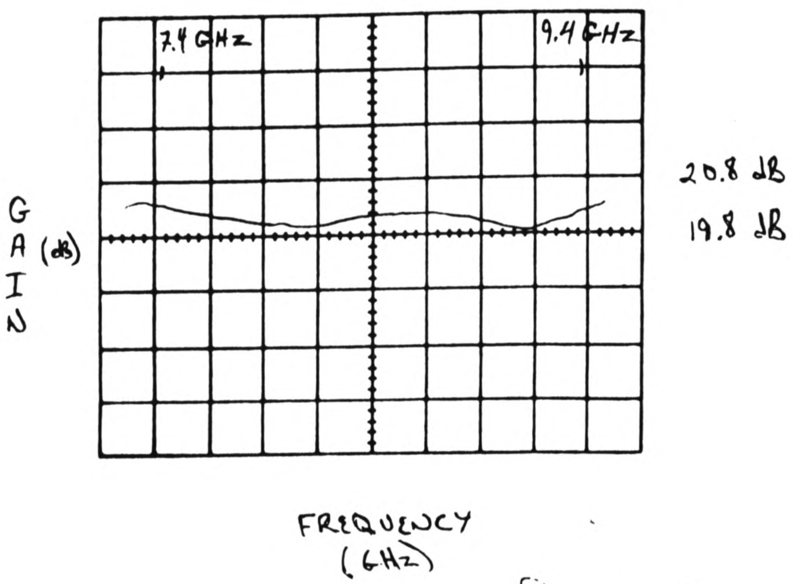
P19706

MITEQ INC / 125 RICEFIELD LANE / HAUPPAUGE, NEW YORK 11787/(516) 543-8873

Amplifier Model AMF-2B-7494-15P

Serial No. 107864

GAIN BANDWIDTH



5/22/87

3.7 T107, 10.7 GHz CONVERTER MODULE

T107 Band Coverage and LO Frequencies

This section describes the T107 frequency converter that converts an X-Band 10.7 GHz (2.8 cm) Front-End signal to the standard 500 to 1000 MHz IF signal.

The Pie Town NM VLBA antenna is the only VLBA antenna site that has a 10.7 GHz receiving band capability. Currently, there are no plans to add the 10.7 GHz capability to the other VLBA sites. The T107 frequency converter used at the Pie Town site is a prototype unit and only one unit has been constructed.

The 10.7 GHz Front-End does not have bandwidth limiting filters, this function is performed by K&L 6FV-10700/X1200-O/OP bandpass filters in T107's RF circuitry. For VLBA K&L filters, the X supplemental code indicates that the bandwidth is defined at the -1 dB points. The RF filter center frequency is 10.7 GHz, the bandwidth is 1200 MHz and the -1 dB band edges are 10.1 and 11.3 GHz, respectively.

This band uses LO frequencies ranging between 9.6 GHz and 11.9 GHz. The following tabulation shows the mixer IF port spectrum, converted and attenuated bands. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The IF port frequencies are in MHz, the others in GHz.

LO Freq	Mixer IF Port	Converted	Attenuated
9.6	500 to 1700	10.1 to 10.6	10.6 to 11.3
9.9	200 to 1400	10.6 to 11.1	10.1 to 10.6 10.6 to 11.3
11.6	300 to 1500	10.6 to 11.2	10.1 to 10.6 10.6 to 11.3
11.9	600 to 1800	10.9 to 11.3	10.1 to 10.9

When the 11.6 and 11.9 GHz LO frequencies are used, the IF spectrum is reversed. It is important to remember this effect when testing the T107 with these LO frequencies.

T107 Size and Location

T107 is a double-width module installed in Rack B, Bin A, Slots 1-2.

T107 Drawings and Data Sheets

The following T107 functional and assembly drawings are found at the end of this section.

C53500K003, Rev C - T107 10.7 GHz Converter Module Block Diagram
D53500A004, Rev A - T107 10.7 GHz Converter Module Assembly
A53500B003, Rev A - T107 10.7 GHz Converter Module Assembly BOM

Data sheets for the Avantek DBX-158M-1 mixer, and Avantek AFT-12633 amplifier follow the drawings. Data sheets for the Narda 4315-1 power divider and Narda 4779-X attenuator are included in the Appendix, Section 6. A data sheet for the Virtech V3I 8012 isolator was not available for this manual.

T107 Specifications

Nominal Gain, dB	14	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+6.3	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	14,000	Noise Temp for 1% added Syst Noise, K	20,000	Nom LO Pwr input, dBm	+1
Avg Noise Figure, dB	17.0	Noise Figure for 1% added Syst Noise, dB	18.4		
15 Volt Power Req't, mA	850				

T107 Differences From the General Converter Block Diagram

The differences between the General Converter Block Diagram of Section 2.1 are the omission of bandpass filters in the LO drive circuitry and the use of an isolator on the output of the RF bandpass filter. T107 does not have a transfer switch.

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. Image response bands are attenuated by T107's K&L 6FV-10700/X1200 bandpass filter which has a -1 dB passband of 10.1 to 11.3 GHz. The following tabulation shows the LO frequency, unwanted (UWSB) and image sidebands in GHz and the attenuation of these bands in dB.

LO Freq	UWSB	UWSB Attn	Image	Image Attn
9.6	19.7 to 21.5	»70	8.1 to 9.1	»54
9.9	20.0 to 21.2	»70	8.9 to 9.4	»42
11.6	21.7 to 22.9	»70	12.1 to 12.6	»55
11.9	22.0 to 23.2	»70	12.4 to 12.9	»59

Noise Temperature

The T107 noise temperature is a composite value that is a function of the noise figures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 14,000 K. A T107 noise temperature of 20,000 K would add 1 K to the system temperature.

Mixer

The AVANTEK DBX-158M-1 is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO and RF frequencies of 8.0 to 15.0 GHz, IF frequencies of DC to 1000 MHz and a nominal LO drive of +10 to +17 dBm. At 10.5 GHz, the typical conversion loss is 5.5 dB and the typical noise figure is 5.5 dB. At 10 GHz, the port-to-port isolations are: 35 dB (RF-IF), 25 dB (RF-LO) and 23 dB (LO-IF). At 10.5 GHz, the RF and LO port VSWR's are about 1.2:1 and the IF port VSWR is 2.0 at 800 MHz.

RCP-LCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths: the isolation between the two mixer LO ports and the transfer switch leakage. As shown in the table above, the module's specified RCP-LCP path isolation is 65 dB.

At 10 GHz the AVANTEK DBX-158M-1 mixer LO to RF isolation is 30 dB and the LO to IF isolation is 25 dB. The NARDA 4315-2 power divider minimum port-to-port isolation is 20 dB. The resultant worst-case isolation of this shunt path is thus about 70 dB.

At 10.7 GHz the typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch is about 75 dB.

VSWR's

The input VSWR is probably about 1.5:1 and is the composite of the VSWR's of the Virtech V3I 8012 Isolator (no value available) and K&L 6FV-10700/X1200 bandpass filter (1.5:1). The output VSWR is the composite VSWR of the Amp/Divider which is about 1.5:1.

RF Input Circuitry

The RF circuitry consists of two Virtech V3I-8012 isolators; one on the input to the K&L 6FV-10700/X1200 RF bandpass filter and one on the output. The output isolator is used to improve the AVANTEK DBX-72M-1 mixer's RF port VSWR. A data sheet for this isolator was not available at the time that this manual was written.

The losses in the RF input path are the insertion losses of the two isolators (estimated at 0.35 dB, each) and the bandpass filter (0.4 dB) for a total loss of 1.1 dB.

The K&L 6FV-10700/X1200 bandpass filter has a center frequency of 10.7 GHz, -1 dB bandwidth of 1200 MHz; and at the center frequency, the insertion loss is 0.4 dB and the VSWR is 1.5:1. Figure 24 shows the filter's typical attenuation vs frequency plot. Note that the filter's attenuation is about 40 dB for frequencies ± 1 bandwidth from the center frequency.

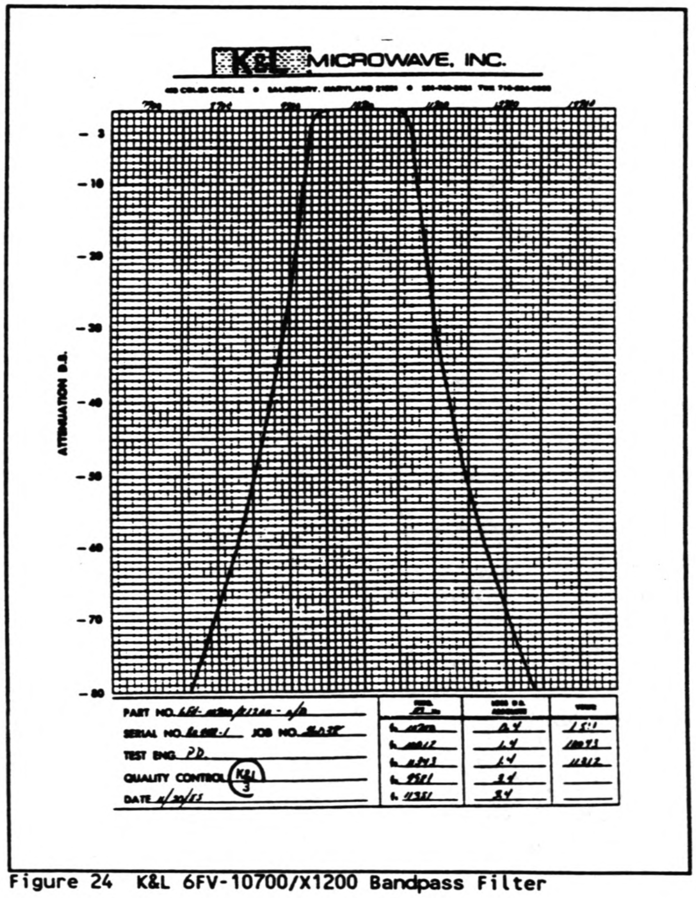


Figure 24 K&L 6FV-10700/X1200 Bandpass Filter

The Virtech V31-8012-2 isolators are probably similar the DITOM D3I 8012 isolators.

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

The LO drive circuitry consists of a NARDA 4772-X attenuator used to set LO gain, an AVANTEK AFT-12633-1 LO amplifier and a NARDA 4315-2 two-way power divider.

The AVANTEK 12633-1 amplifier is designed for operation over the 6 to 12 GHz frequency range, has a 24 dB typical gain and a typical noise figure of 4.2. Over this frequency range, the gain is flat within ± 1.0 dB and the input and output VSWR's are 2.0. A data sheet for this amplifier follows the drawings at the back of this section.

The NARDA 4315-2 power divider has a minimum port-to-port isolation of 20 dB and a maximum insertion loss of 0.5 dB.

The nominal LO input power is +1 dBm and the LO drive to the mixer is +10 dBm. The LO path gain adjustment is described in Test I, Section 2.7.

RF Switching

T107 does not have a transfer switch although the Electronic System Block Diagram, D58001K001 shows a S107A transfer switch.

T107 Power Circuitry

All T107 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 3 and 4 where it is distributed to the amplifiers and gain potentiometers. The common returns for the amplifiers and potentiometers are connected to TB1 terminals 1 and 2. These terminals are connected to P11-34 and P11-42 and a frame ground lug at P11. The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

REVISIONS

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-93	K. TATE	D.WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 9-93
DESIGNED BY	DATE
APPROVED BY	DATE

C53500K003	BLOCK DIAG
D53500A004	ASSEMBLY
NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

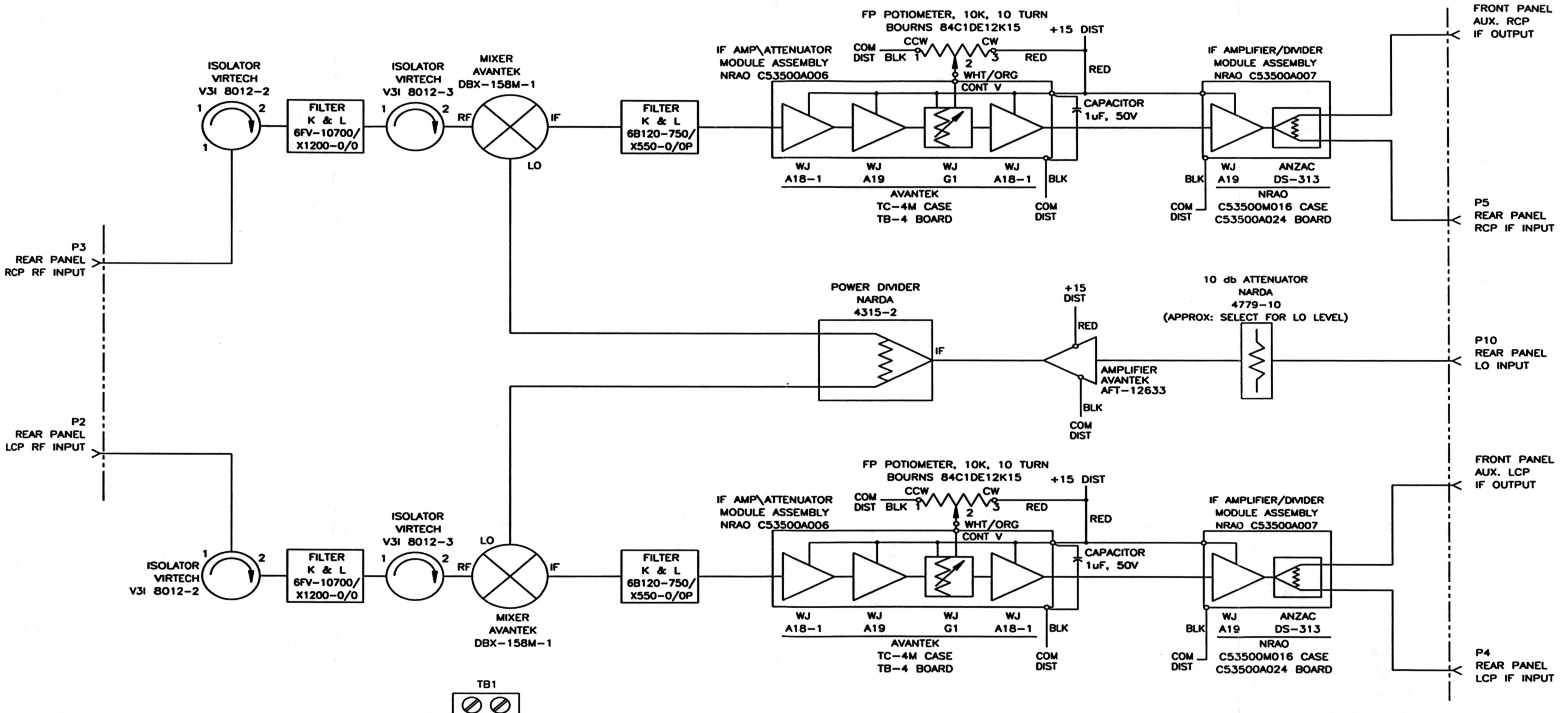
V
L
B
A

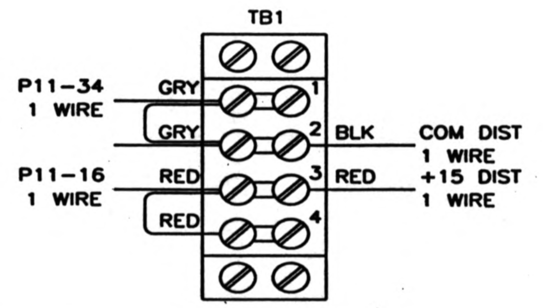
PROJECT T107 CONVERTER MODULE

TITLE T107 10.7 GHZ CONVERTER MODULE
ASSEMBLY BOM

DWG NO. A53500B003 SHEET 1 OF 5

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	4-91	DGS	ES	CHG ORDER 910416-1
B	8-91	DGS	ES	CHG ORDER 910820-1
C	10-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
D	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS





ACAD : 53500K03

NEXT ASSEMBLY	DWG. TYPE
A53500B003	BOM
D53500A004	ASSEMBLY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA
PROJECT T107
CONVERTER MODULE

TITLE T107
10.7 GHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY BW — DATE 10-86
DESIGNED BY ES — DATE 10-86
APPROVED BY ES — DATE 10-86

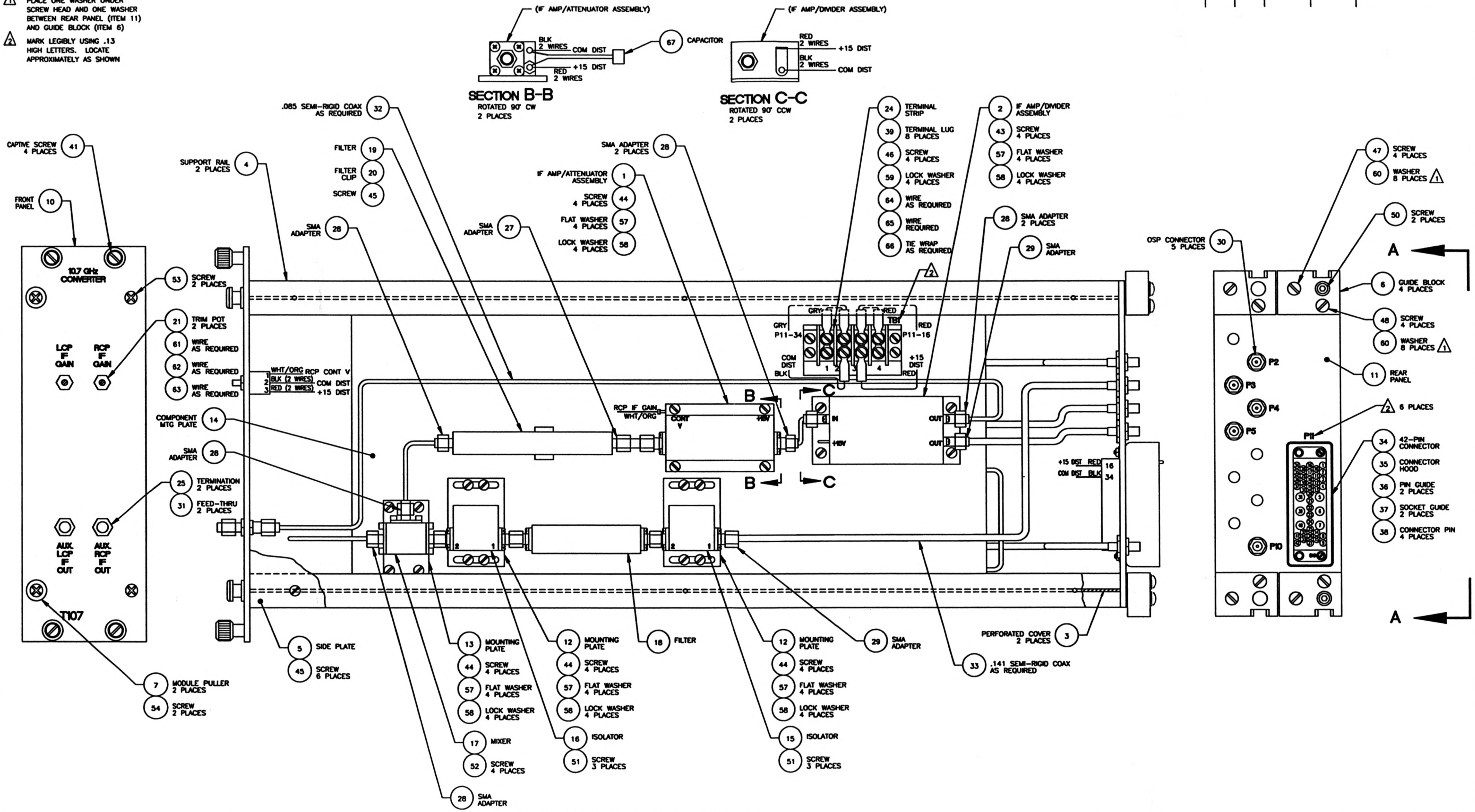
SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K003
REV. D
SCALE NONE

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-93	K. TATE	D.WEBER	REDRAWN ON ACAD

NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 11) AND GUIDE BLOCK (ITEM 6)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



T107 ASSEMBLY – RCP SIDE

ACAD : 53500A4A

C53500K003	BLOCK DIAG
A53500B003	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA
PROJECT T107
CONVERTER MODULE

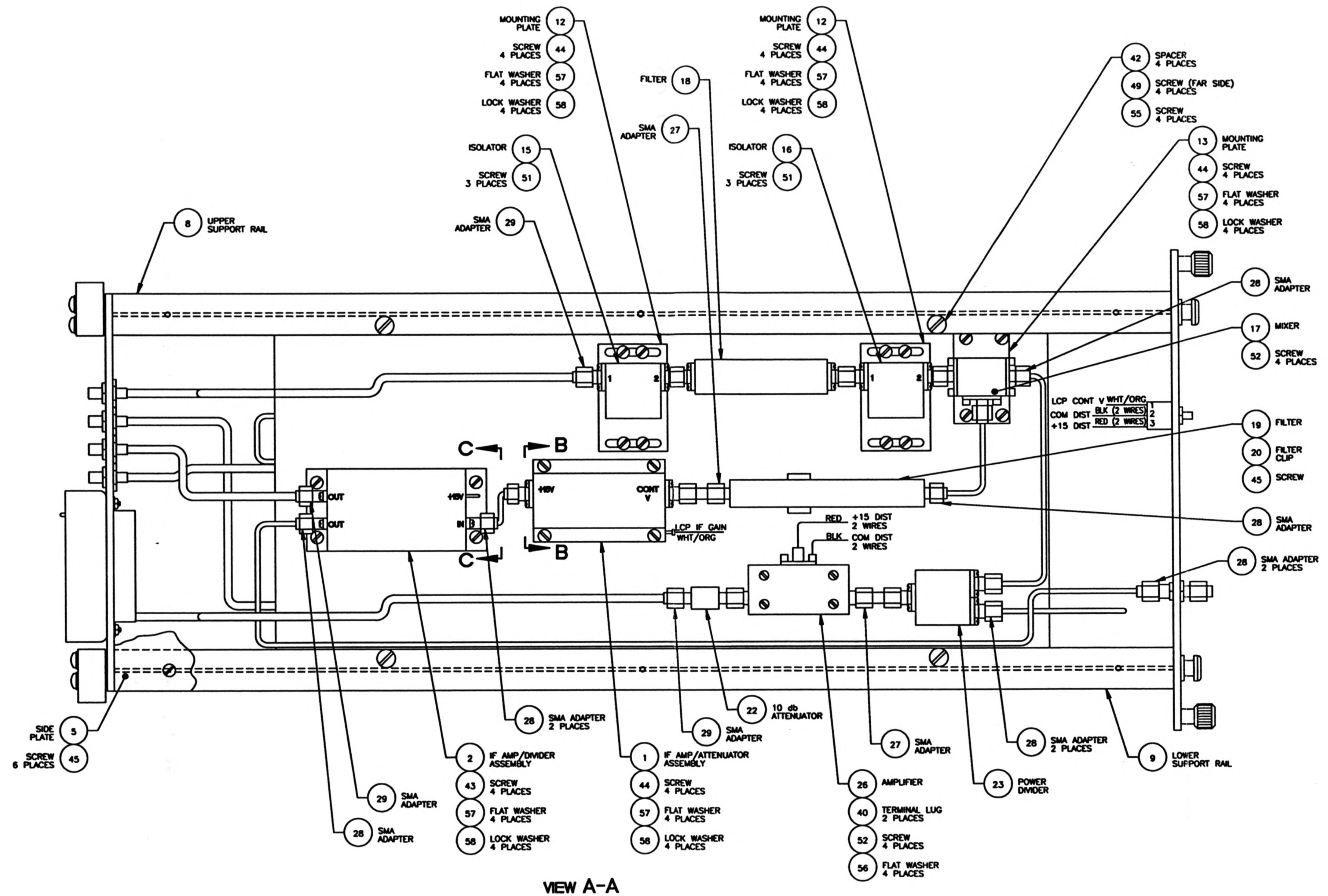
TITLE T107
10.7 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY WIREMAN DATE 10-86
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 2 DRAWING NUMBER D53500A004 REV. A SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



VIEW A-A

LCP SIDE

ACAD : 53500A4B

C53500K003	BLOCK DIAG
A53500B003	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES : ANGLES ±

3 PLACE DECIMALS (.XXX) ±

2 PLACE DECIMALS (.XX) ±

1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T107 CONVERTER MODULE

TITLE T107
10.7 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY G. MORRIS	DATE 10-86
DESIGNED BY	DATE
APPROVED BY	DATE

SHEET NUMBER 2 OF 2 | DRAWING NUMBER D53500A004 | REV. B | SCALE 1/1

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B003 REV A DATE 9-30-93 PAGE 2 OF 5

MODULE T107 NAME 10.7 GHZ CONVERTER DWG# D53500A004 SUB ASSY ________ DWG# ________

SCHEM. DWG# C53500K003 LOCATION ________ QUA/SYS. ________ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53306M014-1	COVER, PERFORATED	2
4		NRAO	C53306M016	RAIL, SUPPORT	2
5		NRAO	C53306M017	PLATE, SIDE	2
6		NRAO	B53306M018	BLOCK, GUIDE	4
7		NRAO	A53306M038	PULLER, MODULE	2
8		NRAO	B53500M001	RAIL, UPPER	1
9		NRAO	B53500M002	RAIL, LOWER	1
10		NRAO	B53500M003	PANEL, FRONT	1
11		NRAO	B53500M004-1	PANEL, REAR	1
12		NRAO	A53500M008-3	PLATE, ISOLATOR MOUNTING	4
13		NRAO	A53500M009	PLATE, MIXER MOUNTING	2
14		NRAO	D53500M025	PLATE, COMPONENT MOUNTING	1
15		VIRTECH	V3I 8012-2	ISOLATOR	2
16		VIRTECH	V3I 8012-3	ISOLATOR	2
17		AVANTEK	DBX-158M	MIXER	2
18		K & L	6FV-10700/X1200-0/0	FILTER	2
19		K & L	6B120-750/X550-0/OP	FILTER	2
20		K & L	M12-A	CLIP, FILTER	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B003 REV A DATE 9-30-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		BOURNS	3862C-122-103A	TRIM POT, 10K PANEL	2
22		NARDA	4779-10	ATTENUATOR, 10 db	1
23		NARDA	4315-2	DIVIDER, POWER	1
24	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
25		SOLITRON	8018-6005	TERMINATION, 50Ω	2
26		AVANTEK	AFT-12633	AMPLIFIER	1
27		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	3
28		SOLITRON	2906-6002	ADAPTER, SMA MALE/.085 COAX	14
29		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 COAX	5
30	P2-P4,P10	OMNI-SPECTRA	4503-7941-00	CONNECTOR, OSP .141 MALE	5
31		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
32		PRECISION TUBE	AA50085	COAX, .085 SEMI-RIGID	AR
33		PRECISION TUBE	AA50141	COAX, .141. SEMI-RIGID	AR
34	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
35		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
36		AMP	200833-2	PIN, GUIDE	2
37		AMP	203964-5	SOCKET, GUIDE	2
38		AMP	201578-1	PIN, 16 GA. CONNECTOR	2
39		ETC/MOLEX	AA-832-06	LUG, TERMINAL	8
40				LUG, TERMINAL	2
41		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B003 REV A DATE 9-30-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42		H.H. SMITH	8365	SPACER, 8-32UNC-2B x .75	4
43				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	8
44				SCREW, PAN HEAD, SS, 4-40UNC-2A x .31	32
45				SCREW, PAN HEAD, SS, 6-32UNC-2A x .25	14
46				SCREW, PAN HEAD, SS, 6-32UNC-2A x .38	4
47				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
48				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
49				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
50				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
51				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	12
52				SCREW, PAN HEAD, SS, 2-56UNC-2A x .50	12
53				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
54				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
55				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .63	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B003 REV A DATE 9-30-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
56				WASHER, FLAT #2	4
57				WASHER, FLAT #4	40
58				WASHER, LOCK #4	40
59				WASHER, LOCK #6	4
60				WASHER, EXT. TOOTH #6	16
61		ALPHA	7055	WIRE, WHT/ORG #22	AR
62		ALPHA	7055	WIRE, BLK #22	AR
63		ALPHA	7055	WIRE, RED #22	AR
64		ALPHA	7056/19	WIRE, GRY #20	AR
65		ALPHA	7056/19	WIRE, RED #20	AR
66		PANDUIT	PLT1M	WRAP, TIE 3.5"	AR
67		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	2
68					
69					
70					
71					
72					
73					
74					
75					
76					

AVANTEK

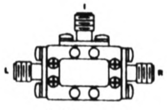
DBX–158L/M/H
DBY–158L/M/H
Duroid Mixer
8 to 15 GHz Double Balanced

FEATURES

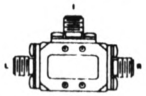
- Single Schottky Diode Quad
- 5.5 dB Conversion Loss
- 30 dB Isolation
- R Port VSWR ≤ 2.0:1

APPLICATIONS

- Low Cost 11.7 to 12.2 GHz Downconverter
- Threat Warning Systems
- Self Protection Jammers
- Wideband Heterodyned Receivers



DBX, p. 16–10



DBY, p. 16–11

DESCRIPTION

The DBX/DBY Series uses precisely matched Schottky-barrier diodes and a "quasi-planar" physical construction for excellent overall symmetry. Construction techniques result in high LO to RF isolation, extremely low single tone intermodulation distortion and very good amplitude and phase match characteristics.

ELECTRICAL SPECIFICATIONS (Measured in a 50-ohm system)

Symbol	Characteristic	Operating Frequencies GHz			Power Level			Specifications		Unit
		f_{LO}	f_{RF}	f_{IF}	LO Port dBm (typ)	Model Suffix	RF Port dBm	Typical $T_c = 25°C$	Guaranteed $T_c = -55°$ to $+100°C$	
BW	Operating Frequency Range	8.0–15.0	8.0–15.0	DC–1.0						GHz
CL	SSB Conversion Loss	8.0–15.0 8.0–15.0	8.0–15.0 8.0–15.0	DC–0.5 DC–1.0				5.5 6.0	7.0 7.5	dB max
NF	SSB Noise Figure	8.0–15.0 8.0–15.0	8.0–15.0 8.0–15.0	0.03–0.5 0.03–1.0				5.5 6.0	7.0 7.5	dB max
ISOL	Isolation Port-to-Port L–R R–L R–I L–I L–I	8.0–15.0 — — 8.0–12.0 12.0–15.0	— 8.0–15.0 8.0–15.0 — —	— — — — —				30 25 30 15 25	20 — — 12 20	dB min
—	VSWR (50 ohm) L R I	8.0–15.0 — —	— 8.0–15.0 —	— — ≤1.0				1.5:1 2.0:1 1.2:1		max
CC	Conversion Compression Point (1 dB)	8.0–15.0 8.0–15.0 8.0–15.0	8.0–15.0 8.0–15.0 8.0–15.0	≤1.0 ≤1.0 ≤1.0	≥+ 7 ≥+10 ≥+17	L M H		+ 2 + 6 +12		dBm typ
IP_3	Third-Order Two-Tone Intercept Point	8.0–15.0 8.0–15.0 8.0–15.0	8.0–15.0 8.0–15.0 8.0–15.0	≤1.0 ≤1.0 ≤1.0	≥+10 ≥+17 ≥+20	L M H	— — —	+ 9 +10 +20	— — —	dBm typ
—	LO Port Drive Level (typical)	8.0–15.0 8.0–15.0 8.0–15.0	8.0–15.0 8.0–15.0 8.0–15.0	DC–1 DC–1 DC–1	+ 7→+13 +10→+17 +17→+24	L M H				dBm

NOTE: Specifications guaranteed at LO Power of +7 dBm for "L" model, +10 dBm for "M" model, and +17 dBm for "H" model.

MAXIMUM RATINGS

Peak Input Current @ 25°C	100 mA DC
Pin Temperature	260° C for 10 seconds
Operating Case Temperature	−55°C to +100°C
Storage Temperature	−65°C to +100°C
Continuous RF Input Power	200 mW @ +25°C 100 mW @ +100°C

WEIGHT: (typical) DBX — 22 grams; DBY — 16 grams (with connectors)

TYPICAL PERFORMANCE AT 25°C

Typical Single Tone Intermodulation Harmonic Suppression at 25°C (dB below desired output)

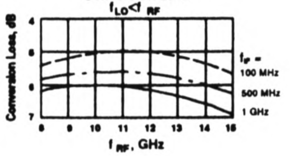
Harmonics of f_{RF}	1	2	3	4
4	>70	>70	>70	>70
3	65	>70	55	>70
2	50	55	50	58
1	0	25	18	40

Harmonics of f_{LO}

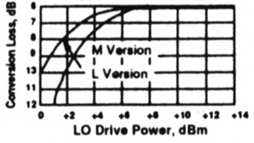
Typical Harmonic Intermodulation Suppression for mixer generated harmonics of the input signals. Suppression numbers are for a f_{RF} signal level at −10 dBm and f_{LO} signal level of:

L Suffix	+7 dBm
M Suffix	+10 dBm
H Suffix	+17 dBm

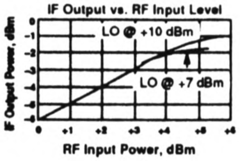
Conversion Loss
$f_{LO} < f_{RF}$



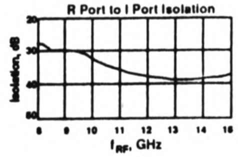
Conversion Loss
f_{LO} = 12 GHz, f_{RF} = 12.5 GHz



IF Output vs. RF Input Level

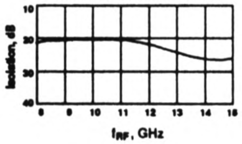


R Port to I Port Isolation

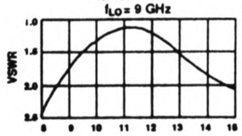


L Port to R Port Isolation

R Port to L Port Isolation



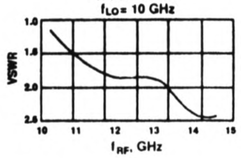
R Port VSWR
f_{LO} = 9 GHz



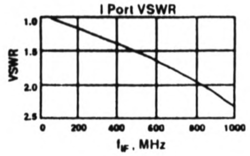
L Port to I Port Isolation

R Port VSWR
f_{LO} = 9 GHz

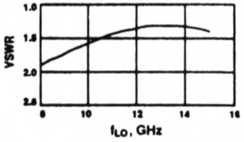
R Port VSWR
f_{LO} = 10 GHz



I Port VSWR



L Port VSWR



AFT—Avanpak Series Amplifiers, Connectorized or Stripline Compatible
AMT—High Performance and Temperature Compensated Connectorized Amplifier Series

AFT Series

Guaranteed Specifications @ 25°C Case Temperature

Model	Frequency Response (GHz) Minimum	Gain (dB) Minimum	Typical Gain (dB)	Noise Figure (dB) Typ./Max.	Power Output for 1 dB Gain Compression (dBm) Minimum	Gain Flatness (±dB) Maximum	Typical Third Order Intercept Point (dBm)	VSWR (50 ohms) Maximum In	VSWR (50 ohms) Maximum Out	Input Power Current @ +12 V[1] Typical (mA)	Case Type
AFT-12631	6-12	7.5	8.0 Typ.	6.0/6.5	+10	0.7	+20	2.0	2.0	75 Typ.	AX2
AFT-12632	6-12	15.0	16.0 Typ.	5.7/6.0	+10	1.0	+20	2.0	2.0	150 Typ.	AX2
~~AFT-12633~~	~~6-12~~	~~22.5~~	~~24.0 Typ.~~	~~4.2/4.5~~	~~+14~~	~~1.0~~	~~+24~~	~~2.0~~	~~2.0~~	~~175 Typ.~~	~~AX4~~
~~AFT-12634~~	~~6-12~~	~~30.5~~	~~32.0 Typ.~~	~~4.2/4.5~~	~~+14~~	~~1.5~~	~~+24~~	~~2.0~~	~~2.0~~	~~225 Typ.~~	~~AX4~~
AFT-12635	6-12	38.0	40.0 Typ.	4.2/4.5	+14	2.0	+24	2.0	2.0	275 Typ.	AX6
AFT-12661	6-12	5.0	5.5 Typ.	7.5/8.0	+20	0.7	+29	2.0	2.0	175 Typ.	AX2
AFT-12662	6-12	13.0	14.0 Typ.	6.0/6.5	+20	1.0	+29	2.0	2.0	250 Typ.	AX2
AFT-12663	6-12	21.0	22.0 Typ.	5.0/5.5	+20	1.0	+29	2.0	2.0	300 Typ.	AX4
AFT-12664	6-12	28.0	29.0 Typ.	4.5/5.0	+20	1.5	+29	2.0	2.0	350 Typ.	AX4
AFT-12665	6-12	36.5	38.0 Typ.	4.5/5.0	+20	2.0	+29	2.0	2.0	400 Typ.	AX6

AMT Series — Temperature Compensated

Guaranteed Specifications @ -54° to +100°C Case Temperature

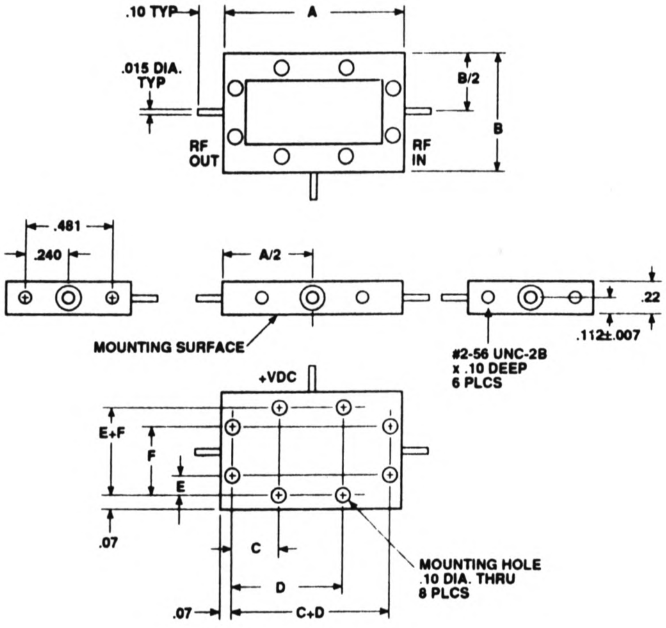
Model	Frequency Response (GHz) Minimum	Gain (dB) Minimum	Gain (dB) Maximum	Noise Figure (dB) Maximum	Power Output for 1 dB Gain Compression (dBm) Minimum	Gain Flatness (±dB) Maximum	Typical Third Order Intercept Point (dBm)	VSWR (50 ohms) Maximum In	VSWR (50 ohms) Maximum Out	Input Power Current @ +12 V[1] Maximum (mA)	Case Type
AMT-12064	6-12	21	29	7.7	+20	1.5	+28	2.0	2.0	520	IX6
AMT-12065	6-12	32	40	5.0	+20	1.5	+28	2.0	2.0	460	IX6
AMT-12066	6-12	37	45	4.5	+20	2.0	+28	2.0	2.0	520	IX8

Note
1. Units contain internal voltage regulator and operate with input voltage of +12 to +15 Vdc.

Case Drawings
AC_, AS_, and AX_

AFT Series: Avanpak™ PIN Package Dimensions - connectors and baseplate removed.

All Avanpaks are supplied with connectors installed; however, they may be removed by the user. If DC filtercon is removed, the user may need to provide external filtering.



CASE	DIMENSION						WEIGHT MAX GRAMS
	A	B	C	D	E	F	
AX2	1.364	.664	.237	.987	.137	.387	26
AC2	1.500	.764	.267	1.093	.187	.437	31
AS2	1.500	.862	.267	1.093	.236	.486	33
AX4	1.850	.664	.237	1.473	.137	.387	36
AC4	2.170	.764	.602	1.428	.187	.437	46
AS4	2.170	.862	.602	1.428	.236	.486	48
AX6	2.336	.664	.237	1.959	.137	.387	44

NOTES (UNLESS OTHERWISE SPECIFIED):

1. DIMENSIONS ARE SPECIFIED IN INCHES
2. TOLERANCES: .XX ± .01
   .XXX ± .005
3. MATERIAL:
   BODY AND RF CONNECTORS — 303 STAINLESS STEEL
   MOUNTING SPACER — ALUMINUM ALLOY
   FILTER BODY — NICKEL PLATED BRASS

3.8 T108, 14 GHz CONVERTER MODULE

T108 Band Coverage, LO Frequencies and Image Response Rejection

This section describes the T108 frequency converter that converts the U-Band (14 GHz/2 cm) Front-End signal to the standard 500 to 1000 MHz IF band.

The 14 GHz Front-End's spectrum is 12.0 to 15.4 GHz, a 3.4 GHz bandwidth, several times greater than most converter bandwidths. Because this conversion bandwidth is so large relative to the IF frequencies, four RF circuitry bandpass filters attenuate image frequency responses. This situation is unique to T108. The 14 GHz Front-End does not have bandpass filters.

Image frequency signal rejection was briefly described in the IF Passband and Out-of-Band discussion of Section 2.1. An image signal is an undesired spurious response that is only twice the IF frequency away from the desired frequency signal. To prevent the IF amplifier from responding to the image frequency signal, it must be attenuated by filtering ahead of the mixer. In this Section 2.1 discussion, an example case showed that in converting a 14 GHz signal to a 0.6 GHz IF, an LO frequency of 13.4 GHz would be used. However, a 12.8 GHz frequency signal mixed with the 13.4 GHz LO would also produce a 0.6 GHz IF signal. The 12.8 GHz signal is called the image and there is nothing peculiar about its character; it is just present in the example's RF spectrum. If the image signal is not attenuated, the IF spectrum is a mixture of the desired signal and the undesired image signal. If the 14 GHz example is changed to use a higher IF frequency, say 5 GHz, the LO frequency would be 9 GHz and the resultant image frequency would be 4 GHz, much further from the 14 GHz signal to be converted.

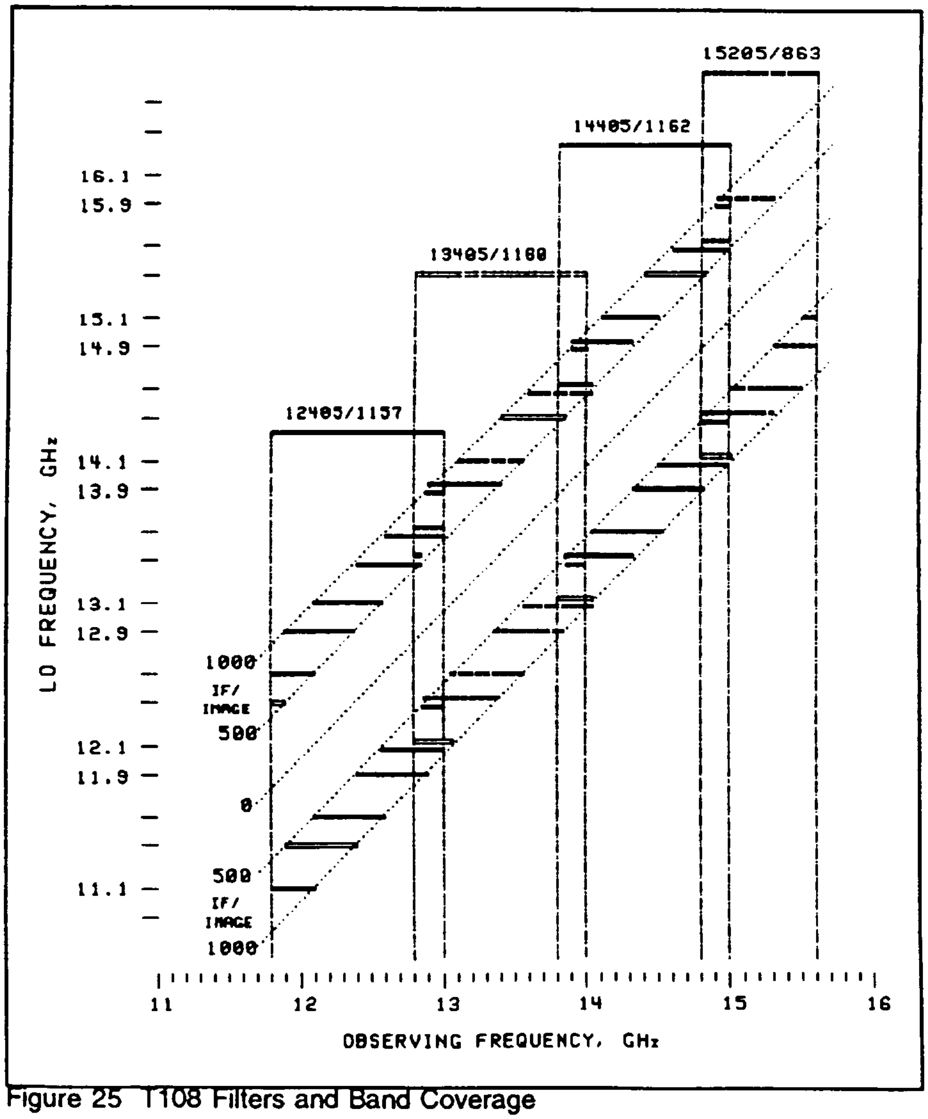


Figure 25 T108 Filters and Band Coverage

One possible solution for the T108 image problem is to use a higher frequency first IF as is done for the 23 and 43 GHz

Front-Ends. There were system constraints that made this approach undesireable; partitioning the 3.4 GHz spectrum into four switch-selectable bands before mixing was the most economical and simplest design.

T108's RF circuitry contains computer-selectable bandpass filters. The Front-End spectrum is separated into four bands, the first three slightly less than 1200 MHz and the fourth is 800 MHz. The filter band edges and bandwidths are: 11.8-13.0 GHz; 12.8-14.0 GHz; 13.8-15.0 GHz; 14.8-15.6 GHz. Note that adjacent frequency filters have a 200 MHz passband overlap.

The T108 LO frequencies and associated observing frequency coverages are listed in the Appendix, Section 6. Figure 25 (previous page) is a graphic counterpart to the T108 portion of this table and shows the observing frequency band, LO frequencies, the RF filter bandpasses and the IF/Image frequency responses. Observing frequency is the X-axis and LO frequency is the Y-axis. The IF/Image frequency responses are bounded by the dotted lines showing the 500 and 1000 MHz IF bounds. The four sets of vertical dash-dot lines delimit the bandpass of the four filters. The center frequency/bandwidth labels indicate the filter's 1 dB bandpasses. The horizontal solid lines indicate IF/Image responses in the 12405/1157 and 14405/1162 filter bandpasses and the horizontal dashed lines indicate IF/Image responses in the 13405/1160 and 15205/863 filter bandpasses.

The figure shows that for a given observing band, a selected bandpass filter and LO frequency, one response will be the desired IF response, the other the undesired image response. Note the IF spectrum reversal resulting from cases in which the LO frequency is greater than the observing frequency. Figure 25 conveniently illustrates the relationships between the bandpass filters and the desired IF and undesired image responses. For example, if the 12405/1157 filter is selected and a 12.9 GHz LO frequency is used, the observing band coverage is 11.9 to 12.4 GHz. The associated image response is 13.4 to 13.9 GHz and is attenuated at least 40 dB by the 12405/1157 filter (Figure 26[1]).

In the bandpass filter overlap regions, the two response lines are slightly separated for convenience in reading the figure. The figure also shows that for some observing frequency regions, one RF filter may be a better choice than another filter. The figure also shows that some LO frequencies are poor choices because they convert only a small portion of the input spectrum.

Worst-case image responses are exemplified by the 12.4 GHz LO frequency in the 12405/1157 filter. Only the lower 100 MHz of the input spectrum is converted and the lower portion of the associated image intrudes into the 12405/1157 filter response. Obviously this LO frequency is not a good choice; a 12.6 GHz LO would convert more of the spectrum and push the image out to the filter's attenuation skirts. In this 12.6 GHz LO case, the image's 13.1 GHz lower band edge frequency would be attenuated about 25 dB and the upper band edge frequency would be attenuated by 40 dB.

T108 Size and Location

T108 is a double-width module installed in Rack B, Bin A, Slots 8-9.

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[1] Figures 26, 27, 28, 29 and 30 are T108 filter attenuation plots generated in the AOC Front-End laboratory and show a noise floor of about -40 dB; this is an artifact of the equipment's performance. The filter's actual attenuation curves probably resemble other K&L filtr plots which typically exhibit attenuation maximums of about 80 dB. At the time that this manual was generated, the T018 K&L filter attenuation plots were not available so the above plots were generated as a substitute.

T108 Drawings and Data Sheets

C53500K004, Rev D - T108 14 GHz Converter Module Block Diagram
D53500A021, Rev B - T108 14 GHz Converter Module Assembly
A53500B004, Rev B - T108 14 GHz Converter Module BOM

C53500S005, Rev B - T108 14 GHz Converter Module Filter Select PCB Schematic Diagram
C53500A019 - T108 14 GHz Converter Module Filter Select PCB Assembly

Data sheets for the RLC SR-4C-D selector switch, the RLC SR-TC-R-D coaxial switch, the WJ M80C mixer, the Allegro UDN-2981 driver and the SMT-S90-1172 and SMT-S91-1279 amplifiers follow the drawings. Data sheets for the Ditom D3I 8016, Omnispectra 2090-6210-00 power divider and Narda 4779-x attenuator are included in the Appendix, Section 6.

T108 Specifications

Nominal Gain, dB	13	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+5.3	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	7,000	Noise Temp for 1% added Syst Noise, K	20,000	Nom LO Pwr input, dBm	0
Avg Noise Figure, dB added Syst Noise, dB	14.1	Noise Figure for 1%	18.4		
15 Volt Power Req't, mA	660				

T108 Difference From the General Converter Block Diagram

Several T108 block diagram features differ from the General Converter Block Diagram of Section 2.1. The differences consist of: the four sets of RF circuitry selector switches and bandpass filters; additional isolators and RF amplifiers in the RF Circuitry; isolators in the LO Drive circuitry; and a digital logic board that decodes the two-bit Filter Select code to drive the filter select switches and front panel filter select LED indicators.

If only one RF filter were used instead of four, T108's block diagram would not differ greatly from the general block diagram; T108 contains a lot of parts.

Unwanted Sideband Rejection

The unwanted (sum frequency) sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. Because the RF and LO frequencies are so high, the attenuation of these sidebands is greatly in excess of 70 dB.

Noise Temperature

The T108 noise temperature is a composite value that is a function of the noise temperatures of the RF amplifier, mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 7000 K. A T108 noise temperature of 20,000 K would add 1 K to the system temperature.

Mixer

The WJ M80C is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO frequencies of 4.0 to 18.0 GHz, RF frequencies of 6.0 to 18 GHz, IF frequencies of

DC to 3000 MHz and a nominal LO drive of +7 dBm. Over the 12 to 15 GHz RF conversion frequency range, the typical conversion loss is about 5.5 dB and the typical noise figure is 7.0 dB. RF port, LO port and IF port VSWR's are 1.5:1, 1.5:1 and 1.75:1, respectively.

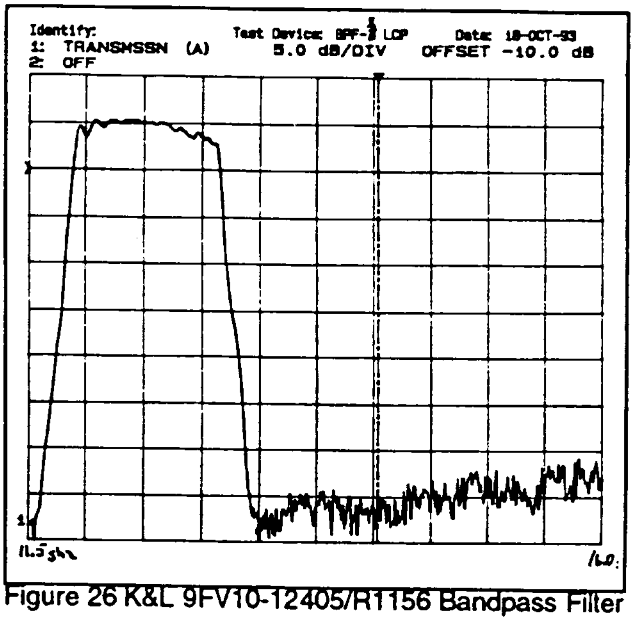

Figure 26 K&L 9FV10-12405/R1156 Bandpass Filter

RCP-LCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths: the isolation between the two mixer LO ports and the transfer switch leakage.

The WJ M80C mixer typical LO to RF isolation is 36 dB for LO frequencies of 3.5 to 14 GHz and the LO to IF isolation is 38 dB for LO frequencies of 9 to 18 GHz. The OMNI-SPECTRA 2090-6210-00 power divider port-to-port isolation is 18 dB, minimum. The DITOM D3I-8016-2 isolators typical isolation is 19 dB. Over the 11.4 to 15.9 GHz range of LO frequencies, the isolation of this shunt path is the sum of the two mixer's LO port to RF port isolation and the two isolators and dividers isolations; this is 128 dB. The LO filter's attenuation is about 1 dB (estimated) for frequencies in the 5000 MHz passband; for frequencies outside the passband, the isolation is increased by the filter's attenuation. Using the attenuation figures from Figure 29 below, the LO filter's add about 40 dB to the 128 dB LO path isolation at frequencies of 7.0 and 18 GHz, respectively.

The typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch at 12 GHz is about 73 dB and decreases to 70 dB at 15.5. From the table above, the module's specified RCP-LCP path isolation is 65 dB.

Since the 4PST selector switches are used to select the filters, the switch isolations are also a concern. The Transco 146C70600 switch has a typical port-to-port isolation of 90 dB over the 12 to 15 GHz frequency range.

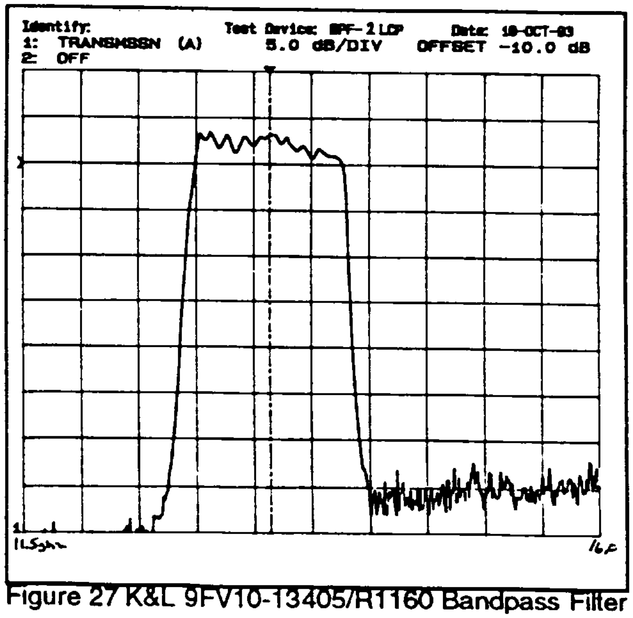

Figure 27 K&L 9FV10-13405/R1160 Bandpass Filter

VSWR's

The input VSWR 1.5:1, (estimated) is the composite of the VSWR's of the RLC SR-TC-R-D transfer switch (1.3:1), the Transco 146C70600 selector switch (1.15:1), selected filter (1.5:1) and Ditom D3I 8016 (1.3:1). At 13 GHz, the RLC Transfer switch typical VSWR is 1.3:1. The Transco 146C70600 switch VSWR is 1.15:1 and the filter VSWR's are about 1.5:1.

The output VSWR is the composite VSWR of the Amp/Divider which is about 1.5:1.

RF Input Circuitry

Four K&L bandpass filters are used in the RF circuitry. These four filter attenuation plots are shown on this and the following pages. The filter types and figure numbers are as follows: 9FV10-12405-E1157 - Figure 26; 9FV10-13405/R1160 - Figure 27; 9FV10-14405/R1162 - Figure 28 and 6FV10-15205/R863 - Figure 29. Figure 30 is a composite response of the four filters to show the filter's frequency overlap. The bandwidths are specified at the -1 dB frequency. Center frequency insertion losses are 0.9 dB for the 9FV filters and 0.6 dB for the 6FV filter.

A DITOM D3I-8016-2 isolator is used to reduce reflections between the Transco selector switch/RF filters and the RF amplifier. This isolator has a typical isolation of 19 dB and a typical insertion loss of 0.5 dB.

The RF amplifier is an SMT-S90-1172[2], characterized over a frequency range of 12.0 to 15.4 GHz, and is fabricated to NRAO specifications. NRAO SMT-S90-1172 specifications are: minimum gain - 18 dB; gain flatness - ± 0.75 dB; 1 dB compression point - +10 dBm; noise figure - 2.5 dB and input and output VSWR's - 1.5:1. A SMT-S90-1172 manufacturer's test data sheet is included in the back of this section.

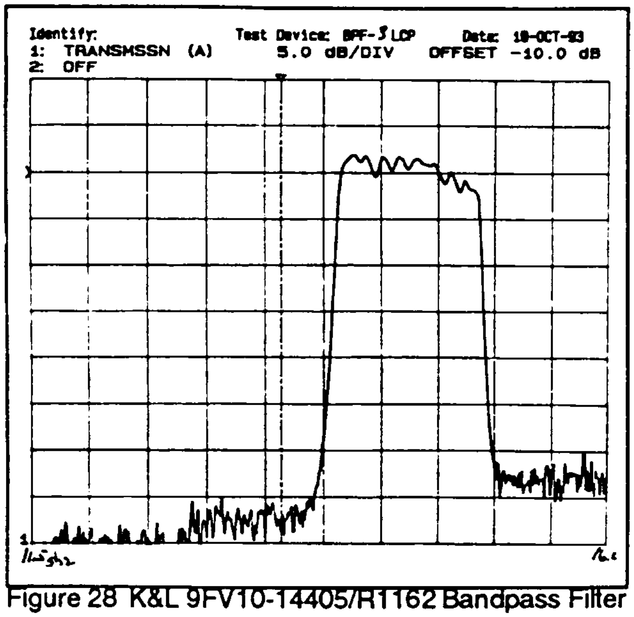

Figure 28 K&L 9FV10-14405/R1162 Bandpass Filter

IF Circuitry

The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

LO Drive Circuitry

The LO signal is input on J10; J1 is the standard LO jack on the other converter modules.

The LO drive circuitry consists of an SMT-S90-1279 amplifier, an OMNI-SPECTRA 2090-6210-00 two-way power divider, DITOM D3I-8016-2 isolators and K&L 6ED10-13500/U5000 LO filters. Figure 31 shows the LO filter attenuation plot.

The SMT-S91-1270 amplifiers are characterized over a frequency range of 11.4 to 15.9 GHz and are fabricated to NRAO specifications. NRAO SMT-S91-1279 specifications are: minimum gain - 12.0 dB; gain flatness - ± 0.5 dB; 1 dB compression point - +11.0 dBm; noise figure - 10. dB and input and output VSWR's - 1.5:1. A SMT-S91-1279 manufacturer's test data sheet is included in the back of this section.

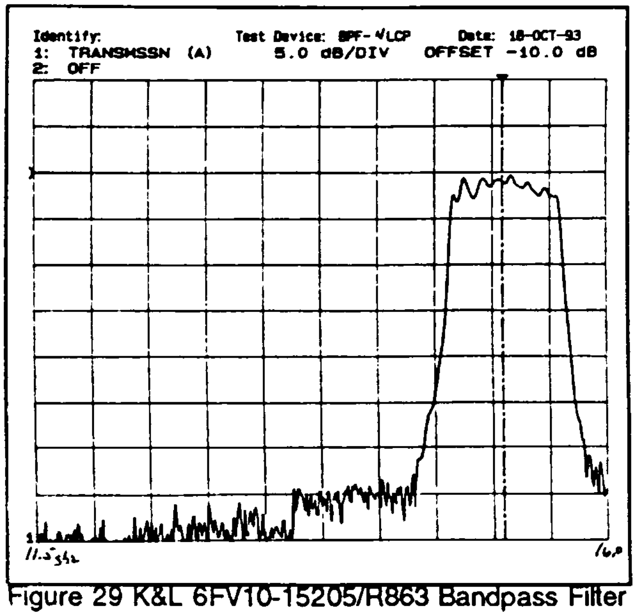

Figure 29 K&L 6FV10-15205/R863 Bandpass Filter

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[2] The Sierra Microwave Technology company has been acquired by the Milliwave company.

RF Switching and Switch Drive Circuitry

T108's RF switching consists of an RLC SR-TC-R-D transfer switch and four Transco 146C70600 4PST selector switches to select the filter inputs and outputs. The RLC SR-4C-D selector switch is interchangeable with the Transco 146C70600 and is used as an alternate in some modules. Data sheets for both switches are included in the rear of this section.

The transfer switch is designated S108A on drawing D58001K001. The T108 Block Diagram shows an RLC SR-TC-R-D transfer switch; some T108's may use the Transco 710C70100 as an alternate unit. The transfer switch is driven by M102, address 17H, bit 0. If bit 0 has a 0 value, the RCP and LCP signals are not interchanged; if bit 0 has a a 1 value, the signals are interchanged. Section 2.5 has data sheets for the two types of transfer switches.

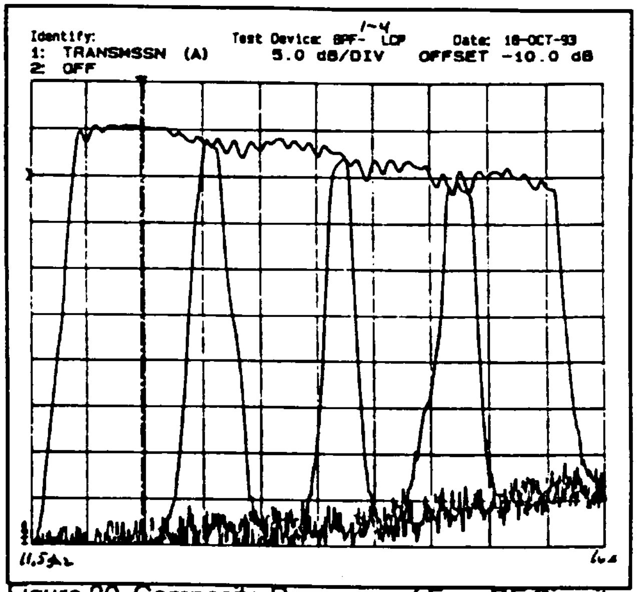

Figure 30 Composite Response of Four RF Circuitry Bandpass Filters

The four filter selector switches are designated S108B, S108C and S108D on drawing D58001K001, VLBA Electronic System Block Diagram (Antenna Electronics). Over the 12 to 15 GHz frequency range, typical VSWR, insertion loss and isolation values are: VSWR - 1.1:1; insertion loss - 0.2 dB and isolation - 90 dB. A Transco 146C70600 data sheet is included in the back of this section. Note that both the filter inputs and outputs are selected; common connections between inputs or outputs could cause undesirable interactions.

The four filter selector switch contacts are driven by individual solenoids; at any time, only one solenoid must be powered. Digital logic board, B53500A195 decodes the two-bit filter select code and drives one of the four solenoids in the four switches. It also drives one of the four front panel filter select indicator LED's.

Refer to sheet 2 of the T108 block diagram C53500K004, the digital logic board schematic C53500S005 and assembly drawing C53500A019, all at the back of this section. The two-bit filter select code iines on P11-19 (MSB) and P11-18 (LSB) are connected to terminals I2 (MSB) and I1 (LSB), respectively, on the digital logic board. The board is marked "SWT. DRIVERS" and is located in the front of T108. These two bits are input to two decoder sections of U4, a 74LS139 decoder chip; each decoder section has four low-true outputs that correspond to the four possible states of I1 and I2. Only one output is ever active low at any time. U4A's outputs are inverted by U3 inverters (74LS04) to drive U1 and U2, UDN2981A relay drivers that source a +28 volt drive to the four switch coils. Each UDN2981 has eight driver circuits and each decoder output drives four UDN2981A inputs. The four active UDN2981A outputs source +28 volt drive to the four associated switch solenoids.

U4B's four low-true outputs each sink current

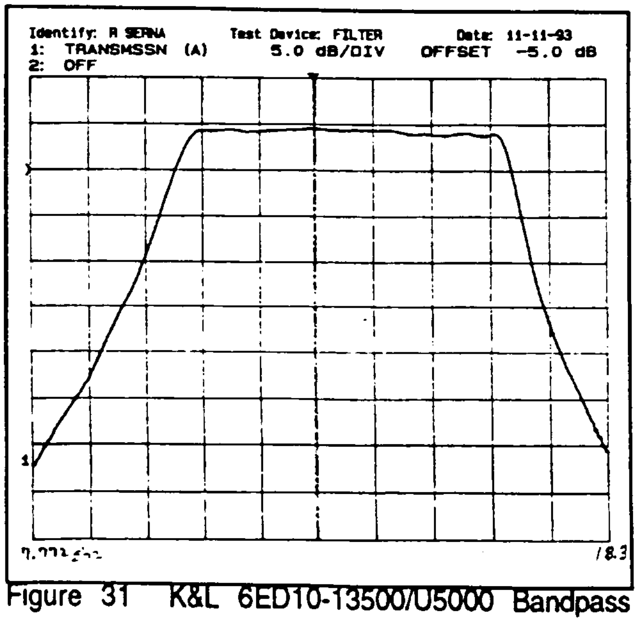

Figure 31 K&L 6ED10-13500/U5000 Bandpass Filter

from one of the front panel filter select indicator LED's as a function of the state of I1 and I2. The indicator LED's have internal current-limiting resistors but the board has terminals for installation of limiting resistors. The state of U4B's outputs are also connected to P11-1, 2, 3 and 4. These four lines also function as a monitor data output to M102 to indicate the state of the filter select logic. The M102 address is 21H and P11 pins 1,2,3 and 4 are input to bits 8, 9, 10 and 11, respectively.

The 74LS139, 74LS04 chips are Low Power Schottky TTL logic chips; data books are readily available so data sheets for these IC's are not included. The UDN2981[3] chip data sheet is included at back of this section, following the drawings.

M102 drives P11-19 (I1, LSB) and P11-18 (I2, MSB). The I1 and I2 signals are high-true TTL logic level signals. The M102 command address is 20H and bits 0 and 1 drive I1 and I2, respectively. The filter selection state table is shown below.

I2	I1	Selected Filter
0	0	9FV10-12405/R1157
0	1	9FV10-13405/R1160
1	0	9FV10-14405/R1162
1	1	6FV10-15205/R863

T108 Power Circuitry

Refer to sheet 2 of the T108 Block Diagram, C53500K004. T108 uses three types of DC power: +15 volts for radio frequency amplifiers, +5 volts for the digital logic board and LED's and +28 volts for filter selector switch control. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 1-4 where it is distributed to the amplifiers and gain control potentiometers. +5 volts from P11-10 is connected to terminal +5V on the digital logic board. +28 volts from P11-29 is connected to terminal +28V on the digital logic board. Power common distribution includes two chassis ground lugs that are the return paths for the +15 and +28 volt devices. These are the SMT amplifiers, the Amp/Attenuator, Amp/Divider and gain potentiometers. The common distribution ground lugs are connected to P11-42 (signal ground). The +5 volt logic common from terminal GND on the digital board is connected to the common distribution ground lugs and also P11-34 (power ground).

The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's +15 volt and common power terminals.

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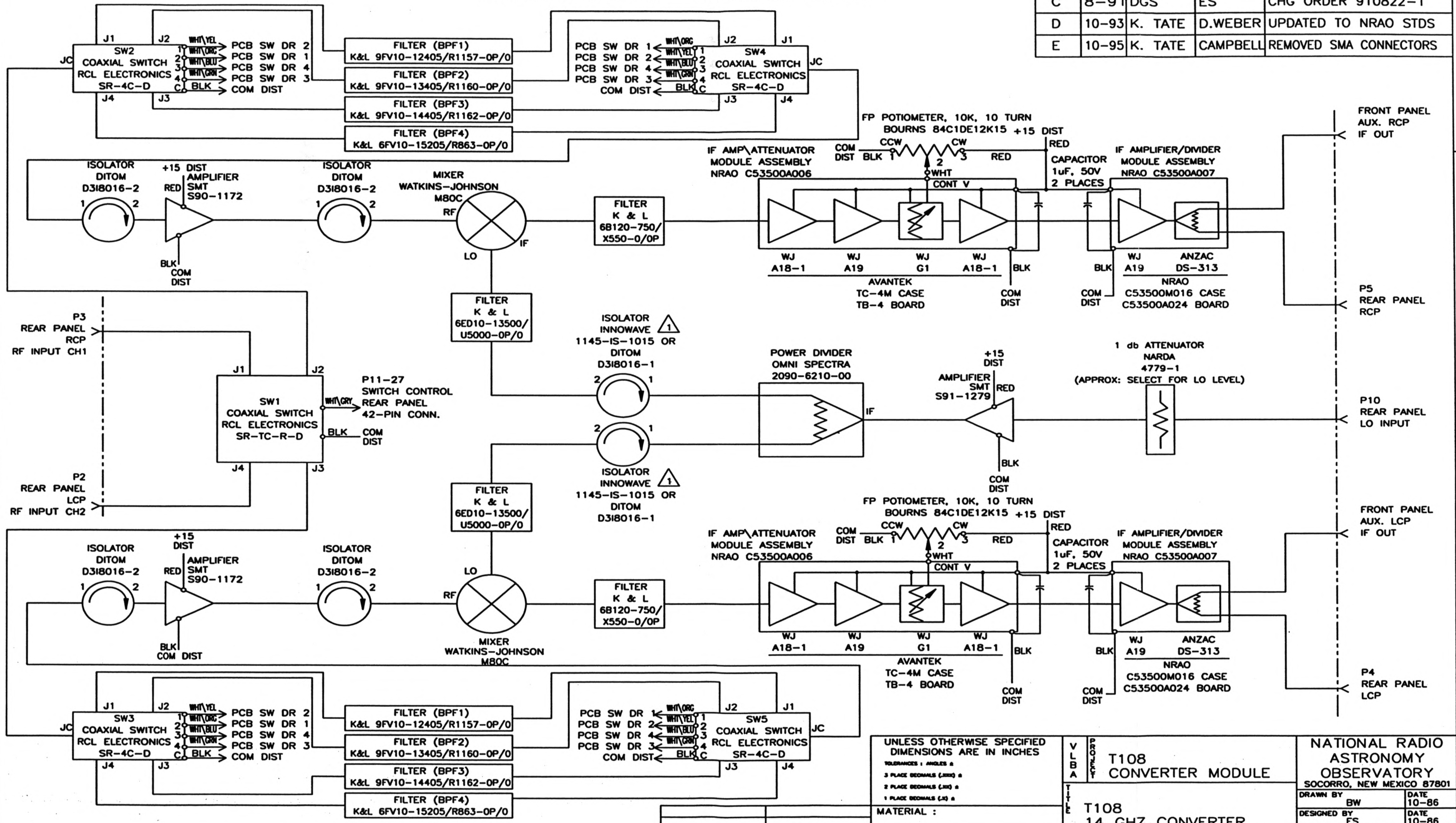
[3] The UDN2981 chips are now manufactured by Allegro.

NOTES:

1. INSTALL INNOWAVE ISOLATOR P/N 1145-IS-1015 IN MODULES 1 & 2 AND DITOM ISOLATOR P/N D318016-1 IN MODULES 3 & LATER

2. ASSEMBLE MODULES USING 6 POLE TRANSO SWITCH, P/N 82152-146C70600 INSTEAD OF 4 POLE RCL ELECTRONICS SWITCH P/N SR-4C-D AS FOLLOWS:
SMA CONNECTOR J3 WILL BE J4 WIRE CONNECTION 3 WILL BE 4
SMA CONNECTOR J4 WILL BE J5 WIRE CONNECTION 4 WILL BE 5

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	5-91	DGS	ES	MAJOR REDESIGN
B	8-91	DGS	ES	CHG ORDER 910802-1
C	8-91	DGS	ES	CHG ORDER 910822-1
D	10-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
E	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

NEXT ASSEMBLY	DWG. TYPE
A53500B004	BOM
D53500A021	ASSEMBLY

VLBA
PROJECT T108 CONVERTER MODULE

TITLE T108 14 GHZ CONVERTER MODULE BLOCK DIAGRAM

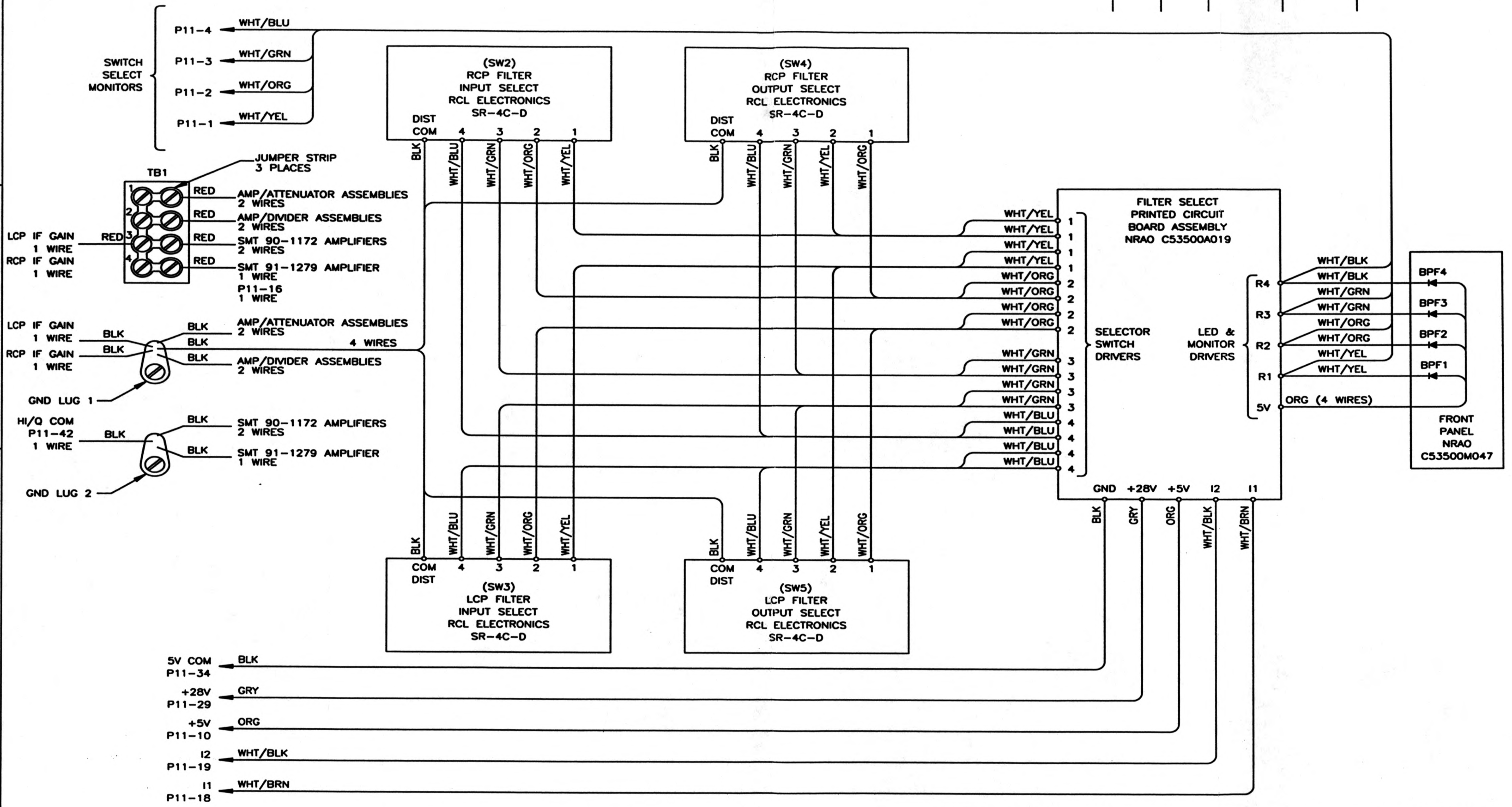
NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY BW DATE 10-86
DESIGNED BY ES DATE 10-86
APPROVED BY ES DATE 10-86

SHEET NUMBER 1 OF 2 DRAWING NUMBER C53500K004 REV. E SCALE NONE

ACAD : 53500A4A

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



SWITCH DRIVER AND POWER WIRING

ACAD : 53500K4B

PROPERTY OF NRAO

A53500B004	BOM
D53500A021	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA

PROJECT T108
CONVERTER MODULE

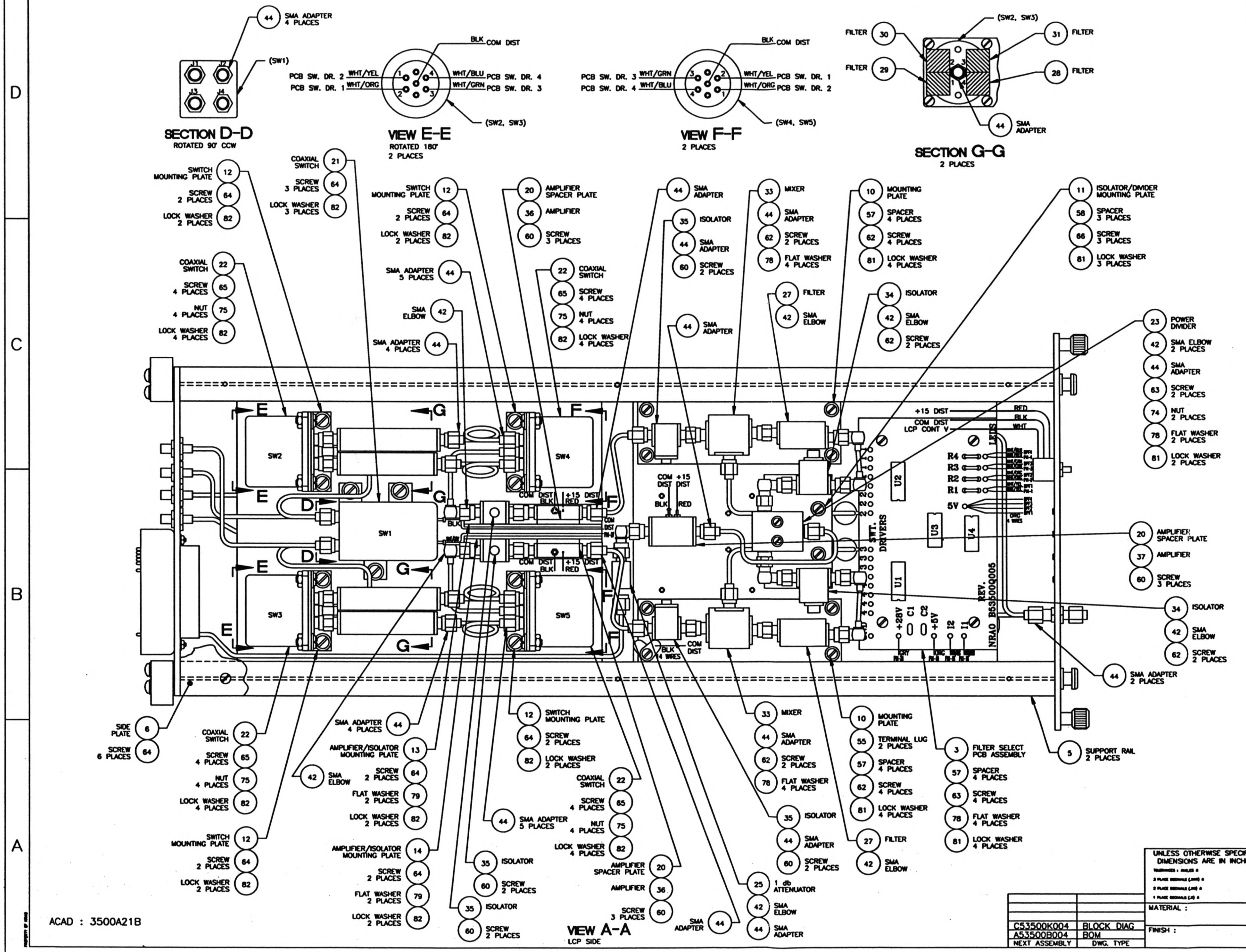
TITLE T108
14 GHZ CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY BW	DATE 10-86
DESIGNED BY ES	DATE 10-86
APPROVED BY ES	DATE 10-86

SHEET NUMBER 2 OF 2
DRAWING NUMBER C53500K004
REV. E
SCALE NONE

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



ACAD : 3500A21B

C53500K004	BLOCK DIAG
A53500B004	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

MATERIAL :

FINISH :

VLBA PROJECT T108
CONVERTER MODULE

TITLE T108
14 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

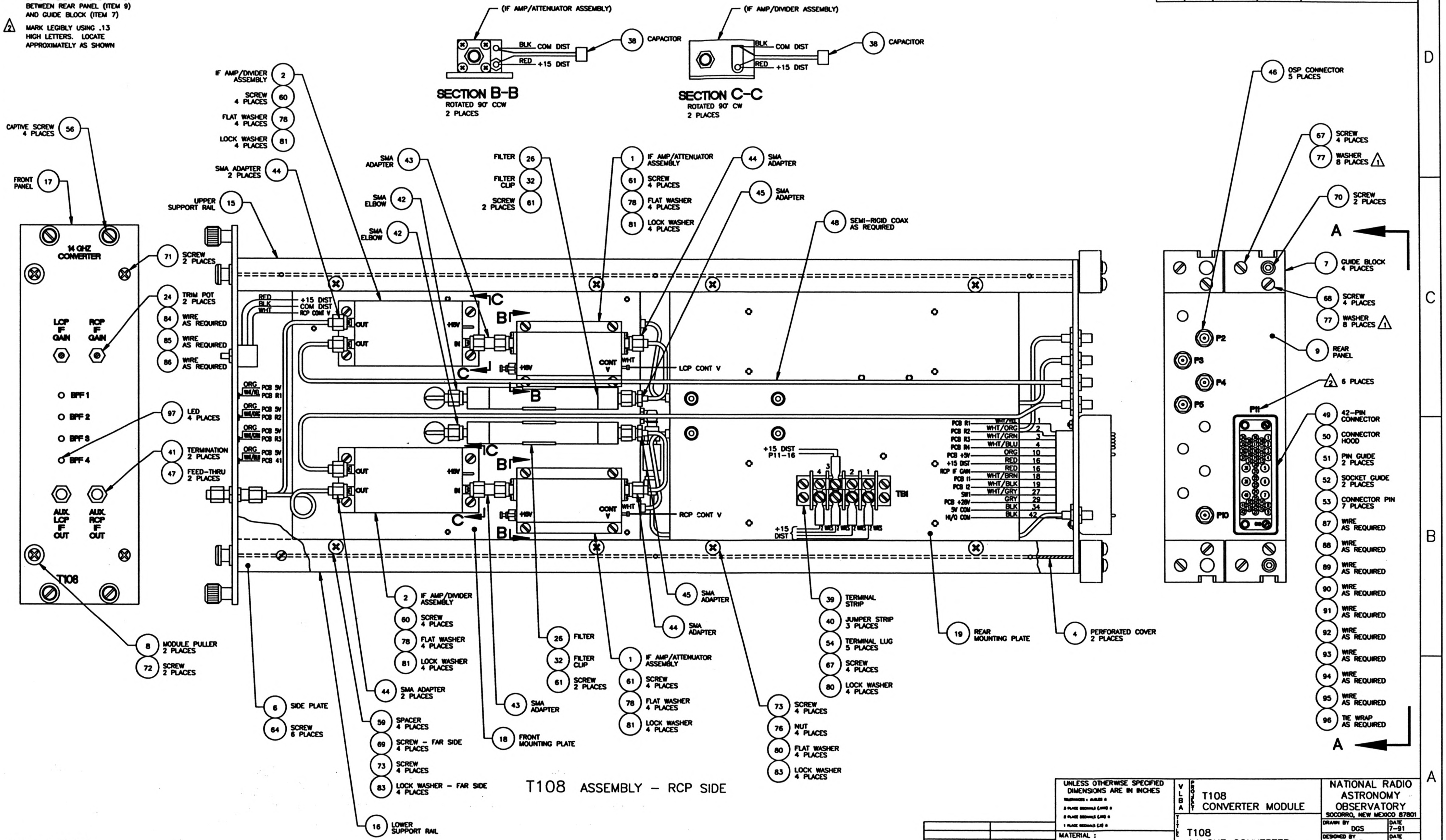
DRAWN BY	DGS	DATE	7-91
DESIGNED BY	ART	DATE	7-91
APPROVED BY	ART	DATE	7-91

SHEET NUMBER 2 OF 2 DRAWING NUMBER D53500A021 REV. B SCALE 1/1

NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 9) AND GUIDE BLOCK (ITEM 7)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	9-91	DGS	ART	CHG ORDER 910822-1
B	10-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS



T108 ASSEMBLY - RCP SIDE

ACAD : 3500A21A

C53500K004	BLOCK DIAG
A53500B004	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA
PROJECT T108
CONVERTER MODULE

TITLE T108
14 GHZ CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

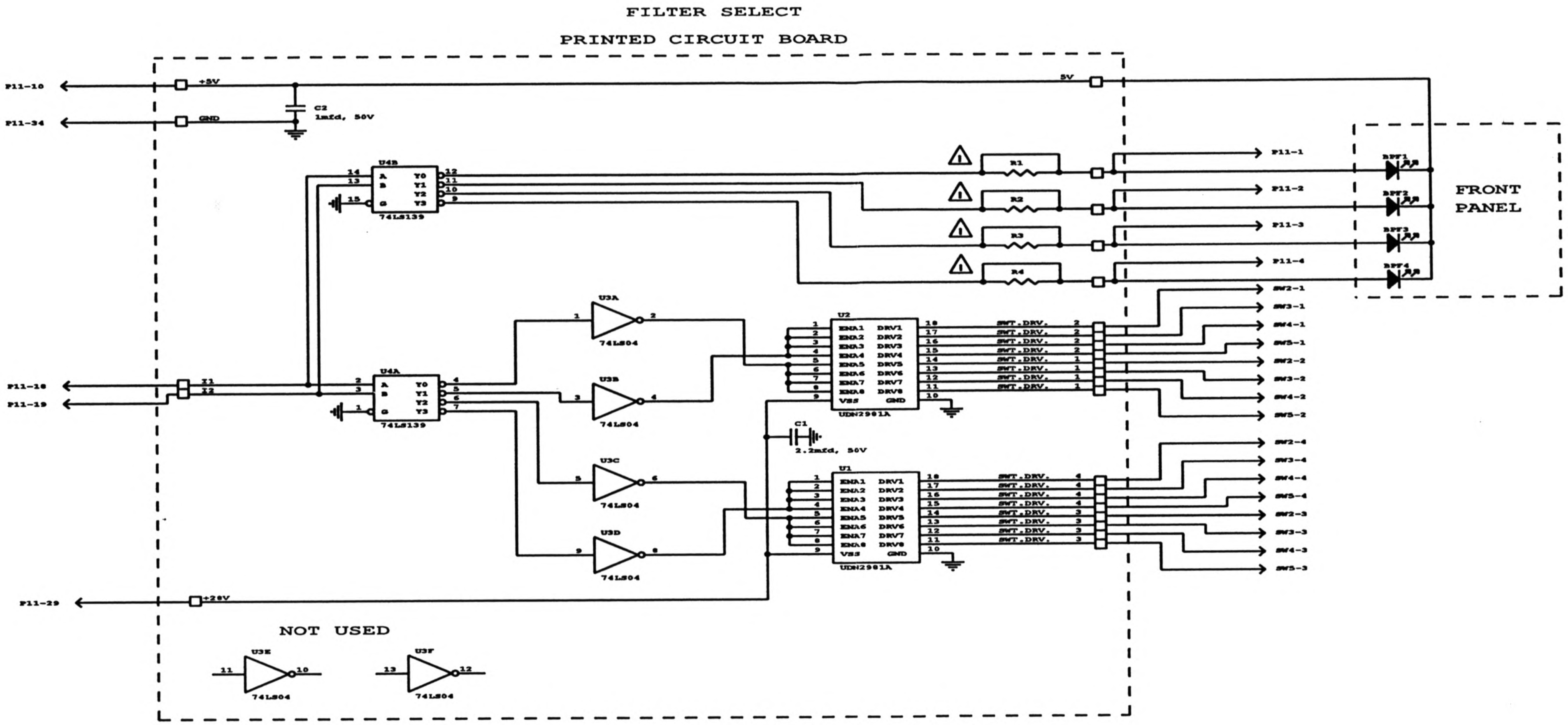
DRAWN BY DGS DATE 7-91
DESIGNED BY ART DATE 7-91
APPROVED BY ART DATE 7-91

SHEET NUMBER 1 OF 2
DRAWING NUMBER D53500A021
REV. B
SCALE 1/1

NOTES:

1. R1-R4 RESISTOR VALUES ARE DETERMINED BY BIAS VALUES OF BPF1-BPF4 LEDS
2. REFER TO NRAO DRAWING NUMBERS D53500A021 AND C53500K004 FOR COMPLETE CONVERTER MODULE WIRING

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	1-93	K. TATE		UPDATED TO NRAO STANDARDS
B	10-93	K. TATE	D. WEBER	ADDED P11, FRONT PANEL



D53500Q005	ARTWORK
C53500F006	DRILL DWG
C53500A019	ASSEMBLY
NEXT ASSEMBLY	DWG TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
3 PLACE DECIMALS (.XXX): ±
2 PLACE DECIMALS (.XX): ±
1 PLACE DECIMALS (.X): ±

MATERIAL:

FINISH:

VLBA PROJECT
T108
CONVERTER MODULE

TITLE
T108 14 GHZ
CONVERTER MODULE
FILTER SELECT PCB
SCHEMATIC DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

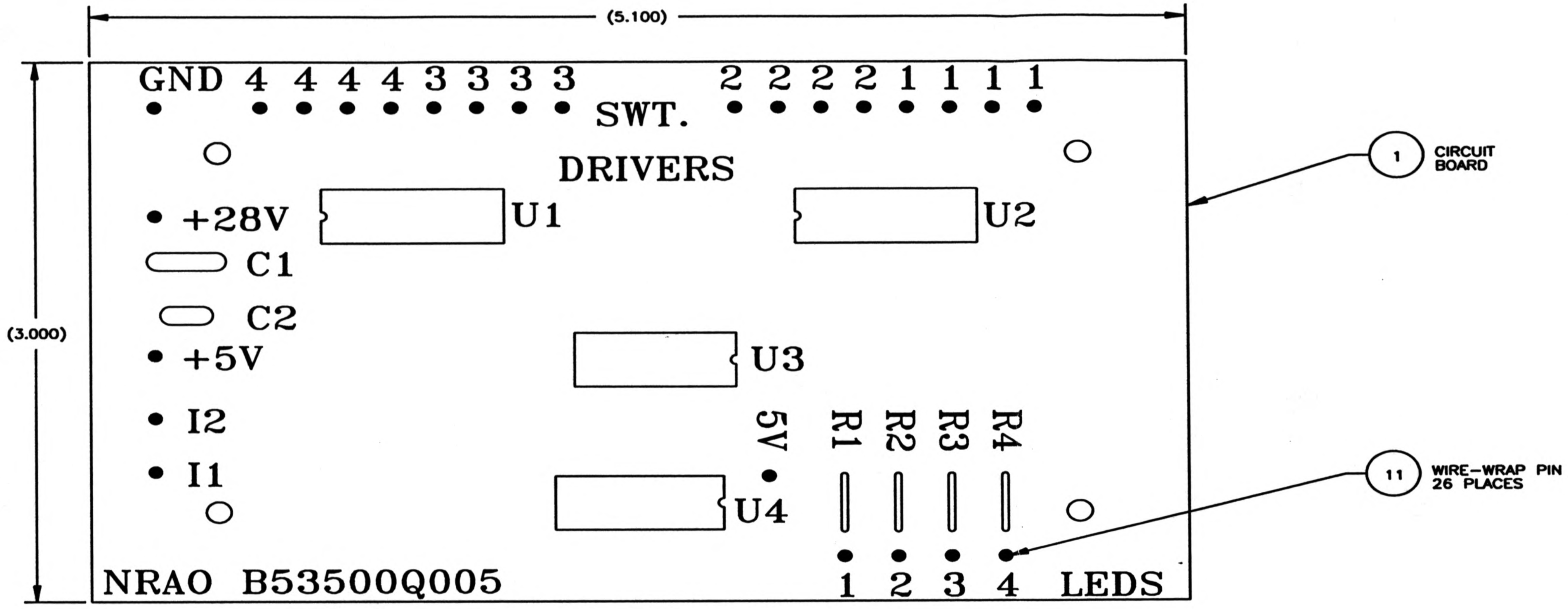
DRAWN BY W. WIREMAN
DATE 3-91
DESIGNED BY
DATE
APPROVED BY
DATE

SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500S005
REV. B
SCALE -

ORCAD : 53500S05

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



COMPONENT SIDE

ITEM NO.	REF. DES.	MANUFACTURER	PART NUMBER	DESCRIPTION	QTY
11				PIN, WIRE-WRAP	26
10	U4	ROBINSON NUGENT	ICT-163-S-TG30	SOCKET, IC, 16-PIN	1
9	U3	ROBINSON NUGENT	ICT-143-S-TG30	SOCKET, IC, 14-PIN	1
8	U1-U2	ROBINSON NUGENT	ICT-183-S-TG30	SOCKET, IC, 18-PIN	2
7	U4	SPRAGUE	SN74LS139N	IC, 16-PIN	1
6	U3	SPRAGUE	SN74LS04N	IC, 14-PIN	1
5	U1-U2	SPRAGUE	UDN2981A	IC, 18-PIN	2
4	R1-R4			JUMPER	4
3	C2	ERIE	RPE113X7R105K050V	CAPACITOR, 1.0uf, 50V	1
2	C1	ERIE	RPE117X7R225R50V	CAPACITOR, 2.2uf, 50V	1
1		NRAO	D53500Q005	BOARD, CIRCUIT	1

NEXT ASSEMBLY	DWG. TYPE
C53500S005	SCHEMATIC
D53500Q005	ARTWORK
C53500P006	DRILL DWG

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ± .005
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT T108
CONVERTER MODULE

TITLE T108 14 GHZ
CONVERTER MODULE
FILTER SELECT
PCB ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY K. TATE DATE 10-93
DESIGNED BY DATE
APPROVED BY DATE

SHEET NUMBER 1 OF 1 DRAWING NUMBER C53500A019 REV. – SCALE 2/1

ACAD : 53500A19

REVISIONS				
REV	DATE	DRAWN BY	APPR'D BY	DESCRIPTION
B	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 10-93			
DESIGNED BY	DATE		C53500K004	BLOCK DIAG
APPROVED BY D. WEBER	DATE 10-93		D53500A021	ASSEMBLY
			NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T108 CONVERTER MODULE

TITLE T108 14 GHZ CONVERTER MODULE
ASSEMBLY BOM

DWG NO. A53500B004 SHEET 1 OF 6

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B004 REV B DATE 10-18-93 PAGE 2 OF 6

MODULE T108 NAME 14 GHZ CONVERTER DWG# D53500A021 SUB ASSY ________ DWG# ________

SCHEM. DWG# C53500K004 LOCATION ________ QUA/SYS. ________ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	D53500A019	ASSY, FILTER SELECT PCB	1
4		NRAO	C53306M014-1	COVER, PERFORATED	2
5		NRAO	C53306M016	RAIL, SUPPORT	2
6		NRAO	C53306M017	PLATE, SIDE	2
7		NRAO	B53306M018	BLOCK, GUIDE	4
8		NRAO	A53306M038	PULLER, MODULE	2
9		NRAO	B53500M004-1	PANEL, REAR	1
10		NRAO	C53500M041	PLATE, ISO/MIXER/FILTER	2
11		NRAO	C53500M042-2	PLATE, ISOLATOR/DIVIDER	1
12		NRAO	C53500M043	PLATE, SWITCH MOUNTING	4
13		NRAO	C53500M044-1	PLATE, AMPLIFIER/ISOLATOR	1
14		NRAO	C53500M044-2	PLATE, AMPLIFIER/ISOLATOR	1
15		NRAO	C53500M045	RAIL, UPPER SUPPORT	1
16		NRAO	C53500M046	RAIL, LOWER SUPPORT	1
17		NRAO	C53500M047	PANEL, FRONT	1
18		NRAO	D53500M048	PLATE, FRONT MOUNTING	1
19		NRAO	D53500M049	PLATE, REAR MOUNTING	1
20		NRAO	C53500M050	PLATE, AMPLIFIER SPACER	3

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B004 REV B DATE 10-18-93 PAGE 3 OF 6

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21	SW1	RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
22	SW2-SW5	RLC ELECTRONICS	SR-4C-D	SWITCH, COAXIAL	4
23		OMNI SPECTRA	2090-6210-00	DIVIDER, POWER	1
24		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	2
25		NARDA	4779-1	ATTENUATOR, 1 db	1
26		K & L	6B120-750/X550-0/0P	FILTER	2
27		K & L	6ED10-13500/U5000-0/0P	FILTER	2
28		K & L	6FV10-15205/R863-0P/0	FILTER	2
29		K & L	9FV10-12405/R1157-0P/0	FILTER	2
30		K & L	9FV10-13405/R1160-0P/0	FILTER	2
31		K & L	9FV10-14405/R1162-0P/0	FILTER	2
32		AUGAT	6014-1A	CLIP, FILTER	2
33		WATKINS-JOHNSON	M80C	MIXER	2
34		DITOM	D3I8016-1	ISOLATOR	2
35		DITOM	D3I8016-2	ISOLATOR	4
36		SMT	S90-1172	AMPLIFIER	2
37		SMT	S91-1279	AMPLIFIER	1
38		SPRAGUE	2C20Z50105M050B	CAPACITOR, 1μf, 50V	4
39	TB1	TRW CINCH	4-140	STRIP, TERMINAL	1
40	TB1	TRW CINCH	140J-1	STRIP, JUMPER	3
41		SOLITRON	8018-6005	TERMINATION, 50Ω	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B004 REV B DATE 10-18-93 PAGE 4 OF 6

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42		SOLITRON	2007-5035-2	ELBOW, SMA MALE/.085 COAX	11
43		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	2
44		SOLITRON	2906-6002	ADAPTER, SMA MALE/.085 COAX	40
45		SOLITRON		ADAPTER, SMA FEM/.085 COAX	2
46	P2-P5,P10	OMNI SPECTRA	2081-0000-00	CONNECTOR, OSP, .085 MALE	5
47		OMNI SPECTRA	2084-0000-00	FEED-THRU, SMA	2
48		PRECISION TUBE	AA50085	COAX, .085 SEMI-RIGID	AR
49	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
50		AMP	202394-2	CONNECTOR, HOOD, 42-PIN	1
51		AMP	200833-2	PIN, GUIDE	2
52		AMP	203964-5	SOCKET, GUIDE	2
53		AMP	201578-1	PIN, 16 GA. CONNECTOR	12
54		ETC/MOLEX	AA-832-06	LUG, TERMINAL	5
55				LUG, TERMINAL	2
56		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
57		KEYSTONE	1593-4	SPACER, 4-40UNC-2B x .19	12
58		H.H. SMITH	8522	SPACER, 8-32UNC-2B x .38	3
59		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4
60				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	25
61				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	12

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B004 REV B DATE 10-18-93 PAGE 5 OF 6

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
62				SCREW, PAN HEAD, SS, 4-40UNC-2A x .38	16
63				SCREW, PAN HEAD, SS, 4-40UNC-2A x .50	6
64				SCREW, PAN HEAD, SS, 6-32UNC-2A x .25	27
65				SCREW, PAN HEAD, SS, 6-32UNC-2A x .38	16
66				SCREW, PAN HEAD, SS, 6-32UNC-2A x .50	3
67				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	8
68				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
69				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
70				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
71				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
72				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
73				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .75	8
74				NUT, HEX, SS, 4-40UNC-2B	2
75				NUT, HEX, SS, 6-32UNC-2B	16
76				NUT, HEX, SS, 8-32UNC-2B	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B004 REV B DATE 10-18-93 PAGE 6 OF 6

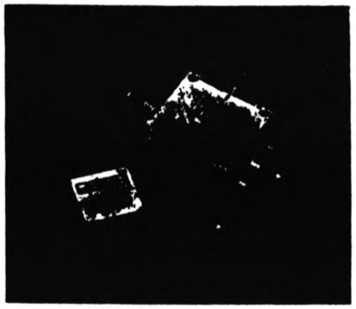
ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
77				WASHER, EXT. TOOTH #6	16
78				WASHER, FLAT, SS, #4	30
79				WASHER, FLAT, SS, #6	4
80				WASHER, FLAT, SS, #8	4
81				WASHER, LOCK, SS, #4	31
82				WASHER, LOCK, SS, #6	33
83				WASHER, LOCK, SS, #8	8
84		ALPHA	7055	WIRE, WHT #22	AR
85		ALPHA	7055	WIRE, BLK #22	AR
86		ALPHA	7055	WIRE, RED #22	AR
87		ALPHA	7055	WIRE, GRY #22	AR
88		ALPHA	7055	WIRE, ORG #22	AR
89		ALPHA	7053	WIRE, WHT/BLK #26	AR
90		ALPHA	7053	WIRE, WHT/YEL #26	AR
91		ALPHA	7053	WIRE, WHT/ORG #26	AR
92		ALPHA	7053	WIRE, WHT/GRN #26	AR
93		ALPHA	7053	WIRE, WHT/BLU #26	AR
94		ALPHA	7053	WIRE, WHT/BRN #26	AR
95		ALPHA	7053	WIRE, WHT/GRY #26	AR
96				WRAP, TIE	AR
97	BPF1-BPF4			LED, GREEN	4
98					

WJ-M80/M80C

DOUBLE-BALANCED MIXER

- ◆ LO 4 TO 18 GHz
  RF 6 TO 18 GHz
- ◆ IF DC TO 3000 MHz
- ◆ LO DRIVE +7 dBm (nominal)
- ◆ WIDE BANDWIDTH
- ◆ LOW NOISE FIGURE

*MIL–M–28837 Screening Available (See "QPL Mixers" Section)



Guaranteed Specifications

Characteristics	Min.	Typ.	Max.	Test Conditions
SSB Conversion Loss and SSB Noise Figure		6.0 dB	8.0 dB	f_R = 6 to 16 GHz f_L = 5 to 17 GHz f_I = 30 to 1000 MHz
		7.0 dB	9.0 dB	f_R = 6 to 18 GHz f_L = 4 to 18 GHz f_I = 1000 to 3000 MHz
Isolation				
L to R	23 dB	36 dB		f_L = 3.5 to 14 G Hz
	18 dB	32 dB		f_L = 14 to 18 GHz
L to I	16 dB	28 dB		f_L = 3.5 to 9 GHz
	23 dB	38 dB		f_L = 9 to 18 GHz
Conversion Compression			1.0 dB	f_R Level +3 dBm f_L Level +7 dBm
Third-Order		+10 dBm		f_{R1} = 13.00 GHz, f_{R2} = 13.01 GHz both at -10 dBm f_L = 14.0 GHz at +7 dBm

Notes:

1 Measured in a 50-ohm system with nominal LO drive and downconverter application only,unless otherwise specified. The I-Port frequency range extends to DC for phase detection, pulse modulation, or attenuator applications, I-Port VSWR degrades from a 50-ohm system at low IF frequencies.

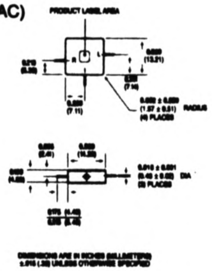
Absolute Maximum Ratings

Operating Temperature ....-54°C to +100°C
Storage Temperature ....-65°C to +100°C
Peak Input Power..........................+23 dBm max. at +25°C, 20 dBm max. at +100°C
Peak Input Current at 25°C ....100 mA DC

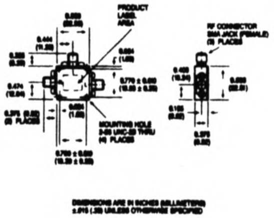
Weight	M80: 6 grams (0.21 oz.) max. M80C: 30 grams (1.06 oz.) max.

Outline Drawings

M80
(MINPAC)

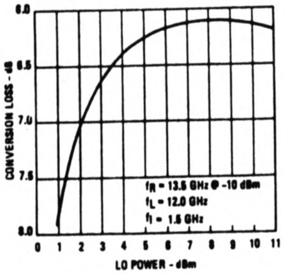


M80C
(CONNECTORIZED)

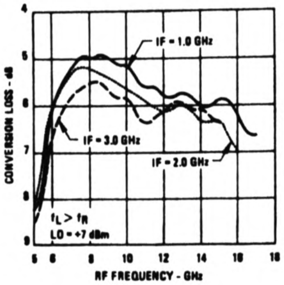


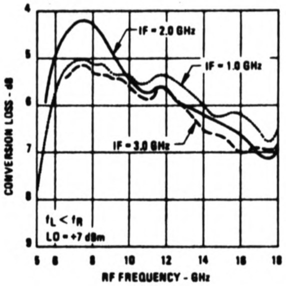
Typical Performance at 25°C

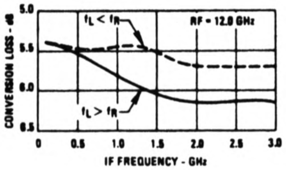
Conversion Loss vs. LO Drive Power



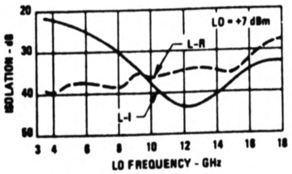
Conversion Loss



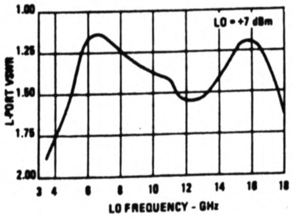


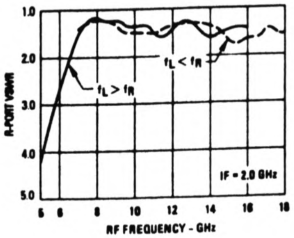


Isolation

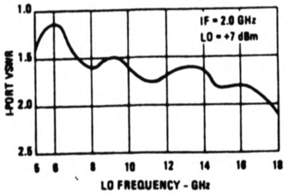


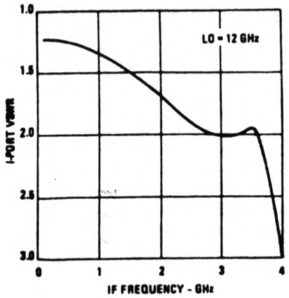
VSWR





VSWR





Typical Two-Tone Intermodulation Performance

f_I = 1.0 GHz
f_{R1} = 13.00 GHz at -10 dBm
f_{R2} = 13.01 GHz at -10 dBm
f_L = 14.0 GHz at +7 dBm
Vertical Scale is 10 dB/Div.

SMT SIERRA MICROWAVE TECHNOLOGY

AMPLIFIER TEST DATA SHEET

NOISE METER S/N 01226
NOISE SOURCE S/N 01171
CURRENT DRAWN FROM AC/DC SUPPLY OF +15 V 96 MA
(120 MA MAX/TYP)

SMT PART # 890-1172
CUST. PART # —
SERIAL # 1400

	GAIN (dB) FLATNESS± .75	VSWR :1 IN	OUT	POWER (dBm) 1dB	SAT	NOISE FIGURE (dB)		
SPEC.	+18.0	1.5:1	1.5:1	+10	–	2.5		

FREQUENCY (GHz)								
12.00	18.0	–	–	16.4	–	2.2		
13.75	18.0	–	–	16.4	–	2.3		
14.75	18.0	–	–	16.5	–	2.3		
15.00	18.0	–	–	16.5	–	2.4		
15.40	18.2	–	–	16.8	–	2.3		
MIN.								
MAX.		1.40:1	1.46:1					

TECH. DATE 9/24/91
QA. R Mazza A 3 DATE 9-24-91

NOTE: DATA TAKEN AT 25 °C.

DWG. NO.
AFD-0001-001

SMT SIERRA MICROWAVE TECHNOLOGY

AMPLIFIER TEST DATA SHEET

NOISE METER S/N 01156.
NOISE SOURCE S/N 01171
CURRENT DRAWN FROM AC/DC SUPPLY OF +15.0 V 108 MA
(— MA MAX/TYP)

SMT PART # 591-1279
CUST. PART # —
SERIAL # 1177

	GAIN (dB) FLATNESS± 0.5	VSWR :1 IN	OUT	POWER (dBm) 1dB	SAT	NOISE FIGURE (dB)		
SPEC.	12.0 MIN	1.50	1.50	+11.0	–	10.0		

FREQUENCY (GHz)								
11.40	13.2	1.36	1.23	+14.0	–	4.0		
12.53	13.0	1.24	1.16	+14.3	–	4.2		
13.65	13.0	1.20	1.23	+13.5	–	4.2		
14.78	13.2	1.25	1.39	+14.2	–	4.1		
15.90	13.0	1.41	1.38	+14.0	–	4.0		
MIN.	12.9	–	–	+13.5	–	–		
MAX.	13.2	1.41	1.46	–	–	4.2		

TECH. DATE 5/24/91
QA. DATE 5-24-91

NOTE: DATA TAKEN AT 25 °C.

DWG. NO.
AFD-0001-001

COAXIAL SWITCH
TYPE MO
DATA SHEET 111A

SWITCH TYPE	**SP3T to SP6T**
ACTUATOR	*** Selective with Solder Terminal**
CONNECTOR	**SMA**
FREQUENCY	**0-18 GHz**

*SOLENOID FOR EACH RF POSITION

DESCRIPTION

The Type MO SP3T to SP6T switch utilizes selective linear actuators for each position. RF geometry is optimized for SMA connectors and operates over a 0-18 GHz frequency band. Individual solenoids mean faster switching time . . . no waiting for the switch to sequence through a number of positions before stopping at the selected position. Separate "selective" solenoids provide positive action and a low actuator current requirement.

These switches are immersion proof and designed for extreme environmental conditions including temperature, vibration and shock.

This switch is part of a Transco family of switches. Other types in this family are referenced below

TYPE	CONN	FREQ
ML	TNC & N	12.4 GHz
M	TNC & N	12.4 GHz
MX	SC	6.5 GHz

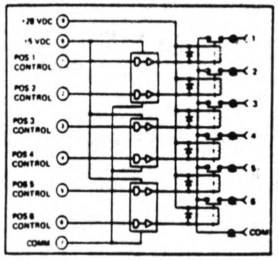
DESIGNED TO MEET MIL-S-3928

STANDARD PRODUCTS

P/N	SCHEMATIC	MIL SPEC
143C70600	1	
144C70600	2	
145C70600	3	
146C70600	4	
146C70600-30	5	TTL Logic
146C70600-8	4	QUALIFIED PRODUCT LIST MIL-S-3928/18-02

SPECIAL CONFIGURATIONS

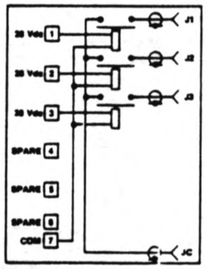
Actuating Voltage
Transient Circuit
TTL Logic Circuit



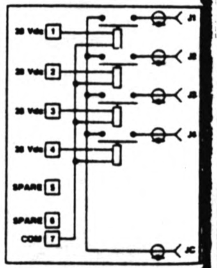
SCHEMATIC 5
146C70600-30

SCHEMATIC

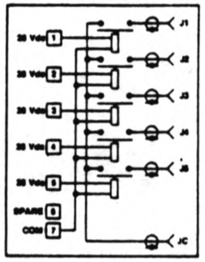
SCHEMATIC 1
3 POS



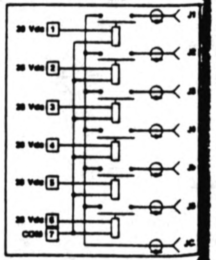
SCHEMATIC 2
4 POS



SCHEMATIC 3
5 POS



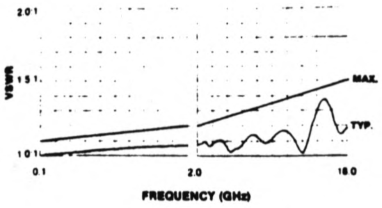
SCHEMATIC 4
6 POS

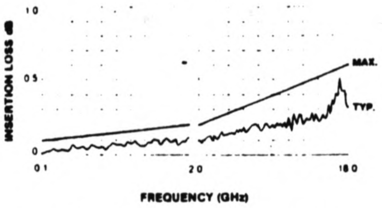


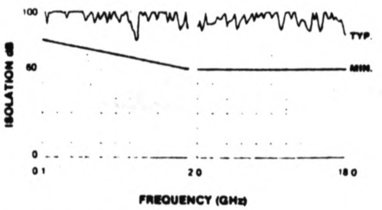
COIL ACTUATION IS NOT AFFECTED BY POLARITY OF SUPPLY VOLTAGE

SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:







LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

LOGIC TRUTH TABLE 146C70600-30

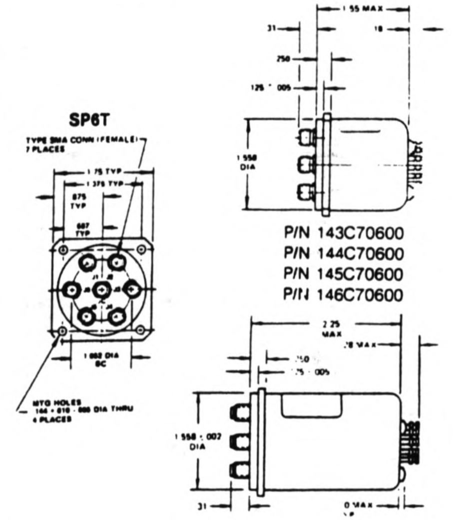
VOLTAGE

28 Vdc 24 to 30 Vdc
5 Vdc 4.5 to 5.5 Vdc
Control Input: (TTL-Compatible)
Level 0: 0-0.4 Vdc
Level 1: 2.4-5.5 Vdc

CONTROL INPUT LOGIC TABLE						RF CONN
1	2	3	4	5	6	RF COM TO
0	0	0	0	0	0	OPEN
1	0	0	0	0	0	RF 1
0	1	0	0	0	0	RF 2
0	0	1	0	0	0	RF 3
0	0	0	1	0	0	RF 4
0	0	0	0	1	0	RF 5
0	0	0	0	0	1	RF 6

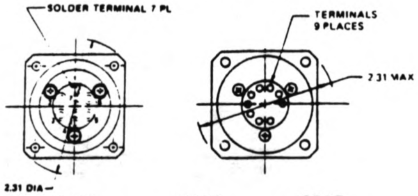
VOLTAGE	20 to 30 Vdc
COIL RESISTANCE	205 ±15 ohms @ 20° C
CURRENT	170 mA max @ 28 Vdc & 20° C
SWITCHING TIME	20 mS max @ 28 Vdc & 20° C
IMPEDANCE	50 ohms nominal
VIBRATION	10 g's sine/random
TEMPERATURE	-55°C to 85°C
LIFE	1,000,000 operations min
WEIGHT	5.5 oz max for the SP6T

DIMENSIONS

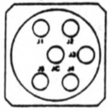


P/N 143C70600
P/N 144C70600
P/N 145C70600
P/N 146C70600

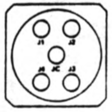
P/N 146C70600-30



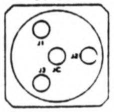
SP5T



SP4T



SP3T



Type C Multi-Position Coaxial Switches (3 to 6 Position)

RLC Electronics' Basic Mid-size Multi-Position Coaxial Switch line provides up to 6 positions in an extremely high reliability, long life and outstanding electrical performance by utilizing high density packaging. The "Multi-Min" electrical characteristics features extremely low insertion loss and VSWR over the entire DC-18 GHz range while maintaining high isolation. The switch is available in the following configurations — manual or remote, 28 Vdc or 115 Vac operation, with or without indicator terminals, failsafe or latching cutthroat.

Specifications

$S^{1-2}C^{-3,4,5,6,7}$

RF POSITIONS	3-6	3-6	3 TO 6 FOR OPTION 40	
Switch type:	SP-3T...6T	SP-3T...6T	SP-3T-40 .... SP-6T-40	
Frequency Range	DC-18 GHz	DC-26.5 GHz	DC-40 GHz	
Ins. Loss (dB max)			Ins. Loss: (dB max)	
DC-4.0 GHz	0.20	0.20	DC-6.0 GHz	0.25
4.0-12.4 GHz	0.30	0.30	6.0-12 GHz	0.40
12.4-18 GHz	0.50	0.50	12-18.5 GHz	0.50
18-26.5 GHz (Opt. 26)	—	0.75	18.5-26.5 GHz	0.75
			26.5-40 GHz	1.00
VSWR: (Max)			VSWR: (Max)	
DC-4.0 GHz	1.25	1.25	DC-6.0 GHz	1.30
4.0-12.4 GHz	1.40	1.40	6.0-12 GHz	1.40
12.4-18 GHz	1.50	1.50	12-18.5 GHz	1.50
18-26.5 GHz (Opt. 26)	—	1.80	18.5-26.5 GHz	1.70
			26.5-40 GHz	2.00
Isolation: (dB Max)			Isolation: (dB Max)	
			DC-18.5 GHz	60
DC-18 GHz	60	60	18.5-26.5 GHz	55
18-26.5 GHz (Opt. 26)	—	40	26.5-40 GHz	45

Power Rating, RF, Cold Switching: See page 5.
Impedance: 50 ohms.
Operating Power 25°C:
(Failsafe): 12 Vdc at 400 ma nom.
28 Vdc at 150 ma nom.
115 Vac at 50 ma nom.
(Latching): 12 Vdc at 462 ma nom. 28 Vdc at 400 ma nom. 115 Vac at 225 ma nom. Current applied 10 ms min.; cutthroat standard, recovery time 100 ms nom.

Connectors, RF: SMA Female
Connectors, Power: Feed through solder lugs.
Life: 1,000,000 operations.
Switching Time: 15 milliseconds max.
Weight: 10 oz.
Environmental Conditions: MIL-S-3928
Operating Mode: Manual, failsafe or latching.
Switching Sequence: Break before make.

To designate the switch desired use:

(1) "M" for Manual or "R" for Remote
(2) "3C", "4C", "5C", or "6C" throw operation.
(3) "A" for 115 Vac, "D" for 28 Vdc power or "H" for 12 Vdc.
(4) "I" for indicators if desired.
(5) "L" for latching cut throat if desired.
(6) "TL" for TTL Driver if desired.
(7) "26" for 26.5 GHz options.

Example: SR-6C-D-I-L is remote, 6 position, 28 Vdc, with indicators, latching cutthroat switch.

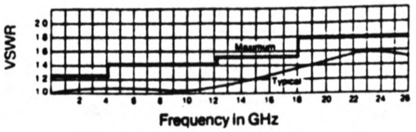
Specials requiring closer tolerances, different frequency ranges, special connectors, different materials, finishes, etc. can be furnished upon request.

RLC ELECTRONICS, INC.
83 Radio Circle, Mt. Kisco, N.Y. 10549 • (914) 241-1334

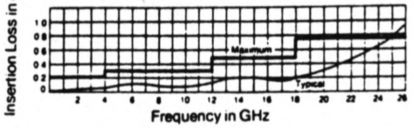
Typical Operating Curves

DC-18 & DC-26 GHz Switches

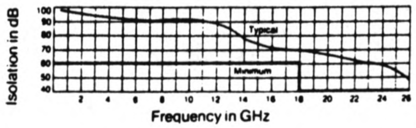
VSWR Vs. Frequency



Insertion Loss Vs. Frequency

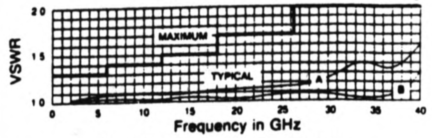


Isolation Vs. Frequency

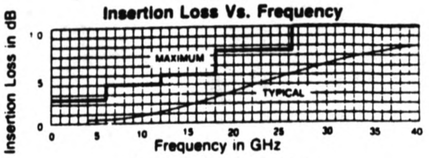


DC-40 GHz Switches

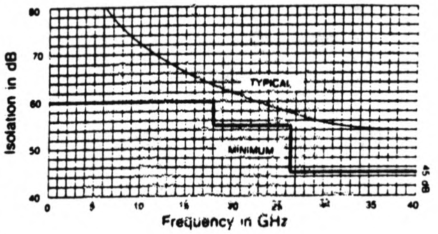
VSWR Vs. Frequency



Insertion Loss Vs. Frequency

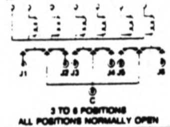


Isolation Vs. Frequency

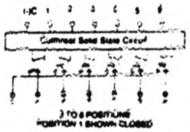


Schematics

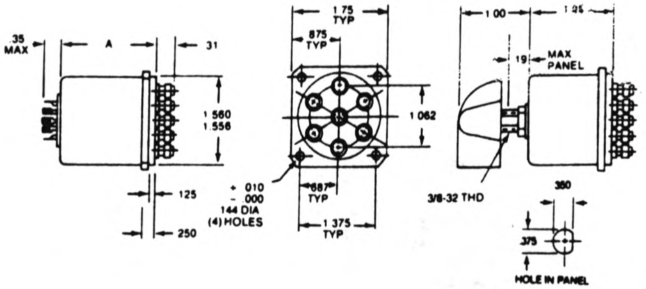
Failsafe



Latching



Outlines



MODEL NO.	A
SR- • C-D	1.58
SR- • C-D-I	1.58
SR- • C-D-L	3.00
SR- • C-D-I-L	4.00
SR- • C-D-TL	2.25
SR- • C-D-I-TL	2.50
SR- • C-D-L-TL	4.00
SR- • C-D-I-L-TL	4.40
SR- • C-H same as SR- • C-D	

Tolerances unless otherwise specified are: .xx, ± .02; .xxx, ± .005.

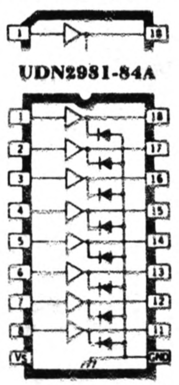
RLC ELECTRONICS, INC.
83 Radio Circle, Mt. Kisco, N.Y. 10549 • (914) 241-1334

2981 THRU 2984

8-CHANNEL SOURCE DRIVERS

UDN2982/84LW

UDN2981-84A



Dwg. No. A-10,843

ABSOLUTE MAXIMUM RATINGS at 25°C Free-Air Temperature

Output Voltage Range, V_{CE}
  (UDN2981A & UDN2982A/LW) . . . . 5 V to 50 V
  (UDN2983A & UDN2984A/LW) . . . . 35 V to 80 V
Input Voltage, V_{IN}
  (UDN2981A & UDN2983A) . . . . . . 15 V
  (UDN2982A/LW & UDN2984A/LW) . . . . 20 V
Output Current, I_{OUT} . . . . -500 mA
Package Power Dissipation,
  P_D . . . . See Graph
Operating Temperature Range,
  T_A . . . . -20°C to +85°C
Storage Temperature Range,
  T_S . . . . -55°C to +150°C

Note that the UDN2982/84A (dual in-line package) and UDN2982/84LW (small-outline IC package), respectively, are electrically identical and share a common pin number assignment.

Recommended for applications requiring separate logic and load grounds, load supply voltages to 80 V, and load currents to 500 mA, the UDN2981A through UDN2984A/LW 8-channel source drivers are used as interfaces between standard low-power digital logic and relays, solenoids, stepping motors, magnetic print hammers, and LEDs.

The UDN2981A and UDN2983A drivers are for use with 5 V logic systems–TTL, Schottky TTL, DTL, and 5 V CMOS. The UDN2982A/LW and UDN2984A/LW drivers are intended for MOS interface (PMOS and CMOS) operating from supply voltages of 6 to 16 V. The UDN2981A and UDN2982A/LW will withstand a maximum output OFF voltage of 50 V, while the UDN2983A and UDN2984A/LW will withstand an output voltage of 80 V. In all cases, the output is switched ON by an active high input level. All devices incorporate input current limiting resistors and output transient suppression diodes.

The suffix 'A' (all devices) indicates an 18-lead plastic dual in-line package with copper lead frame for optimum power dissipation. Under normal operating conditions, these devices will sustain 120 mA continuously for each of the eight outputs at an ambient temperature of +50°C and a supply of 15 V.

The suffix 'LW' (UDN2982LW and UDN2984LW only) indicates a surface-mountable wide-body SOIC package.

FEATURES

- TTL, DTL, PMOS, or CMOS Compatible Inputs
- 500 mA Output Source Current Capability
- Transient-Protected Outputs
- Output Breakdown Voltage to 80 V
- DIP or SOIC Packaging

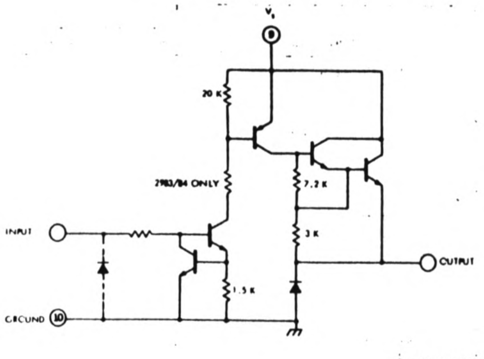
Always order by complete part number, e.g., UDN2981A.
Note that all devices are not available in both package types.

ELECTRICAL CHARACTERISTICS at T_A = +25°C (unless otherwise specified).

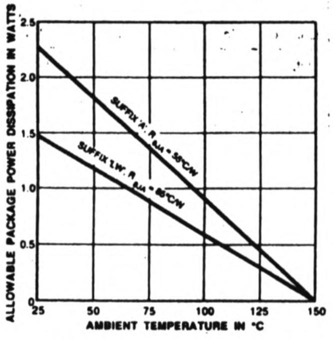
Characteristic	Symbol	Applicable Devices	Test Conditions	Test Fig.	Limits Min.	Typ.	Max.	Units
Output Leakage Current	I_{CEX}	UDN2981/82†	V_{IN} = 0.4 V*, V_S = 50 V, T_A = +70°C	1	—	—	200	µA
		UDN2983/84†	V_{IN} = 0.4 V*, V_S = 80 V, T_A = +70°C	1	—	—	200	µA
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	All	V_{IN} = 2.4 V, I_{OUT} = -100 mA	2	—	1.6	1.8	V
			V_{IN} = 2.4 V, I_{OUT} = -225 mA	2	—	1.7	1.9	V
			V_{IN} = 2.4 V, I_{OUT} = -350 mA	2	—	1.8	2.0	V
Input Current	$I_{IN(ON)}$	UDN2981/83A	V_{IN} = 2.4 V	3	—	140	200	µA
			V_{IN} = 3.85 V	3	—	310	450	µA
		UDN2982/84†	V_{IN} = 2.4 V	3	—	140	200	µA
			V_{IN} = 12 V	3	—	1.25	1.93	mA
Output Source Current	I_{OUT}	UDN2981/83A	V_{IN} = 2.4 V, V_{CE} = 2.0 V	2	-350	—	—	mA
		UDN2982/84†	V_{IN} = 2.4 V, V_{CE} = 2.0 V	2	-350	—	—	mA
Supply Current (Outputs Open)	I_S	UDN2981/82†	V_{IN} = 2.4 V*, V_S = 50 V	4	—	—	10	mA
		UDN2983/84†	V_{IN} = 2.4 V*, V_S = 80 V	4	—	—	10	mA
Clamp Diode Leakage Current	I_R	UDN2981/82†	V_R = 50 V, V_{IN} = 0.4 V*	5	—	—	50	µA
		UDN2983/84†	V_R = 80 V, V_{IN} = 0.4 V*	5	—	—	50	µA
Clamp Diode Forward Voltage	V_F	All	I_F = 350 mA	6	—	1.5	2.0	V
Turn-On Delay	t_{ON}	All	0.5 E_{IN} to 0.5 E_{OUT}, R_L = 100Ω, V_S = 35 V	—	—	1.0	2.0	µs
Turn-Off Delay	t_{OFF}	All	0.5 E_{IN} to 0.5 E_{OUT}, R_L = 100Ω, V_S = 35 V	—	—	5.0	10	µs

NOTES: Negative current is defined as coming out of (sourcing) the specified device terminal.
*All inputs simultaneously.
† Complete part number includes suffix to identify package style: A = DIP, LW = SOIC.

ONE OF EIGHT DRIVERS



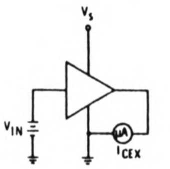
Dwg No A-10,242B



Dwg GP-018A

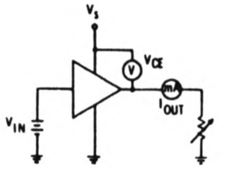
TEST FIGURES

FIGURE 1



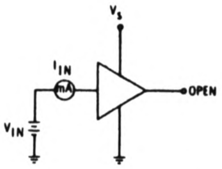
Dwg No A-11,083

FIGURE 2



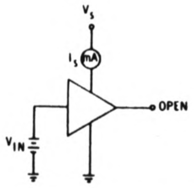
Dwg No A-11,084

FIGURE 3



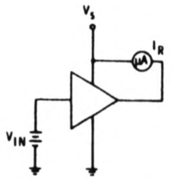
Dwg No A-11,085

FIGURE 4



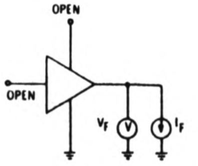
Dwg No A-11,086

FIGURE 5



Dwg No A-11,087

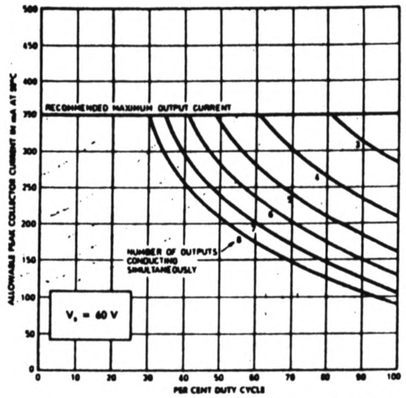
FIGURE 6



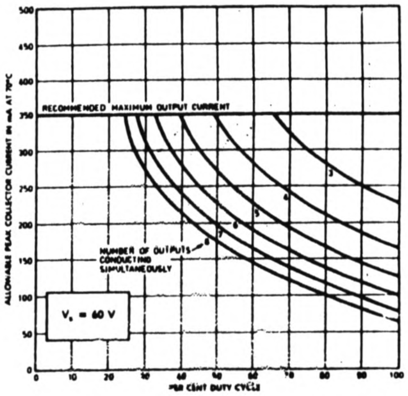
Dwg No A-11,088

ALLOWABLE PEAK COLLECTOR CURRENT AS A FUNCTION OF DUTY CYCLE

SERIES UDN2983/84A

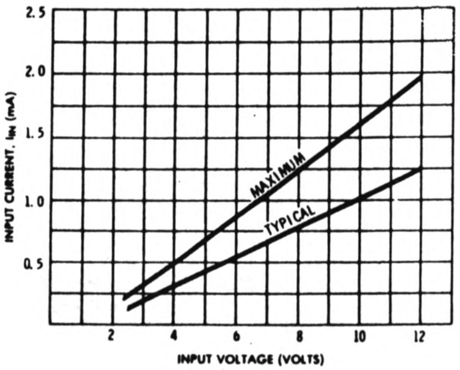


Dwg. No. A-11,109B



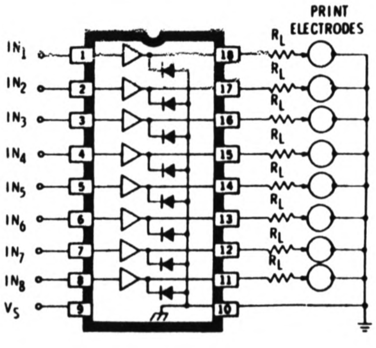
Dwg. No. A-11,110B

INPUT CURRENT AS A FUNCTION OF INPUT VOLTAGE



Dwg. No. A-11,115B

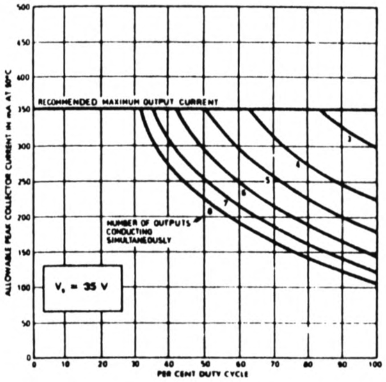
TYPICAL ELECTROSENSITIVE PRINTER APPLICATION



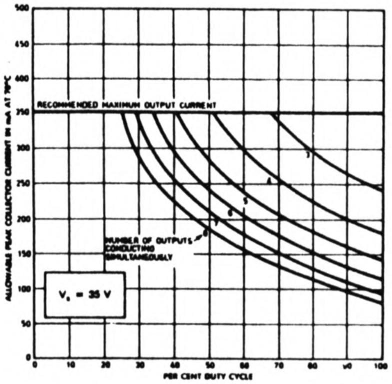
Dwg. No. A-11,113A

ALLOWABLE PEAK COLLECTOR CURRENT AS A FUNCTION OF DUTY CYCLE

SERIES UDN2980A

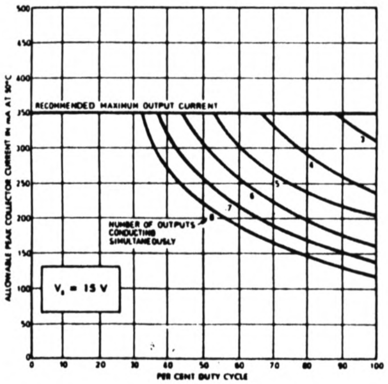


Dwg No A-11,106B



Dwg No A-11,111B

SERIES UDN2981/82A



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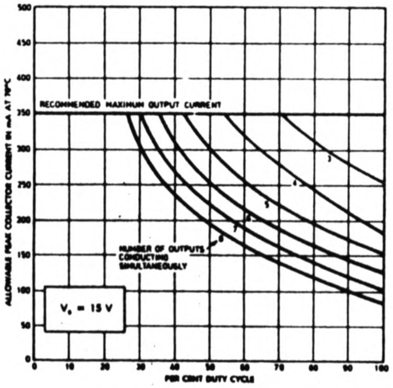


Dwg No A-11,108B

3.9 T110, 43 GHz/ALT CONVERTER MODULE

T110 Band Coverage and LO Frequencies

This section describes the T110 frequency converter, a dual mode module that converts the Q-Band (43 GHz/0.7 cm) Front-End signal or an ALT (alternate Front-End) input to the standard 500 to 1000 MHz IF band.

The 43 GHz Front-End output is a first IF signal centered on 8.4 GHz and is produced by mixing the 43 GHz signal from the cooled preamplifier with an LO signal. After mixing, the first IF is filtered by a K&L 8400/1000 bandpass filter and then amplified by a 35 dB amplifier that drives T110 through interconnecting coax cables. As a result of this conversion, the 43 GHz Front-End's output frequency band is in the neighborhood of the other Front-Ends output frequencies.

The ALT input is intended for a future Front-End that outputs a first IF band near 8.4 GHz - possibly a future 86 GHz Front-End. Selector switches on the T110 inputs select either the 43 GHz or the ALT Front-End signals for conversion.

Since RF bandpass filters are installed in the 43 GHz Front-End, they are not included in the T110 RF circuitry.

The 43 GHz Front-End covers the 41.0 to 45.0 GHz band. The second LO frequencies used by T110 range from 7.4 to 9.4 GHz, and during observations they are selected in conjunction with the first LO frequency. Refer to the LO frequency table in Section 6. The table lists twenty-four sets of first and second LO frequencies to be used for the 41.0 to 45.0 GHz Front-End band.

A mixer in the 43 GHz Front-End converts the 43 GHz signal to a first IF signal that is filtered by the 8400/1000 bandpass filter and output to T110. The first IF spectrum is 7.7 to 9.1 GHz at the -3 dB frequencies. Synthesizer #3 provides the LO signal for this conversion. Since these filters are in the Front-End, T110's RF circuitry does not contain bandpass filters for the first IF signal. Four T110 LO frequencies (Synthesizer #2) are used in this mode: 7.4, 7.6, 7.9 and 8.1 GHz. In conjunction with the appropriate T110 LO frequencies, Synthesizer #3 is stepped in 200 and 300 MHz steps to cover the 43 GHz Front-End's output spectrum. The T110 LO frequencies, mixer IF port spectrum, converted and attenuated bands are tabulated below. The converted band is that passed by the 750/X550 IF Bandpass filter and the attenuated bands are mixer IF port frequencies attenuated by the filter. The mixer IF port frequencies are in MHz, the converted and attenuated frequencies in GHz.

LO Freq	Mixer IF Port	Converted	Attenuated
7.4	300 to 1700	7.9 to 8.4	7.7 to 7.9 8.4 to 9.1
7.6	100 to 1500	8.1 to 8.6	7.7 to 8.1 8.6 to 9.1
7.9	200* to 1200	8.4 to 8.9	7.7 to 8.4 8.9 to 9.1
8.1	400** to 1000	8.6 to 9.1	7.7 to 8.6

* 200 MHz below the LO frequency, approaching the image.
** 400 MHz below the LO frequency, approaching the image.

T110 Size and Physical Location

T110 is a double-width module installed in Rack B, Bin C, Slots 11-12.

T110 Drawings and Data Sheets

The following T110 functional and assembly drawings are found at the end of this section.

C53500K010, Rev B - T110 43 GHz/ ALT Converter Module Block Diagram
D53500A020, Rev A - T110 43 GHz/ALT Converter Module Assembly
A53500B019, Rev A - T110 43 GHz/ALT GHz Converter Module Assembly BOM

C53500A009, Rev B - T106 8.4/23 GHz Converter Module IF Gain Relay Assembly
C53500A023 - T106 8.4/23 GHz Converter Module IF Gain Relay PCB Assembly

Data sheets for the Transco 909C70100 selector switch, WJ M77C mixer and Miteq AMF-2B-7494 amplifier follow the drawings. Data sheets for the Ditom D3I 7011 isolator, Triangle YL-56 power divider and Narda 4772-x attenuator are included in the Appendix, Section 6.

T110 Specifications

Nominal Gain, dB	14	Gain Flatness, ± dB	2	LCP-RCP Path Isol, dB	65
Nom Output Pwr @ Std Syst Temp, dBm	-40	Min Out Pwr @ 1% Compression, dBm	+4	Nom Output Pwr Density, dBm/MHz	-67
Avg Noise Temp, K	6,500	Noise Temp for 1% added Syst Noise, K	32,000	Nom LO Pwr input, dBm	+2
Avg Noise Figure, dB	13.7	Noise Figure for 1% added Syst Noise, dB	20.4		
15 Volt Power Req't, mA	650				

Unwanted Sideband and Image Band Attenuation

Unwanted sidebands are attenuated by the K&L 6B120-750/X550 IF bandpass filter described in Section 2.5. Image response bands are attenuated by the 43 GHz Front-End's 8400/1000 bandpass filter which has a -3 dB passband of 7.7 to 9.1 GHz. The following tabulation shows the LO frequencies, unwanted (UWSB) and image sidebands in GHz.

LO Freq	UWSB	UWSB Attn	Image
7.4	15.6 to 16.5	»70	6.4 to 6.9
7.6	15.3 to 16.2	»70	6.6 to 7.1
7.9	15.6 to 16.5	»70	6.9 to 7.4
8.1	15.8 to 16.7	»70	8.6 to 9.1

T110 Differences from the General Converter Block Diagram

Three features of the T110 Block Diagram are different from the general converter block diagram of Section 2.1. A pair of 43 GHz/ALT selector switches selects the output of either Front-End for conversion. The RF circuitry bandpass filters have been omitted and a DPDT Relay Module A53500A009 selects the Amp/Attenuator control voltages from a pair of 43 GHz or a pair of ALT gain control potentiometers. The 6B120-750/X550 IF filter, Amp/Attenuator and Amp/Divider are used for the IF circuitry. These components were described in Section 2.5.

Noise Temperature

The T110 noise temperature is a composite value that is a function of the noise temperatures of the mixer, Amp/Attenuator and Amp/Divider. The average of the measured noise temperatures of the LCP and RCP channels is 6500 K. A T110 noise temperature of 32,000 K would add 1 K to the system temperature.

Mixer

The WJ M77C is an important component; a data sheet follows the drawings at the rear of this section. This mixer is designed for LO frequencies of 7.0 to 15.0 GHz, RF frequencies of 8.0 to 12.5 GHz, IF frequencies of DC to 2500 MHz and a nominal LO drive of +10 dBm. At the 8.4 GHz conversion frequency, the typical conversion loss is 5.0 dB and the typical noise figure is 7.0 dB.

RCP-LCP Isolation

The RCP-LCP isolation is a function of the isolation properties of two shunt paths: the isolation between the two mixer LO ports and the transfer switch leakage.

The WJ M77C mixer typical LO to RF isolation is 35 dB and the LO to IF isolation is also 35 dB. The KDI/Englemen D307M power divider port-to-port isolation is 21 dB. Over the 7.4 to 9.4 GHz range of LO frequencies, the isolation of this shunt path is the sum of the two mixer LO port's to RF port isolation and the divider's isolation; this is 91 dB. The filter's attenuation is about 0.3 dB for frequencies in the 2500 MHz passband; for frequencies outside the passband, the isolation is increased by the filter's attenuation. Using the attenuation figures from two paragraphs above, the LO filter's add 20 dB to the 95 dB LO path isolation at frequencies of 5.9 and 10.9 GHz, respectively.

The typical RCP-LCP path isolation of the RLC SRC-TC-R-D transfer switch at 8.4 GHz is about 78 dB. From the table above, the module's specified RCP-LCP path isolation is 65 dB.

Since the SPDT selector switches are used to select either the 43 GHz or ALT Front-End outputs for conversion, the isolation of this switch is also a concern. The Transco 909C70100 switch has a port-to-port isolation of 60 dB at 8 GHz.

Isolation Between the 43 GHz and ALT Front-End Inputs

Two Transco 909C70100 SPDT coaxial selector switches (S110A and S110B) select the outputs of either the 43 GHz Front-End or the ALT Front-End for conversion. Since the frequencies of these two signals are similar, switch isolation is an important consideration because the coupling between the unselected signals and selected signals should be very small. At 8 GHz the switch's isolation between inputs is typically 90 dB.

VSWR's

The input VSWR 1.25:1 (estimated) is the composite of the VSWR's of the Transco 909C70100 selector switch (1.1:1) and the Ditom D3I 7011 isolator (1.18:1).

The output VSWR is the composite VSWR of the Amp/Divider which is 1.5:1.

RF Circuitry

The losses in the RF input path are the insertion losses of the Transco 909C70100 selector switch, 0.1 dB; Ditom D31 7011 isolator, 0.35 dB; and the RLC SR-TC-R-D transfer switch, 0.3 dB.

IF Circuitry

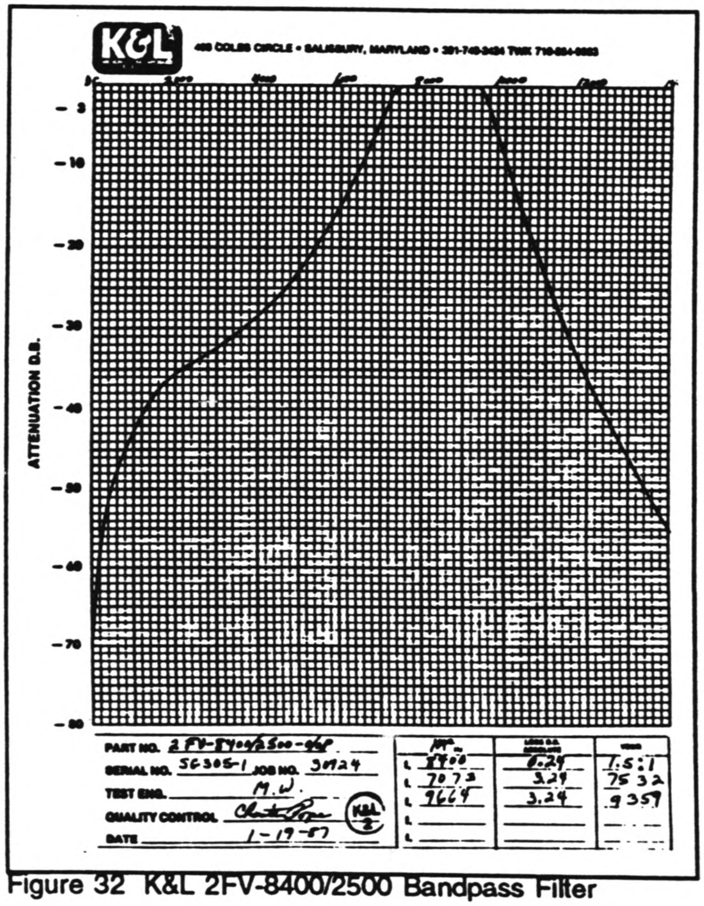
The IF path Amp/Attenuator, Amp/Divider and 6B120-750/X550 If bandpass filter were described in Section 2.5. IF gain adjustment is described in Test I, Section 2.7.

A DPDT IF Gain Relay Assembly C53500A009 selects the Amp/Attenuator control voltages from a pair of 43 GHz or a pair of ALT gain control potentiometers. The assembly drawing is included in Section 2.5.

LO Drive Circuitry

The LO isolation filter is a K&L 2FV-8400/2500, which is a two-section bandpass filter. The IF signals to be passed without attenuation range from 7.4 to 9.4 GHz. Frequencies outside this passband are attenuated to improve the RF-LO and IF-LO isolations between the mixer's LO ports. Figure 32 shows the filter's attenuation curve. The insertion loss is about 0.3 dB and the VSWR is about 1.5:1. This plot shows that the filter's attenuation is about 10 dB for frequencies that are one 3 dB bandwidth above or below the center frequency. These frequencies are 5.9 and 10.9 GHz, respectively.

The LO amplifier is a MITEQ AMF-2B-7494-15P that is a special order adaption of the AMF-2B amplifier series for NRAO; the amplifier is characterized over the 7.4 to 9.4 Ghz LO frequency range. The gain is 15 dB and is flat over this band within ± 0.5 dB; the noise figure is about 3.3; maximum input and output VSWR is 1.9 and the 1 dB compression point is about 18.5 dB. During module alignment, the amplifier gain is adjusted to produce a +10 dBm drive to the WJ M77C mixers. The gain is determined by the selection of the appropriate NARDA 4772-X pad. The LO amplifier gain procedure is described in Test I, LO Powr, Gain and Flatness, Section 2.7. A MITEQ test data sheet for this amplifier is included at the rear of this section.



PART NO. 2FV-8400/2500-96P

SERIAL NO. SC305-1 JOB NO. 30124

TEST ENG. M.W.

QUALITY CONTROL

DATE 1-19-87

8400	0.24	1.5:1
7073	3.24	7532
9664	3.24	9359

Figure 32 K&L 2FV-8400/2500 Bandpass Filter

RF Switching

The transfer switch is designated S110C on drawing D58001K001. The T110 Block Diagram shows an RLC SR-TC-R-D transfer switch; some T110's may use the Transco 710C70100 as an alternate unit. The transfer switch is driven by M102, address 19H, bit 0. If bit 0 has a 0 value, the RCP and LCP signals are not interchanged; if bit 0 has a a 1 value, the signals are interchanged. Section 2.5 has a data sheet for the transfer switch.

Two Transco 909C70100 SPDT selector switches (S110A and S110B) are used to select either Front-End input. At 8 GHz typical values are: VSWR - 1.1:1, insertion loss - 0.15 dB and the isolation is 90 dB. This switch is described in Section 2.5. A +28 input to terminal 1 (P11-24) will select the ALT Front-End signal and a +28 volt input to terminal 2 (P11-25) will select the 43 GHz Front-End signal. The switch coil common is connected to the module common distribution. This pair of switches is driven by M102, address 1AH, bit 0. If bit 0 has a 0 value, the 43 GHz Front-End is selected; if bit 0 has a 1 value, the ALT Front-End is selected.

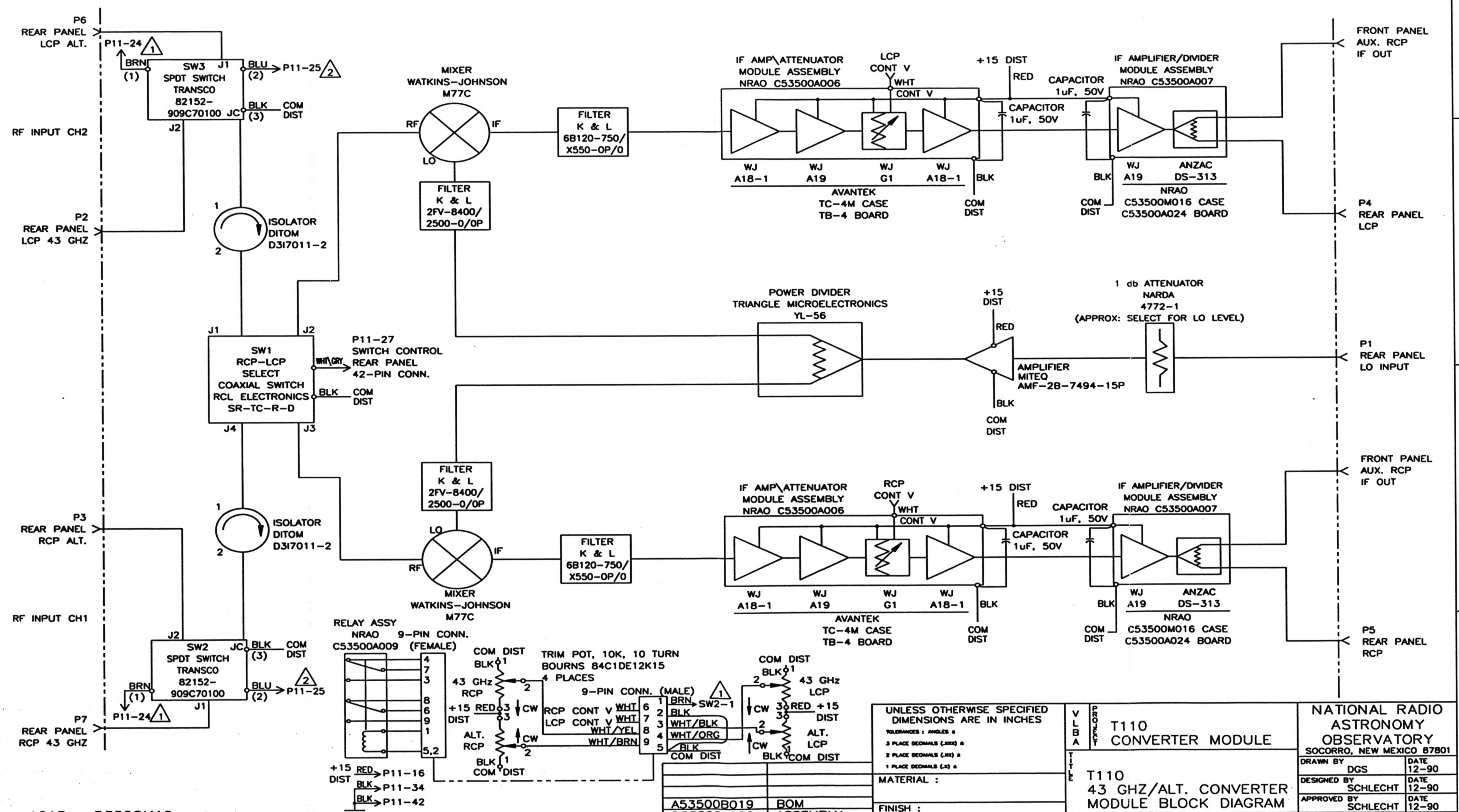
T110 Power Circuitry

All T110 active components are powered by +15 volts. +15 volts from P11-16 is connected to TB1 (terminal strip 1) terminals 1-4 where it is distributed to the amplifiers. The common returns for these devices are connected to a frame ground lug that is connected to P11-34 and P11-42. This ground is also the ground return for the +28 volt drive to the transfer switch. The Amp/Attenuator has a 1.0 uF bypass capacitor connected across the amplifier's power terminals.

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	11-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS
C	10-95	K. TATE	CAMPBELL	REMOVED SMA CONNECTORS

NOTES:

1. P11-24 IS CONNECTED TO SW2, SW3, AND RELAY MODULE ASSY
2. P11-25 IS CONNECTED TO SW2 AND SW3



A53500B019	BOM
D53500A020	ASSEMBLY
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA PROJECT
T110
CONVERTER MODULE

TITLE
T110
43 GHZ/ALT. CONVERTER
MODULE BLOCK DIAGRAM

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY DGS	DATE 12-90
DESIGNED BY SCHLECHT	DATE 12-90
APPROVED BY SCHLECHT	DATE 12-90

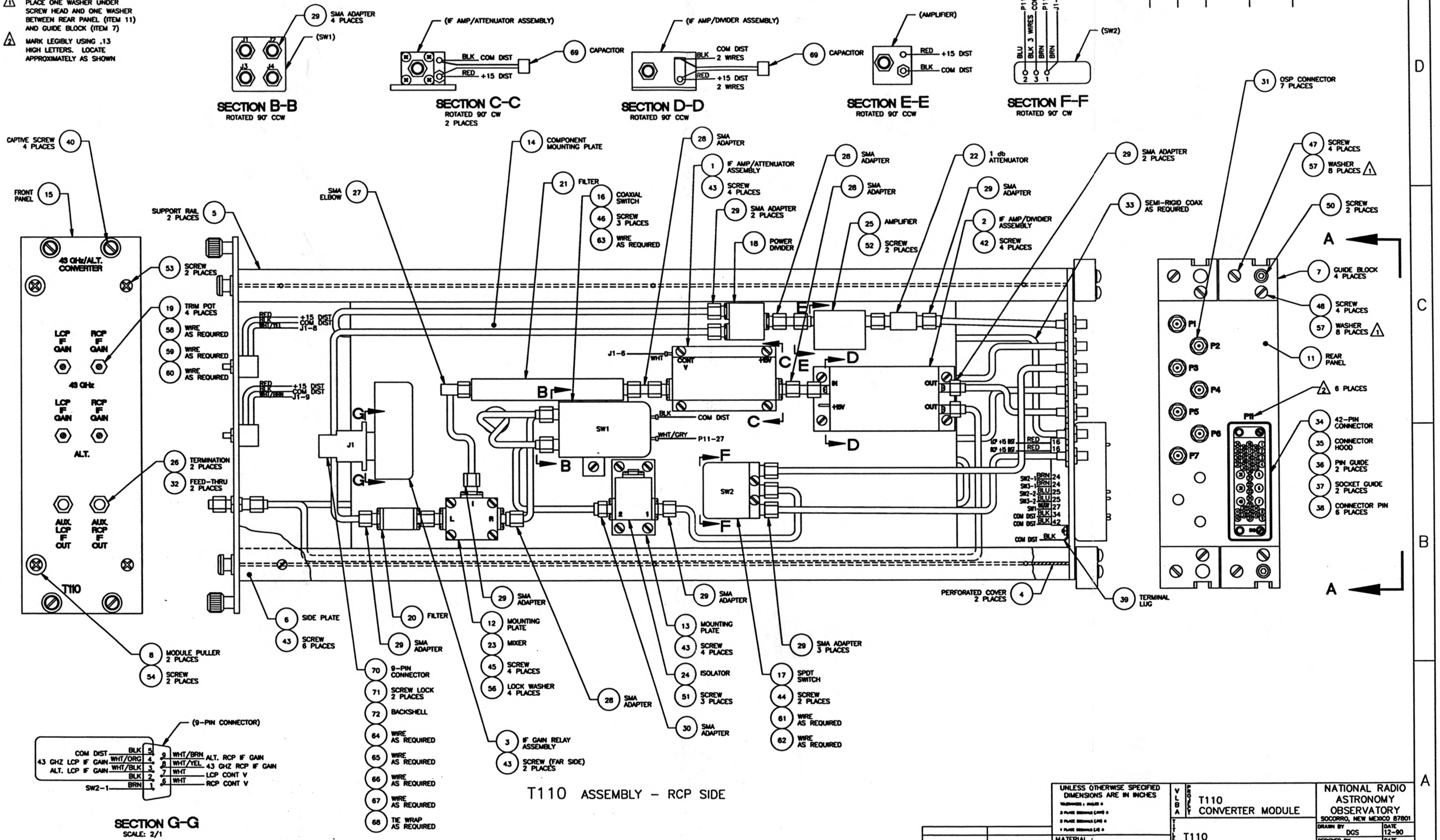
SHEET NUMBER 1 OF 1
DRAWING NUMBER C53500K010
REV. C
SCALE NONE

PROPERTY OF NRAO

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-93	K. TATE	D.WEBER	UPDATED TO NRAO STDS

NOTES:

1. PLACE ONE WASHER UNDER SCREW HEAD AND ONE WASHER BETWEEN REAR PANEL (ITEM 11) AND GUIDE BLOCK (ITEM 7)
2. MARK LEGIBLY USING .13 HIGH LETTERS. LOCATE APPROXIMATELY AS SHOWN



T110 ASSEMBLY - RCP SIDE

ACAD : 3500A20A

C53500K010	BLOCK DIAG
A53500B019	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±
MATERIAL :
FINISH :

VLBA PROJECT
T110
CONVERTER MODULE

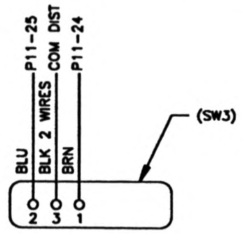
TITLE
T110
43 GHZ/ALT. CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

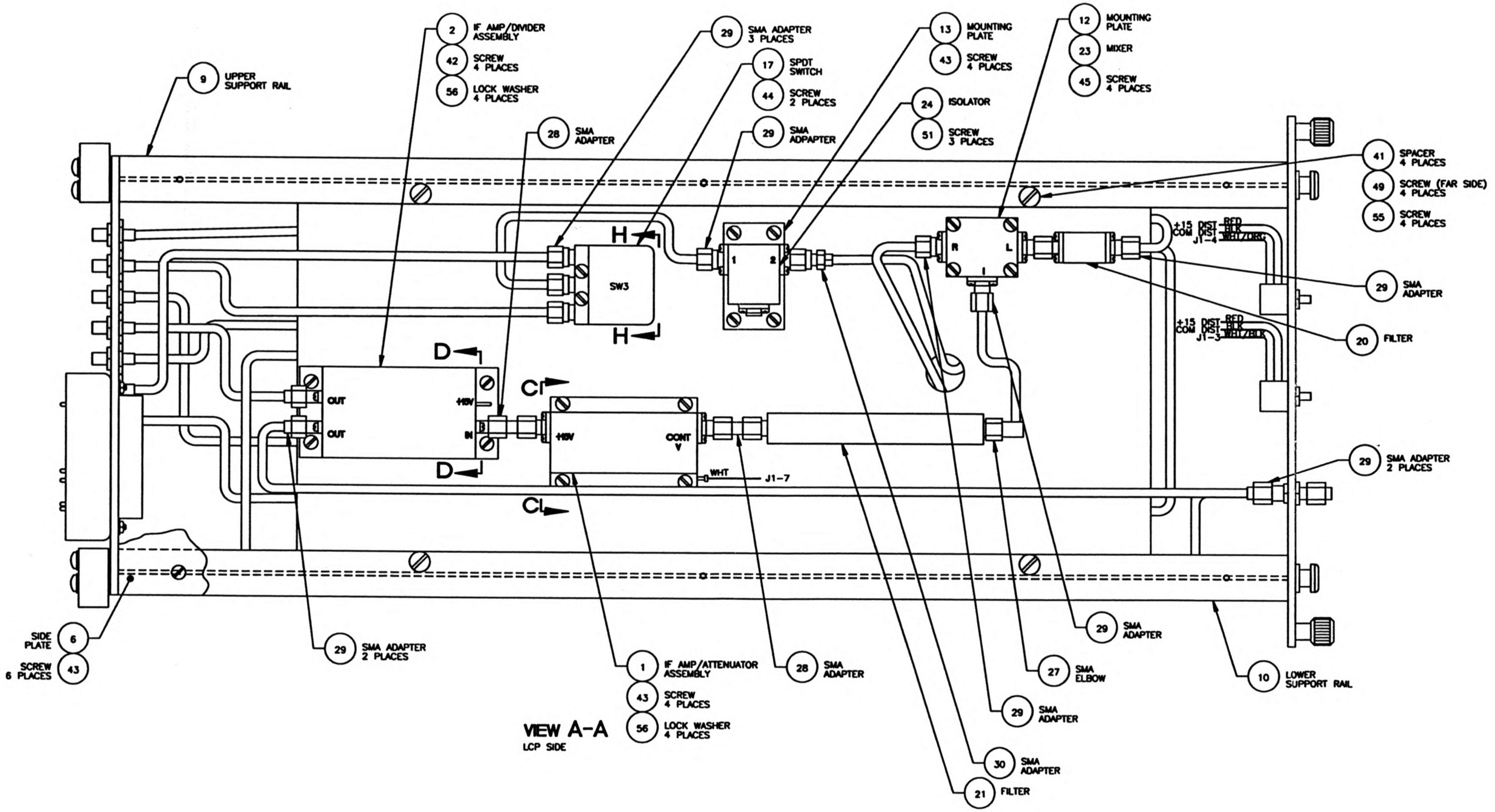
DRAWN BY DGS	DATE 12-90
DESIGNED BY ES	DATE 12-90
APPROVED BY ES	DATE 12-90

SHEET NUMBER 1 OF 2 DRAWING NUMBER D53500A020 REV. A SCALE 1/1

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION



SECTION H-H
ROTATED 90° CW



VIEW A-A
LCP SIDE

ACAD : 3500A20B

C53500K010	BLOCK DIAG
A53500B019	BOM
NEXT ASSEMBLY	DWG. TYPE

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES : ANGLES ±
3 PLACE DECIMALS (.XXX) ±
2 PLACE DECIMALS (.XX) ±
1 PLACE DECIMALS (.X) ±

MATERIAL :

FINISH :

VLBA
PROJECT T110
CONVERTER MODULE

TITLE T110
43 GHZ/ALT. CONVERTER
MODULE ASSEMBLY

NATIONAL RADIO
ASTRONOMY
OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY DSG	DATE 12-90
DESIGNED BY ES	DATE 12-90
APPROVED BY ES	DATE 12-90

SHEET NUMBER 2 OF 2
DRAWING NUMBER D53500A020
REV. A
SCALE 1/1

REVISIONS				
REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	10-93	K. TATE	D. WEBER	UPDATED TO NRAO STANDARDS

DRAWN BY K. TATE	DATE 10-93			
DESIGNED BY	DATE		C53500K010	BLOCK DIAG
APPROVED BY D. WEBER	DATE 10-93		D53500A020	ASSEMBLY
			NEXT ASSY	USED ON

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

V
L
B
A

PROJECT T110 CONVERTER MODULE

TITLE T110 43 GHZ/ALT. CONVERTER MODULE ASSEMBLY BOM

DWG NO. A53500B019 SHEET 1 OF 5

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B019 REV A DATE 10-28-93 PAGE 2 OF 5

MODULE T110 NAME 43 GHZ/ALT. CONVERTER DWG# D53500A020 SUB ASSY ______ DWG# ______

SCHEM. DWG# C53500K010 LOCATION ______ QUA/SYS. ______ PREPRD BY K. TATE APPRVD BY D. WEBER

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
1		NRAO	C53500A006	ASSY, IF AMP/ATTENUATOR	2
2		NRAO	C53500A007	ASSY, IF AMP/DIVIDER	2
3		NRAO	C53500A009	ASSY, IF GAIN RELAY	1
4		NRAO	C53306M014-1	COVER, PERFORATED	2
5		NRAO	C53306M016	RAIL, SUPPORT	2
6		NRAO	C53306M017	PLATE, SIDE	2
7		NRAO	B53306M018	BLOCK, GUIDE	4
8		NRAO	A53306M038	PULLER, MODULE	2
9		NRAO	B53500M001	RAIL, UPPER	1
10		NRAO	B53500M002	RAIL, LOWER	1
11		NRAO	B53500M004-1	PANEL, REAR	1
12		NRAO	B53500M029	PLATE, MIXER MOUNTING	2
13		NRAO	B53500M030	PLATE, ISOLATOR MOUNTING	2
14		NRAO	D53500M040	PLATE, COMPONENT MOUNTING	1
15		NRAO	C53500M033	PANEL, FRONT	1
16	SW1	RLC ELECTRONICS	SR-TC-R-D	SWITCH, COAXIAL	1
17	SW2, SW3	TRANSCO	82152-909C70100	SWITCH, SPDT	2
18		TRIANGLE MICROELECTRONICS	YL-56	DIVIDER, POWER	1
19		BOURNS	84C1DE12K15	TRIM POT, 10K PANEL	4
20		K & L	2FV-8400/2500-0/0P	FILTER	2

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B019 REV A DATE 10-28-93 PAGE 3 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
21		K & L	6B120-750/X550-0/OP	FILTER	2
22		NARDA	4772-1	ATTENUATOR, 1 db	1
23		WATKINS-JOHNSON	M77C	MIXER	2
24		DITOM	D3I7011-2	ISOLATOR	2
25		MITEQ	AMF-2B-7494-15P	AMPLIFIER	1
26		SOLITRON	8018-6005	TERMINATION, 50Ω	4
27		SOLITRON	2912-6001	ELBOW, SMA MALE/.141 COAX	2
28		SOLITRON	2993-6001	ADAPTER, SMA MALE/MALE	5
29		SOLITRON	2902-6001	ADAPTER, SMA MALE/.141 COAX	27
30		SOLITRON	2002-5015-00	ADAPTER, SMA FEM./.141 COAX	2
31	P1-P7	OMNI-SPECTRA	2081-0000-00	CONNECTOR, OSP .141 MALE	7
32		OMNI-SPECTRA	2084-0000-00	FEED-THRU, SMA	2
33		PRECISION TUBE	AA50141	COAX, .141, SEMI-RIGID	AR
34	P11	AMP	204186-5	CONNECTOR BLOCK, 42-PIN	1
35		AMP	202394-2	CONNECTOR HOOD, 42-PIN	1
36		AMP	200833-2	PIN, GUIDE	2
37		AMP	203964-5	SOCKET, GUIDE	2
38		AMP	201578-1	PIN, 16 GA. CONNECTOR	6
39				LUG, TERMINAL	1
40		SOUTHCO	47-11-204-10	SCREW, CAPTIVE	4
41		H.H. SMITH	9244	SPACER, 8-32UNC-2B x .44	4

BILL OF MATERIAL
NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B019 REV A DATE 10-28-93 PAGE 4 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
42				SCREW, PAN HEAD, SS, 4-40UNC-2A x .19	8
43				SCREW, PAN HEAD, SS, 4-40UNC-2A x .25	30
44				SCREW, PAN HEAD, SS, 4-40UNC-2A x .63	4
45				SCREW, PAN HEAD, SS, 4-40UNC-2A x .75	8
46				SCREW, PAN HEAD, SS, 6-32UNC-2A x .25	3
47				SCREW, PAN HEAD, SS, 6-32UNC-2A x .75	4
48				SCREW, PAN HEAD, SS, 6-32UNC-2A x .88	4
49				SCREW, PAN HEAD, SS, 8-32UNC-2A x .63	4
50				SCREW, SOCKET HEAD, SS, 6-32UNC-2A x .38	2
51				SCREW, FLAT HEAD, SS, 2-56UNC-2A x .25	6
52				SCREW, FLAT HEAD, SS, 4-40UNC-2A x .25	2
53				SCREW, FLAT HEAD, SS, HP GREY, 6-32UNC-2A x .38	2
54				SCREW, FLAT HEAD, SS, 6-32UNC-2A x .75	2
55				SCREW, FLAT HEAD, SS, 8-32UNC-2A x .75	4

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

X ELECTRICAL X MECHANICAL BOM # A53500B019 REV A DATE 10-28-93 PAGE 5 OF 5

ITEM #	REF DES	MANUFACTURER	PART NUMBER	DESCRIPTION	TOTAL QTY.
56				WASHER, LOCK #4	18
57				WASHER, EXT. TOOTH #6	16
58		ALPHA	7055	WIRE, WHT #22	AR
59		ALPHA	7055	WIRE, BLK #22	AR
60		ALPHA	7055	WIRE, RED #22	AR
61		ALPHA	7055	WIRE, BLU #22	AR
62		ALPHA	7055	WIRE, BRN #22	AR
63		ALPHA	7055	WIRE, WHT/GRY #22	AR
64		ALPHA	7055	WIRE, WHT/BLK #22	AR
65		ALPHA	7055	WIRE, WHT/BRN #22	AR
66		ALPHA	7055	WIRE, WHT/YEL #22	AR
67		ALPHA	7055	WIRE, WHT/ORG #22	AR
68				WRAP, TIE	AR
69		SPRAGUE	2C20Z50105M050B	CAPACITOR, MONOLITHIC CERAMIC, 1μf, 50V	4
70	J1	TRW CINCH	DE-9P	CONNECTOR, 9-PIN D-SUB	1
71		AMP	200833-2	SCREW LOCK, MALE	2
72		WPI		BACKSHELL	1
73					
74					
75					
76					

WJ-M77/M77C
WJ-MY77/MY77C

DOUBLE-BALANCED MIXER

- ◆ LO 7.0 TO 15.0 GHz
- ◆ RF 8.0 TO 12.5 GHz
- ◆ IF DC TO 2500 MHz
- ◆ LO DRIVE +10 dBm (nominal)
- ◆ LOW NOISE FIGURE

*MIL–M–28837 Screening Available (See "QPL Mixers" Section)

Guaranteed Specifications [1]

Characteristics	Min.	Typ.	Max.	Test Conditions
SSB Conversion Loss and SSB Noise Figure		5.0 dB	7.0 dB	f_R 8 to 12.5 GHz f_L 7 to 13.5 GHz f_I 30 to 1000 MHz
		5.5 dB	7.5 dB	f_R 8 to 12.5 GHz f_L 7 to 14.5 GHz f_I 1000 to 2000 MHz
		6.0 dB	8.0 dB	f_R 8 to 12.5 GHz f_L 7 to 15.0 GHz f_I 2000 to 2500 MHz
Isolation				
L to R	20 dB	35 dB		f_L 7 to 15 GHz
L to I	20 dB	35 dB		f_L 8 to 12 GHz
	15 dB	30 dB		f_L 7 to 14 GHz
	10 dB	20 dB		f_L 14 to 15 GHz
Conversion Compression			1.0 dB	f_R level +4 dBm f_L level +10 dBm
Third Order Input Intercept Point		+15 dBm		f_{R_1} = 10.00 GHz; f_{R_2} = 10.01 GHz both at -6 dBm f_L = 11.0 GHz at +10 dBm
Single Tone IM Suppression				f_R 8 to 12.5 GHz at -10 dBm
f_L f_R				
2 x 2		60 dB		
2 x 3		70 dB		
3 x 2		37 dB		
3 x 3		59 dB		
3 x 4		> 70 dB		
4 x 3		> 70 dB		
4 x 4		> 70 dB		

Notes 1 Measured in a 50-ohm system with nominal LO drive and downconverter application only, unless otherwise specified. The I-Port frequency range extends to DC for phase detection, pulse modulation, or attenuator applications, I-Port VSWR degrades from a 50-ohm system at low IF frequencies.

Absolute Maximum Ratings

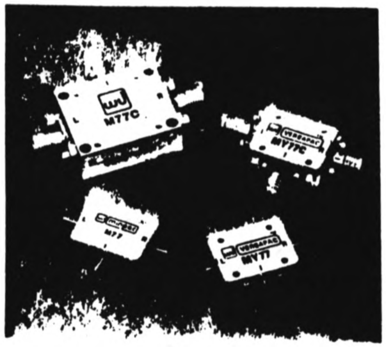
Operating Temperature .... -54°C to +100°C

Storage Temperature .... -65°C to +100°C

Peak Input Power .... +23 dBm max. at +25°C, +20 dBm max. at +100°C

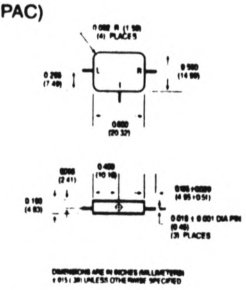
Peak Input Current at 25°C .... 100 mA DC

Weight M77:	9 grams (0.32 oz.) max.	MY77:	7.9 grams (0.28 oz.) max.
M77C:	36 grams (1.27 oz.) max.	MY77C:	20.0 grams (0.70 oz.) max.

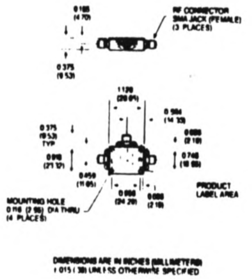


Outline Drawings

M77
(MINPAC)

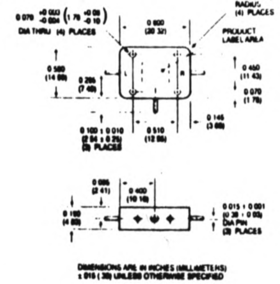


M77C
(CONNECTORIZED)

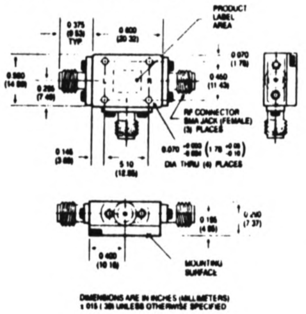


Outline Drawings

MY77
(VERSAPAC)

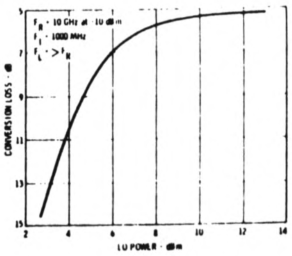


MY77C
(CONNECTORIZED)

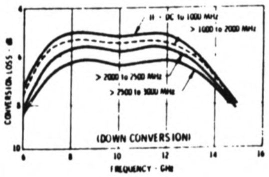


Typical Performance at 25°C*

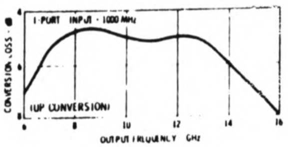
Conversion Loss Vs. LO Drive



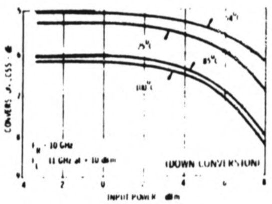
Conversion Loss vs. Frequency



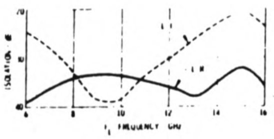
Conversion Loss vs. Output Frequency



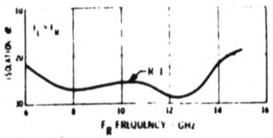
Conversion Loss vs. RF Input Power



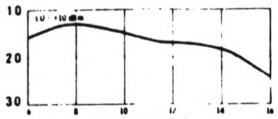
Isolation vs. Frequency



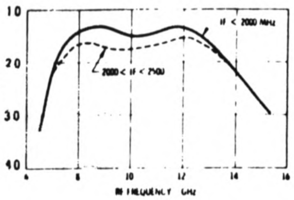
Isolation vs. Frequency



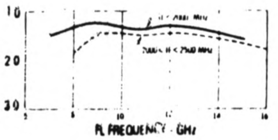
L-Port VSWR vs. Frequency



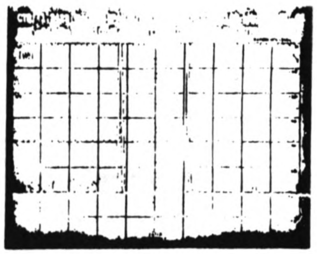
R-Port VSWR vs. Frequency



I-Port VSWR vs. f_L



Typical Two-Tone Performance



Typical Two-Tone Performance: f_I = 1250 MHz, f_R = 10.25 GHz ± 1 MHz f_R @ -10 dBm, $f_L > f_R$, f_L = 11.5 GHz @ +10 dBm. Vertical scale = 10 dB/cm.

*Typical performance applies to the MINPAC™ model and does not necessarily reflect the performance of the VERSAPAC® model

MITEQ

Project No.: 1711 66

File No.:

TEST DATA

Model No.: AMF-2B-7494-15P

Serial No.: 107864

Frequency: 7.4 - 9.4 GHz

Purchase Order No.:

Specification:

Frequency (GHz)	7.4-9.4 GHz	Output Power (dBm) at 1 dB Compression	+15 dBm min.
Gain (dB)	15 dB min.	Voltage	+15 VDC
Gain Flatness (dB)	± 0.5 db max.	I Measured Current (ma)	115 mA
VSWR Input	2:1 max.	Noise Figure (dB)	No SPEC
VSWR Output	2:1 max.		

Test Data:

Frequency (GHz)	Gain (dB)	VSWR In	VSWR Out	Noise Figure (dB)	Output Power (dBm) at 1 dB Compression
7.4	SEE ATTACHED GRAPH	1.89:1	1.75:1	3.11	+ 17.6
7.9		max.	max.	3.29	+ 18.2
8.4		↓	↓	3.51	+ 18.4
8.9				3.37	+ 19.2
9.4				3.24	+ 16.8

Tested By:

Date: 5/22/87

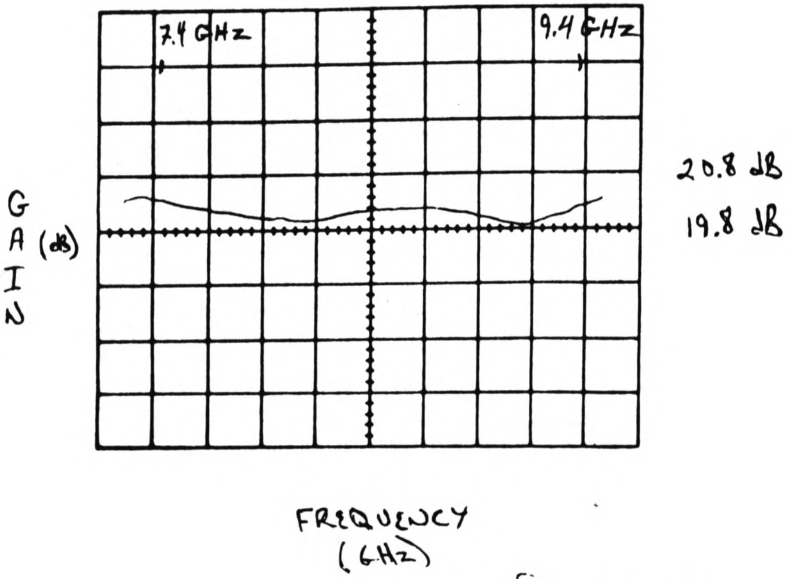
P19706

MITEQ INC / 125 RICEFIELD LANE / HAUPPAUGE, NEW YORK 11787 / (516) 543-8873

Amplifier Model AMF-2B-7494-15P

Serial No. 107864

GAIN BANDWIDTH



5/22/87

4.0 LIST OF CONVERTER FUNCTIONAL DRAWINGS

C53500K005, Rev C - T101 330 MHz Converter Module Block Diagram
D53500A015, Rev C - T101 330 MHz Converter Module Assembly
A53500B002, Rev B - T101 330 MHz Converter Module Assembly BOM

C53500A011, Rev A - T101 330 MHz Converter Module Converter Unit Assembly
C53500A025 - T101 330 MHz Converter Module Converter Unit PCB Assembly
C53500A017 - T101 330 MHz Converter Module Input Amplifier Assembly

D53500K007, Rev E - T102 610 MHz Filter Module Block Diagram
D53500A001, Rev C - T102 610 MHz Filter Module Assembly
A53500B009, Rev C T102 610 MHz Filter Module BOM

C53500A018, Rev A - T102 610 MHz Filter Module Input Amplifier Assembly
B53500K006, Rev C - T102 610 MHz Filter Module Filter Block Diagram
D53500A013 - T102 610 MHz Filter Module Filter Unit Assembly
D53500A022 - T102 610 MHz Filter Module Filter Unit PCB Assembly

C53500K001, Rev D - T103 1.5 GHz Converter Module Block Diagram
D53500A002, Rev C - T103 1.5 GHz Converter Module Assembly
A53500B001, Rev B - T103 1.5 GHz Converter Module Assembly BOM

A53500A012, Rev A - T103 1.5 GHz Converter Module LO Amplifier/Detector Assembly
A53500A008, Rev B - T103 1.5 GHz Converter Module LO Amp/Det PCB Assembly

C53500K008, Rev D - T104 2.3 GHz Converter Module Block Diagram
D53500A016, Rev B - T104 2.3 GHz Converter Module Assembly
A53500B010, Rev B - T104 2.3 GHz Converter Module Assembly BOM

C53500K002, Rev D - T105 4.8onverter Module Block Diagram
D53500A003, Rev C - T105 4.8 GHz Converter Module Assembly
A53500B002, Rev B - T105 4.8 GHz Converter Module Assembly BOM

C53500K009, Rev E - T106 8.4/23 GHz Converter Module Block Diagram
D53500A010, Rev F - T106 8.4/23 GHz Converter Module Assembly
A53500B005, Rev B - T106 8.4/23 GHz Converter Module Assembly BOM

C53500A009, Rev B - T106 8.4/23 GHz Converter Module IF Gain Relay Assembly
C53500A023, Rev B - T106 8.4/23 GHz Converter Module IF Gain Relay PCB Assembly

C53500K003, Rev C - T107 10.7 GHz Converter Module Block Diagram
D53500A004, Rev A - T107 10.7 GHz Converter Module Assembly
A53500B003, Rev A - T107 10.7 GHz Converter Module Assembly BOM

C53500K004, Rev D - T108 14 GHz Converter Module Block Diagram
D53500A021, Rev B - T108 14 GHz Converter Module Assembly
A53500B004, Rev B - T108 14 GHz Converter Module BOM

C53500S005, Rev B - T108 14 GHz Converter Module Filter Select PCB Schematic Diagram
C53500A019 - T108 14 GHz Converter Module Filter Select PCB Assembly

C53500K010, Rev B - T110 43 GHz/ ALT Converter Module Block Diagram
D53500A020, Rev A - T110 43 GHz/ALT Converter Module Assembly
A53500B019, Rev A - T110 43 GHz/ALT GHz Converter Module Assembly BOM

C53500A006, Rev B - Converter Module IF Amp/Attenuator Assembly

C53500A007, Rev A - Converter Module IF Amp/Divider Assembly

5.0 DATA SHEETS FOR COMMERCIAL COMPONENTS

This section contains the following commercial component data sheets:

K&L Tubular Bandpass Filters
Anzac DS-313 Power Divider
Ditom Isolators
Narda 4772-X Attenuators
Omni-Spectra 2090-62XX Power Dividers
Merrimac PDM-20 Series Power Dividers
KDI-Triangle Series YL D300 Power Dividers
Narda 4315-2 Power Divider

ubular Filters

◆ Features - *Bandpass*

K&L tubular bandpass filters are available in four different series ranging in size from .25 inch diameter to 1.25 inch diameter to cover the frequency range of 40MHz to 6.0GHz. K&L uses a .05dB Chebyshev design to yield low insertion loss in the passband and high attenuation levels in the stopband. The tubular filter design is made up of small resonating sections. These sections are capacitively coupled to provide the specified passband response and selectivity required. This coupling structure provides a DC block.

In choosing the best tubular filter to meet the user's needs, K&L recommends the use of the .50 inch diameter; Model 120. This series has convenient size, broad frequency range, versatility of design, and is the most economical.

The two larger series, .75 inch diameter and 1.25 inch diameter, offer the user lower insertion loss, lower frequency operation, and higher power capabilities. The .25 inch diameter offers the user miniature size and volume, higher frequency operations and less weight.

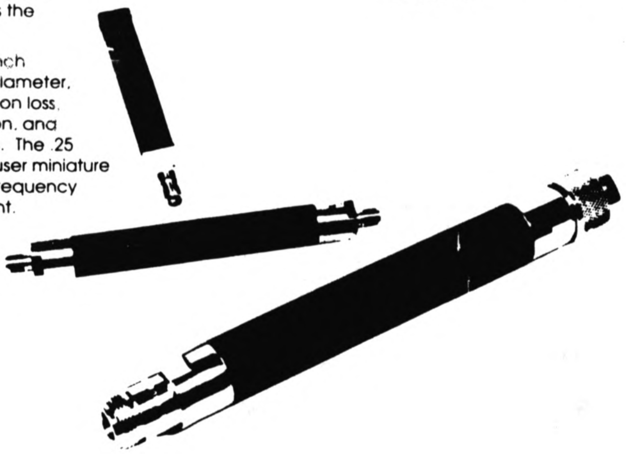
◆ To Order

5 B121 - 500 / T 80 - O / O
1 2 3 4 5 6 7 8 9

1. Number of sections
2. B - Bandpass
3. Model
    250 - .25"
    120 - .50"
    340 - .75"
    110 - 1.25"
4. Circuit structure
5. Center frequency (MHz)
6. Supplemental codes (see page 17)
7. Bandwidth (MHz)
8. Input connector
9. Output connector

◆ Mechanical

For sizes and connectors, see pages 69 and 70.



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ubular Filters

To determine the maximum insertion loss of the tubular filter at center frequency the follow formula is used:

Insertion loss at center frequency =

$$\frac{\text{(Loss constant)(No. of sections + 1/2)}}{\text{\% 3dB BW}} + 0.2$$

EXAMPLE:
Center frequency = 500MHz
3dB bandwidth = 80MHz
Number of sections = 5
Filter model: B120
Find the insertion loss at center frequency
From the table the loss constant is shown to be 2.0

The percent 3dB bandwidth is:

$$\frac{\text{3dB BW(100)}}{\text{Center Frequency}} = \frac{(80)(100)}{500} = 16\%$$

By substituting in the formula we find the insertion loss =

$$\frac{(2)(5 + 1/2)}{16} + 0.2 = 0.9\text{dB}$$

◆ Insertion Loss/Loss Constant

Loss Constant vs. Frequency vs. Model

	Center Frequency (MHz)									
Model	40	41 50	51 65	66 100	101 200	201 400	401 1000	1001 2000	2001 4000	4001 6000
B250						5.0	4.0	3.5	3.0	2.5
B120				3.5	3.0	2.5	2.0	1.8	1.6	
B340		3.0	2.5	2.2	2.0	1.6	1.4	1.2		
B110	2.5	2.4	2.2	1.8	1.6	1.3	1.2			

◆ Specifications - Bandpass

Model	Diameter Inches	Frequency Range (MHz)	3dB % of Center	VSWR (1)	No. of Sections (Watts)	Impedance (Ohms)	Average Power	Shock	Vibration	Humidity	Temperature Range
B250	1/4	200- 6000(2)	4-40%	1.5:1 or Less	2-8	50 75	2	30G, 11ms	10G 5-2000Hz	0-95%	-55°C +85°C
B120*	1/2	100- 2500	4-40%	1.5:1 or Less	2-10	50 75	18	30G, 11ms	10G 5-2000Hz	0-95%	-55°C +85°C
B340	3/4	50- 1700	4-40%	1.5:1 or Less	2-10	50 75	40	30G, 11ms	10G 5-2000Hz	0-95%	-55°C +85°C
B110	1-1/4	40- 600	4-40%	1.5:1 or Less	2-10	50 75	200	30G, 11ms	10G 5-2000Hz	0-95%	-55°C +85°C

*Most versatile, fits most applications

1. 50 Ohms standard

2. For frequency above 6,000MHz, combline and interdigital filters are better suited

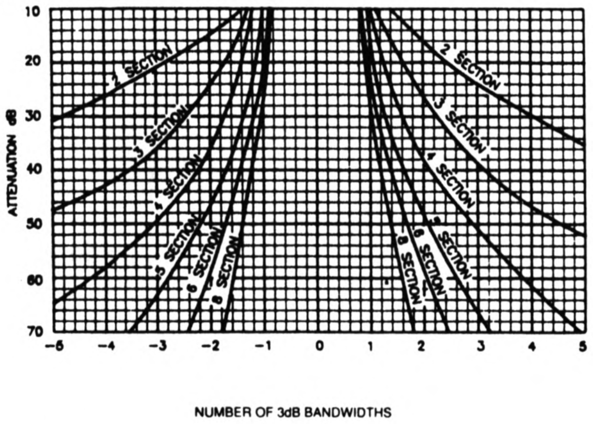
ubular Filters

◆ Attenuation

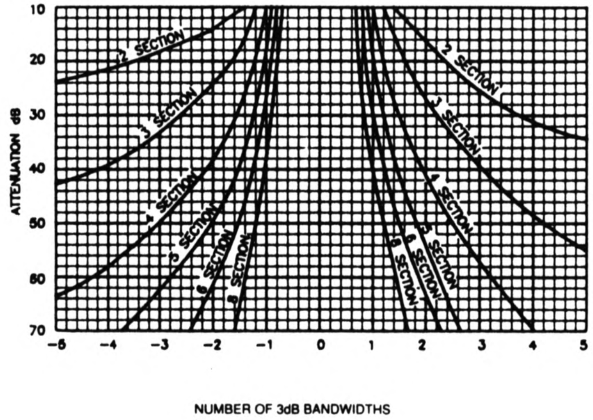
The following curves are used in determining the out-of-band attenuation for K&L's four series of tubular filters. The curves show minimum stopband in dB, as multiples of 3dB bandwidth for filters with 2 through 8 sections. For more than 8 sections please contact the factory.

For the most part, tubular filters are free of spurious responses. However due to case moding or when resonance develops, spurious responses can occur. It is therefore advisable that the user specify the frequency which is to be spurious-free. By doing so, K&L can incorporate compensating networks to eliminate the spurious responses at no degradation in the passband frequencies.

◆ For Bandwidths 4 to 5%



◆ For Bandwidths 5 to 15%



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ubular Filters

◆ Attenuation

To determine which series of curves to use, first calculate the percentage 3dB bandwidth from the formula:

$$\% \text{ BW} = \frac{\text{3dB BW}}{\text{Center frequency}} \text{ X } 100$$

To determine the number of bandwidths (3dB) from center frequency, use the following formula:

$$\text{No. 3dB BW} = \frac{\text{Reject freq.} - \text{Center freq.}}{\text{3dB BW}}$$

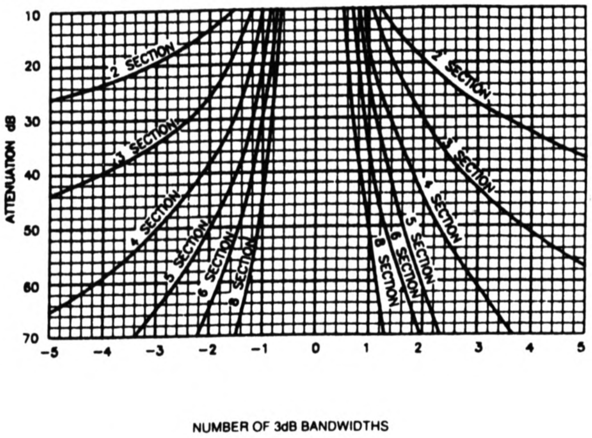
EXAMPLE:

Center frequency = 300MHz
3dB bandwidth = 50MHz
Number of sections = 6
Determine attenuation at 200MHz and 400MHz:

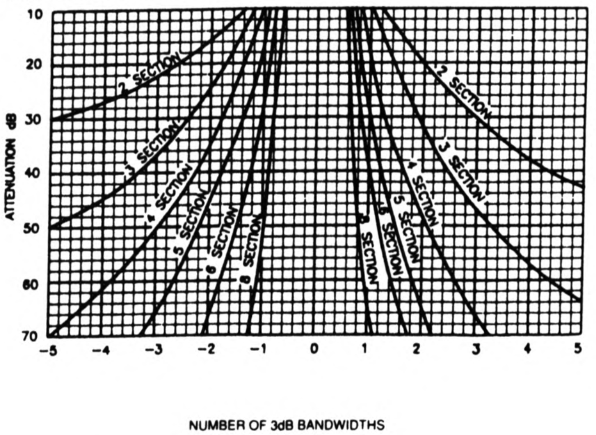
1. Calculate % BW = $\frac{50 \text{ X } 100}{300}$ =17%
2. -3dB BW = $\frac{200\text{-}300}{50}$ = -2 BW
3. +3dB BW= $\frac{400\text{-}300}{50}$ =+2 BW

Referring to the curve for 15%-30%, a 6 section response -2 BW yields 64dB, and +2 BW yields greater than 70dB.

◆ For Bandwidths 15 to 30%



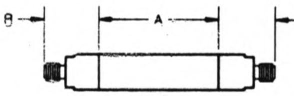
◆ For Bandwidths 30 to 70%



Tubular Filters

◆ Features

The length of a tubular filter is determined by adding the "A" and "B" dimensions. The "B" dimension is obtained from the table below and the "A" dimension is obtained from Length vs. Frequency tables on the following page



EXAMPLE:

A 3-section bandpass filter Model B120 with a center frequency of 300MHz and with SMA connectors has an "A" dimension of 2 inches and a "B" dimension of 0.8 inches. The total length is 3.6".

Connector Style	Connector Code	"B" Dimension (Inches)				Figure
		.25 Diameter	.50 Diameter	.75 Diameter	1.25 Diameter	
"N" Female	N	NR*	1.28	1.4	1.7	
"N" Male	NP	NR*	1.23	1.31	1.65	
BNC Female	B	NR*	1.0	1.35	1.42	
BNC Male	BP	NR*	.93	1.45	1.35	
TNC Female	T	NR*	1.0	1.35	1.42	
TNC Male	TP	NR*	.93	1.45	1.35	
SMC Female (Screw On)	S	.6	.73	.73	.73	
SMC Male (Screw On)	SP	NR*	.81	.81	.81	
SMB Female (Snap On)	A	.6	.73	.73	.73	
SMB Male (Snap On)	AP	NR*	.81	.81	.81	
"F" Female	F	NR*	1.05	1.05	1.05	
SMA Female (Standard)	O	.6	.8	.8	.8	
SMA Female (Right Angle)	DO	NR*	.6	.6	.6	2
SMA Female (Right Angle Square)	EO	.55	.65	.65	.65	5
SMA Male (Standard)	OP	.73	.85	.85	.85	
SMA Male (Right Angle)	DP	NR*	.6	.6	.6	2
SMA Male (Right Angle Square)	EP	.55	.65	.65	.65	5
Cable, RG 188 (Right Angle Stand.)	C	.45	.5	.5	.5	1
Cable, RG 188 (Straight)	CS	.45	.55	.55	.55	3
Solder Lug	L	.40	.45	.45	.45	4
PC Mount (Right Angle)	P	•	•	•	•	•

NR* - Not recommended

• For PC mount, contact factory

Figure 1

Figure 2

Figure 3

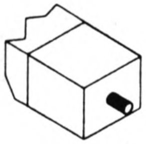


Figure 4

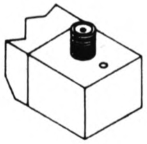


Figure 5

Tubular Filters

◆ Approximate* Dimension "A" - Length vs. Frequency

◆ B250

No. of	Frequency (MHz)					
Sections	200-300	300-400	400-1000	1000-3000	3000-4000	4000-6000
2	1.10	1.00	.90	.80	.70	.50
3	2.00	1.90	1.40	1.20	1.00	.70
4	2.90	2.80	1.90	1.70	1.30	.90
5	3.80	3.60	2.40	2.10	1.60	1.10
6	4.70	4.40	2.90	2.5	1.90	1.30
7	5.60	5.20	3.40	2.90	2.20	1.60
8	6.50	6.00	3.90	3.30	2.50	1.90

◆ L250

No. of	Frequency (MHz)							
Sections	300-600	600-1000	1000-1300	1300-1700	1700-2300	2300-3000	3000-5000	5000-20000
2	.65	.55	.40	.50	.45	.40	.40	
3	1.00	.90	.70	.85	.75	.70	.75	
4	1.45	1.25	1.00	1.20	1.10	1.00	1.50	Contact factory for exact size at higher frequencies
5	1.90	1.65	1.30	1.55	1.40	1.30	1.40	
6	2.30	2.00	1.60	1.95	1.70	1.55	1.75	
7	2.75	2.40	1.90	2.30	2.00	1.85	2.10	
8	3.20	2.75	2.20	2.65	2.35	2.15	2.45	
9	3.65	3.10	2.50	3.00	2.70	2.45	2.80	
10	4.10	3.50	2.80	3.35	3.00	2.75	3.10	

◆ B120

No. of	Frequency (MHz)				
Sections	100-130	130-180	180-350	350-700	700-2500
2	2.00	1.60	1.30	1.10	.90
3	3.15	2.60	2.00	1.65	1.40
4	4.30	3.60	2.70	2.20	1.95
5	5.45	4.55	3.40	2.70	2.45
6	6.60	5.55	4.10	3.25	3.00
7	7.75	6.55	4.80	3.80	3.50
8	8.90	7.55	5.50	4.35	4.00
9	-	8.55	6.20	4.90	4.55
10	-	9.50	6.90	5.40	5.00

◆ L120

No. of	Frequency (MHz)						
Sections	60-70	70-90	90-150	150-200	200-400	400-800	800-3000
2	2.45	2.10	1.80	1.55	1.10	.75	.65
3	3.85	3.15	2.80	2.45	1.80	1.20	1.10
4	5.20	4.20	3.85	3.40	2.55	1.70	1.50
5	6.60	5.25	4.85	4.30	3.25	2.15	1.95
6	8.00	6.30	5.90	5.20	3.95	2.60	2.40
7	9.40	7.30	6.95	6.15	4.70	3.00	2.80
8	-	8.35	7.95	7.00	5.40	3.50	3.25
9	-	9.40	8.95	8.00	6.10	3.95	3.70
10	-	-	-	8.90	6.80	4.40	4.10

◆ B340

No. of	Frequency (MHz)				
Sections	50-80	80-140	140-230	230-500	500-1700
2	3.00	2.00	•1.50	1.30	1.10
3	4.50	3.00	2.25	1.85	1.60
4	6.00	3.95	3.00	2.40	2.10
5	7.50	4.90	3.75	2.95	2.60
6	9.00	5.90	4.50	3.50	3.10
7	-	6.85	5.25	4.10	3.60
8	-	7.80	6.00	4.60	4.10
9	-	8.80	6.75	5.15	4.60
10	-	-	7.50	5.70	5.10

◆ L340

No. of	Frequency (MHz)							
Sections	40-60	60-80	80-100	100-200	200-400	400-600	600-1000	1000-2000
2	3.90	3.10	2.20	2.00	1.20	1.00	.90	.80
3	5.90	4.80	3.50	3.15	2.00	1.60	1.35	1.25
4	8.00	6.45	4.75	4.30	2.70	2.15	1.80	1.65
5	-	8.10	6.00	5.40	3.40	2.70	2.25	2.00
6	-	-	7.30	6.50	4.10	3.25	2.70	2.45
7	-	-	8.60	7.65	4.90	3.85	3.15	2.85
8	-	-	-	8.75	5.55	4.40	3.60	3.30
9	-	-	-	-	6.40	5.00	4.00	3.70
10	-	-	-	-	7.00	5.50	4.50	4.10

◆ B110

No. of	Frequency (MHz)				
Sections	40-55	55-80	80-200	200-400	400-600
2	3.00	2.80	2.40	2.00	1.60
3	4.00	3.80	3.20	2.80	2.30
4	5.00	4.80	4.00	3.60	3.00
5	6.50	6.00	5.20	4.40	3.80
6	8.00	7.20	5.60	5.20	4.60
7	9.50	8.40	6.40	6.00	5.40
8	-	9.60	7.20	6.80	6.20
9	-	-	8.60	7.60	7.00
10	-	-	-	8.50	7.80

◆ L110

No. of	Frequency (MHz)				
Sections	30-40	40-80	80-200	200-600	600-1000
2	3.65	2.40	2.00	1.30	1.00
3	5.45	3.55	2.85	2.00	1.55
4	7.25	4.75	3.70	2.60	2.00
5	9.10	6.00	4.55	3.25	2.60
6	-	7.15	5.40	3.90	3.10
7	-	8.35	6.25	4.55	3.65
8	-	9.50	7.10	5.20	4.20
9	-	-	7.95	5.85	4.70
10	-	-	8.80	6.50	5.20

* Length shown at left is less connectors. Dimensions and weight are approximate

◆ Weight (Ounces)

B250	B120	B340	B110
1/4 oz per inch	3/4 oz per inch	3/4 oz per inch	1 1/2 oz per inch

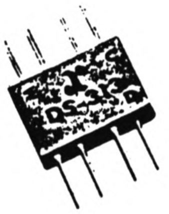
◆ Weight (Ounces)

L250	L120	L340	L110
1/4 oz per inch	3/4 oz per inch	3/4 oz per inch	1 1/2 oz per inch

MODEL DS-313

TWO-WAY IN-PHASE POWER DIVIDER 10-2000 MHz

0.6 dB Typical Midband Loss
28 dB Typical Midband Isolation
1.2:1 Typical Midband VSWR



Guaranteed Specifications*

(From −55°C to +85°C)

Frequency Range		10-2000 MHz
Insertion Loss (Less coupling)	20-1000 MHz	1.1 dB Max
	10-1500 MHz	1.3 dB Max
	1500-2000 MHz	1.8 dB Max
Isolation	20-1000 MHz	23 dB Min
	10-1500 MHz	18 dB Min
	1500-2000 MHz	12 dB Min
Amplitude Balance	20-1000 MHz	0.3 dB Max
	10-1500 MHz	0.4 dB Max
	1500-2000 MHz	0.6 dB Max
Phase Balance	20-1000 MHz	4° Max
	10-1500 MHz	6° Max
	1500-2000 MHz	8° Max
VSWR (All Ports)	20-1000 MHz	1.5 Max
	10-1500 MHz	1.6 Max
	1500-2000 MHz	1.8 Max

Operating Characteristics

Impedance	50 Ohms Nominal
Maximum Power Rating or Input Power	250 mW Max
Internal Load Dissipation	50 mW Max
Package Type	Flatpack (FP-2) (See page 474 for physical dimensions.)

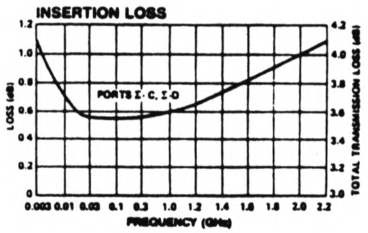
Environmental

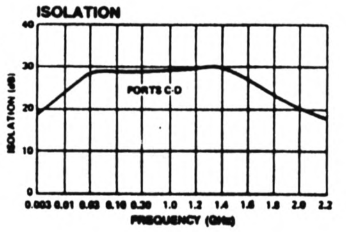
These units are designed to meet the environmental and screening requirements of Table 1A, page 496 of the Adams-Russell catalog.

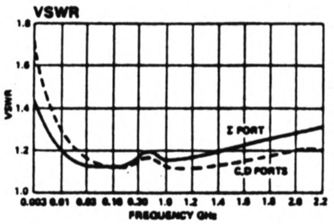
Pin Configuration	Σ; P1, Output 'C'; P4, Output 'D'; P8 Case and all other pins ground.

*All specifications apply with 50 ohm source and load impedance

Typical Performance







Ordering Information

Model No.	Part No.	Connectors	Unit Price (5-9 Units)
DS-313	8559	Pin	$67

Delivery is from stock.

ANZAC — Make the Connection... — Adams Russell COMPONENTS GROUP

80 Cambridge Street, Burlington, MA 01803 Fax (617) 273-1921

For Technical Information, Call (617) 273-3333

For Ordering Information, Call (617) 273-3333

DITOM
MICROWAVE INC

Single Junction — Octave/Broadband

Isolators and Circulators

Frequency[1] Range (GHz)	Isolator Model Number	Circulator Model Number	Isolation (dB)		Insertion Loss (dB)		VSWR (+dBm)		Power[2] (Watts)		Operating Temperature Range[3] (°C)	Outline Number	Approx Weight Oz (gm)
			Typ	Min	Typ	Max	Typ	Max	Avg	Pk			
2.0-4.0	D3I 2040	D3C 2040	20	18	0.40	0.50	1 25	1.30	2	20	0 to +50	1	3 5 (100)
2.0-6.0	D3I 2060	D3C 2060	15	14	0.70	0.80	1.45	1.50	2	20	0 to +50	1	3.5 (100)
2.0-8.0	D3I 2080	D3C 2080		12		1.10		1.85	2	20	0 to +50	1	6.9 (195)
2.6-5.2	D3I 2652	D3C 2652	20	18	0.40	0.50	1 25	1.30	2	20	0 to +50	1	3.5 (100)
3.0-6.0	D3I 3060	D3C 3060	21	19	0.35	0.40	1 25	1.30	2	20	0 to +50	2	2 0 (60)
3.5-7.0	D3I 3570	D3C 3570	20	18	0.35	0 40	1 25	1 30	2	20	0 to +50	3	1 2 (35)
3.7-8.3	D3I 3783	D3C 3783	18	17	0.50	0.60	1.30	1.35	2	20	0 to +50	3	1 2 (35)
4.0-8.0	D3I 4080	D3C 4080	22	20	0.35	0.40	1 18	1.25	2	20	-10 to +60	3	1.2 (35)
6.0-12.4	D3I 6012	D3C 6012	19	17	0.50	0.60	1.30	1.35	2	20	-10 to +60	6	1 0 (30)
7.0-11.0	D3I 7011	D3C 7011	22	20	0.35	0.40	1 18	1.25	2	500	-30 to +85	4	1.0 (30)
7.0-18.0	D3I 7018	D3C 7018	16	15	0 90	1 00	1 45	1.50	2	30	-10 to +85	5	0 9 (25)
8.0-12.4	D3I 8012	D3C 8012	22	20	0 35	0.40	1 18	1.25	2	500	-30 to +85	4	1 0 (30)
8.0-18.0	D3I 8018	D3C 8018	17	16	0.70	0.80	1 40	1.45	2	30	-10 to +85	5	0 9 (25)
8.0-20.0	D3I 8020	D3C 8020		15	0.70	1.00		1.45	2	30	-10 to +85	5	0 9 (25)
8.0-16.0	D3I 8016	D3C 8016	19	17	0.50	0.60	1 30	1.35	2	30	-20 to +65	5	0 9 (25)
10.0-20.0	D3I 1020	D3C 1020	17	16	0.60	0.70	1.35	1.40	2	30	-20 to +65	5	0 9 (25)
12.0-18.0	D3I 1218	D3C 1218	22	20	0.45	0.50	1.18	1.25	2	30	-20 to +65	5	0.9 (2
18.0-26.5	D3I 1826	D3C 1826	20	18	0.70	0.80	1 35	1.40	2	30	-20 to +65	5	0 9
20.0-30.0	D3I 2030	D3C 2030	20	18	0.60	0.70	1 35	1.40	2	30	-20 to +65	5*	0 9
20.0-40.0	D3I 2004	D3C 2004		13		1.20		1.60	2	30	-20 to +65	5*	0 9
26.5-40.0	D3I 2640	D3C 2640	15	14	0.80	1.00	1.45	1 50	2	30	-20 to +65	5*	0 9

Single Junction — EW/Broadband

Isolators and Circulators

Frequency[1] Range (GHz)	Isolator Model Number	Circulator Model Number	Isolation (dB)		Insertion Loss (dB)		VSWR (+dBm)		Power[2] (Watts)		Operating Temperature Range[5] (°C)	Outline Number	Approx Weight Oz (gm)
			Typ	Min	Typ	Max	Typ	Max	Avg	Pk			
2.6-5.3	DMI 2652	DMC 2652	16	15	0.90	1.00	1.45	1.50	2	20	-30 to +75	9	0.70 (20)
5.0-10.7	DMI 5011	DMC 5011	16	15	0.90	1.00	1.40	1.45	2	20	-30 to +75	10	0.53 (15)
5.9-12.5	DMI 5912	DMC 5912	19	17	0.50	0.60	1.30	1.35	2	20	-40 to +85	10	0.53 (15)
6.0-18.0	DMI 6018	DMC 6018	15	14	0.90	1.00	1 45	1 50	2	20	0 to +85	11	0.40 (11)
6.5-13.1	DMI 6513	DMC 6513	17	16	0.70	0.80	1.40	1.45	2	20	-40 to +85	11	0 40 (11)
6.5-18.0	DMI 6518	DMC 6518	15	14	0.90	1.00	1.45	1 50	2	20	0 to +85	11	0.40 (11)
7.4-17 2	DMI 7417	DMC 7417	18	16	0 60	0 80	1 40	1 45	2	20	-55 to +85	11	0 40 (11)
10.4-18.4	DMI 1018	DMC 1018	20	17	0 50	0.80	1 30	1 35	2	20	-55 to +85	11	0.40 (11)

Notes.

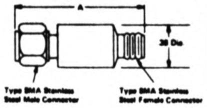
1. Other frequencies available on request.
2. Consult factory for power handling capability of circulator.
3. Storage temperature range is -55°C to +100°C. All units will operate -54°C to +85 C. Consult factory for specifications.
4. Connector and termination locations are interchangeable.
5. Storage temperature range is -55°C to +125°C.

See Outline Drawings on Page 3.

Outline Number	Dimension Inches (Centimeters) A	B	C	D	E	F	G	H	J
9**	1 00 (2 54)	1 00 (2 54)	0 38 (0 97)	0 19 (0 48)	0 19 (0 48)	0 650 (1 651)	0 10 (0 25)	0 800 (2 032)	0 40 (1 02)
10**	0 75 (1 91)	0 75 (1 91)	0 38 (0 97)	0 19 (0 48)	0 19 (0 48)	0 425 (1 079)	0 10 (0 25)	0 550 (1 397)	0 27 (0 69)
11***	0 50 (1 27)	0 58 (1 47)	0 38 (0 97)	0 19 (0 48)	0 19 (0 48)	— —	0 10 (0 25)	0 300 (0 762)	— —

FREQUENCY RANGE (GHz)	MODEL	ATTENUATION dB		POWER INPUT		VSWR (Max)		WEIGHT (Max)	
		NOMINAL	DEVIATION DC-6	AVG. (W)Max	PEAK (kW)Max	DC-4.0	4-6	Oz	Gr
DC-6	4772	0	±0.3	2	0.2	1.25	1.40	0.5	14
		0.5	±0.3	2	0.2	1.25	1.40	0.5	14
		1.0	±0.3	2	0.2	1.25	1.40	0.5	14
		1.5	±0.3	2	0.2	1.25	1.40	0.5	14
		2.0	±0.3	2	0.2	1.25	1.40	0.5	14
		2.5	±0.3	2	0.2	1.25	1.40	0.5	14
		3.0	±0.3	2	0.2	1.25	1.40	0.5	14
		3.5	±0.3	2	0.2	1.25	1.40	0.5	14
		4.0	±0.3	2	0.2	1.25	1.40	0.5	14
		4.5	±0.3	2	0.2	1.25	1.40	0.5	14
		5.0	±0.3	2	0.2	1.25	1.40	0.5	14
		5.5	±0.3	2	0.2	1.25	1.40	0.5	14
		6.0	±0.3	2	0.2	1.25	1.40	0.5	14
		6.5	±0.4	2	0.2	1.25	1.40	0.5	14
		7.0	±0.4	2	0.2	1.25	1.40	0.5	14
		7.5	±0.4	2	0.2	1.25	1.40	0.5	14
		8.0	±0.4	2	0.2	1.25	1.40	0.5	14
		8.5	±0.4	2	0.2	1.25	1.40	0.5	14
		9.0	±0.4	2	0.2	1.25	1.40	0.5	14
		9.5	±0.4	2	0.2	1.25	1.40	0.5	14
		10.0	±0.3	2	0.2	1.25	1.40	0.5	14
		10.5	±0.4	2	0.2	1.25	1.40	0.5	14
		11.0	±0.4	2	0.2	1.25	1.40	0.5	14
		11.5	±0.4	2	0.2	1.25	1.40	0.5	14
		12.0	±0.4	2	0.2	1.25	1.40	0.5	14
		12.5	±0.4	2	0.2	1.25	1.40	0.5	14
		13.0	±0.4	2	0.2	1.25	1.40	0.5	14
		13.5	±0.4	2	0.2	1.25	1.40	0.5	14
		14.0	±0.4	2	0.2	1.25	1.40	0.5	14
		15.0	±0.4	2	0.2	1.25	1.40	0.5	14
		16.0	±0.4	2	0.2	1.25	1.40	0.5	14
		17.0	±0.4	2	0.2	1.25	1.40	0.5	14
		18.0	±0.4	2	0.2	1.25	1.40	0.5	14
		19.0	±0.4	2	0.2	1.25	1.40	0.5	14
		20.0	±0.3	2	0.2	1.25	1.40	0.5	14
		23.0	±0.3	2	0.2	1.25	1.40	0.5	14
		24.0	±0.3	2	0.2	1.25	1.40	0.5	14
		25.0	±0.3	2	0.2	1.25	1.40	0.5	14
		26.0	±0.3	2	0.2	1.25	1.40	0.5	14
		30.0	±0.5	2	0.2	1.25	1.40	0.5	14
		32.0	±0.5	2	0.2	1.25	1.40	0.5	14
		35.0	±0.3	2	0.2	1.25	1.40	0.5	14
		40.0	±0.5	2	0.2	1.25	1.40	0.5	14
		50.0	±0.75	2	0.2	1.25	1.40	0.5	14
		60.0	±0.75	2	0.2	1.25	1.40	0.5	14

Ordering Information:
Specify Model No. and add dash number suffix for Attenuation in dB.
For example: 4779-0.5
Model No ┘ └── Attenuation



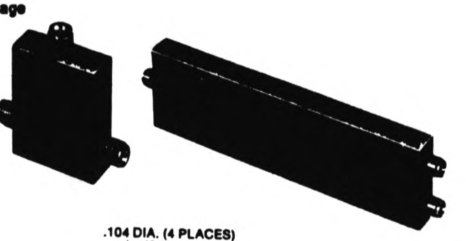
Model No.	A 1-20 dB	A 30-60 dB
4772 4778 4779	1.20 1.24 1.24	1.40 1.40 1.40

FREQUENCY RANGE (GHz)	MODEL	ATTENUATION dB		POWER INPUT		VSWR (Max)		WEIGHT (Max)	
		NOMINAL	DEVIATION DC-12.4	AVG. (W)Max	PEAK (kW) Max	DC-4	4-12.4	Oz	Gr
DC-12.4	4778	0	±0.3	2	0.2	1.15	1.30	0.5	14
		0.5	±0.3	2	0.2	1.15	1.30	0.5	14
		1.0	±0.3	2	0.2	1.15	1.30	0.5	14
		1.5	±0.3	2	0.2	1.15	1.30	0.5	14
		2.0	±0.3	2	0.2	1.15	1.30	0.5	14
		2.5	±0.3	2	0.2	1.15	1.30	0.5	14
		3.0	±0.3	2	0.2	1.15	1.30	0.5	14
		3.5	±0.3	2	0.2	1.15	1.30	0.5	14
		4.0	±0.3	2	0.2	1.15	1.30	0.5	14
		4.5	±0.3	2	0.2	1.15	1.30	0.5	14
		5.0	±0.3	2	0.2	1.15	1.30	0.5	14
		5.5	±0.3	2	0.2	1.15	1.30	0.5	14
		6.0	±0.3	2	0.2	1.15	1.30	0.5	14
		6.5	±0.4	2	0.2	1.15	1.30	0.5	14
		7.0	±0.4	2	0.2	1.15	1.30	0.5	14
		7.5	±0.4	2	0.2	1.15	1.30	0.5	14
		8.0	±0.4	2	0.2	1.15	1.30	0.5	14
		8.5	±0.4	2	0.2	1.15	1.30	0.5	14
		9.0	±0.4	2	0.2	1.15	1.30	0.5	14
		9.5	±0.4	2	0.2	1.15	1.30	0.5	14
		10.0	±0.3	2	0.2	1.15	1.30	0.5	14
		10.5	±0.4	2	0.2	1.15	1.30	0.5	14
		11.0	±0.5	2	0.2	1.15	1.30	0.5	14
		11.5	±0.4	2	0.2	1.15	1.30	0.5	14
		12.0	±0.5	2	0.2	1.15	1.30	0.5	14
		12.5	±0.4	2	0.2	1.15	1.30	0.5	14
		13.0	±0.5	2	0.2	1.15	1.30	0.5	14
		13.5	±0.5	2	0.2	1.15	1.30	0.5	14
		14.0	±0.5	2	0.2	1.15	1.30	0.5	14
		15.0	±0.5	2	0.2	1.15	1.30	0.5	14
		16.0	±0.5	2	0.2	1.15	1.30	0.5	14
		17.0	±0.5	2	0.2	1.15	1.30	0.5	14
		18.0	±0.5	2	0.2	1.15	1.30	0.5	14
		19.0	±0.5	2	0.2	1.15	1.30	0.5	14
		20.0	±0.5	2	0.2	1.15	1.30	0.5	14
		23.0	±0.5	2	0.2	1.15	1.30	0.5	14
		24.0	±0.5	2	0.2	1.15	1.30	0.5	14
		25.0	±0.5	2	0.2	1.15	1.30	0.5	14
		26.0	±0.5	2	0.2	1.15	1.30	0.5	14
		30.0	±0.8	2	0.2	1.35	1.35	0.5	14
		32.0	±0.8	2	0.2	1.35	1.35	0.5	14
		35.0	±0.8	2	0.2	1.35	1.35	0.5	14
		40.0	±0.3	2	0.2	1.15	1.30	0.5	14
		50.0	±1.2	2	0.	1.35	1.30	0.5	14
		60.0	±1.2	2	0.2	1.35	1.30	0.5	14

narda

Two-Way • Tapered • Isolated • Ultra Broadband Power Dividers

- Octave, Multi-Octave And Decade Frequency Coverage
- Low Insertion Loss
- Excellent Amplitude And Phase Balance
- High Isolation Between Output Ports
- Low VSWR
- Power: 80 Watts Maximum
- Meets MIL-E-5400 and MIL-E-16400 Environments



New designs include operation through 26 GHz and retain the performance of lower frequency units. These units are ideal for multi-octave ECM systems. These units function as either dividers or combiners to facilitate system performance.

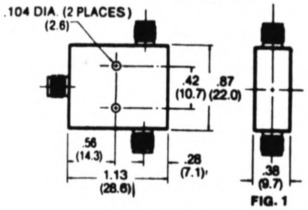


FIG. 1

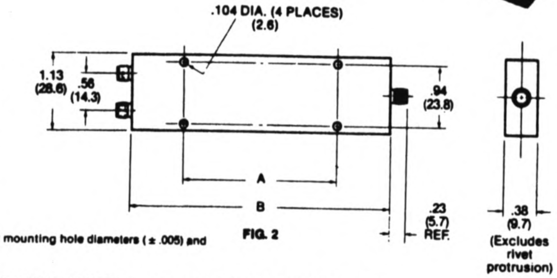
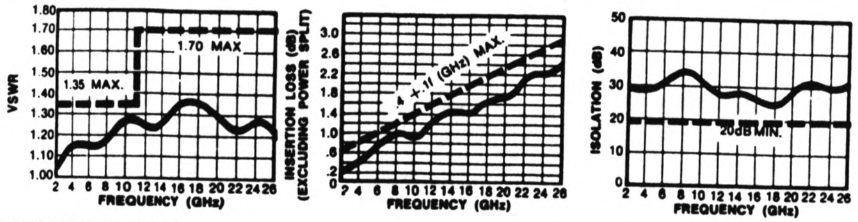


FIG. 2

NOTE. All dimensions are ± .020, except mounting hole diameters (± .005) and mounting hole location (± .010).

TYPICAL PERFORMANCE PART NO. 2090-6202-00



SPECIFICATIONS

PART NO.	MODEL NO.	FREQUENCY RANGE (GHz)	VSWR (max.)	ISOLATION dB (min.)	INSERTION LOSS dB (max.)	OUTPUT UNBALANCE		MAX. INPUT POWER** (watts)	SIZE, INCHES (mm)		WEIGHT	
						AMP. (dB)	PHASE (deg.)		A	B	FIG.	oz. g
2090-6201-00	204928	0.5-26.0	1.35 (0.5 to 11) GHz 1.70 (11 to 26) GHz	12 (0.5 to 1) GHz 20 (1 to 26) GHz	0.4 +.15f	0.5	5°	80	9.40 (239)	11.02 (291)	2	8.0 226
2090-6202-00	204948	2.0-26.0	1.35 (2 to 1) GHz 1.70 (11 to 26) GHz	20	0.4 +.1f	0.5	5°	40	2.40 (61.1)	4.02 (102)	2	2.9 83
2090-6203-00	204968	8.0-26.0	1.50 (8 to 18) GHz 1.90 (18 to 26) GHz	18	0.4 + .05f	0.5	5°	20	—	—	1	1.1 30
2090-6204-00	204927	0.5-18.0	1.35 (0.5 to 11) GHz 1.70 (11 to 18) GHz	20 (0.5 to 3) GHz 23 (3 to 18) GHz	0.2 +.17f	0.3	5	80	9.40 (239)	11.02 (291)	2	8.0 226
2090-6205-00	204947	2.0-18.0	1.35 (2 to 11) GHz 1.70 (11 to 18) GHz	20 (2 to 3) GHz 23 (3 to 18) GHz	0.2 +.07f	0.3	5	40	2.40 (61.1)	4.02 (102)	2	2.9 83
2090-6210-00	*204967	8.0-18.0	1.50	18	0.2 +.03f	0.3	5	20	—	—	1	1.1 30

*To 18 GHz

**Maximum input power with output loads of VSWR ≤ 2.0:1. Derate to 10% of listed value when arbitrarily terminated.

Note: f is frequency in GHz.

M/A-COM Control Components Division • 21 Continental Blvd., Merrimack, NH 03054-4343 • Tel (603) 424-4111 Fax (603) 424-6580

Merrimac

PDM-20 series

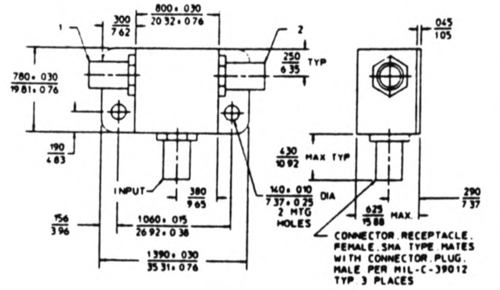
0° TWO WAY POWER DIVIDERS/COMBINERS
Broadband, Lumped Element Design, SMA

- 50 kHz to 2 GHz Frequency Range
- Multi-Octave Bandwidths
- Uniform Phase and Amplitude Balance
- Low Insertion Loss

Model Number	Frequency Range MHz	Frequency Performance MHz	Isolation dB.		Insertion Loss, dB		Phase Balance		Amplitude Balance		VSWR max.		Input Power*
			Min.	Typ.	Max	Typ.	Max.	Typ.	Max.	Typ.	In	Out	
PDM-20-10	0.05 - 20	0.05 - 20	30	33	0.5	0.3	1°	0.5°	0.2	0.1	1.3:1	1.2:1	2W max
PDM-20-50	1 - 100	1 - 100	30	35	0.5	0.3	1°	0.5°	0.2	0.1	1.3:1	1.2:1	3W max.
PDM-20-250	10 - 500	10 - 400	30	32	0.5	0.4	2°	1°	0.2	0.1	1.3:1	1.2:1	3W max.
		10 - 500	30	32	0.6	0.5	2°	1°	0.2	0.1	1.3:1	1.2:1	3W max.
PDM-20-500	5 - 1000	5 - 1000	25	30	1.0	0.7	2°	1°	0.2	0.1	1.3:1	1.2:1	1W max.
PDM-20-1100	200 - 2000	500 - 1500	23	27	1.0	0.3	4°	2°	0.3	0.1	1.4:1	1.2:1	2W max.
		200 - 2000	15	20	1.5	0.8	6°	3°	0.3	0.1	2.0:1	1.5:1	2W max.

*Average Power into matched loads

Package Outline



NOTES:
1. Tolerance on 3 place decimals ± .020(.51) except as noted.
2. Dimensions in inches over millimeters.
3. SMA Female connectors to meet interface requirements of MIL-C-39012

MERRIMAC In-Phase, Power Dividers/Combiners are available for frequencies from 10 kHz to 18 GHz, with outputs from two to sixteen and for powers up to several kilowatts.

The PDM-20 series of connectorized 2-way In-Phase Power Dividers/Combiners cover a very broad frequency range from 50 kHz to 2 GHz, using lumped element design, which provide very broad bandwidths. All units are designed to meet MIL-P-23971 requirements and can be supplied screened to meet specific military and space applications.

COMMON SPECIFICATIONS

Impedance:	50 Ω nom.
Internal Load Dissipation:	
PDM-20-1100:	125 mW max.
All Others:	250 mW max.
Weight, nominal:	1 oz. (28 g)
Operating Temperature:	−55° to +85°C

Contact MERRIMAC for further details. (11/89

41 Fairfield Place, West Caldwell, N.J. 07006 • (201)575-1300 • FAX:(201) 575-0531 • Telex: 6853128

IN-PHASE 2-WAY SMA, N, TNC

DIVIDERS, POWER

0.5-18 GHz

SERIES YL
D300

GENERAL INFORMATION:

KDI/Triangle's Two-way Stripline in phase power dividers, Series YL, and D300 have excellent phase and amplitude balance The internal resistive element is a ceramic pad and can, therefore, handle relatively high values of CW and peak power. Series YL is of Stripline construction, thereby ensuring excellent electrical and environmental performance.

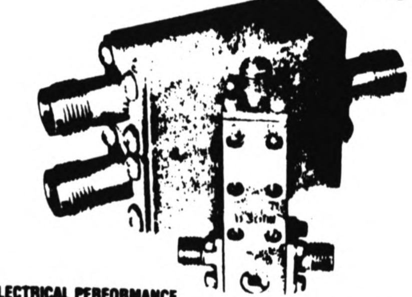
GENERAL SPECIFICATIONS:

Frequency Range:	0.5-18.0 GHz
RF Impedance:	50 OHMS
RF Power:	The power handling capability for load VSWR's less than 1.50 is 1 watt CW and 1 kW peak for frequencies up to 2.0 GHz, and 400 mW CW and 0.4 kW peak for frequencies from 2 0 GHz to 18.0 GHz.
Temp. Information:	Operating temperature from −55°C to +85°C
Environment:	MIL-E-5400, MIL-STD-202, MIL-E-16400 MIL-STD-883 (Special request only).
Connectors:	SMA or N standard, others on request TNC for D314T, D318T only

Notes:

1 If the frequency band of interest is narrower than that listed, it should be indicated when ordering Performance will be optimized over the band of interest and improved delivery may be provided. A special part number may be assigned.

2 Output connectors are normally provided in line with input (Figures 1 &3) unless specified at time of order (Figure 2). Add "S" to part number (i.e YL S)

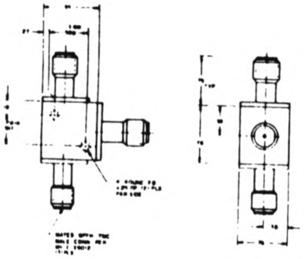


ELECTRICAL PERFORMANCE

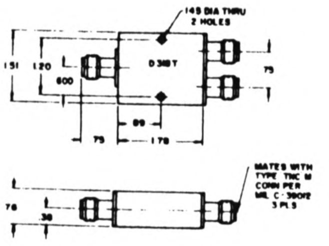
Model No.	Frequency Range GHz	Max.* In/Out VSWR	Max. Insertion Loss dB	Min.* Isolation dB	Phase Balance Degrees	Amplitude Balance dB	Out-line SMA	Out-line N*
OCTAVE BANDS								
YL-18	0.5-1.0	1.20/1.15	0.2	22	2	0.15	7	3
YL-19	0.75-1.50	1.20/1.15	0.2	21	2	0.15	10	5
YL-23	1.0-2.0	1.20/1.15	0.2	21	2	0.2	6	2
YL-25	1.5-3.0	1.25/1.20	0.3	21	3	0.2	8	1
YL-33	2.0-4.0	1.25/1.20	0.3	21	3	0.2	3	1
YL-48	4.0-8.0	1.30/1.25	0.4	20	4	0.3	2	1
YL-56	7.0-14.0	1.40/1.35	0.5	19	6	0.4	1	6
YL-56	9.0-18.0	1.45/1.40	0.7	19	8	0.4	1	N/A
MULTI-OCTAVE BANDS								
YL-70	0.5-2.0	1.25/1.15	0.4	22	2	0.2	10	5
YL-71	1.0-4.0	1.30/1.20	0.4	21	2	0.2	6	2
YL-72	2.0-8.0	1.30/1.25	0.5	20	3	0.2	4	2
YL-74	6.0-18.0	1.50/1.40	0.8	16	6	0.4	1	N/A
YL-76	1.0-12.4	1.50/1.40	1.0	16	6	0.4	9	4
YL-78	2.0-18.0	1.50/1.40	1.4	16	8	0.4	5	N/A
D301M	1.0-1.5	1.70/1.30	0.5	12	1	0.2	(see DWG)	
	1.5-2.0	1.60/1.30	0.5	15	1	0.2		
	2.0-4.0	1.50/1.30	0.4	20	1	0.2		
	4.0-8.0	1.50/1.40	0.5	18	2	0.2		
	8.0-12.0	1.50/1.40	0.8	16	3	0.3		
	12.0-16.0	1.60/1.50	0.9	15	4	0.3		
	16.0-18.5	1.70/1.60	1.2	12	7	0.4		
POPULAR & COMMUNICATION BANDS								
YL-80	0.95-1.3	1.20/1.15	0.2	23	2	0.1	11	1
YL-82	1.7-2.4	1.25/1.20	0.2	23	2	0.1	8	1
YL-84	3.6-4.3	1.25/1.20	0.3	23	2	0.15	3	1
YL-86	5.7-6.5	1.25/1.20	0.3	22	2	0.15	2	1
YL-88	7.1-7.7	1.30/1.25	0.4	22	3	0.15	2	7
YL-90	8.0-12.4	1.35/1.30	0.5	20	3	0.2	1	6
YL-92	12.0-18.0	1.50/1.40	0.7	18	6	0.3	1	N/A
YL-94	14.0-16.0	1.40/1.35	0.5	20	5	0.2	1	6
TYPE TNC CONNECTORS								
D314T	6-16.5	1.50/1.40	1.0	15	10	0.5	(see DWG)	
D318T	2-10 10-18	1.8 2.2	0.8 1.6	13 13	6 10	0.4 0.5	(see DWG)	

*UNITS WITH TYPE N CONNECTORS: Up to 4.0 GHz multiply VSWR's by 1.05 and subtract 2.0dB from isolation. Above 4 0 GHz multiply VSWR's by 1.10, and subtract 3.0dB from isolation. Add suffix "N" to model no

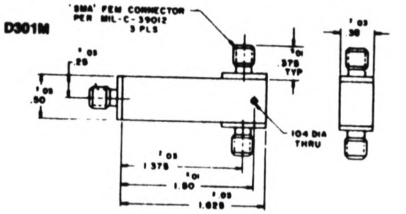
D314T



D318T



D301M



KDI/triangle
ELECTRONICS

31 Farinella Drive • East Hanover, NJ 07936 • Phone: (201) 884-1423
TWX: (710) 986-8202 • FAX: (201) 884-0445

Power Dividers

SPECIFICATIONS

FREQUENCY RANGE GHz	MODEL	VSWR Input (Max)	VSWR Output	INSERTION LOSS (Max)	ISOLATION dB (Min)	AMP BAL dB (Max)	PHASE BAL Degrees (Max)	AVERAGE* POWER Watts A	B	C	WEIGHT Oz	Gr
2-Way Power Dividers												
0.5-1.0	4311-2	1.25	1.15	0.4	22	0.2	2.0	30	20	3	1.1	30
1-2	4312-2	1.25	1.15	0.35	20	0.2	2.0	30	20	3	0.9	23
2-4	4313-2	1.30	1.20	0.4	20	0.2	2.0	30	20	3	0.8	20
4-8	4314-2	1.35	1.25	0.6	20	0.2	2.0	30	20	3	0.8	20
8-12.4	4315-2	1.35	1.30	0.5	20	0.2	3.0	30	10	1	0.8	20
12-18	4316-2	1.40	1.35	0.7	19	0.3	6.0	30	10	1	0.8	20
18-26.5	4317-2	2.00	2.00	1.0	15	0.5	12.0	30	10	1	0.8	22
4-Way Power Dividers												
0.5-1.0	4311B-4	1.45	1.30	0.9	22	0.3	3.0	30	10	1	2.9	80
1-2	4312B-4	1.40	1.25	0.8	20	0.3	3.0	30	10	3	2.0	56
2-4	4313B-4	1.35	1.35	0.6	20	0.3	3.0	30	10	1	2.0	56
4-8	4314B-4	1.45	1.35	0.5	20	0.3	3.0	30	20	3	2.7	75
8-12.4	4315-4	1.45	1.35	0.8	18	0.4	4.0	30	10	1	2.2	60
12-18	4316-4	1.5	1.4	1.5	18	0.5	6.0	30	10	1	2.2	60

*Average Power Rating into a load VSWR of (A) 1.2 to 1, (B) 2 to 1 and (C) ∞VSWR

NOTE: (1) Connectors; All models provide SMA (Female) connectors except model 4317-2 which uses 3.5mm (Female) type

LORAL
Microwave-Narda

narda

6.0 APPENDIX

The Appendix contains:

May 1992 list of VLBA Frequency Converter Bands and LO Frequencies
List of NRAO Technical Reports, memoranda and drawings relevant to the frequency converter modules
List of Converter Commercial Components
VSWR Table
Noise Temperature-Noise Figure Graph and Table

MAY 1992 LIST OF VLBA FREQUENCY CONVERTER BANDS AND LO FREQUENCIES
ALL FREQUENCIES IN GHz

MODULE	BAND (FREQ RANGE) WAVELENGTH	FRONT-END FREQ RANGE	LO FREQ[1] (SYNTH #1)	LO FREQ[1] (SYNTH #2)	LO FREQ[2] (SYNTH #3)
T103	1.5 (1.35 - 1.75)	1.1 - 1.6*		2.1	
	20 cm	1.4 - 1.9*		2.4	
T104	2.3 (2.15 - 2.35)	1.9 - 2.4*		2.9	
	13 cm	2.1 - 2.6*		3.1	
T105	4.8 (4.6 - 5.1)	4.4 - 4.9		3.9	
	6 cm	4.6 - 5.1		4.1	
		4.6 - 5.1*		5.6	
		4.9 - 5.4*		5.9	
T106	8.4 (8.0 - 8.8)	7.9 - 8.4	7.4		
	4 cm	8.1 - 8.6	7.6		
		8.1 - 8.6*	9.1		
		8.4 - 8.9*	9.4		
T107	10.7 (10.2 - 11.2)	10.1 - 10.6	9.6		
	2.8 cm	10.4 - 10.9	9.9		
		10.6 - 11.1*	11.6		
		10.9 - 11.4*	11.9		
T108	15/ (14.4 - 15.4)	11.9 - 12.4	11.4		
	2 cm	12.1 - 12.6	11.6		
		12.4 - 12.9	11.9		
		12.6 - 13.1	12.1		
		12.9 - 13.4	12.4		
		13.1 - 13.6	12.6		
		13.4 - 13.9	12.9		
		13.6 - 14.1	13.1		
		13.9 - 14.4	13.4		
		14.1 - 14.6	13.6		
		14.4 - 14.9	13.9		
		14.6 - 15.1	14.1		
		14.9 - 15.4	14.4		
		11.9 - 12.4*	12.9		
		12.1 - 12.6*	13.1		
		12.4 - 12.9*	13.4		
		12.6 - 13.1*	13.6		
		12.9 - 13.4*	13.9		
		13.1 - 13.6*	14.1		
		13.4 - 13.9*	14.4		
		13.6 - 14.1*	14.6		
		13.9 - 14.1*	14.9		
		14.1 - 14.6*	15.1		
		14.4 - 14.9*	15.4		
		14.6 - 15.1*	15.6		
		14.9 - 15.4*	15.9		
T106	23 (21.7 - 24.1)	21.5 - 22.0	8.9		12.1
	1.3 cm	21.8 - 22.3	8.9		12.4
		22.0 - 22.5	8.9		12.6
		22.3 - 22.8	8.9		12.9
		22.5 - 23.0	8.9		13.1
		22.8 - 23.3	8.9		13.4
		23.0 - 23.5	8.9		13.6
		23.3 - 23.8	8.9		13.9
		23.5 - 24.0	8.9		14.1
		23.8 - 24.3	8.9		14.4
		21.5 - 22.0	9.1		11.9

		21.7 - 22.2	9.1		12.1
		22.0 - 22.5	9.1		12.4
		22.2 - 22.7	9.1		12.6
		22.5 - 23.0	9.1		12.9
		22.7 - 23.2	9.1		13.1
		23.0 - 23.5	9.1		13.4
		23.2 - 23.7	9.1		13.6
		23.5 - 24.0	9.1		13.9
		23.7 - 24.2	9.1		14.1
T110	43 (41.0 - 45.0)	40.6 - 41.1		7.4	10.9
	0.7 mm	41.2 - 41.7		7.4	11.1
		42.1 - 42.6		7.4	11.4
		42.7 - 43.2		7.4	11.6
		43.6 - 44.1		7.4	11.9
		44.2 - 44.7		7.4	12.1
		40.8 - 41.3		7.6	10.9
		41.4 - 41.9		7.6	11.1
		42.3 - 42.8		7.6	11.4
		42.9 - 43.4		7.6	11.6
		43.8 - 44.3		7.6	11.9
		44.4 - 44.9		7.6	12.1
		41.1 - 41.6		7.9	10.9
		41.7 - 42.2		7.9	11.1
		42.6 - 43.1		7.9	11.4
		43.2 - 43.7		7.9	11.6
		44.1 - 44.6		7.9	11.9
		44.7 - 45.2		7.9	12.1
		41.3 - 41.8		8.1	10.9
		41.9 - 42.4		8.1	11.1
		42.8 - 43.3		8.1	11.4
		43.4 - 43.9		8.1	11.6
		44.3 - 44.8		8.1	11.9
		44.9 - 45.4		8.1	12.1

Notes:

* Indicates that the IF spectrum is reversed.
1 Synthesizers 1 and 2 are used as LO sources for the Frequency Converters.
2 Synthesizer 3 provides the first LO for the 23 and 43 GHz Front-Ends, see the T106 and T110 descriptions.

For the 23 GHz band, the first IF is 9.4 - 10.1 GHz, T106 converts this to the Standard IF band.
For the 43 GHz band, the first IF is 7.9 - 8.9 GHz, T110 converts this to the Standard IF band.

List of NRAO Technical Reports, memoranda and drawings relevant to the frequency converter modules

VLBA Technical Report No. 15 (Rev A), AN INTRODUCTION TO THE VLBA RECEIVING AND RECORDING SYSTEM by A. R. Thompson, March 10, 1993

Technical Manual draft for CONVERTER MODULES, by Erich Schlect, undated.

VLBA Technical Report No. 5 (Rev. June 1990) LIST OF CURRENT MONITOR AND CONTROL POINTS (JUNE 15, 1990) by D. S. Bagri

VLBA Technical Report No. 2 MODEL F103, 1.5 GHz CRYOGENIC FRONT-END R. Norrod, September 1986

VLBA Technical Report No. 10 MODEL F104, 2.3 GHz CRYOGENIC FRONT-END R. Norrod, M. Masterman June 3, 1991

VLBA Technical Report No. 3 MODEL F105, 4.8 GHz CRYOGENIC FRONT-END R. Norrod, December 1986

VLBA Technical Report No. 11 MODEL F110, 43 GHz CRYOGENIC FRONT-END R. Norrod, M. Masterman March, 1992

D58001K001, Electronic System Block Diagram (Antenna Electronics), Rev E

VLBA Electronics Memo No. 30, I.F. SIGNAL PROCESSING: PRELIMINARY SPECIFICATIONS by Larry R. D'Addario, 15 November 1984

VLBA Electronics Memo No. 39, DYNAMIC RANGE AND INTERFERENCE THRESHOLDS IN THE FRONT-END AND IF UNITS by A. R. Thompson and E. Schlecht, March 1, 1985

VLBA Electronics Memo No. 62, Notes on Gain Distribution in the VLBA Front-End and Converter Systems, by Erich Schlecht, February 14, 1986

List of Converter Commercial Components

DATA SHEET ITEMS FROM T101 - T110, 610 FLTR, AMP/ATN & AMP/DIV PARTS LISTS

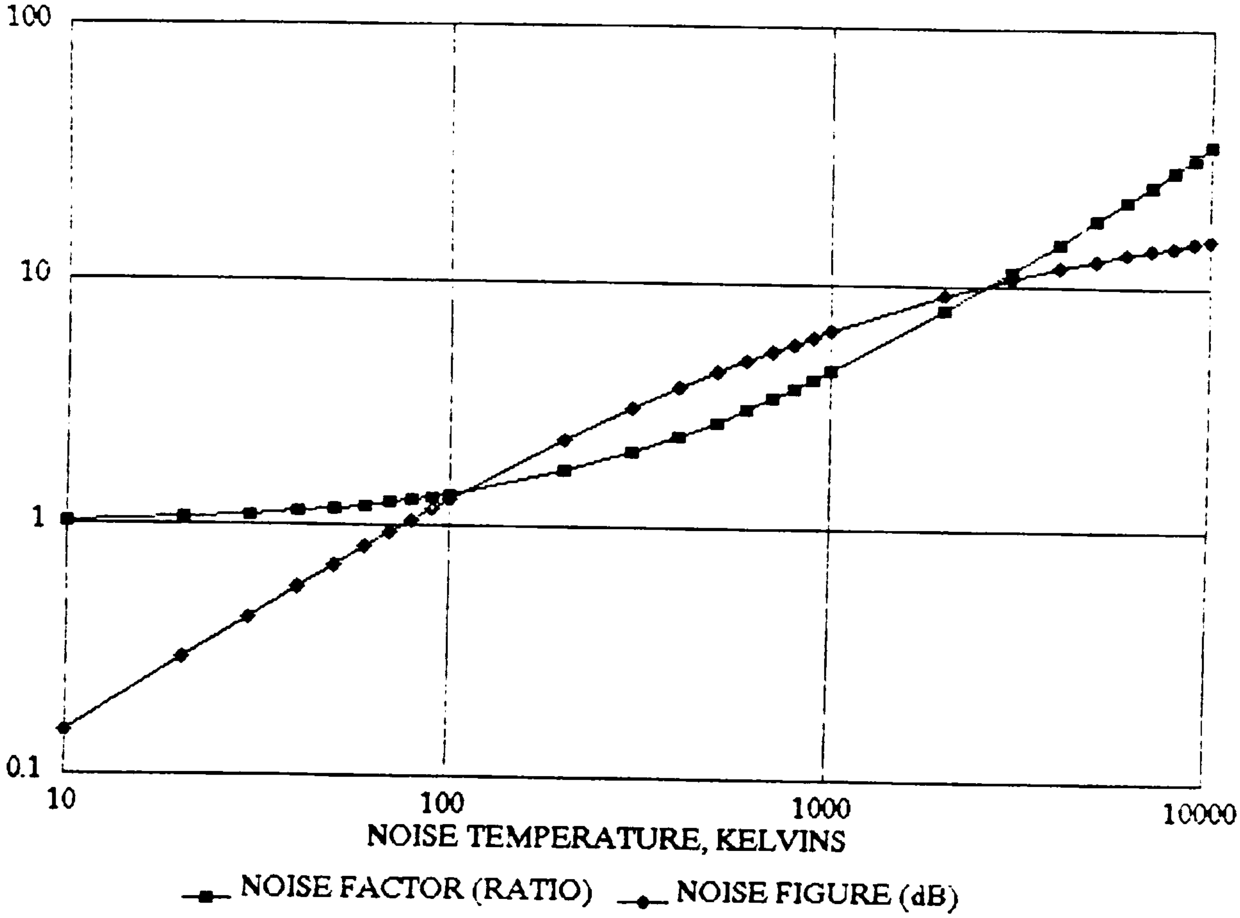
Company	Used In:	Part No.	Component Function
ANZAC	610 FLTR	DS-313	POWER DIVIDER
"	AMP/DIV	"	"
AVANTEK	T107	DBX-158M-1	MIXER
"	T105	DBX-72M	:
AVANTEK	610 FLTR	UTO-1012	AMPLIFIER
"	610 FLTR	GPD-1003	"
"	610 FLTR	UTO-509	"
"	LO AMP/DET	UTO-2013	"
"	LO AMP/DET	UTO-2321	"
"	T107	AFT-12633-1	"
AVANTEK	AMP/ATN	TC-4	CASE
COMPAC	AMP/DIV	R-51120-075-1	CASE
CUSTOM COMP'NT	LO AMP/DET	CCI15BD-4EQ (BD-4)	BACK DIODE DET
DITOM	T103	DF1170	ISOLATOR
"	T104	D3I-2040-2	"
"	T105	D3I-4080-2	"
"	T106	D3I-7011-2	"
"	T108	D3I-8016-2	"
"	T110	D3I-7011-2	"
INNOWAVE	T108	1145IS-1015	ISOLATOR
KDI/ENGLEMAN	T103	D307M	POWER DIVIDER
"	T104	D307M	"
"	T105	D310M	"
K&L	T102	4B120-611/30-0/0	FILTER
"	T101	3B120-827/50-0P/0	"
"	T101	6B120-327/X30-0/0	"
"	T103	6B120-750/X550-0/0P	"
"	T104	3B250-3000/600-0/0P	"
"	T104	6B120-750/X550-0/0P	"
"	T105	3B250-4100/1300-0P/0	"
"	T105	6B120-750/X550-0/0P	"
"	T106	2FV-8400/2500-0/0P	"
"	T106	6B120-750/X550-0/0P	"
"	T106	6FV-8400/X960-0/0P	"
"	T107	6FV-10700/X1200-0/0	"
"	T107	6B120-750/550-0/0P	"
"	T108	6B120-750/X550-0/0P	"
"	T108	6ED10-13500/U5000-0P	"
"	T108	6FV10-15205/R863-0P	"
"	T108	9FV10-12405/R1157-0P	"
"	T108	9FV10-13405/R1160-0P	"
"	T108	9FV10-14405/R1162-0P	"
"	T110	2FV-8400/2500-0/0P	"
"	T110	6B120-750/X550-0/0P	"
"	610 FLTR	3B120-111/5.5-P/P	"
"	610 FLTR	5B120-111/5.5-P/P	"
"	610 FLTR	8B51-11/4-P/P	"
MERRIMAC	T102	PDM-20-500	POWER DIVIDER
MINI-CIRCUITS	610 FLTR	MCL-TFM-4H	MIXER

MITEQ	T104	AMF-2B-2830-18P	AMPLIFIER
"	T105	AMF-2B-4156	"
"	T106	AMF-2B-7494-15P	"
"	T110	AMF-2B-7494-15P	"
NARDA	T101	4772-2	ATTENUATOR
"	T103	"	"
"	T104	"	"
"	T102	4772-3	"
"	T104	"	"
"	T102	4773-5	"
"	T105	"	"
"	T102	4778-16	"
"	T106	"	"
"	T106	4778-12	"
"	T110	"	"
"	T106	4778-3	"
"	T107	4778-9	"
NARDA	T107	4315-2	POWER DIVIDER
OMNI-SPECTRA	T104	4503-7491-00	.141 MALE OSP CONN
"	T103	"	"
"	T102	"	"
"	T101	"	"
"	T105	"	"
"	T106	"	"
"	T110	"	"
"	T101	2084-0000-00	FEED-THRU SMA
"	T102	"	"
"	T104	"	"
"	T105	"	"
"	T106	"	"
"	T101	2993-6005	PLUG-PLUG ELBOW
"	T102	2081-0000-00	PLUG-PLUG SMA ADAPT
"	T106	2081-0000-00	"
"	T106	2002-5015-00	SMA FEMALE
"	T108	"	"
"	T110	"	"
"	T106	2007-5054-00	PLUG-PLUG RT ANGLE
"	T108	4503-7985-00	OSP PLUGS
"	T108	2007-5055-02	SMA CONNECTORS
"	610 FLTR	2052-1201-00	SMA MOUNT JACK
"	610 FLTR	2062-0000-00	SMA PC BOARD CONN
"	610 FLTR	2084-0000-00	SMA JACK-JACK
OMNI-SPECTRA	T108	2090-6210-00	POWER DIVIDER
PRECISION TUBE	T101	AA50141	.141 SEMI-RIGID
"	T104	"	"
"	T105	"	"
"	T106	"	"
"	T107	"	"
"	T110	"	"
PRECISION TUBE	T107	AA50085	.085 SEMI-RIGID
"	T108	"	"
"	610 FLTR	"	"
Q-Bit	610 FLTR	QBH-160	"
RLC	T108	SR-TC-R-D	TRANSFER SWITCH
	T103	"	"
SMT	T108	S90-1172	AMPLIFIER
	T108	S91-1279	"

SOLITRON	T102	8018-6005	50 OHM TERMINATION
"	T101	"	"
"	T103	"	"
"	T104	"	"
"	T105	"	"
"	T106	"	"
"	T108	"	"
"	T110	"	"
"	T110	2902-6001	.141 CABLE PLUG, OMNISPECTRA ?
"	T101	"	"
"	T104	2993-6005	PLUG-PLUG SMA ELBOW
"	T103	"	"
"	T105	"	"
"	T103	"	"
"	T104	"	"
"	T105	"	"
"	T106	"	"
"	T101	2993-6001	PLUG-PLUG SMA ADAPT
"	T110	"	"
"	T107	"	"
"	T108	"	"
"	T107	2906-6002	.086 CABLE PLUG
"	T108	"	"
"	T110	2912-6001	SMA RIGHT ANGLE PLUG
"	AMP/DIV	2950-6200	SMA CONNECTOR
SVSNTEK	T105	DBX-72M-1	MIXER (see Avantek DBX-72M)
TRANSCO	T102	909C70100	SPDT SWITCH
"	T106	"	"
"	T110	"	"
TRANSCO	T108	146C70600	4PST SWITCH
TRANSCO	T101	710C70100	TRANSFER SWITCH
"	T104	"	"
"	T105	"	"
"	T106	"	"
"	T107	"	"
"	T110	"	"
"			
TRIANGLE	T106	YL-56	POWER DIVIDER
"	T110	"	"
VARI-L	T104	DBM1150H	MIXER
VIRTECH	T107	V31-8012-2	ISOLATOR
"	T107	V31-8012-3	"
WATKINS-JOHNSON	T103	M2TC	MIXER
"	T106	M77C	"
"	T110	"	"
"	T108	8M0C	"
WATKINS-JOHNSON	610 FLTR	A18-1	AMPLIFIER
"	AMP/ATN	"	"
"	610 FLTR	A19	"
"	AMP/ATN	"	"
"	AMP/DIV	"	"
WATKINS-JOHNSON	AMP/ATN	G1	ATTN/LEVEL DET

THE EFFECT OF VSWR ON TRANSMITTED POWER

VSWR	VSWR (dB)	RETURN LOSS (dB)	TRANS. LOSS (dB)	VOLT. REFL. COEFF.	POWER TRANS. (%)	POWER REFL. (%)
1.00	.0	∞	.000	.00	100.0	.0
1.01	.1	46.1	.000	.00	100.0	.0
1.02	.2	40.1	.000	.01	100.0	.0
1.03	.3	36.6	.001	.01	100.0	.0
1.04	.3	34.2	.002	.02	100.0	.0
1.05	.4	32.3	.003	.02	99.9	.1
1.06	.5	30.7	.004	.03	99.9	.1
1.07	.6	29.4	.005	.03	99.9	.1
1.08	.7	28.3	.006	.04	99.9	.1
1.09	.7	27.3	.008	.04	99.8	.2
1.10	.8	26.4	.010	.05	99.8	.2
1.11	.9	25.7	.012	.05	99.7	.3
1.12	1.0	24.9	.014	.06	99.7	.3
1.13	1.1	24.3	.016	.06	99.6	.4
1.14	1.1	23.7	.019	.07	99.6	.4
1.15	1.2	23.1	.021	.07	99.5	.5
1.16	1.3	22.6	.024	.07	99.5	.5
1.17	1.4	22.1	.027	.08	99.4	6
1.18	1.4	21.7	.030	.08	99.3	.7
1.19	1.5	21.2	.033	.09	99.2	.8
1.20	1.6	20.8	.036	.09	99.2	.8
1.21	1.7	20.4	.039	.10	99.1	.9
1.22	1.7	20.1	.043	.10	99.0	1.0
1.23	1.8	19.7	.046	.10	98.9	1.1
1.24	1.9	19.4	.050	.11	98.9	1.1
1.25	1.9	19.1	.054	.11	98.8	1.2
1.26	2.0	18.8	.058	.12	98.7	1.3
1.27	2.1	18.5	.062	.12	98.6	1.4
1.28	2.1	18.2	.066	.12	98.5	1.5
1.29	2.2	17.9	.070	.13	98.4	1.6
1.30	2.3	17.7	.075	.13	98.3	1.7
1.32	2.4	17.2	.083	.14	98.1	1.9
1.34	2.5	16.8	.093	.15	97.9	2.1
1.36	2.7	16.3	.102	.15	97.7	2.3
1.38	2.8	15.9	.112	.16	97.5	2.5
1.40	2.9	15.6	.122	.17	97.2	2.8
1.42	3.0	15.2	.133	.17	97.0	3.0
1.44	3.2	14.9	.144	.18	96.7	3.3
1.46	3.3	14.6	.155	.19	96.5	3.5
1.48	3.4	14.3	.166	.19	96.3	3.7
1.50	3.5	14.0	.177	.20	96.0	4.0
1.52	3.6	13.7	.189	.21	95.7	4.3
1.54	3.8	13.4	.201	.21	95.5	4.5
1.56	3.9	13.2	.213	.22	95.2	4.8
1.58	4.0	13.0	.225	.22	94.9	5.1
1.60	4.1	12.7	.238	.23	94.7	5.3
1.62	4.2	12.5	.250	.24	94.4	5.6
1.64	4.3	12.3	.263	.24	94.1	5.9
1.66	4.4	12.1	.276	.25	93.8	6.2
1.68	4.5	11.9	.289	.25	93.6	6.4
1.70	4.6	11.7	.302	.26	93.3	6.7
1.72	4.7	11.5	.315	.26	93.0	7.0
1.74	4.8	11.4	.329	.27	92.7	7.3
1.76	4.9	11.2	.342	.28	92.4	7.6
1.78	5.0	11.0	.356	.28	92.1	7.9
1.80	5.1	10.9	.370	.29	91.8	8.2
1.82	5.2	10.7	.384	.29	91.5	8.5
1.84	5.3	10.6	.398	.30	91.3	8.7
1.86	5.4	10.4	.412	.30	91.0	9.0
1.88	5.5	10.3	.426	.31	90.7	9.3
1.90	5.6	10.2	.440	.31	90.4	9.6
1.92	5.7	10.0	.454	.32	90.1	9.9
1.94	5.8	9.9	.468	.32	89.8	10.2
1.96	5.8	9.8	.483	.32	89.5	10.5
1.98	5.9	9.7	.497	.33	89.2	10.8
2.00	6.0	9.5	.512	.33	88.9	11.1
2.50	8.0	7.4	.881	.43	81.6	18.4
3.00	9.5	6.0	1.249	.50	75.0	25.0
3.50	10.9	5.1	1.603	.56	69.1	30.9
4.00	12.0	4.4	1.938	.60	64.0	36.0
4.50	13.1	3.9	2.255	.64	59.5	40.5
5.00	14.0	3.5	2.553	.67	55.6	44.4
5.50	14.8	3.2	2.834	.69	52.1	47.9
6.00	15.6	2.9	3.100	.71	49.0	51.0
6.50	16.3	2.7	3.351	.73	46.2	53.8
7.00	16.9	2.5	3.590	.75	43.7	56.2
7.50	17.5	2.3	3.817	.76	41.5	58.5
8.00	18.1	2.2	4.033	.78	39.5	60.5
8.50	18.6	2.1	4.240	.79	37.7	62.3
9.00	19.1	1.9	4.437	.80	36.0	64.0
9.50	19.6	1.8	4.626	.81	34.5	65.5
10.00	20.0	1.7	4.807	.82	33.1	66.9
11.00	20.8	1.6	5.149	.83	30.6	69.4
12.00	21.6	1.5	5.466	.85	28.4	71.6
13.00	22.3	1.3	5.762	.86	26.5	73.5
14.00	22.9	1.2	6.040	.87	24.9	75.1
15.00	23.5	1.2	6.301	.88	23.4	76.6
16.00	24.1	1.1	6.547	.88	22.1	77.9
17.00	24.6	1.0	6.780	.89	21.0	79.0
18.00	25.1	1.0	7.002	.89	19.9	80.1
19.00	25.6	.9	7.212	.90	19.0	81.0
20.00	26.0	.9	7.413	.90	18.1	81.9
25.00	28.0	.7	8.299	.92	14.8	85.2
30.00	29.5	.6	9.035	.94	12.5	87.5



Noise Temp. (Kelvins)	Noise Fig. (Ratio)	Noise Fig. (dB)
0	1.00	0.00
10	1.03	0.15
20	1.07	0.29
30	1.10	0.43
40	1.14	0.56
50	1.17	0.69
60	1.21	0.82
70	1.24	0.94
80	1.28	1.06
90	1.31	1.17
100	1.34	1.29
200	1.69	2.28
300	2.03	3.08
400	2.38	3.76
500	2.72	4.35
600	3.07	4.87
700	3.41	5.33
800	3.76	5.75
900	4.10	6.13
1000	4.45	6.48
2000	7.90	8.97
3000	11.34	10.55
4000	14.79	11.70
5000	18.24	12.61
6000	21.69	13.36
7000	25.14	14.00
8000	28.59	14.56
9000	32.03	15.06
10000	35.48	15.50