VLA Technical Report No. 34

L.O. TRANSMITTER (L3C)

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March 1978

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2.0 FUNCTION

The Antenna Local Oscillator Transmitter (L3) Module produces the required local oscillator signals which are returned from the antenna Vertex Room to the Central Electronics Room. 1200 and 1800 MHz signals from the 50 MHz Harmonic Generator (L2C) Module are filtered using phase-lock loops. The 1200 MHz is amplitude modulated with the 5 MHz signal from the 5 to 50 MHz VCXO (L1) Module and the 1800 MHz is amplitude modulated with monitor data from the Antenna Buffer (M4). These modulated signals are combined and go to the IF Combiner (T2).

The unmodulated 1200 and 1800 MHz are combined to produce 600 MHz and 3000 MHz. A part of the 600 MHz signal goes to the Antenna L.O. Receiver (L4). There it is phase compared with the 600 MHz produced using 1200 and 1800 MHz received from the Central Electronics Room. The error signal is amplified in L5 module and is used to phase-lock the 5 MHz VCXO in L1. The 1200 MHz is also given to a doubler to produce 2400 MHz. The signals at 600 MHz and 2400 MHz are used as reference signals for the 17 to 20 GHz L.O. unit (F3) and the Modem (T1) respectively. The 3000 MHz is used as reference by Upconverter Pump (F2) and 2-4 GHz Synthesizers (L6's). Also 2400 MHz forms an alternate reference for the L6's.

The module is RFI shielded to minimize radiation of L-Band signals in Vertex Room. The radiated signals eventually may enter the L-Band feed or front-end and degrade the L-Band observations. During prototype testing it was realized that RFI shielding of the module is a must to keep the system generated interference in L-Band down to acceptable level. During the L-Band testing variable leakage from the OMQ connectors was observed. It was found necessary to put SMA connectors on the lines bringing 1800 and 1200 MHz signals from L2C to L3J1 and L3J2. Therefore it was decided that these two jacks should have SMA connectors on 0·141" semi-rigid cable about 2" long projecting from the back panel of the module. This makes it necessary

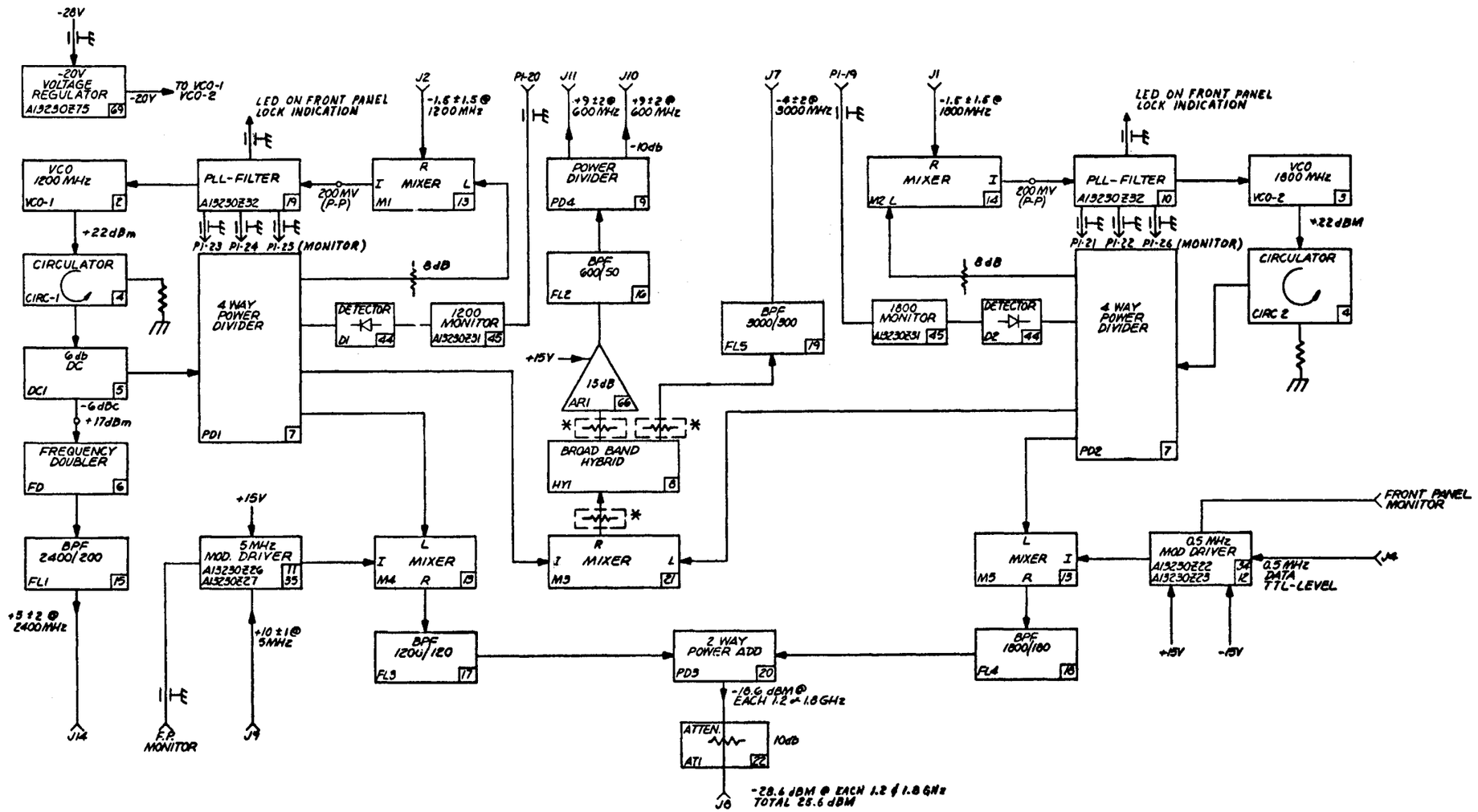
that before the module is pulled out of the rack, these two connectors are unscrewed. To protect from accidental pulling the module back panel should be screwed to bin plate using a fastener.

3.0 THEORY OF OPERATION

A block diagram of the Antenna L.O. Transmitter series C (L3C) with input and output connections and power levels is given in Figure 1.

About +22 dBm output signals at 1800 and 1200 MHz from voltage controlled oscillators VCO-2 and VCO-1 are given to 4-way power dividers PD2 and PD1 through a circulator CIRC-2 in case of 1800 MHz and through a circulator CIRC-1 and a 6 dB directional coupler DC-1 in case of 1200 MHz. The need for the isolators is discussed under phase-lock loop operation. The coupled output at 1200 MHz from the 6 dB directional coupler goes to a frequency doubler and a 2400/200 MHz band-pass filter. This provides an output of +5 dBm at 2400 MHz at J14.

One output from each of the two 4-way power dividers is detected and filtered, and is used for monitoring 1200 and 1800 MHz oscillator outputs (see Figure 7). The second set of outputs from the two power dividers PD-1 and PD-2 are used to phase-lock the two voltage controlled oscillators at 1200 and 1800 MHz by phase comparing them in mixers M1 and M2 respectively with the 1200 and 1800 MHz signals from the 50 MHz Harmonic Generator (L2C) Module coming in at J2 and J1. 8 dB attenuators are put in the path of the signals from the power dividers PD1 and PD2 before they are given to L-ports of the mixers M1 and M2. This is done to provide optimum L-port drive for phase detector application. The phase error signals from M1 and M2 are given to the AFC ports of the oscillators through phase-lock loop filters to phase-lock the oscillators to incoming 1200 and 1800 MHz reference signals. The third set of outputs from the power dividers PD-1 and PD-2 are mixed in a mixer M3 (Anzac type MD-525-4). The 1200 MHz is given to I-port and 1800 MHz to L-port of the mixer to give output at 600 and 3000 MHz. The mixer output at R-port is given to a broadband 3 dB hybrid. One output of the hybrid goes through a 3000/300 MHz band-pass filter to provide a -4 dBm 3 GHz output at J7. The other output of the hybrid goes to a 15 dB gain



NOTES: (ALL FOR REF INFORMATION ONLY)
1. J1, J2, J7, J8, J9, J10, J11 & J14 ARE ON REAR PANEL.
2. P1- POWER CONN (AMP 42 PIN)
3. AT1 13 — ITEM NUMBERS PER BOM A13230E65. — REF DESIG PER IEEE NO. 315 & NRAO SPEC.
4. ALL MONITOR/CONTROL AND POWER SUPPLY CONNECTIONS GO THRU FILTER FEED THRUS MOUNTED ON THE SHIELD OF AMP CONNECTOR P1.

* OPTIONAL (3dB)- TO ADJUST OUTPUT LEVELS.

FIGURE 1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES: ANGLES ±; 3 PLACE DECIMALS (.XXX): ±; 2 PLACE DECIMALS (.XX): ±; 1 PLACE DECIMALS (.X): ±.	VLA	L3 L.O. TRANSMITTER	NATIONAL RADIO ASTRONOMY OBSERVATORY CHARLOTTESVILLE, VA. 22901	
MATERIAL:	TITLE	BLOCK DIAGRAM	DRAWN BY	DATE 12-7-77
FINISH:			DESIGNED BY	DATE
NEXT ASSY / USED ON			APPROVED BY	DATE 3-10-78
		SHEET NUMBER	DRAWING NUMBER D13230B22	REV. / SCALE

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	7/21/76			ADDED NOTE 2 & OUTPUT OF C1

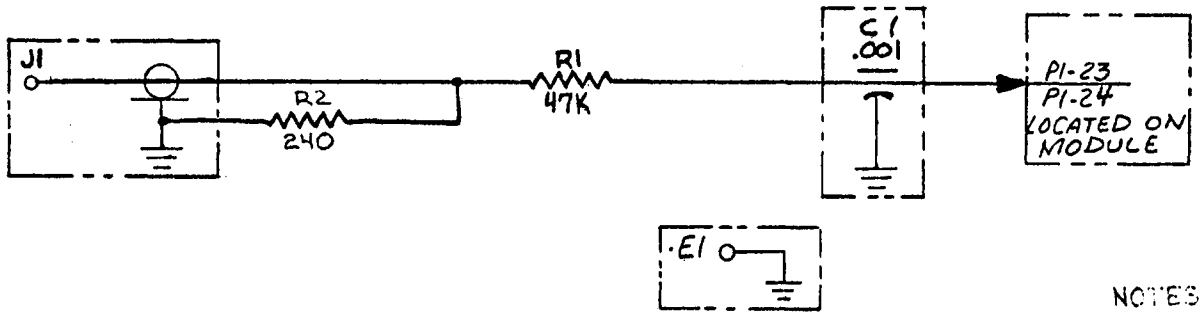


FIGURE 7

NOTES:
1. UNLESS OTHERWISE SPECIFIED
   A. ALL RESISTOR VALUES ARE IN OHMS
   B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. BRACKETED COMPONENTS ARE LOCATED ON C13230P39

LAST COMPONENT DESIG. USED								
R	C	E						
2	1	1						

COMP. DESIG. NOT USED								

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

MATERIAL:

FINISH:

NEXT ASSY	USED ON
A13230231	A13230233

VLA PROJECT: L3/L14 CENTRAL LO FILTER

TITLE: MONITOR FILTER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY	DATE
DESIGNED BY	DATE
APPROVED B	DATE 9/24/75

SHEET NUMBER | DRAWING NUMBER B13230512 | REV. A | SCALE

BRUNING 40-22 24984

amplifier at 600 MHz, a 600/50 MHz band-pass filter and a two-way power divider PD-4. A loaded helical cavity resonator BPF instead of standard ½" coaxial tubular filters has been used to get good phase stability with temperature variation ($<0.1^{\circ}/^{\circ}C$). The bandwidth of the filter is 50 MHz so that the 100 and 200 MHz sidebands on the 600 MHz are low ($\lesssim$-100 dBc). The sidebands are generated due to sidebands on the 1200 and the 1800 MHz reference signals at J2 and J1, finite isolations between R- and L-ports of the mixers M1 and M2 and output ports of the 4-way power dividers PD-1 and PD-2. This has been done to avoid problems of false locking and phase stability in 17-20 GHz L.O. modules. One output of the 2-way power divider PD-4 provides a +9 dBm at 600 MHz at J11 and is used as reference for 17-20 GHz L.O. module. The second output from PD-4 is connected to J10 and is required for the Antenna L.O. Receiver (L4). It may be required to put a 3 dB pad at one of the three positions (shown 3 dB optional) to adjust 600 and 3000 MHz output levels to specified range. The fourth set of outputs from the two 4-way power dividers PD-1 and PD-2 are amplitude modulated. The 1200 MHz from PD-1 is modulated in mixer M4 by a 5 MHz signal from the 5 to 50 MHz VCXO module and the 1800 MHz from PD-2 is modulated in mixer M5 by 500 kHz data from the Antenna Buffer. The outputs of the two modulators M4 and M5 are passed through 10% bandwidth BPFs at 1200 and 1800 MHz before they are combined using a two-way power combiner PD-3. The output from the power combiner goes through a 10 dB attenuator to J8.

3.1 1200 and 1800 MHz Modulators

About +15 dBm power at 1200 MHz is given to the L-port of the double balanced mixer M4. The 5 MHz modulation along with a DC bias from the 5 MHz modulator driver are applied at the I-port of the mixer. A variation of the I-port current produces the required 5 MHz amplitude modulation. For power level of

+7 dBm or more at L-port and insertion loss from L- to R-port of at least 25 dB the phase variation due to modulation is $<0.1^{\circ}$ for the modulation sidebands of -10 dBc with respect to the carrier. The DC level at the I-port of the mixer is set for the output at R-port of about -14 dBm. For this value of DC at the I-port and ±5 MHz sideband level of -10 dBc the second and higher order harmonic sidebands of 5 MHz should be at least 30 dB below the ±5 MHz sidebands. The 1800 MHz signal is processed in another modulator in similar fashion except that the 500 kHz sidebands are 15 dB below the 1800 MHz carrier.

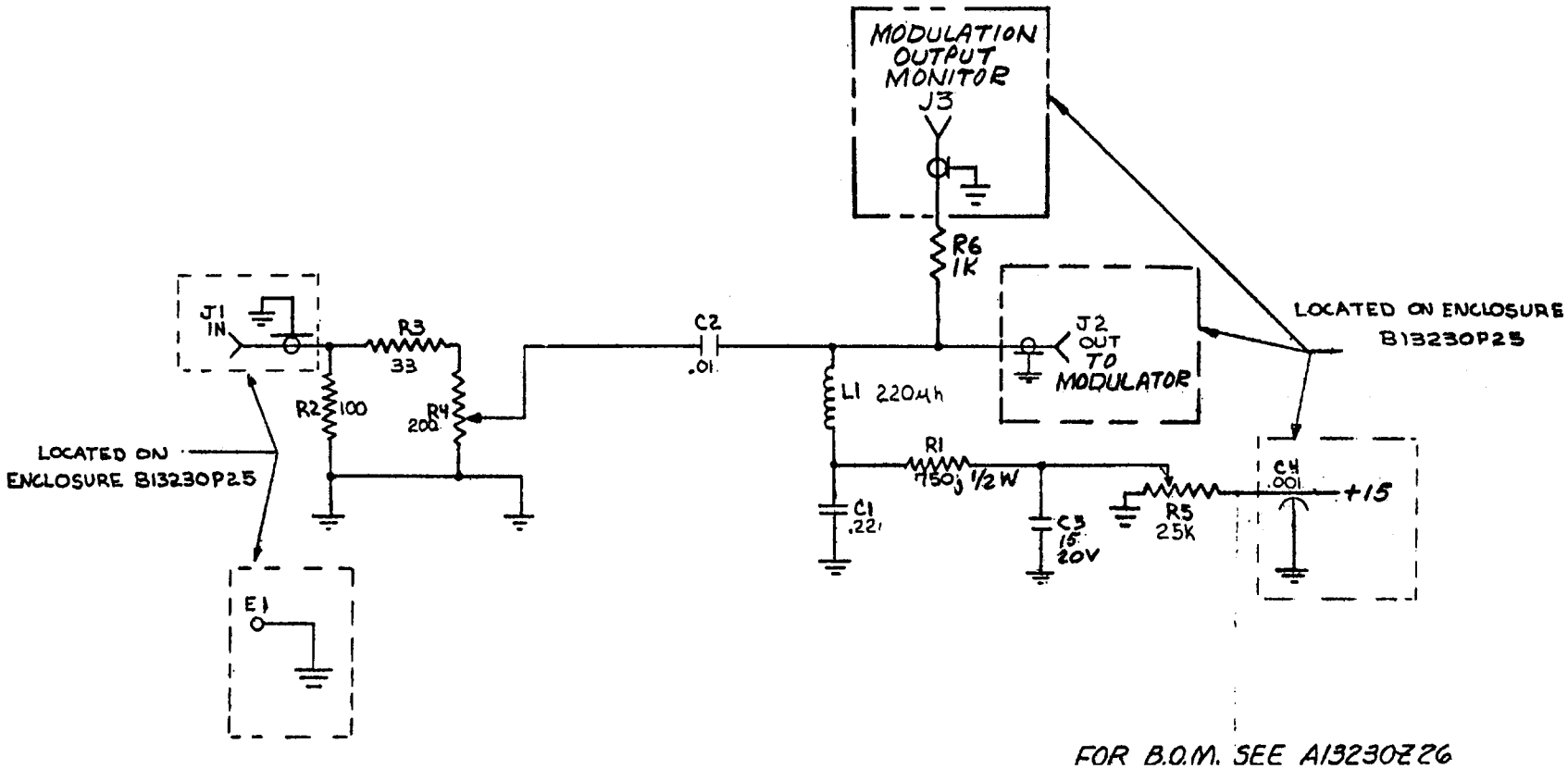
4.0 CIRCUIT DESCRIPTION

4.1 5 MHz Modulator Driver - Reference Schematic B13230S9 (Figure 2)

The 5 MHz Modulator Driver receives 5 MHz signal coming from L1 module. It provides the 5 MHz signal along with DC bias to I-port of the 1200 MHz modulator. In the unit, R5 is used to adjust the DC bias which controls the carrier level in the modulator. A +10 dBm 5 MHz signal is applied to the modulator through a π attenuator and C2. Level of the 5 MHz to the modulator is adjusted by varying R4. The 1200 MHz carrier and the 5 MHz sideband levels are set by observing output at J8. The modulation signal can be monitored on "5 MHz MOD" front panel BNC jack.

4.2 Data Modulator Driver - Reference Schematic C13230S7 (Figure 3)

The Data Modulator Driver is given the 500 kHz TTL level signal received from the Antenna Buffer module. It provides the 500 kHz signal along with DC bias to the I-port of the 1800 MHz modulator. The TTL sink input is coupled by C14 to a limiter circuit R3, CR1 and CR2. The output is set by R4 and applied to a non-inverting amplifier U1 having a gain of 3. The output of U1 is coupled via C6 and summed with adjustable bias from R7 and R8. The sum is passed through a filter consisting of C7, L1, C8, L2 and C9 which has a low pass cut-off at about 3 MHz. The filter source impedance is established by R9 (240 Ω) and load impedance by R10, R11 and U2. The filter drives a unity gain amplifier U2 to provide low impedance drive through R15 and a 10 MHz low pass filter. The level of the 1800 MHz carrier is adjusted by varying R7 and modulation sidebands by R4 and can be set by observing the output at J8. The modulation signal can be monitored on "DATA MOD" front panel BNC jack.



FOR B.O.M. SEE A13230Z26

NOTES:
1. UNLESS OTHERWISE SPECIFIED
A. ALL RESISTOR VALUES ARE IN OHMS, 1/4 WATT
B. ALL CAPACITOR VALUES ARE IN MICROFARADS

LAST COMPONENT DESIG. USED								
R	C	L						
6	4	1						

COMP. DESIG. NOT USED								

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

VLA PROJECT: L3 LO TRANSMITTER

TITLE: 5 MHz MODULATOR DRIVER SCHEMATIC

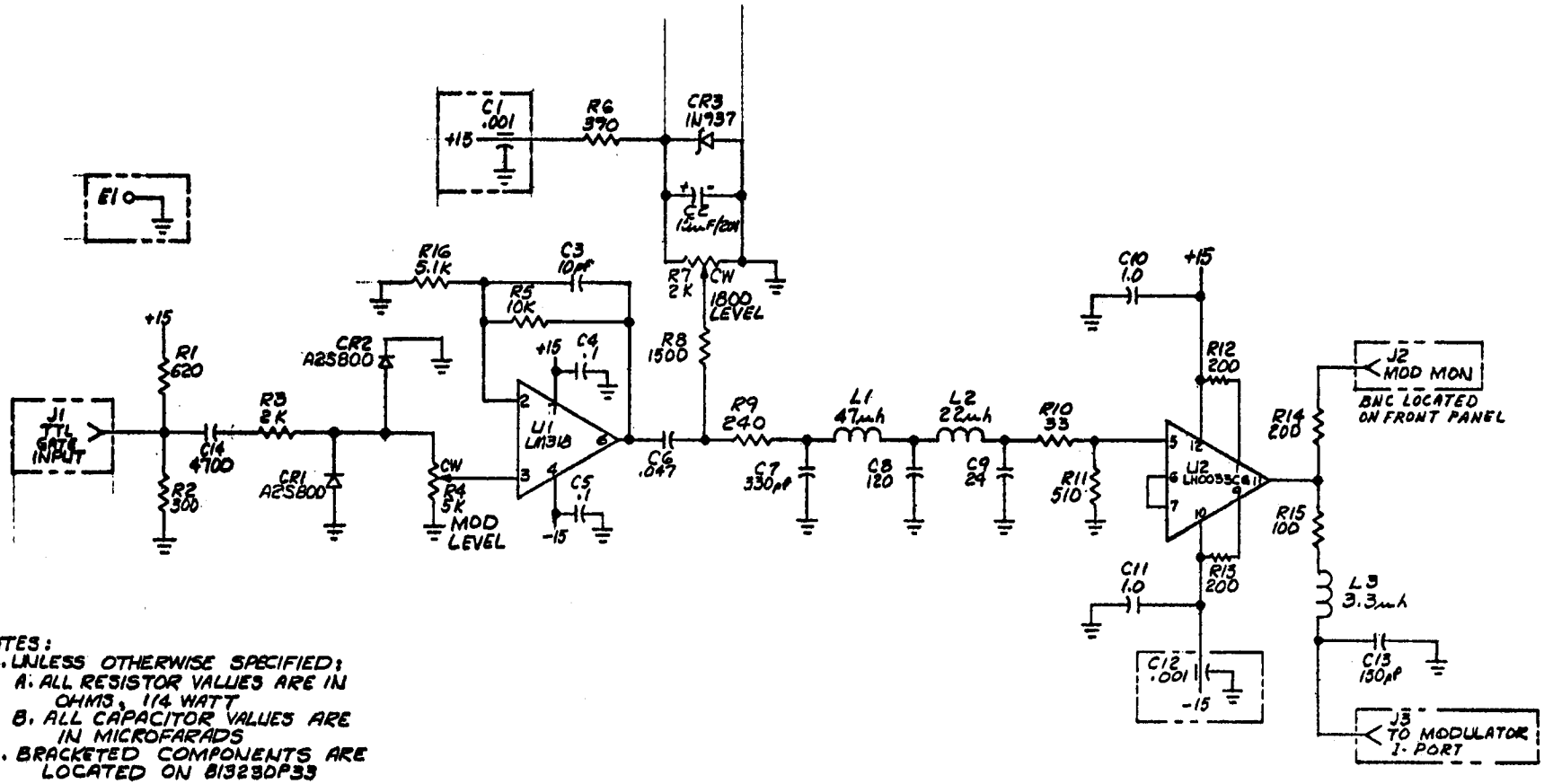
NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY — DATE 10-14-74
DATE 6-17-75
APPROVED BY — DATE 9/24/75

SHEET NUMBER — DRAWING NUMBER B13230S9 — REV. — SCALE —

FIGURE 2

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	1-10-78	T. GLASS	[illegible]	CR1 & CR2: "A25800" WAS "HP2800"



NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   A. ALL RESISTOR VALUES ARE IN OHMS, 1/4 WATT
   B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. BRACKETED COMPONENTS ARE LOCATED ON 813230P33

LAST COMPONENT DESIG USED						
C	CR	J	L	R	U	
14	3	3	3	16	2	

NEXT ASSY	813230223
USED ON	

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

MATERIAL:

FINISH:

VLA PROJECT: L3 LO TRANSMITTER / L10 CENTRAL LO TRANSMITTER

TITLE: DATA MODULATOR DRIVER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY: DATE 6/14/78
DESIGNED BY: DATE 6/14/78
APPROVED BY: DATE

SHEET NUMBER | DRAWING NUMBER C1323057 | REV A | SCALE

FIGURE 3

4.3.1 Phase-lock loop operation

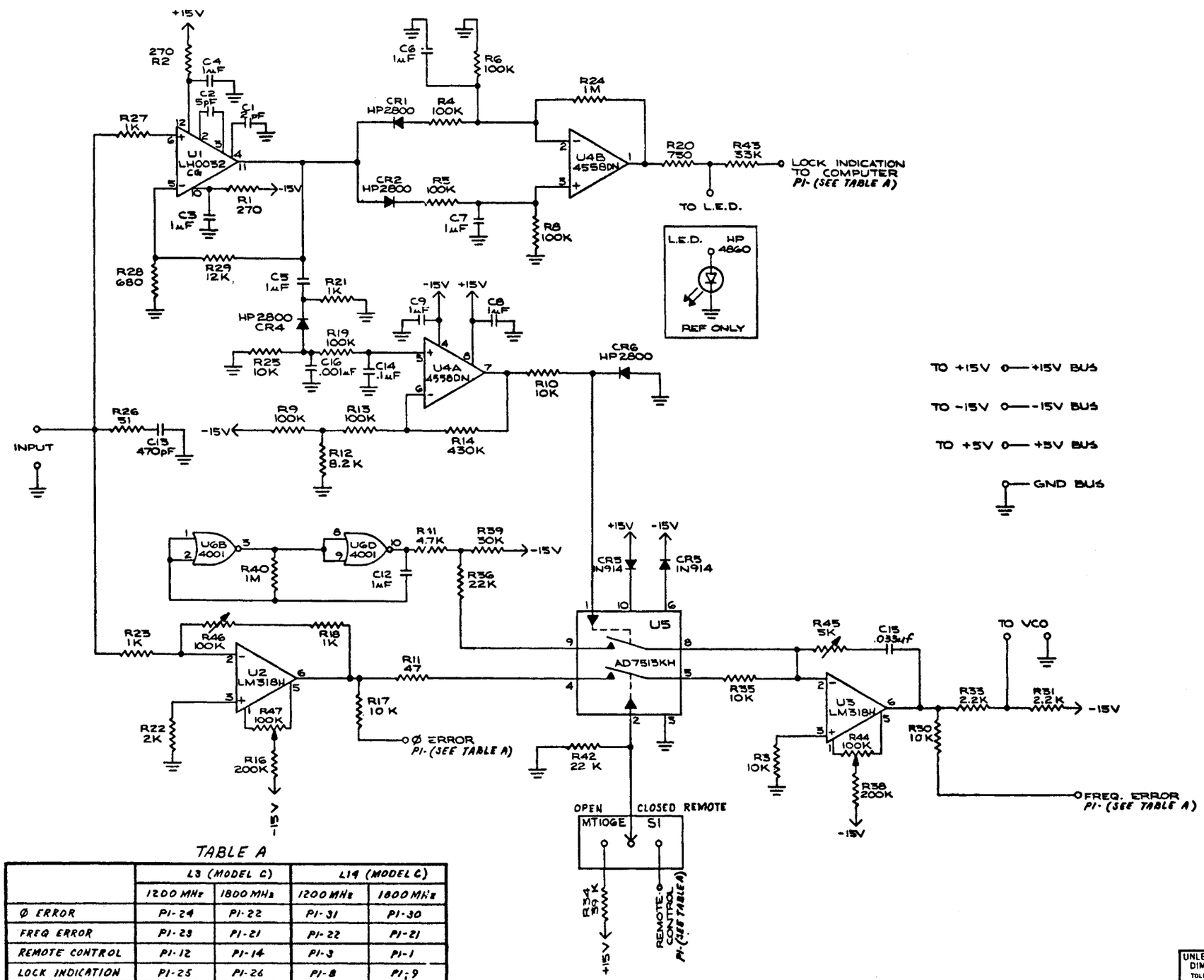
The basic purpose of the phase-lock loops at 1200 and 1800 MHz is to provide filtering to eliminate the harmonics of 50 MHz as sidebands on these signals.

In a DC IF loop (when the VCO and reference are compared without offset) it is possible for direct injection of the reference into the VCO cavity and cause injection locking. The lock range by injection decreases with reducing injection level and approaches zero at the oscillator noise level. In present case the injection locked phase of the oscillator could be in quadrature to the active lock phase since the ring modulators used as phase detectors are quadrature devices. A possible model is to consider the net phase of the output to be vector sum of the amplitudes of the free running VCO (V_{osc}) and the reference signal that is injected (V_{ref}) and the phase error value = arc tan (V_{ref}-/V_{osc}). In our case the reference signal has a maximum value of 0 dBm, the mixer isolation is about -25 dB from R- to L-port, the 4-way power divider provides -6 dB and isolator -20 dB isolation giving a reference signal level at VCO output of -51 dBm. With the VCO output level of +22 dBm, the phase error is $\lesssim 0.01^{\circ}$. However if the isolator is not used this error could be $\sim 0.15^{\circ}$ which is appreciable.

4.3.2 Phase-lock loop board - Reference Schematic D13230S13 (Fig. 4)

The phase-lock loop PC board contains loop DC amplifier and integrator. Loop out-of-lock indication circuit and VCO sweep circuit. When the VCO output frequency is different from the input reference signal a free running multivibrator output is connected to the input of the loop integrator. This makes the

REV.	DATE	DRAWN BY	APPRVD BY	DESCRIPTION
B	6-7-77			REVISED & REDRAWN
C	6-23-77			"R34" WAS "R5", VALUE WAS 3.9K. R42 WAS 2.2K, R31 WAS 820Ω. REMOVED R32, R37, C10 & C11
D	9-27-77			ADDED C15
E	11-28-77			C15 WAS 9100 pF C16 WAS C15 C.O. Nº 770729-D58-1 " " 770228-D58 " " 761215-D58
F	3-3-78			CHG: R17 WAS 33K, R24 WAS 4.7M, R30 WAS 33K REMOVED R7-510K & R15-33K ADD: TABLE "B"



NOTES:
1. ALL MONITOR/CONTROL POINTS AND POWER SUPPLY CONNECTIONS GO THRU FILTER FEED THRUS (SPECTRUM CONTROL TYPE) MOUNTED ON SHIELD OF AMP CONNECTOR P1

TABLE A

	L3 (MODEL C)		L14 (MODEL C)	
	1200 MHz	1800 MHz	1200 MHz	1800 MHz
Ø ERROR	P1-24	P1-22	P1-31	P1-30
FREQ ERROR	P1-23	P1-21	P1-22	P1-21
REMOTE CONTROL	P1-12	P1-14	P1-3	P1-1
LOCK INDICATION	P1-25	P1-26	P1-8	P1;9

FIGURE 4

NEXT ASSY	USED ON
	A13230E92

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

PROJECT: L3/L14 LO TRANSMITTER/CENTRAL LO FILTER
TITLE: PHASE LOCK LOOP P.C. BOARD SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY — DATE 6-7-77
DESIGNED BY — DATE
APPROVED BY — DATE
SHEET NUMBER 1 OF 1 — DRAWING NUMBER D13230513 — REV F — SCALE ~

integrator output to vary in sawtooth fashion and sweeps the oscillator frequency. When the oscillator frequency is within the pulling range of the loop, the loop should acquire lock and the multivibrator signal to the integrator is cut off.

The output from the phase detector is terminated at the input of the phase-lock loop board by a 51 Ω (R26) in series with a 470 pF (C13). It is amplified by the operational amplifier (U2) to ±10 V p-p for a 2π radian phase change. It can be monitored at ϕ-error monitor point. The loop can be opened manually by setting the three position toggle switch S1 in open position or by an external +5 V signal at "REMOTE" in the remote position of the toggle switch. The loop open/close function is performed by one section of the dual SPST switch AD7513 (U5). The other section of the U5 is used to connect a free running multivibrator output to the input of the integrator U3 and is controlled by out-of-lock indication circuitry consisting of U1 and U4A.

When a beat signal is present at the input of the phase-lock board, output of the wideband amplifier U1 coupled by C5 to CR4 drives the amplifier U4A. Output of the amplifier U4A is used to connect the multivibrator output to the input of the integrator U3. Output of U1 is AC coupled to the diode CR4 for the following reason. In this type of circuit phase detector current to the integrator has to be larger than the sweep current to acquire lock. The phase detector output amplified by U2 may be such that it compensates the multivibrator output. In that case the phase detector output will vary at the same rate as that of the multivibrator and the loop will not be allowed to lock. Since the multivibrator rate is

very slow ($\lesssim$1 Hz), the U1 output to CR4 is cut off by the high pass filter C5R1. This causes to open the switch disconnecting the multivibrator output to integrator and the loop should lock. The multivibrator is made up of U6B and U6D and the time constant is determined by R40 and C12. Also the output of U1 is given to the amplifier U4B through diodes CR1 and CR2. When the phase-lock board input exceeds about 40 to 50 mV such that U1 output is able to drive the diodes CR1 or CR2 the U4B output will go high and switch 'ON' the LED to indicate that the loop is out-of-lock. Diodes CR3 and CR5 are connected in +15 V and -15 V DC power lines of the MOSFET analog switch AD7513 (U5) to protect it from damage due to transients.

The integrator consists of the operational amplifier U3 and the time-constants are formed by R35, R45 and C15. With the phase-lock loop set up properly and in lock the output of the integrator should be close to +4V. The resistors R33 and R31 change the integrator output swing from ±15 V to 0 to -15 V DC as required by the VCO. Also output of the integrator is monitored through a 10 k resistor (R30) and is labeled as 'FREQ. ERROR'. When no signal is present at the input of the phase-lock board U1 output is zero and the multivibrator output is not connected to the integrator and thus the integrator output is not sweeped. However depending on the DC offset bias conditions of the operational amplifiers U2 and U3 the integrator will swing to either +ve or -ve extreme (more than 13 V) and stay there. In this case though LED will not come 'ON' to indicate that the loop is not in lock but the integrator output can be used to indicate no signal condition. This is done by computer.

4.3.3 Loop parameters

For the theory of phase-lock loops and terminology used here refer to Phase-Lock Techniques by F.M. Gardner (John Wiley & Sons, Inc., New York 1966).

To minimize phase difference between the reference and signal a second order high gain integrator was chosen for the loop filter. Also as forced sweep is required for this system the loop parameters were optimized between good lock acquisition and low noise performance.

From the VCO data the mean value of the oscillator AFC port sensitivity is 0.5 MHz/Volt. Further the gain of the DC offset network at the output of the integrator is 0·5. Therefore the VCO gain constant

$$K_o = 0{\cdot}5 \times (0{\cdot}5 \times 10^6 \times 2\pi \text{ rad/Volt}) = 1{\cdot}57 \times 10^6 \text{ rad/Volt}$$

The gain setting of the DC amplifier U1 makes the phase detector output swing of ±10 V for a 2π radian change. Therefore at zero crossing the phase detector gain constant K_D = 10 V/rad.

$$\therefore K_v = K_o K_D = 15{\cdot}7 \times 10^6$$

For best lock acquisition it is desirable to have as large a loop natural frequency (ω_n) as possible. However noise and stability considerations force to limit the same. Consider the accuracy with which the loop tracks the input signal and the frequency over which the system will pull into lock. Assume a 0·1% ripple on the power supply tuning the VCO (say about 15 mV in 15 V DC) at 120 Hz. This will cause the VCO to deviate by about 7·5 kHz (500 x 10^3 Hz/Volt x 0·015 V). From Equations

(4·12) and (4·13) on page 31 of Gardner we get the peak residual phase deviation.

$$\theta_e = \Delta\omega \cdot \omega_m / \omega_n^2$$

Where $\Delta\omega$ = peak frequency deviation and ω_m = modulating frequency. For $\theta_e < 0^\circ.1$ requires $\omega_n/2\pi \sim 25$ kHz. We chose $\omega_n/2\pi = 35$ kHz, i.e. $\omega_n = 220 \times 10^3 \frac{\text{rad}}{\text{sec}}$.

For good lock acquisition characteristics we chose a damping factor of 2 (see Gardner page 48). With the above parameters this will give (i) the pull in range (see Gardner page 45)

$$\Delta\omega_p/2\pi = \frac{1}{\pi}\sqrt{3\ \omega_n K_v}\ \text{Hz} = \left(\frac{1}{\pi}\right) \cdot \sqrt{2 \times 220 \times 10^3 \times 15{\cdot}7 \times 10^6} \sim 1\ \text{MHz}$$

and (ii) the lock in range (see Gardner page 43)

$$\Delta\omega_L/2\pi = 2\zeta\ \omega_n/2\pi = 140\ \text{kHz}.$$

Essentially these will be limited by the bandwidth of the first op. amplifiers U2. In practice the pull in range may be limited to ≈ 300 kHz.

From Gardner, page 9, Equation (2·10) we can express

$$\omega_n = \left(\frac{K_o K_D}{\tau_1}\right)^{\frac{1}{2}}$$

$$\zeta = \frac{\tau_2}{2} \cdot \left(\frac{K_o K_D}{\tau_1}\right)^{\frac{1}{2}}$$

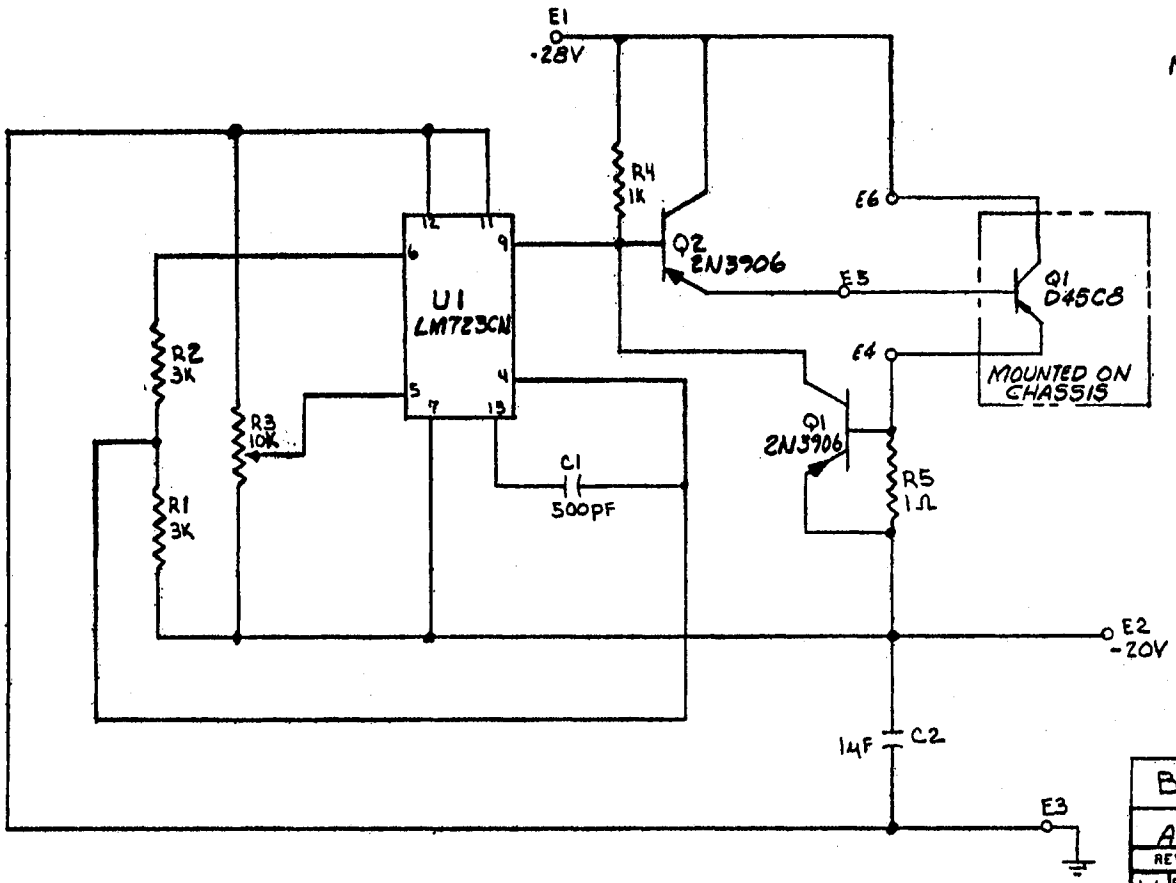
where τ_1 = R35·C15 and τ_2 = R45·C15 in our case. Using $\omega_n = 220 \times 10^3$ rad/sec and $\zeta = 2$, we get $\tau_1 = 320\ \mu S$ and $\tau_2 = 20\ \mu S$. For C15 = 0·033 μF this gives R35 = 10 kHz and R45 ~ 600 Ω.

4.4 Negative Voltage Regulator - Reference Schematic B13230S10 (Fig. 5)

A negative twenty Volt power supply is required for the 1200 and 1800 MHz voltage controlled oscillators. This is supplied by regulating down the -28 V power available in the B-Rack. The voltage is adjusted to -20 V by adjusting the potentiometer R3. The series regulator transistor Q1 (D45C8) is mounted on the module chassis to provide heat sink. Nominal load current is about 250 mA for the two oscillators. The regulator current limit is 600 mA.

LAST COMPONENT DESIG USED				
C	R	U	Q	E
2	5	1	2	6

NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   A. ALL RESISTOR VALUES ARE IN OHMS, 1/4W
   B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. FOR B.O.M. SEE A13230Z75 FOR L3
   " " " A13230Z28 FOR L14



REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
B	11-30-77			TITLE WAS "L14 CENTRAL LO TRANSMITTE
A	3/8/76			ADDED "Q1" & VALUES TERMINALS

VLA PROJECT: L3/L14

TITLE: NEGATIVE VOLTAGE REGULATOR SCHEMATIC

NATIONAL RAD ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 2290

DRAWN BY		DATE 11-27-
DESIGNED BY		DATE
APPROVED BY		DATE 9/26

SHEET NUMBER | DRAWING NUMBER B13230S10 | REV. 1 | SCALE

FIGURE 5.

5.0 TEST AND ADJUSTMENTS

5.1 Testing and Adjustments of 1200 and 1800 MHz Oscillators

The test and adjustment procedure for both 1200 and 1800 MHz oscillators is similar and we will describe it for only 1200 MHz VCO. For adjusting mechanical tuning of these oscillators allow at least half an hour of oscillator warm-up time.

a) RF output power from the oscillator as measured using a power meter should be at least +22 dBm.

b) Connect the AFC port of the oscillator to a negative voltage power supply through a 10 k resistor. Measure the frequency of the oscillator using output at OMQ jack L3J8 with a spectrum analyzer. Adjust the mechanical tuning of the oscillator so that the frequency change with AFC voltage of zero to -13 V DC swings the oscillator frequency equally on both sides of the nominal frequency.

c) With the AFC port of the VCO still connected to the power supply measure the FM tuning slope of the oscillator. It should be about 0·4 to 0·6 MHz/Volt around -7 Volt at the AFC port.

d) Remove the power supply from the AFC port of the VCO and restore normal connection.

5.2 Procedure to Set-up Phase-lock Loop Boards - Reference Block Diagram D13230B22 and Circuit Schematic D13230S13

As in the case of adjustment of the oscillators procedure to set-up both 1200 and 1800 MHz phase-lock loop PC boards are similar. Here we will describe it for 1200 MHz phase-lock board with connections for 1800 MHz phase-lock adjustments in brackets.

a) With L3J2 [L3J1] terminated and U2 gain pot R46 set to maximum adjust U2 DC offset pot R47 so that the

DC output of the amplifier U2 as measured at 'ϕ-ERROR' monitor point is within ±100 mV.

b) Connect a -3 dBm signal at 1200 [1800] MHz from L2C module to L3J2 [L3J1].

c) Set the toggle switch S1 to open position and connect a variable negative voltage power supply through a 10 k resistor to AFC port of the oscillator. Measure the phase detector output beat frequency as measured at the input of the phase-lock board by an oscilloscope. Adjust the AFC port voltage so that the beat frequency is $\lesssim$10 kHz. The amplitude of the beat signal should be about 200 to 400 mV p-p.

d) Adjust the gain pot R46 such that the output of the operational amplifier U2 as measured at the 'ϕ-ERROR' monitor point is 20 V p-p. The DC offset should be within ±200 mV.

e) Check that the output of the integrator going to the oscillator is sweeping between 0 and about -13 V at approximately 1 Hz (the multivibrator output frequency rate). Otherwise check the multivibrator output at pin 10 of U6 by a scope. It should be switching between +0·8 V and +5 V at ~1 Hz.

f) Remove the DC power supply from the AFC port of the VCO and restore the phase-lock board output to the AFC port of the VCO. Check that the VCO frequency is swinging by about 2 MHz on either side of the oscillator nominal frequency at the multivibrator switching rate.

g) Set the switch S1 to 'REMOTE' position.

h) Apply a pulse generator output of 100 μs duration TTL +ve with ~100 cycle repetition rate to the 'REMOTE' terminal on the PC board. Adjust the integrator

damping pot R47 to damping as shown in Figure 6 by observing integrator output at VCO AFC terminal by an oscilloscope.

i) Remove the pulse generator signal.

j) Check DC offset voltage at 'ϕ-ERROR' monitor point with loop in lock. Adjust the bias pot on the integrator (R44) to get the offset to within ±100 mV.

k) Check the output of the integrator at the 'FREQ-ERROR' monitor point. It should be approximately +4 V.

l) Every time setting the switch S1 to OPEN and again to CLOSE the loop should lock back within one cycle of the multivibrator. Otherwise the damping pot R45 may have to be adjusted slightly.

m) Set the switch S1 to 'REMOTE' position.

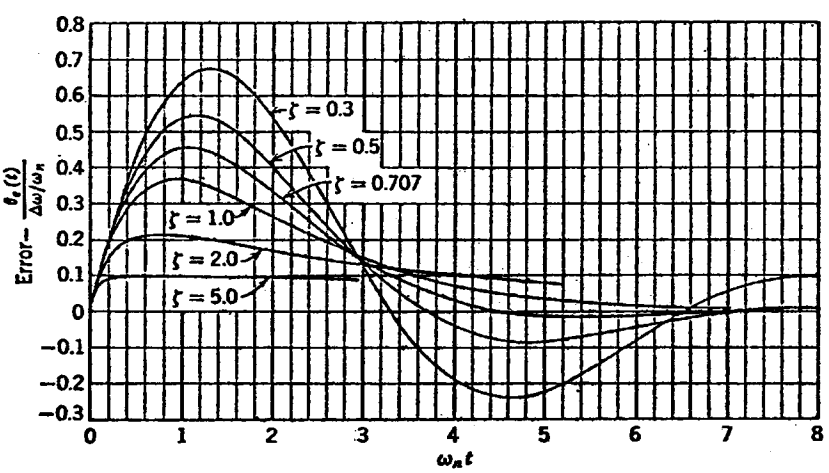
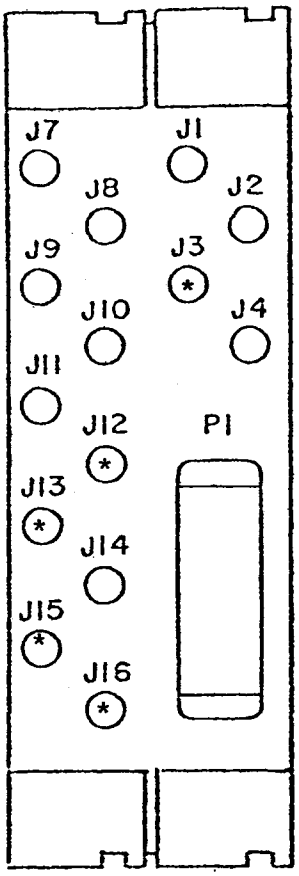


FIGURE 6: DAMPING ADJUSTMENT OF PHASE-LOCK LOOP PC BOARD. Correct damping as shown by ζ = 2.0 curve, underdamping as shown by ζ = 0.707 and overdamping as shown by ζ = 5.0 curves.

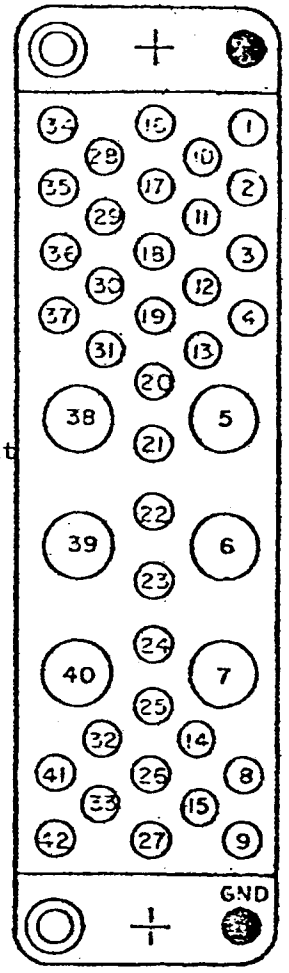
6.0 INPUT-OUTPUT CONNECTIONS AND POWER LEVELS



DOUBLE WIDE MODULE
(REAR VIEW)

CONN	FUNCTION
J1	-1·5 ± 1·5 dBm @ 1800 MHz Input
J2	-1·5 ± 1·5 dBm @ 1200 MHz Input
J3	
J4	0·5 MHz Data "TTL" Input
J7	-4 ± 2 dBm @ 3000 MHz Output
J8	1·2 & 1·8 GHz -28·5 (-25·5) dBm Output
J9	+10 ± 1 dBm @ 10 MHz Input
J10	+9 ± 2 dBm @ 600 MHz Output
J11	+9 ± 2 dBm @ 600 MHz Output
J12	
J13	
J14	+5 ± 2 dBm @ 2400 MHz Output
J15	
J16	

LEGEND: No parenthesis - L.O. power at each carrier.
Parenthesis - total L.O. power.



P1 (REAR VIEW)

P1

PIN	FUNCTION	WIRE COLOR	PIN	FUNCTION	WIRE COLOR
1			22	1800 MHz PLL Phase-Error	
2			23	1200 MHz VCO Control Voltage	
3			24	1200 MHz PLL Phase-Error	
4			25	1200 MHz PLL not locked (logic level)	
5			26	1800 MHz PLL not locked (logic level)	
6			27		
7			28	-28VDC	
8			29		
9			30		
10	+5VDC		31		
11			32		
12	Open 1200 MHz PLL (Control, CMOS)		33		
13			34	PWR. GROUND	BLACK
14	Open 1800 MHz PLL (Control, CMOS)		35		
15			36		
16	+15VDC		37		
17	-15VDC		38		
18			39		
19	1800 MHz VCO Output Power		40		
20	1200 MHz VCO Output Power		41		
21	1800 MHz VCO Control Voltage		42	HIGH QUAL. GROUND	

* INDICATES A FUNCTION NOT FOUND IN THIS MODULE.

7.0 BILLS OF MATERIALS

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A13230Z23
DATA SET: LO TRANSMITTER BOM: MOD BOARD 0

MOD-Q/S-Q/M		DESCR	VALUE		MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L03		NSA			A13230Z23	NRAO	01	A13230Z23	MOD BOARD	0	0.00
L03	01	EPCD			C13230M56	NRAO	02	A13230Z23	DATA MODULATOR DRIVER	6	0.00
L03	01	R 01	620.0		RCR07 621-5S		03	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 02	300.0		RCR07 301-5S		04	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 03	2.0	K	RCR07 202-5S		05	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 04	5.0	K	3339P-1-502	BOURNS	06	A13230Z23	POT.CERMET,4TURN,+-10%		1.98
L03	01	R 05	10.0	K	RCR07 103-5S		07	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 06	390.0		RCR07 391-5S		08	A13230Z23	RESISTOR 1/4W		0.06
L03	01	P 07	2.0	K	3339P-1-202	BOURNS	09	A13230Z23	POT.CERMET,4TURN,+-10%		1.98
L03	01	R 08	1.5	K	RCR07 152-5S		10	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 09	240.0		RCR07 241-5S		11	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 10	33.0		RCR07 330-5S		12	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 11	510.0		RCR07 511-5S		13	A13230Z23	RESISTOR 1/4W		0.06
L03	03	R 12	200.0		RCR07 201-5S		14	A13230Z23	RESISTOR 1/4W		0.06
L03		R 13	200.0		RCR07 201-5S		14	A13230Z23	RESISTOR 1/4W		0.06
L03		R 14	200.0		RCR07 201-5S		14	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 15	100.0		RCR07 101-5S		15	A13230Z23	RESISTOR 1/4W		0.06
L03	01	R 16	5.1	K	RCR07 512-5S		16	A13230Z23	RESISTOR 1/4W		0.06
L03	01	C 02	15.0	UF	CS13BE156K	SPRAGUE	17	A13230Z23	CAPACITOR,TANTALUM 20VDC		0.24
L03	01	C 03	10.0	PF	CM04CD100J03	ARCO	18	A13230Z23	CAPACITOR MICA 500WVDC		0.11
L03		C 05	0.1	UF	8121-050-651-104M	ERIE	19	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		0.19
L03	02	C 04	0.1	UF	8121-050-651-104M	ERIE	19	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		0.19
L03	01	C 06	0.047	UF	8121-050-651-473M	ERIE	20	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		0.16
L03	01	C 07	330.0	PF	CM04FA331J03	ARCO	21	A13230Z23	CAPACITOR MICA 500WVDC		0.19
L03	01	C 08	120.0	PF	CM04FD121J03	ARCO	22	A13230Z23	CAPACITOR MICA 500WVDC		0.11
L03	01	C 09	24.0	PF	CM04ED240J03	ARCO	23	A13230Z23	CAPACITOR MICA 500WVDC		0.11
L03	02	C 10	1.0	UF	8131-050-651-105M	ERIE	24	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		1.23
L03		C 11	1.0	UF	8131-050-651-105M	ERIE	24	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		1.23
L03	01	C 13	150.0	PF	CM04FD151J03	ARCO	25	A13230Z23	CAPACITOR MICA 500WVDC		0.11
L03	01	C 14	4700.0	PF	8121-050-651-472M	ERIE	26	A13230Z23	CAPACITOR,MONOLYTHIC 50VDC		0.11
L03	01	L 01	47.0	UH	9230-60	MILLER	27	A13230Z23	CHOKE,RF MICRO MINATURE		0.28
L03	01	L 02	22.0	UH	9230-52	MILLER	28	A13230Z23	CHOKE,RF MICRO MINATURE		0.55
L03	01	L 03	3.3	UH	9230-32	MILLER	29	A13230Z23	CHOKE,RF MICRO MINATURE		0.46
L03	02	CR 01			A2S800	AERTECH	30	A13230Z23	DIODE,SHOTTKEY		1.05
L03		CR 02			A2S800	AERTECH	30	A13230Z23	DIODE,SHOTTKEY		1.05
L03	01	CR 03			1N937B	MOTOROLA	31	A13230Z23	DIODE,REF TC 9.0V		4.58
L03	01	U 01			LM318H	NAT SEMICOND	32	A13230Z23	OP AMP		1.88
L03	01	U 02			LH0033CG	NAT SEMICOND	33	A13230Z23	AMPLIFIER,OP FET		14.49
L03	01	X			DP-5178	ROB NUGENT	34	A13230Z23	SOCKET,8 PIN TO-5		1.98
L03	01	X			MP12100S	ROB NUGENT	35	A13230Z23	SOCKET,12 PIN TO-8 SQUARE		0.28
L03		EPCA			B13230AB08	NRAO	36	A13230Z23	DATA MODULATOR DRIVER	4	3.00
L03		DSH			C13230S07	NRAO	37	A13230Z23	DATA MODULATOR DRIVER	2	0.00

*** TOTAL COST= 35.38 ***

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A13230Z26
DATA SET: LO TRANSMITTER BOM: 5 MHZ MOD DRIVER 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		NSA		A13230Z26	NRAO	1	A13230Z26	5 MHZ MOD DRIVER 0	0.00
L03	1	EPCD		B13230M59	NRAO	2	A13230Z26	5 MHZ MOD FILTER DR DIAG 6	0.00
L03	2	MPP		1589-2	KEYSTONE	3	A13230Z26	STANDOFF,SWAGE 2-56 1/8H	0.06
L03	1	R 03	33.0	RCR07 330-5S		4	A13230Z26	RESISTOR 1/4W	0.06
L03	2	C 01	0.22 UF	8131-050-651-224M	ERIE	7	A13230Z26	CAPACITOR,MONOLYTHIC 50VDC	0.21
L03		C 03	0.22 UF	8131-050-651-224M	ERIE	7	A13230Z26	CAPACITOR,MONOLYTHIC 50VDC	0.21
L03	1	C 02	0.01 UF	8121-050-651-103M	ERIE	8	A13230Z26	0.01UF,50WVDC,CAP.(RED CAP)	.39
L03	1	L 01	220.0 UH	9230-76	MILLER	9	A13230Z26	CHOKE,RF MICRO MINATURE	0.85
L03	01	R 04	1.0 K	3339H-1-102	BOURNS	05	A13230Z26	POTENTIOMETER 4 TURN	1.53
L03	01	R 05	20.0 K	3339H-1-203	BOURNS	06	A13230Z26	POTENTIOMETER 4 TURN	1.53
L03	1	R 01	750.0	RCR20 751-5S		10	A13230Z26	RESISTOR 1/2W	0.07
L03	1	R 02	100.0	RCR07 101-5S		11	A13230Z26	RESISTOR 1/4W	0.06
L03	1	EPCA		A13230AB07	NRAO	17	A13230Z26	5 MHZ MODULATION FILTER 4	0.00
L03		DSH		B13230S09	NRAO	18	A13230Z26	5 MHZ MOD DRIVER ASSY 2	0.00

*** TOTAL COST= 5.03 ***

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A13230Z27
DATA SET: LO TRANSMITTER BOM: 5 MHZ MCD DRIVER 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		NSA		A13230Z27	NRAO	1	A13230Z27	5 MHZ MCD DRIVER 0	0.00
L03	1	NSB		A13230Z26	NRAO	2	A13230Z27	5 MHZ MCD DRIVER 0	0.00
L03	3	J 01		OSM-211	OMNI-SPECTRA	3	A13230Z27	JACK BLKHD FDTHRU	2.15
L03	1	C 04	0.001UF	FB3B10F102W	SPEC CONTROL	4	A13230Z27	CAPACITOR,FEEDTHRU SCREW MT	0.66
L03	1	E 04		1587-1	KEYSTONE	5	A13230Z27	TERMINAL,TURRET .125 4-40THD	0.09
L03		J 03		OSM-211	OMNI-SPECTRA	03	A13230Z27	JACK BLKHD FDTHRU	2.15
L03		J 02		OSM-211	OMNI-SPECTRA	03	A13230Z27	JACK BLKHD FDTHRU	2.15
L03		E 04		B13230M98	NRAO	05	A13230Z27	TERMINAL, TURRET MCD N	0.00
L03		OSH		B13230S09	NRAO	06	A13230Z27	5 MHZ MCD DRIVER ASSY 2	0.00
L03	1	MPP		B13230M41	NRAO	16	A13230Z27	5MHZ MCD FILTER ENCLOSUREN	1.61
L03	01	MPP		2400(NRAO)	PAMONA	16	A13230Z27	ENCLOSURE,RF	1.55
L03	2	H		FHSS 2-56 X 0.250	HW	17	A13230Z27	FLAT HEAD SLOTTED SS SCREW	0.02

*** TOTAL COST= 10.40 ***

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A1323CZ31
DATA SET: LO TRANSMITTER BOM: MONITOR FILTER 0

MOD-O/S-O/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		NSA		A13230Z31	NRAO	1	A13230Z31	MONITOR FILTER 0	0.00
L03		NSA		A13230Z31	NRAO	1	A13230Z31	MONITOR FILTER 0	0.00
L03	1	MPN		C13230M68	NRAO	2	A1323CZ31	MONITOR FILTER BOX M	7.97
L03	1	MPN		C13230M68	NRAO	2	A13230Z31	MONITOR FILTER BOX M	7.97
L03		DSH		B13230S12	NRAO	3	A13230Z31	MONITOR FILTER SCHEMATIC 2	0.00
L03		DSH		B13230S12	NRAO	3	A13230Z31	MONITOR FILTER SCHEMATIC 2	0.00
L03	01	DSA		C13230P39	NRAO	4	A13230Z31	MONITOR FILTER ASSEMBLY 1	0.00
L03	01	DSA		C13230P39	NRAO	4	A13230Z31	MONITOR FILTER ASSEMBLY 1	0.00
L03	01	MPP		3754(NRAO)	PAMONA	02	A13230Z31	ENCLOSURE,RF	1.55
L03	01	MPP		3754(NRAO)	PAMONA	02	A13230Z31	ENCLOSURE,RF	1.55
L03	1	J		OSM-211	OMNI-SPECTRA	16	A13230Z31	JACK BLKHD FDTHRU	2.15
L03	1	J		OSM-211	OMNI-SPECTRA	16	A13230Z31	JACK BLKHD FDTHRU	2.15
L03	1	C 01	0.001UF	FB3810F102W	SPEC CONTROL	17	A13230Z31	CAPACITOR,FEEDTHRU SCREW MT	0.66
L03	1	C 01	0.001UF	FB3810F102W	SPEC CONTROL	17	A13230Z31	CAPACITOR,FEEDTHRU SCREW MT	0.66
L03	1	E		1587-1	KEYSTONE	18	A13230Z31	TERMINAL,TURRET .125 4-40THD	0.09
L03		F		B13230M98	NRAO	18	A13230Z31	TERMINAL, TURRET MCD N	0.00
L03		F		B13230M98	NRAO	18	A13230Z31	TERMINAL, TURRET MCD N	0.00
L03	1	F		1587-1	KEYSTONE	18	A13230Z31	TERMINAL,TURRET .125 4-40THD	0.09
L03	1	R 01	47.0 K	RCR07 473-5S		19	A13230Z31	RESISTOR 1/4W	0.06
L03	1	R 01	47.0 K	RCR07 473-5S		19	A13230Z31	RESISTOR 1/4W	0.06
L03	1	R 02	240.0	RCR07 241-5S		20	A13230Z31	RESISTOR 1/4W	0.06
L03	1	R 02	240.0	RCR07 241-5S		20	A13230Z31	RESISTOR 1/4W	0.06

*** TOTAL COST= 25.08 ***

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A13230Z32
DATA SET: LO TRANSMITTER BOM: PHASE LOCK LOOP PC BOARD 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		NSA		A13230Z32	NRAO	01	A13230Z32	PHASE LOCK LOOP PC BOARD 0	0.00
L03		NSA		A13230Z32	NRAO	01	A13230Z32	PHASE LOCK LOOP PC BOARD 0	0.00
L03	00	DSA		B13230P37	NRAO	02	A13230Z32	PHASE LK LOOP PCB ASSY 1	0.00
L03	00	DSA		B13230P37	NRAO	02	A13230Z32	PHASE LK LOOP PCB ASSY 1	0.00
L03	01	EPCD		B13230M69	NRAO	03	A13230Z32	LO TRANS/CNT LO FILT DR D6	0.00
L03	01	EPCD		B13230M69	NRAO	03	A13230Z32	LO TRANS/CNT LO FILT DR D6	0.00
L03		DSH		D13230S13	NRAO	04	A13230Z32	PHASE LK LOOP PCB SCHEM 2	0.00
L03		DSH		D13230S13	NRAO	04	A13230Z32	PHASE LK LOOP PCB SCHEM 2	0.00
L03		EPCA		B13230AB11	NRAO	05	A13230Z32	PHASE LOCK LOOP 4	0.00
L03		EPCA		B13230AB11	NRAO	05	A13230Z32	PHASE LOCK LOOP 4	0.00
L03		EPCS		B13230AB30	NRAO	06	A13230Z32	PH LK LOOP PC BD SILKSCRN5	15.00
L03		EPCS		B13230AB30	NRAO	06	A13230Z32	PH LK LOOP PC BD SILKSCRN5	15.00
L03	02	R 01	270.0	RCR07 271-5S		07	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R 01	270.0	RCR07 271-5S		07	A13230Z32	RESISTOR 1/4W	0.06
L03		R 02	270.0	RCR07 271-5S		07	A13230Z32	RESISTOR 1/4W	0.06
L03		R 02	270.0	RCR07 271-5S		07	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R 03	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R 03	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 35	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 10	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 35	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 25	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 25	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03		R 10	10.0 K	RCR07 103-5S		08	A13230Z32	RESISTOR 1/4W	0.06
L03	07	R 04	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03	07	R 04	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 13	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 19	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 19	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 13	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 09	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 05	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 05	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 06	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 08	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 09	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 06	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03		R 08	100.0 K	RCR07 104-5S		09	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 07	~~510.0 K~~	~~RCR07 514-5S~~ Deleted		10	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 07	~~510.0 K~~	~~RCR07 514-5S~~ Deleted		10	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 11	47.0	RCR07 470-5S		11	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 11	47.0	RCR07 470-5S		11	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 12	8.2 K	RCR07 822-5S		12	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 12	8.2 K	RCR07 822-5S		12	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 14	430.0 K	RCR07 434-5S		13	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R 14	430.0 K	RCR07 434-5S		13	A13230Z32	RESISTOR 1/4W	0.06
L03		R 17	10k ~~33.0 K~~	~~RCR07 333-5S~~		14	A13230Z32	RESISTOR 1/4W	0.06
L03		R 17	10k ~~33.0 K~~	~~RCR07 333-5S~~		14	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R 15	~~33.0 K~~	~~RCR07 333-5S~~ Deleted		14	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R 15	~~33.0 K~~	~~RCR07 333-5S~~ Deleted		14	A13230Z32	RESISTOR 1/4W	0.06
L03		R 43	33.0 K	RCR07 333-5S		14	A13230Z32	RESISTOR 1/4W	0.06
L03		R 43	33.0 K	RCR07 333-5S		14	A13230Z32	RESISTOR 1/4W	0.06

MOD-Q/S-Q/M		DESCR		VALUE		MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		R	30	10k ~~33.0~~	~~K~~	~~RCR07 333-5S~~		14	A13230Z32	RESISTOR 1/4W	0.06
L03		R	30	10k ~~33.0~~	~~K~~	~~RCR07 333-5S~~		14	A13230Z32	RESISTOR 1/4W	0.06
L03		R	27	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03		R	21	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R	18	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03	04	R	18	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03		R	23	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03		R	23	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03		R	27	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03		R	21	1.0	K	RCR07 102-5S		15	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	16	200.0	K	RCR07 204-5S		16	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	16	200.0	K	RCR07 204-5S		16	A13230Z32	RESISTOR 1/4W	0.06
L03		R	38	200.0	K	RCR07 204-5S		16	A13230Z32	RESISTOR 1/4W	0.06
L03		R	38	200.0	K	RCR07 204-5S		16	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	20	750.0		RCR07 751-5S		17	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	20	750.0		RCR07 751-5S		17	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	22	2.0	K	RCR07 202-5S		18	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	22	2.0	K	RCR07 202-5S		18	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	24	1M ~~4.7~~	~~M~~	~~RCR07 475-5S~~		19	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	24	1M ~~4.7~~	~~M~~	~~RCR07 475-5S~~		19	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	26	51.0		RCR07 510-5S		20	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	26	51.0		RCR07 510-5S		20	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	28	680.0		RCR07 681-5S		21	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	28	680.0		RCR07 681-5S		21	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	29	12.0	K	RCR07 123-5S		22	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	29	12.0	K	RCR07 123-5S		22	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	33	2.2	K	RCR07 222-5S		23	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	31	2.2	K	RCR07 222-5S		23	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	31	2.2	K	RCR07 222-5S		23	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	33	2.2	K	RCR07 222-5S		23	A13230Z32	RESISTOR 1/4W	0.06
L03	02	R	36	22.0	K	RCR07 223-5S		25	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	36	22.0	K	RCR07 223-5S		25	A13230Z32	RESISTOR 1/4W	0.06
L03		R	42	22.0	K	RCR07 223-5S		25	A13230Z32	RESISTOR 1/4W	0.06
L03		R	42	22.0	K	RCR07 223-5S		25	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	34	39.0	K	RCR07 393-5S		26	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	34	39.0	K	RCR07 393-5S		26	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	39	30.0	K	RCR07 303-5S		28	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	39	30.0	K	RCR07 303-5S		28	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	40	1.0	M	RCR07 105-5S		29	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	40	1.0	M	RCR07 105-5S		29	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	41	4.7	K	RCR07 472-5S		30	A13230Z32	RESISTOR 1/4W	0.06
L03	01	R	41	4.7	K	RCR07 472-5S		30	A13230Z32	RESISTOR 1/4W	0.06
L03	01	C	01	2.0	PF	DM10 020D	ARCO	31	A13230Z32	CAPACITOR MICA 500WVDC	0.14
L03	01	C	01	2.0	PF	DM10 020D	ARCO	31	A13230Z32	CAPACITOR MICA 500WVDC	0.14
L03	01	C	02	5.0	PF	DM10 050D	ARCO	32	A13230Z32	CAPACITOR MICA 500WVDC	0.14
L03	01	C	02	5.0	PF	DM10 050D	ARCO	32	A13230Z32	CAPACITOR MICA 500WVDC	0.14
L03		C	05	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	07	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	06	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	04	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	09	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	12	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03	08	C	03	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	08	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	12	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03	08	C	03	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C	04	1.0	UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		C 07	1.0 UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C 06	1.0 UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C 08	1.0 UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C 05	1.0 UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C 09	1.0 UF	8131-050-651-105M	ERIE	33	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	1.23
L03		C 16		8101-100-651-102M	ERIE	34	A13230Z32	CAPACITOR,MONOLYTHIC 100V	0.26
L03		C 16		8101-100-651-102M	ERIE	34	A13230Z32	CAPACITOR,MONOLYTHIC 100V	0.26
L03	01	C 13	470.0 PF	8101-050-651-471M	ERIE	35	A13230Z32	470PF,50WVDC,CAP.	.33
L03	01	C 13	470.0 PF	8101-050-651-471M	ERIE	35	A13230Z32	470PF,50WVDC,CAP.	.33
L03	01	C 14	0.1 UF	8121-050-651-104M	ERIE	36	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	0.19
L03	01	C 14	0.1 UF	8121-050-651-104M	ERIE	36	A13230Z32	CAPACITOR,MONOLYTHIC 50VDC	0.19
L03	01	C 15	0.033UF	617.4	MIAL/USA	37	A13230Z32	CAPACITOR,POLYST 600WDC	0.52
L03	01	C 15	0.033UF	617.4	MIAL/USA	37	A13230Z32	CAPACITOR,POLYST 600WDC	0.52
L03	04	CR 01		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 06		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03	04	CR 01		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 02		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 02		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 04		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 04		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03		CR 06		A2S800	AERTECH	38	A13230Z32	DIODE,SHOTTKEY	1.05
L03	02	CR 03		1N914B	GE	39	A13230Z32	DIODE,GENL PUR	0.07
L03		CR 05		1N914B	GE	39	A13230Z32	DIODE,GENL PUR	0.07
L03	02	CR 03		1N914B	GE	39	A13230Z32	DIODE,GENL PUR	0.07
L03		CR 05		1N914B	GE	39	A13230Z32	DIODE,GENL PUR	0.07
L03	01	U 01		LH0032CG	NAT SEMICOND	40	A13230Z32	OP AMP,FET ULTRA FAST	17.38
L03	01	U 01		LH0032CG	NAT SEMICOND	40	A13230Z32	OP AMP,FET ULTRA FAST	17.38
L03	02	U 02		LM318H	NAT SEMICOND	41	A13230Z32	OP AMP	1.88
L03		U 03		LM318H	NAT SEMICOND	41	A13230Z32	OP AMP	1.88
L03		U 03		LM318H	NAT SEMICOND	41	A13230Z32	OP AMP	1.88
L03	02	U 02		LM318H	NAT SEMICOND	41	A13230Z32	OP AMP	1.88
L03	01	U 04		RC-4558DN	RAYTHEON	42	A13230Z32	OP AMP DUAL HIGH GAIN	0.45
L03	01	U 04		RC-4558DN	RAYTHEON	42	A13230Z32	OP AMP DUAL HIGH GAIN	0.45
L03	01	U 05		AD7513KH	ANALOG DEV	43	A13230Z32	SWITCH,ANALOG	3.50
L03	01	U 05		AD7513KH	ANALOG DEV	43	A13230Z32	SWITCH,ANALOG	3.50
L03	01	U 06		CD4001AE	RCA	44	A13230Z32	COS/MOS NOR GATE	0.23
L03	01	U 06		CD4001AE	RCA	44	A13230Z32	COS/MOS NOR GATE	0.23
L03	01	X		MP12100S	ROB NUGENT	45	A13230Z32	SOCKET,12 PIN TO-8 SQUARE	0.28
L03	01	X		MP12100S	ROB NUGENT	45	A13230Z32	SOCKET,12 PIN TO-8 SQUARE	0.28
L03	02	X		SD-5178	ROB NUGENT	46	A13230Z32	SOCKET,PC BD 8 PIN TO-5	1.94
L03	02	X		SD-5178	ROB NUGENT	46	A13230Z32	SOCKET,PC BD 8 PIN TO-5	1.94
L03	01	X		ICN-083-S3	ROB NUGENT	47	A13230Z32	SOCKET,8 PIN DIL	0.25
L03	01	X		ICN-083-S3	ROB NUGENT	47	A13230Z32	SOCKET,8 PIN DIL	0.25
L03	01	X		DP-51710-T-23	ROB NUGENT	48	A13230Z32	SOCKET, 10 PIN TO-5	3.18
L03	01	X		DP-51710-T-23	ROB NUGENT	48	A13230Z32	SOCKET, 10 PIN TO-5	3.18
L03	01	X		ICN-143-S3	ROB NUGENT	49	A13230Z32	SOCKET,14 PIN DIL	0.27
L03	01	X		ICN-143-S3	ROB NUGENT	49	A13230Z32	SOCKET,14 PIN DIL	0.27
L03	12	E		1502-2	KEYSTONE	51	A13230Z32	TERMINAL,TURRET 1/16 STK	0.02
L03	12	E		1502-2	KEYSTONE	51	A13230Z32	TERMINAL,TURRET 1/16 STK	0.02
L03	04	H		1589-2	KEYSTONE	52	A13230Z32	STANDOFF,SWAGE 2-56 1/8H	0.06
L03	04	H		1589-2	KEYSTONE	52	A13230Z32	STANDOFF,SWAGE 2-56 1/8H	0.06
L03	01	S 01		MTM106E-PC	ALCO	53	A13230Z32	SWITCH, TOGGLE PC	1.61
L03	01	S 01		MTM106E-PC	ALCO	53	A13230Z32	SWITCH, TOGGLE PC	1.61
L03		P 44		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03	03	P 44		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03		P 47		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03		P 46		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98

MOD-O/S-O/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L03		R 47		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03		R 46		3339P-1-104	BOURNS	54	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03	01	R 45		3339P-1-502	BOURNS	55	A13230Z32	POT.CERMET,4TURN,+-10%	1.98
L03	01	R 45		3339P-1-502	BOURNS	55	A13230Z32	POT.CERMET,4TURN,+-10%	1.98

*** TOTAL COST= 116.54 ***

V L A D A T A L I S T I N G

MODULE: L03
DATA SET: LO TRANSMITTER

PROJECT NO. 13230

DRAWING NO.: A13230Z65
BOM: LO TRANSMITTER TOP ASSY 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L03		NST		A13230Z65	NRAO	01	A13230Z65	LO TRANSMITTER TOP ASSY	0	0.00
L03	01	VC 01		SSC-0222(A)	SOLID ST TECH	02	A13230Z65	OSCILLATOR 1200MHZ		322.00
L03	01	VC 02		SSC-0223(A)	SOLID ST TECH	03	A13230Z65	OSCILLATOR 1800MHZ		322.00
L03	02	CIRC1		101102660	ADDINGTON LAB	04	A13230Z65	ISOLATOR,TEE		190.00
L03		CIRC2		101102660	ADDINGTON LAB	04	A13230Z65	ISOLATOR,TEE		190.00
L03	01	DC 01		2023-6121-06	OMNI-SPECTRA	05	A13230Z65	DIRECTIONAL COUPLER 1-2 GHZ		110.00
L03	01	FD		D-6-4	ANZAC	06	A13230Z65	DOUBLER		71.00
L03	02	PD 01		PD8304-4M	VECTRONICS	07	A13230Z65	DIVIDER,PWR 4WAY 0.8-2GHZ		170.00
L03		PD 02		PD8304-4M	VECTRONICS	07	A13230Z65	DIVIDER,PWR 4WAY 0.8-2GHZ		170.00
L03	01	HY 01		H-183-4	ANZAC	08	A13230Z65	BROAD BAND HYBRID 30MHZ-3GHZ		250.00
L03	01	EP		PDM-20-500	MERRIMAC	09	A13230Z65	SPLITTER,PWR 5-1000MHZ		58.00
L03	01	DC 02		PDM-20-500	MERRIMAC	09	A13230Z65	SPLITTER,PWR 5-1000MHZ		58.00
L03		EPCP		B13230P37	NRAO	10	A13230Z65	PHASE LK LOOP PCB ASSY	1	0.00
L03	02	EPCP		B13230P37	NRAO	10	A13230Z65	PHASE LK LOOP PCB ASSY	1	0.00
L03	01	NSB		A13230Z26	NRAO	11	A13230Z65	5 MHZ MOD DRIVER	0	0.00
L03	01	NSB		A13230Z23	NRAO	12	A13230Z65	MOD BOARD	0	0.00
L03		M 04		M1J	WATKINS JOHN	13	A13230Z65	MIX,DBL BAL DC-1GHZ SMA CON		73.00
L03		M 05		M1J	WATKINS JOHN	13	A13230Z65	MIX,DBL BAL DC-1GHZ SMA CON		73.00
L03	03	M 01		M1J	WATKINS JOHN	13	A13230Z65	MIX,DBL BAL DC-1GHZ SMA CON		73.00
L03	01	M 02		M1H	WATKINS JOHN	14	A13230Z65	MIX,DBL BAL 2-6GHZ SMA CON		115.00
L03	01	FL 01		4B120-2400/200-0	K&L MICROWAVE	15	A13230Z65	FILTER,TUBULAR BP		45.00
L03	01	FL 02		4MC10-600/50-00	K&L MICROWAVE	16	A13230Z65	MINI-FILTER END CONN		150.00
L03	01	FL 03		4B120-1200/120-0	K&L MICROWAVE	17	A13230Z65	FILTER,TUBULAR BP		45.00
L03	01	FL 04		4B120-1800/180-0	K&L MICROWAVE	18	A13230Z65	FILTER,TUBULAR BP		45.00
L03	01	FL 05		4B120-3000/300-0	K&L MICROWAVE	19	A13230Z65	FILTER,TUBULAR BP		45.00
L03	01	PD 03		20493	OMNI-SPECTRA	20	A13230Z65	POWER DVDR,2 WAY,1-2GHZ		126.00
L03	01	M 03		MD-525-4	ANZAC	21	A13230Z65	MIXER,DBL BAL 5MHZ-4GHZ		149.00
L03	01	AT 01		FP87-10	TEXSCAN	22	A13230Z65	10DB ATTENUATOR		35.00
L03	04	H		47-10-204-10	SOUTHCO	24	A13230Z65	FASTNER,CAPTIVE		0.67
L03	01	MPM		C13230M32	NRAO	25	A13230Z65	FRONT PANEL	B	20.00
L03	01	MPM		D13230M25	NRAO	26	A13230Z65	PARTITION PLATE	M	37.14
L03	01	MPM		C13231M23	NRAO	27	A13230Z65	PANEL, REAR	E	13.00
L03	04	MPM		C13231M25	NRAO	28	A13230Z65	GUIDE, MODIFIED	U	1.00
L03	02	MPM		D13231M21-1	NRAO	32	A13230Z65	L&R SIDE PLATES	L	24.00
L03	01	NSA		A13230Z22	NRAO	34	A13230Z65	DATA MODULATOR	0	0.00
L03	01	NSB		A13230Z27	NRAO	35	A13230Z65	5 MHZ MOD DRIVER	0	0.00
L03	09	P		OSM-531-3	OMNI-SPECTRA	36	A13230Z65	PLUG RT ANGL RG188		3.57
L03	42	P		OSM-201-1A	OMNI-SPECTRA	37	A13230Z65	CONNECTOR,PLUG 141SR		0.85
L03	15	P		OSM-201-1	OMNI-SPECTRA	38	A13230Z65	CONNECTOR,PLUG 141SR		0.94
L03	01	P		OSM-202-1A	OMNI-SPECTRA	39	A13230Z65	CONNECTOR,JACK 141SR		1.88
L03	01	MPM		B13231M16	NRAO	40	A13230Z65	4-WAY PWR MTG BRACKET	M	10.00
L03	09	J		OMQ-3043-75	OMNI-SPECTRA	41	A13230Z65	JACK,BLKHD RP MOUNT 141SR		1.50
L03	01	P		202394-2	AMP SPEC IND	42	A13230Z65	HOOD,PIN(42 AND 50 BLOCK)		0.87
L03	01	P		OSM-218	OMNI-SPECTRA	43	A13230Z65	ADAPTER,STRGHT PLUG/PLUG		4.56
L03		D 02		20090	OMNI-SPECTRA	44	A13230Z65	DETECTOR 10MHZ-12.4GHZ		60.00
L03	02	D 01		20090	OMNI-SPECTRA	44	A13230Z65	DETECTOR 10MHZ-12.4GHZ		60.00
L03	02	NSB		A13230Z31	NRAO	45	A13230Z65	MONITOR FILTER	0	0.00
L03		NSB		A13230Z31	NRAO	45	A13230Z65	MONITOR FILTER	0	0.00
L03		NSA		A13230Z32	NRAO	47	A13230Z65	PHASE LOCK LOOP PC BOARD	0	0.00
L03	02	NSA		A13230Z32	NRAO	47	A13230Z65	PHASE LOCK LOOP PC BOARD	0	0.00
L03	02	CR 01		5082-4860	HEWLETT PACK	48	A13230Z65	LED,W/RESISTOR,LIMIT		0.65
L03		CR 02		5082-4860	HEWLETT PACK	48	A13230Z65	LED,W/RESISTOR,LIMIT		0.65

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L03	02	P		KC-19-153	KINGS	49	A13230Z65	CONNECTOR, PNL BNC		2.35
L03	01	P		204186-5	AMP SPEC IND	50	A13230Z65	BLOCK,PIN 42 MIXED		1.68
L03	16	P		204188-1	AMP SPEC IND	51	A13230Z65	CONTACT, PIN		0.23
L03	01	J 04		OMQ-3043-53	OMNI-SPECTRA	52	A13230Z65	JACK,BLKHD RP MAT RG188		2.20
L03	02	P		203964-6	AMP SPEC IND	53	A13230Z65	GUIDE SOCKET		0.21
L03	01	P		200833-4	AMP SPEC IND	54	A13230Z65	GUIDE PIN		0.23
L03	01	P		202514-1	AMP SPEC IND	55	A13230Z65	GROUND GUIDE PIN		0.42
L03	04	H		PHSS 6-32 X 0.625	HW	56	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	04	H		PHSS 6-32 X 0.750	HW	57	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	04	H		FHSS 6-32 X 0.375	HW	58	A13230Z65	FLAT HEAD SLOTTED SS SCREW		0.02
L03	14	H		FHSS 6-32 X 0.250	HW	59	A13230Z65	FLAT HEAD SLOTTED SS SCREW		0.02
L03	02	H		HSHS 6-32 X 0.250	HW	60	A13230Z65	HEX-SOCKET HD SLOTTED SS		0.02
L03	02	H		PHSS 6-32 X 1.250	HW	61	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	44	H		PHSS 4-40 X 0.250	HW	62	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	08	H		FHSS 2-56 X 0.250	HW	63	A13230Z65	FLAT HEAD SLOTTED SS SCREW		0.02
L03	05	H		PHSS 2-56 X 0.500	HW	64	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	08	H		PHSS 2-56 X 0.375	HW	65	A13230Z65	PAN HEAD SLOTTED SS		0.02
L03	01	AR 01		6201-60	WATKINS JOHN	66	A13230Z65	SPEC TABLE 2-6		190.00
L03	25	C		51-723-301	SPEC CONTROL	67	A13230Z65	RFI SUPP FILTER SOLDER		2.00
L03	01	NSB		A13230Z75	NRAO	69	A13230Z65	-20V REGULATOR PCB ASSY	O	0.00
L03	01	MPZ		B13231M26	NRAO	70	A13230Z65	REAR SPACER	M	2.00
L03	01	EP		D45C8	GE	71	A13230Z65	TRANSISTOR, POWER PNP		0.54
L03	08	MPZ		B13231M28	NRAO	72	A13230Z65	PARTITION PLATE SPACER	M	5.00
L03	02	MPM		B13231M29	NRAO	73	A13230Z65	FR PAN TUNING SHAFT SHLD	M	10.00
L03	04	MPM		B13231M30	NRAO	74	A13230Z65	PWR CONN SHIELD SPACER	M	1.50
L03	16	MPM		B13231M31	NRAO	75	A13230Z65	PWR CONN PIN CNTR FERRULE	M	0.50
L03	01	MPM		B13231M33	NRAO	76	A13230Z65	POWER CONN SHIELD BOX	L	5.00
L03	01	MPM		B13231M34	NRAO	77	A13230Z65	GASKET, SHIELD BOX	U	2.00
L03	01	MPM		GASKETAMPCONN	TECKNIT	77	A13230Z65	PER B13231M36		2.25
L03	01	DSH		D13230S13	NRAO	78	A13230Z65	PHASE LK LOOP PCB SCHEM	2	0.00
L03	01	MPM		D13231M12-1	NRAO	79	A13230Z65	BAR, SUPPORT, TOP & BOTT	G	25.00
L03	01	MPM		D13231M12-2	NRAO	80	A13230Z65	BAR, SUPPORT, TOP & BOTT	G	25.00
L03	01	MPM		B13231M22	NRAO	81	A13230Z65	BLOCK,RF SHIELD	L	12.00
L03	03	EP	0.001UF	FB3B10F102W	SPEC CONTROL	82	A13230Z65	CAPACITOR,FEEDTHRU SCREW	MT	0.66
L03	08	H		M12-A	K&L MICROWAVE	83	A13230Z65	MOUNTING CLIP		0.05
L03	75	H		SST1M-MP	PANDUIT	84	A13230Z65	TIE WRAP,CABLE		0.02
L03	9	FT		20-11101	TECKNIT	85	A13230Z65	1/8 ROUND RFI BRAID		1.80
L03	1	FT		20-11110	TECKNIT	86	A13230Z65	1/8X3/32 SQUARE RFI BRAID		1.80
L03	02	MPM		84-30223	TECKNIT	87	A13230Z65	INTERFACE SEAL		2.00
L03	02	MPM		84-30224	TECKNIT	88	A13230Z65	INTERFACE SEAL		2.00

*** TOTAL COST= 3676.76 ***

V L A D A T A L I S T I N G

MODULE: L03 PROJECT NO. 13230 DRAWING NO.: A13230Z75
DATA SET: LO TRANSMITTER BOM: -20V REGULATOR PCB ASSY 0

MOD-Q/S-Q/M		DESCR	VALUE		MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L03		NSA			A13230Z75	NRAO	01	A13230Z75	-20V REGULATOR PCB ASSY	0	0.00
L03	01	EPCP			B13230P64	NRAO	02	A13230Z75	-20V REG PCB ASSY	1	0.00
L03	01	DSH			B13230S10	NRAO	03	A13230Z75	NEG VOLTAGE REG SCHEM	2	0.00
L03	01	EPCA			A13230AB36	NRAO	04	A13230Z75	-20 V REG PCB AW	4	0.00
L03	01	MPN			B13231M35	NRAO	05	A13230Z75	-20V REG PCB DRILL DIAG	6	0.00
L03	02	R 01	3.0	K	RCR07 302-5S		06	A13230Z75	RESISTOR 1/4W		0.06
L03		R 02	3.0	K	RCR07 302-5S		06	A13230Z75	RESISTOR 1/4W		0.06
L03	01	R 03	10.0	K	89PR10K	BECKMAN	07	A13230Z75	POTENTIOMETER,PC		0.81
L03	01	R 04	1.0	K	RCR07 102-5S		08	A13230Z75	RESISTOR 1/4W		0.06
L03	01	R 05	1.0		RCR20 1R0-5S		09	A13230Z75	RESISTOR 1/2W		0.07
L03	02	Q 01			2N3906	MOTOROLA	10	A13230Z75	TRANSISTOR,AMPLIFIER PNP		0.12
L03		Q 02			2N3906	MOTOROLA	10	A13230Z75	TRANSISTOR,AMPLIFIER PNP		0.12
L03	01	U 01			LM723CN	NAT SEMICOND	11	A13230Z75	REGULATOR,VOLTAGE 2-37VDC		0.65
L03	01	C 01	500.0	PF	10TS-T50	SPRAGUE	12	A13230Z75	CAPACITOR,CERAMIC DISK		0.05
L03	01	C 02	1.0	UF	8131-050-651-105M	ERIE	13	A13230Z75	CAPACITOR,MONOLYTHIC 50VDC		1.23
L03	06	E			1502-2	KEYSTONE	14	A13230Z75	TERMINAL,TURRET 1/16 STK		0.02
L03	02	X			3-LPS-B	CINCH	15	A13230Z75	SOCKET,TRANSISTOR TO-5,TO-18		0.12
L03	01	X			ICN-143-S3	ROB NUGENT	16	A13230Z75	SOCKET,14 PIN DIL		0.27
L03	04	H			1596-2	KEYSTONE	17	A13230Z75	STANDOFF,SWAGE 2-56 3/8H		0.08

*** TOTAL COST= 4.18 ***

*** TOTAL COST FOR MODULE L03 IS 3902.83 ***

L3 - ANTENNA L.O. TRANSMITTER

V L A D A T A L I S T I N G

MODULE: L10 PROJECT NO. 13240 DRAWING NO.: A13230Z22
DATA SET: CENTRAL LO TRANSMITTER BOM: DATA MODULATOR 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L10		NSA		A13230Z22	NRAO	1	A13230Z22	DATA MODULATOR	0	0.00
L10	1	MPN		B13230M38	NRAO	2	A13230Z22	DATA FILTER END PANEL	J	8.12
L10	1	MPN		B13230M30	NRAO	3	A13230Z22	RECEIVER DATA AMPLIFIER	J	3.71
L10	1	MPN		B13230M29	NRAO	4	A13230Z22	RECEIVER DATA AMPLIFIER	J	6.72
L10	1	MPN		B13230M27	NRAO	5	A13230Z22	RECEIVER DATA AMPLIFIER	J	2.73
L10	1	MPN		B13230M46	NRAO	6	A13230Z22	DATA MOD DRVR END PANEL	J	0.00
L10	1	MPN		B13230M49	NRAO	7	A13230Z22	DTA MOD DRVR SIDE PANEL	J	0.00
L10	8	H		PHSS 4-40 X 0.500	HW	8	A13230Z22	PAN HEAD SLOTTED SS		0.02
L10	8	H		FHSS 4-40 X 0.375	HW	9	A13230Z22	FLAT HEAD SLOTTED SS SCREW		0.02
L10	3	J 01		OSM-211	OMNI-SPECTRA	17	A13230Z22	JACK BLKHD FDTHRU		2.15
L10		J 02		OSM-211	OMNI-SPECTRA	17	A13230Z22	JACK BLKHD FDTHRU		2.15
L10		J 03		OSM-211	OMNI-SPECTRA	17	A13230Z22	JACK BLKHD FDTHRU		2.15
L10	1	E 01		1587-1	KEYSTONE	18	A13230Z22	TERMINAL,TURRET .125 4-40THD		0.09
L10	1	C 01	0.001UF	FB3B10F102W	SPEC CONTROL	19	A13230Z22	CAPACITOR,FEEDTHRU SCREW MT		0.66
L10		C 12	0.001UF	FB3B10F102W	SPEC CONTROL	19	A13230Z22	CAPACITOR,FEEDTHRU SCREW MT		0.66
L10	1	NSB		A13230Z23	NRAO	20	A13230Z22	MOD BOARD	0	0.00
L10		DSH		C13230S07	NRAO	21	A13230Z22	DATA MODULATOR DRIVER	2	0.00

*** TOTAL COST= 28.80 ***

8.0 MANUFACTURER'S DATA SHEETS

FREQUENCY (MHz)	POWER (mW)	RUNNING MODEL NUMBER	LOCKED MODEL NUMBER
750- 850	300	SSC-0101	SSX-0122
850- 980	300	SSC-0102	SSX-0123
980- 1100	250	SSC-0103	SSX-0101
1080- 1220	250	SSC-0104	SSX-0124
1200- 1340	250	SSC-0105	SSX-0102
1300- 1520	250	SSC-0106	SSX-0125
1500- 1720	200	SSC-0107	SSX-0103
1640- 1780	150	SSC-0108	SSX-0126
1720- 1920	150	SSC-0109	SSX-0127
1880- 2080	150	SSC-0111	SSX-0128
2000- 2320	125	SSC-0115	SSX-0104
2320- 2550	50	SSC-0110	SSX-0131
3600- 3900	10*	SSCM-0121	SSX-0121
3600- 4130	10	SSCM-0106	SSX-0106
3850- 4200	10*	SSCM-0107	SSX-0107
4330- 4930	10*	SSCM-0108	SSX-0108
5400- 5900	10	SSCM-0109	SSX-0109
5855- 6445	10*	SSCM-0110	SSX-0110
6400- 6950	10*	SSCM-0111	SSX-0111
6800- 7200	10	SSCM-0112	SSX-0112
7000- 7525	10	SSCM-0113	SSX-0113
7500- 8000	10	SSCM-0114	SSX-0114
7975- 8500	10	SSCM-0115	SSX-0115
10630-11230	10	SSCM-0116	SSX-0116
11200-11770	10	SSCM-0117	SSX-0117
11630-12300	10	SSCM-0118	SSX-0118
12130-12700	10	SSCM-0119	SSX-0119
12630-13230	10	SSCM-0120	SSX-0120
13750-14250	10	SSCM-0122	SSX 0129
16000-16500	10	SSCM-0123	SSX-0130

*See option H

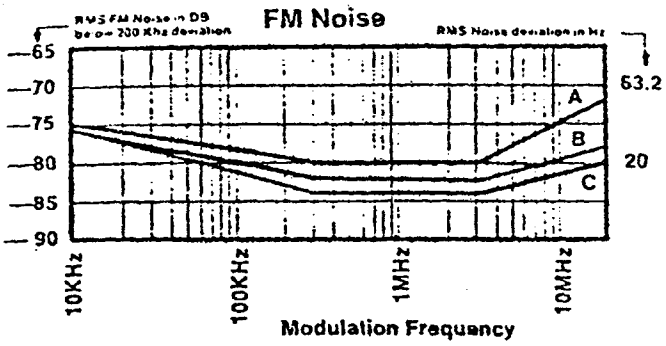
These products represent state of the art performance in high stability tuneable sources. They are typically realized as follows. Models SSC-0100 are Bi-Polar transistor oscillators wherein the frequency determining element is both lumped and distributed in nature. The consequences of this are excellent long and short term frequency stability. Models SSCM-0100 consist of a suitable Model SSC-0100 followed by a harmonic generator. Models SSX-0100 are either of the above integrated with a phase lock system. The loop phase comparator is of a sampling nature, and the reference can either be included or external. All units can be mechanically tuned over the full bandwidth, and as an option can be provided with AFC capability of typically ±0.1% bandwidth. AFC frequency range is typically DC - 10MHz, except for Models SSX-0100, where it is 200 KHz - 10 MHz.

PERFORMANCE DATA

Typical Operating Parameters for SSX series			
	Input voltage	Load	Temp
Freq	——	——	See options
Power	**	2 DB/1.5:1	0.01 DB/°C

Typical Operating Parameters for SSC & SSCM series			
	Input voltage	Load	Temp
Freq	.02% / v.	1% / 1.5:1	.001% /°C
Power	**	2 DB/1.5:1	0.01 DB/°C

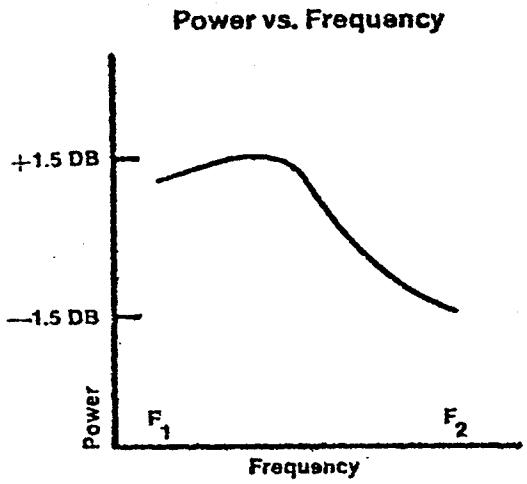
**Power leveling via input voltage change not advised



Maximum permissible demodulated FM noise in any 3 KHz window from 10 KHz to 10 MHz

Curve A — Oscillators at 11630 and above
Curve B — Oscillators between 6800 MHz and 11629 MHz
Curve C — Oscillators below 6800 MHz

Note: These noise limits apply over the ambient temperature range of 10°C to 50°C. Outside this range, but in the range of —30°C to 60°C, the limits are relaxed 2 DB.



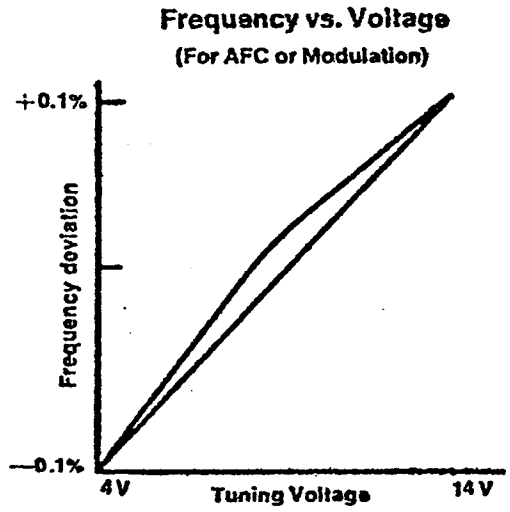
Harmonic Rejection: –30 DBC for freq.<3GHz
–50 DBC for freq.>3 GHz

Discreet Spurious Rejection: —60 DBC

AM Noise: —100 DBC/KHz

Input Power: —20 VDC @ 350 mA Typ For SSX series
—20 VDC @ 125 MA for SSC & SSCM series

Operating Temperature: —30 to 60°C Typ



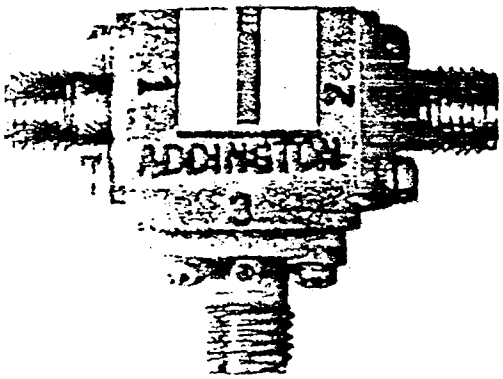
AVAILABLE OPTIONS

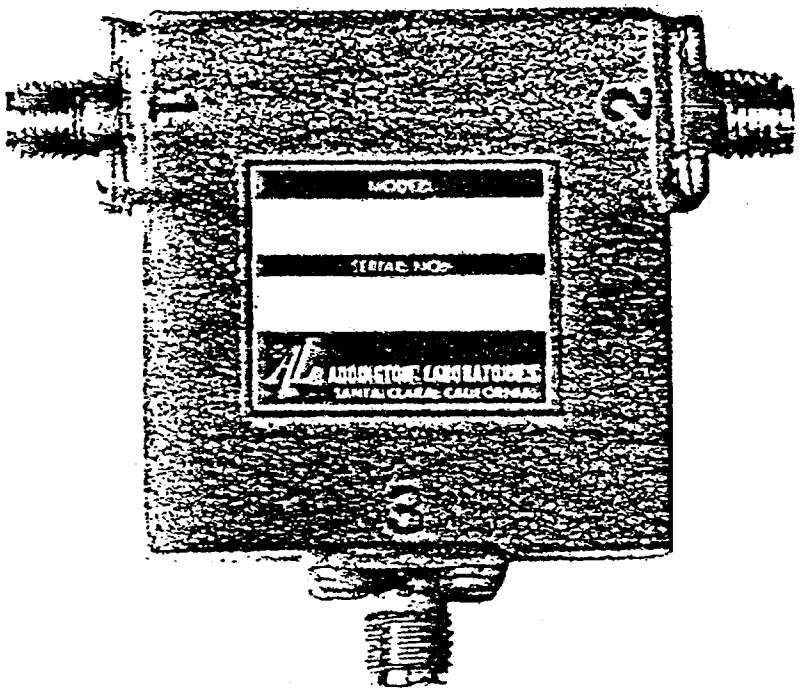
- **A** Separate modulation input with coax connector.
- **B** External reference oscillator input less reference oscillator.
- **C** ±0.005% Stability crystal
- **D** ±0.002% Stability crystal
- **E** ±0.0005% Stability crystal and internal crystal oven.
- **F** Internal crystal oven less crystal (requires crystal to SST specs).
- **H** 50 mW MIN., 25°C, 50 OHM Load
- **LLA** Lock limit alarm
- **W** Waveguide output

SOLID STATE TECHNOLOGY

3650 Charles Street
Santa Clara, California
95050 (408) 247-8620

3 Port Tee Circulators





Circulators listed can also be furnished with any of the following options:

- Special mounting
- Choice of connectors
- High power-peak or average
- Extreme environment
- Y or customized configurations
- Cryogenic temperatures
- Magnetic shielding

Before specifying non-standard devices, it may be helpful to review the notes at the beginning of the catalog. For quick and competent assistance in design or proposal preparation, contact Addington Laboratories' engineering department either directly or through your local representative.

Tee Circulators (Octave Band)

FREQUENCY (GHz) OPERATING	ISOLATION (dB) 2-1	INS. LOSS (dB) 1-2	VSWR (max.) All Ports	SIZE IN INCHES (Approx.) L H W	WEIGHT (ounces) Approx.	MODEL NUMBER (Specify on order)	CONNECTOR (female) All Ports
.500-1.00	17	1.0	1.35	5½ x 1¼ x 5½	50	100100001	N
1.00-2.00	20	0.4	1.25	3 13/32 x 1 x 3½	16	100100004	N
1.20-2.40	20	0.4	1.25	3 13/32 x 1 x 3½	16	100100007	N
2.00-4.00	20	0.4	1.25	1 25/32 x 1 x 2 3/32	10	100100012	3MM
2.60-5.20	20	0.4	1.25	1⅝ x 1 x 1 27/32	8	100100015	3MM
3.00-6.00	20	0.4	1.25	1 7/16 x ⅜ x 1½	5	100100018	3MM
4.00-8.00	20	0.4	1.25	1 5/32 x ⅝ x 1 5/16	3	100100021	3MM
5.00-10.0	20	0.4	1.25	1 x ⅝ x 1 3/16	3	100100024	3MM
8.00-16.0	18	0.5	1.30	⅝ x ⅝ x 13/16	1	100100173	3MM

Sizes and weights given are for "T" configuration. "Y" configuration available on request.

Specify Your Own Band

(Bandwidths to 35% with f_o in the ranges noted)

FREQUENCY (GHz) SPECIFY f_o	ISOLATION (dB) 2-1	INS. LOSS (dB) 1-2	VSWR (max.) All Ports	SIZE IN INCHES (Approx.) L H W	WEIGHT (ounces) Approx.	MODEL NUMBER (See footnote)	CONNECTOR (female) All Ports
.250-.400	20	0.4	1.25	4 19/32 x 1 x 4 11/16	30	1001xxxxx	N
.400-.600	20	0.4	1.25	2½ x 1 x 2½	16	1001xxxxx	N
.600-.900	20	0.4	1.25	2 3/16 x 1 x 2⅜	12	1001xxxxx	N
.900-1.40	20	0.4	1.25	1 17/32 x 1 x 1 17/32	10	1001xxxxx	3MM
1.40-2.00	20	0.4	1.25	2¼ x 1 x 2⅜	12	1001xxxxx	3MM
2.00-3.50	20	0.4	1.25	1 13/16 x 1 x 1 13/16	10	1001xxxxx	3MM
3.50-5.00	20	0.4	1.25	1½ x 1 x 1¾	7	1001xxxxx	3MM
5.00-8.00	20	0.4	1.25	1½ x ⅝ x 1½	4	1001xxxxx	3MM
8.00-12.0	20	0.4	1.25	15/16 x ⅝ x 1 3/32	2	1001xxxxx	3MM
12.0-18.0	18	0.5	1.30	11/16 x ⅝ x 21/32	1	1001xxxxx	3MM

Balance of Model No. will be supplied by factory at time of order.

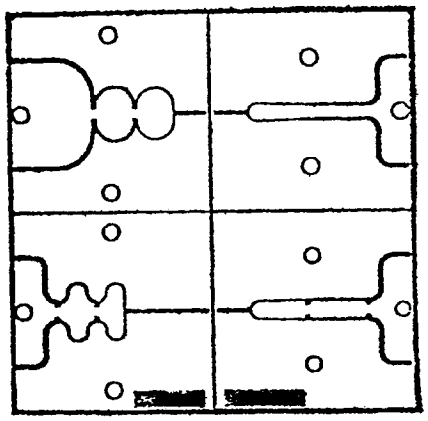
BROADBAND ISOLATED POWER DIVIDERS
MICROSTRIPLINE

These Isolated Power Dividers incorporate two-section impedance transformers for broadband performance, and thin-film chip resistors for high isolation and good power handling capacity. The units are available as substrates with chrome/copper/gold conductor patterns for solder-tab connection to adjacent microstrip circuits, or packaged in a metal housing with type SMA connectors. For phase-coherent signals, these units can be used as isolated power combiners with identical performance. For non-coherent signals, the loss of the two-way unit will increase by 3 dB when used as a combiner.

Frequency GHz	VSWR Input	VSWR Output	Size 2 - Way	Size 4 - Way	Ins. Loss 2 - Way	Model No. 2 - Way	Price 2 - Way
0.8 - 2.0	1.35	1.20	1 x 2	2 x 2	0.3 dB	PD8304-2	$ 85.-
1.0 - 2.5	1.35	1.20	1 x 1.75	2 x 2	0.3 dB	PD8305-2	$ 85.-
1.5 - 3.75	1.35	1.25	1 x 1.5	2 x 1.75	0.4 dB	PD8306-2	$ 90.-
2.0 - 5.4	1.40	1.25	1 x 1	2 x 1	0.5 dB	PD8307-2	$ 90.-
3.0 - 7.8	1.45	1.30	1 x 1	2 x 1	0.5 dB	PD8308-2	$ 90.-

For the corresponding 4-way models, use suffix -4 with model number. Additional price is $ 35.- for the 4-way version.

Amplitude Balance	± 0.3 dB max.
Phase Balance	± 3° max.
Isolation	20 dB min., 30 dB typ.
Insertion Loss, 4-Way	2 x loss of 2-Way
Material	99.5 % Alumina
Conductors	Chrome/Copper/Gold
Input Power Capacity	
Any Load Impedance	2 W CW max. (2-way)
	4 W CW max. (4-way)
For 2:1 max. Mismatch	10 W CW max. (2-way)
	20 W CW max. (4-way)



For the packaged configuration with type SMA (female) connectors, use suffix " M " with model number. Additional price is $ 50.- for the 2-way models, $ 75.- for the 4-way units.

Other frequency ranges, bandwidths and connector configurations as well as 8-way dividers are available on special order.

VECTRONICS MICROWAVE CORPORATION

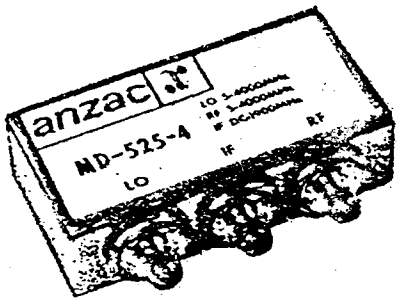
276 LINCOLN BOULEVARD • MIDDLESEX, NEW JERSEY 08846 • (201) 356-2377

New Brunswick FTS 201 846 4500

Data Sheet PD8300, 6/71

WIDEBAND DOUBLE BALANCED MIXER

5 MHz - 4 GHz
DC - 1.9GHz (IFPort)



FEATURES

- Wideband — 5 MHz - 4 GHz
- +10 dbm Typ. Third Order Intercept Point
- DC (IF) Port
- Standard Connectors: TNC, SMA

GUARANTEED SPECIFICATIONS

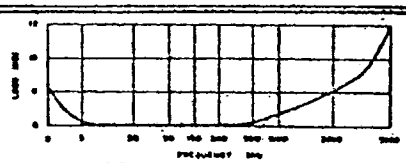
Frequency Range:			
L (LO) Port	5 MHz - 4 GHz		
R (RF) Port	5 MHz - 4 GHz		
X (IF) Port	DC - 1.9 GHz		
Conversion Loss:			
5 MHz - 3 GHz	9.0 db Max.		
3 GHz - 4 GHz	10.0 db Max.		
Isolation (db Min.):	L-R	L-X	R-X
5-50 MHz	20	20	20
50 MHz - 2 GHz	25	30	30
2 GHz - 4 GHz	20	25	20
LO Power Required:	+10 to +13 dbm (all specifications guaranteed with +10 dbm LO)		
Input Power Total:	400 mW Max. @ +25°C (derate linearly to +125°C @ 3.2 mW/°C		
X Port Input Current:	50 ma Max.		
Operating Temperature Range:	-54°C to +85°C		
D.C. Polarity:	Positive — with two in-phase signals applied to LO and RF Ports		
Impedance:	50 ohms (all ports)		

TYPICAL PERFORMANCE

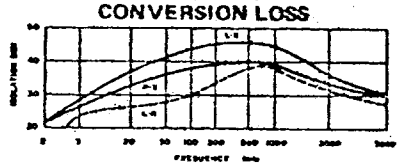
Noise Figure:	Within 1 db of Conversion Loss
1 db Compression Point:	+6 dbm (with +10 dbm LO)
1 db Desensitization Level:	+3 dbm (with +10 dbm LO)
Two-Tone IM Ratio - 3rd Order with two -10 dbm signals:	-55 db (with +10 dbm LO)

NOTES:

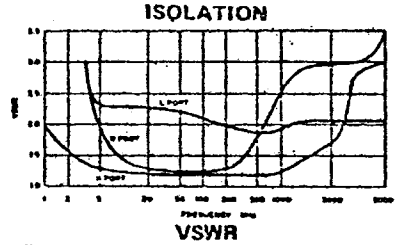
1. Conversion Loss specified with IF frequencies from 10 MHz to 1 GHz.
2. IF Port response is down 3.5 db at DC, and down 3 db at 1.9 GHz (see curve).



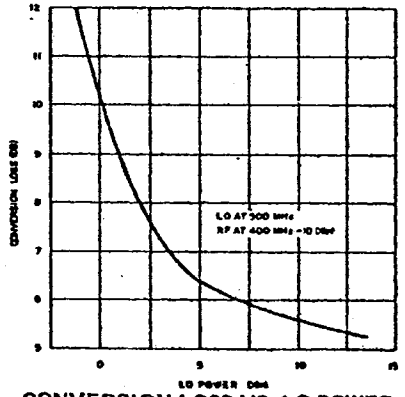
CONVERSION LOSS



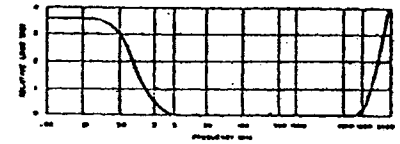
ISOLATION



VSWR



CONVERSION LOSS VS. LO POWER



IF PORT RESPONSE

TYPICAL PERFORMANCE

DESCRIPTION

The Model MD-525 is a high level double balanced mixer having a wide frequency range of 5 MHz to 4 GHz at the LO and RF Ports, and DC-1.9 GHz at the IF Port.

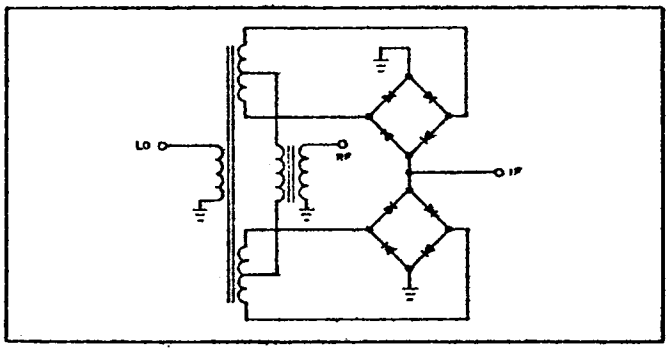
Among the many outstanding features of this device is its +10 dbm third order intercept point with +10 dbm LO.

ENVIRONMENTAL

This Device Has Been Designed to Meet the Following Environmental and Physical Conditions of MIL-STD-202.

Thermal Shock:	Method 107, Test Condition A -55°C to +85°C, 30 minutes at temperature extremes, 5 cycles
Humidity:	Method 103, Test Condition B (96 hours)
Barometric Pressure:	Method 105, Test Condition D 100,000 feet
Moisture Resistance:	Method 106
Life Test:	Method 108, Test Condition B (250 hours)
Vibration:	Method 204, Test Condition B 10-2,000 Hz, 15 G peak
High Impact Shock:	Method 207

SCHEMATIC

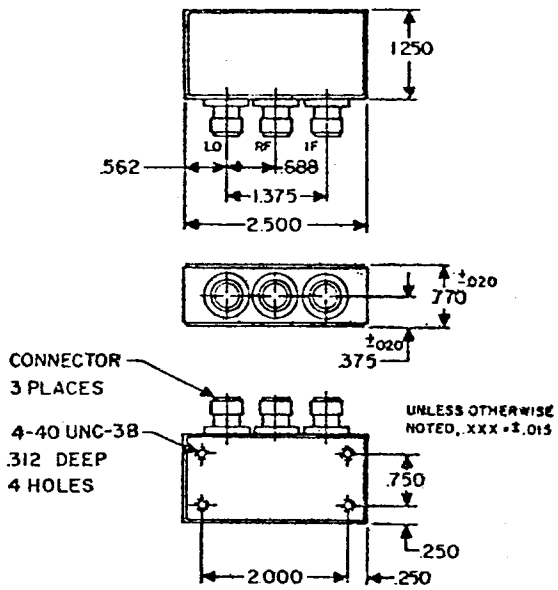


ORDERING INFORMATION

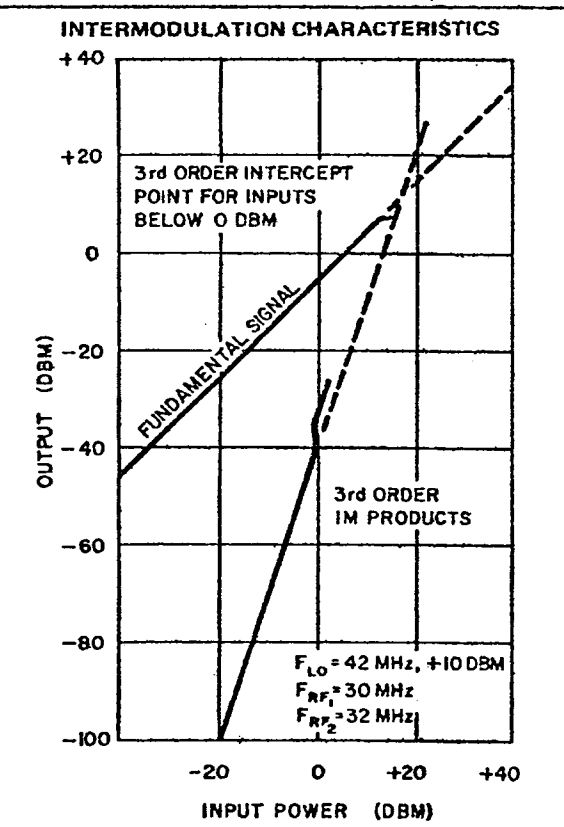
Please specify Model No. and Connector Type when ordering.

Model MD-525:	$175.00 (1-5 Qty.)
Connector Types:	TNC or SMA Standard. Type BNC available on special order $190.00)
Availability:	Stock
Terms:	Net 30, f.o.b. factory

MECHANICAL DATA



Mounting Area.	3.13 sq. in.	20 sq. cm.
Volume:	2.35 cu. in.	38 cu cm.
Weight (approx.)	3 ounces	85 grams



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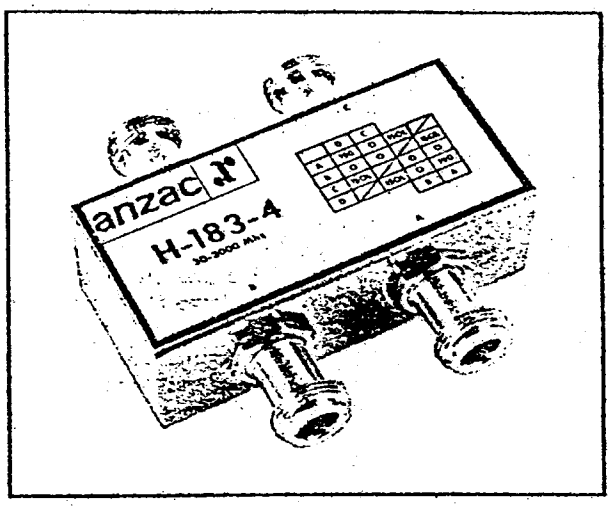
BROADBAND MICROWAVE HYBRID JUNCTION

30 MHz—3 GHz

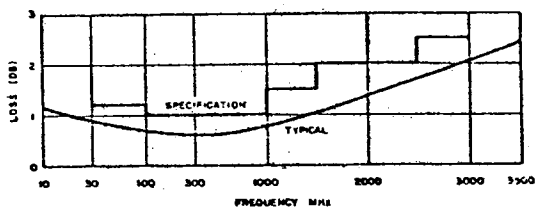


FEATURES

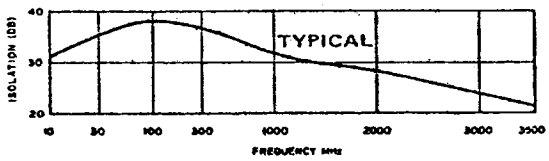
- 7-Octave Coverage — 30 MHz - 3 GHz
- Useful from 10 MHz to 3.5 GHz
- Excellent Isolation
- Rugged Construction for Severe Environment
- Standard Connectors: TNC, SMA or N

GUARANTEED SPECIFICATIONS

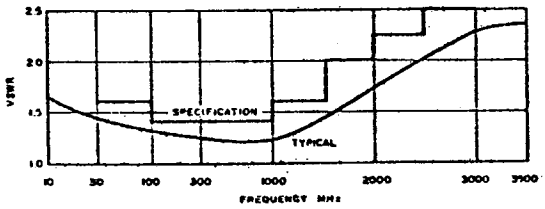
Frequency Range:	30 MHz - 3 GHz
Insertion Loss:	
30-100 MHz	1.2 db Max.
100 MHz - 1 GHz	1.0 db Max.
1-1.5 GHz	1.5 db Max.
1.5-2.5 GHz	2.0 db Max.
2.5-3 GHz	2.5 db Max.
Isolation:	
30 MHz - 1 GHz	25 db Min.
1-3 GHz	20 db Min.
VSWR (All Ports):	
30 MHz - 1.5 GHz	1.6 : 1 Max.
100 MHz - 1 GHz	1.4 : 1 Max.
1.5-2 GHz	2.0 : 1 Max.
2-2.5 GHz	2.25 : 1 Max.
2.5-3 GHz	2.5 : 1 Max.
Impedance:	50 ohms
Amplitude Balance (A to C or D, and B to C or D):	0.4 db Max.
Phase Unbalance:	
30 MHz - 1 GHz	5° Max.
1 GHz - 3 GHz	5°/GHz
Input Power:	5 Watts Max.



LOSS



ISOLATION



VSWR

ENVIRONMENTAL

This Device Has Been Designed to Meet the Following Environmental and Physical Conditions of MIL-STD-202.

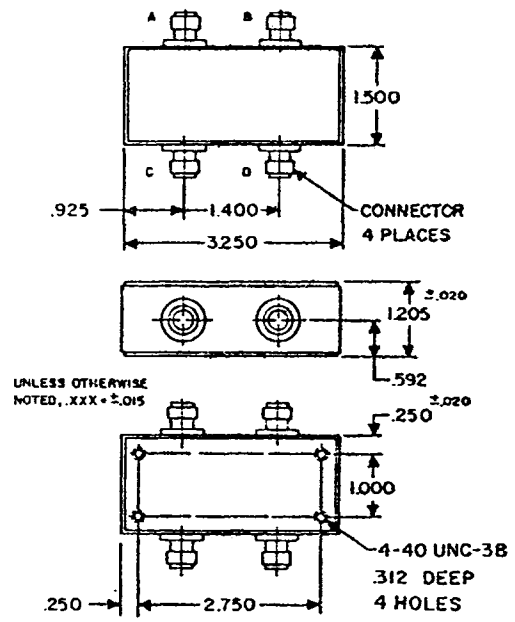
Thermal Shock:	Method 107, Test Condition A -55°C to +85°C, 30 minutes at temperature extremes, 5 cycles
Humidity:	Method 103, Test Condition B (96 hours)
Barometric Pressure:	Method 105, Test Condition D 100,000 feet
Moisture Resistance:	Method 106
Life Test:	Method 108, Test Condition B (250 hours)
Vibration:	Method 204, Test Condition B 10-2,000 Hz, 15 G peak
High Impact Shock:	Method 207

DESCRIPTION

Anzac's Model H-183 is a 4-port hybrid junction which combines excellent operating characteristics from the HF portion of the spectrum into the S-band portion with small size and light weight. Signals fed into any port appear as equal outputs at the opposite port pair. The phase difference between outputs is 0° if the input port is B or C, and 180° if the input port is A or D. So long as the loads on the output ports are equal, but not necessarily at the characteristic impedance of the device, the adjacent port is isolated from the input.

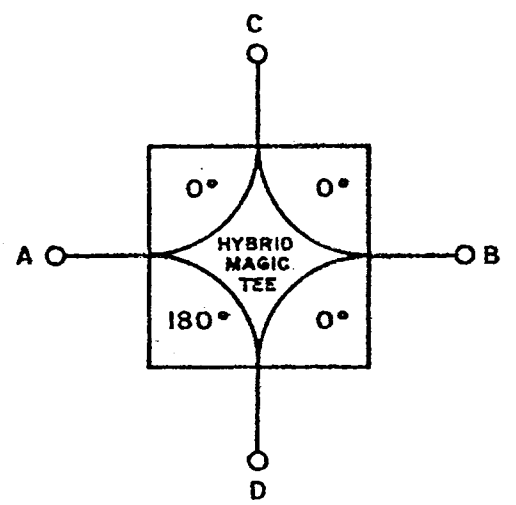
If two signals are simultaneously applied to either port pair, the vector sum will appear at one of the opposite ports and the vector difference at the other.

MECHANICAL DATA



Mounting Area:	4.88 sq. in.	31.5 sq. cm.
Volume:	5.85 cu. in.	.96 cu. cm.
Weight (approx.)	7 ounces	200 grams

SCHEMATIC



APPLICATIONS

- Antenna beamforming networks
- Antenna feed structures
- Isolated signal splitters
- Monopulse comparators
- Balanced mixers and modulators
- Phase or amplitude comparators
- Multiplexers
- Power dividers and summers
- Frequency discriminators
- Reflectometers

ORDERING INFORMATION

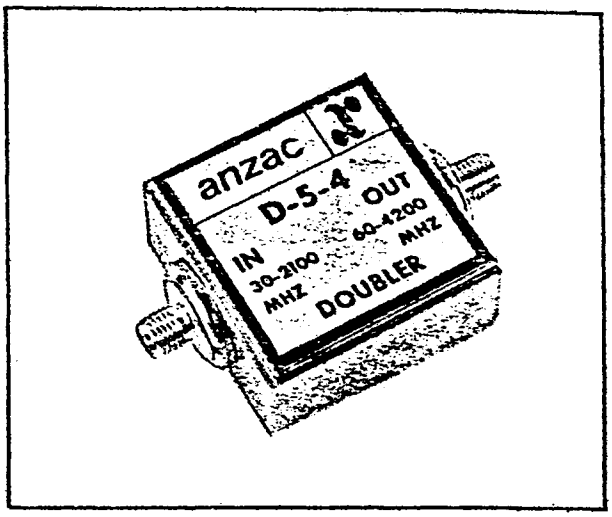
Please specify Model No. and Connector Type when ordering.

Model H-183:	$250.00 (1-5 Qty.)
Connector Types:	TNC, SMA or N Standard
Availability:	Stock
Terms:	Net 30, f.o.b. factory

Printed in U.S.A.

anzac ELECTRONICS
Division of Adams-Russell
39 Green Street, Waltham, Massachusetts 02154 • (617) 899-1900 • TWX 710-324-6484

UHF BROADBAND FREQUENCY DOUBLERS



100 MHz—2.6 GHz OUTPUT (D-6-4)
60 MHz—4.2 GHz OUTPUT (D-5-4)

FEATURES

- Conversion Loss 13 db Max.
- Untuned
- Meets MIL Environments
- Low Spurious Noise
- Standard Connectors: BNC, TNC or SMA

GUARANTEED SPECIFICATIONS

	D-6-4		D-5-4	
Input Frequency Range:	50 MHz - 1.3 GHz		30 MHz - 2.1 GHz	
Output Frequency Range:	100 MHz - 2.6 GHz		60 MHz - 4.2 GHz	
Conversion Loss:	13 db Max. @ 20 mw input		13 db Max. @ 30 mw input	
Spurious (referred to Output F_2):	OUTPUT FREQUENCY (MHz)			
	100-1000	1000-2600	60-1000	1000-4200
F_1	-25 db	-15 db	-25 db	-15 db
F_3	-30 db	-20 db	-30 db	-20 db
F_4	-12 db	-12 db	-12 db	-20 db

TYPICAL PERFORMANCE

	D-6-4	D-5-4
Input VSWR:	1.8 : 1	1.5 : 1 (30 MHz - 1 GHz) 1.8 : 1 (1-2.1 GHz)
Input/Output Impedance:	50 ohms	50 ohms
Input Power (Loss increased 2 db @ mw and 100 ms):	20 mw Nom.	30 mw Nom.
Input Power:	1 Watt	1 Watt
Operating Temperature Range (0.5 db Max. Loss Variation):	-55°C to +85°C (Both models)	

DESCRIPTION

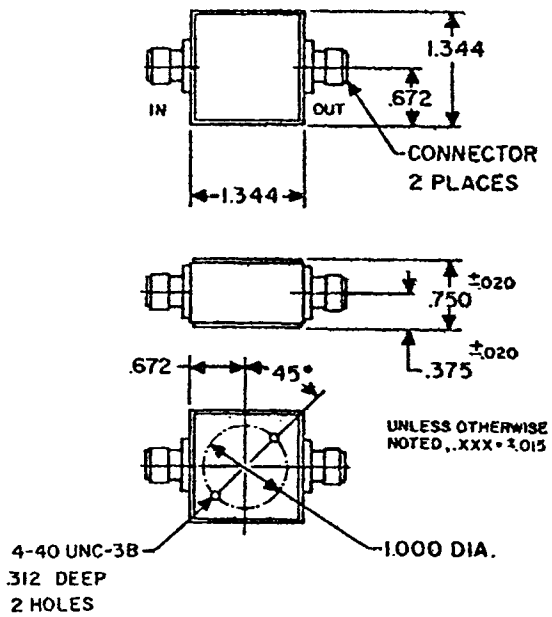
These doublers are small, low noise, untuned devices used to double any frequency in the 30-2100 MHz frequency range with minimum spurious generation.

ENVIRONMENTAL

These Devices Have Been Designed to Meet the Following Environmental and Physical Conditions of MIL-STD-202.

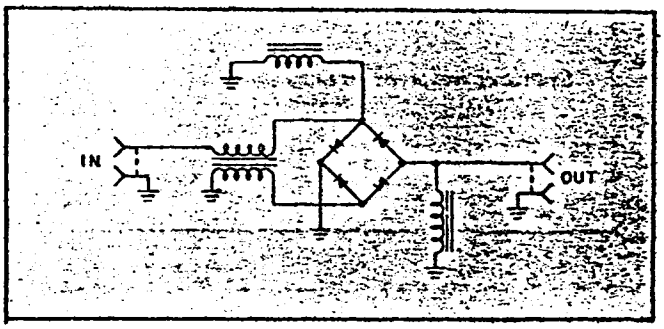
Thermal Shock:	Method 107, Test Condition A -55°C to +85°C, 30 minutes at temperature extremes, 5 cycles
Humidity:	Method 103, Test Condition B (96 hours)
Barometric Pressure:	Method 105, Test Condition D 100,000 feet
Moisture Resistance:	Method 106
Life Test:	Method 108, Test Condition B (250 hours)
Vibration:	Method 204, Test Condition B 10-2,000 Hz, 15 G peak
High Impact Shock:	Method 207

MECHANICAL DATA



Mounting Area:	1.9 sq. in.	12 sq. cm.
Volume:	1.4 cu. in.	23 cu. cm.
Weight (approx.)	1.8 ounces	50 grams

SCHEMATIC



ORDERING INFORMATION

Please specify Model No. and Connector Type when ordering.

Model	Price (1-5 Qty.)	Connector Types	Availability
D-6-4	$ 75.00	BNC, TNC, SMA	Stock
D-5-4	$150.00	BNC, TNC, SMA	Stock

Terms: Net 30, f.o.b. factory

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Division of Adams-Russell
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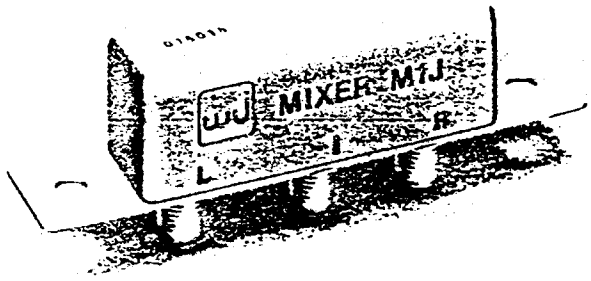
WJ-M1J

DOUBLE-BALANCED MIXER

LO, RF	300 TO 2000 MHz
IF	DC TO 1000 MHz

- HIGH ISOLATION: >50 dB (TYP.)
- LOW NOISE FIGURE: 6 dB (TYP.)
- HERMETICALLY SEALED



Guaranteed Specifications*

Characteristics	Min.	Max.	Test Conditions
SSB Conversion Loss			f_L & f_R 1000 to 1800 MHz
		7.0 dB	f_I DC to 200 MHz
		8.5 dB	f_I 200 to 1000 MHz
			f_L & f_R 300 to 2000 MHz
		8.0 dB	f_I DC to 200 MHz
		9.0 dB	f_I 200 to 1000 MHz
SSB Noise Figure			f_L & f_R 1000 to 1800 MHz
		7.0 dB	f_I 10 to 200 MHz
		8.5 dB	f_I 200 to 1000 MHz
			f_L & f_R 300 to 2000 MHz
		8.0 dB	f_I 10 to 200 MHz
		9.0 dB	f_I 200 to 1000 MHz
Isolation			
L to R	40 dB		f_L 300 to 1000 MHz
L to I	25 dB		
R to I	20 dB		f_R 300 to 1000 MHz
L to R	35 dB		f_L 1000 to 2000 Mhz
L to I	25 dB		
R to I	20 dB		f_R 1000 to 2000 MHz
Conversion Compression		1.0 db	f_R level = 0 dBm
Desensitization Level		1.0 dB	f_{R2} level = −2 dBm

*Measured in a 50-ohm system with f_L at +7 dBm.

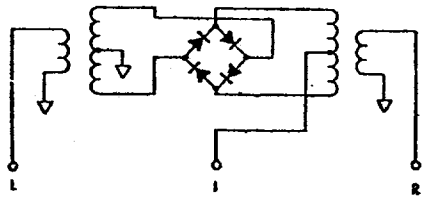
Weight 31 grams (1.1 oz.) maximum

Connectors SMA Female

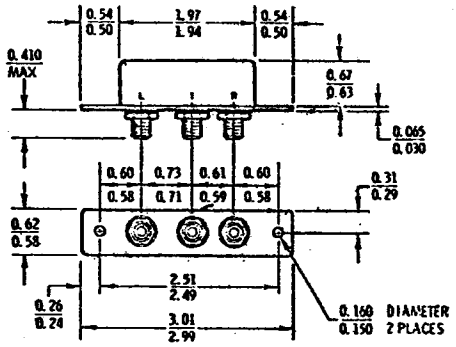
Absolute Maximum Ratings

Storage
Temperature .....−65°C to +100°C
Operating
Temperature .....−54°C to +100°C
Peak Input
Power .....400 mW max. at 25°C
Derate to 50 mW at 100°C (4.67 mW/°C)
Peak Input Current .....50 mA

Schematic Diagram

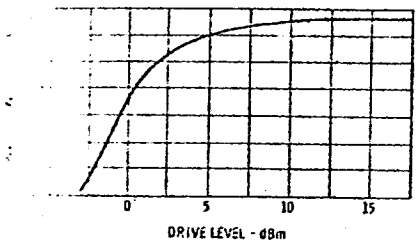


Outline Drawing

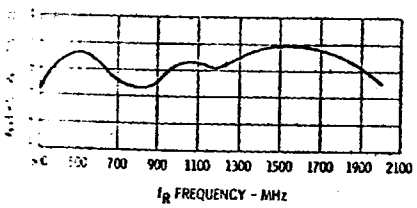


NOTE: DIMENSIONS ARE IN INCHES.

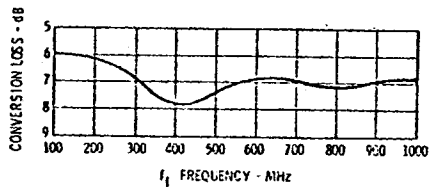
Typical Performance at 25°C



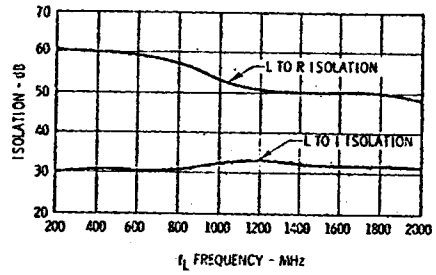
Drive Level: The minimum recommended drive level is +4 dBm. The maximum recommended drive level is −13 dBm.



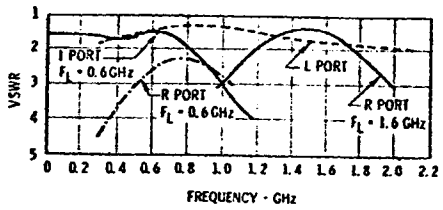
Conversion Loss vs. Input Frequency: Conversion loss of the mixer when used in a SSB system. The frequency ordinate refers to the R-port (f_R) with f_I at 150 MHz. Data plotted with an f_L level of +7 dBm.



Conversion Loss vs. f_I Frequency: Conversion loss of the mixer when used in a SSB system. The frequency ordinate refers to the I-port (f_I) with f_R at 1200 MHz and f_L swept from 200 to 1100 MHz.



Isolation vs. Frequency: Level of the f_L signal fed through to the R- and I-ports with respect to the level of the f_L signal at the L-port.



VSWR vs. Frequency: VSWR of the L-, I- and R-ports in a 50-ohm system with f_L at +7 dBm. Some variation in the R-port VSWR will occur as a function of the L-port frequency. Curves for the R-port VSWR are plotted for L-port frequencies of 0.6 and 1.6 GHz. Also shown are the L-port VSWR and the I-port VSWR with f_L at 0.6 GHz.

Harmonics of f_R					
$5f_R$	>71	>71	>71	>71	>71	>71
$4f_R$	>71	>71	>71	>71	>71	>71
$3f_R$	>71	>71	>71	>71	>71	>71
$2f_R$	>71	>71	>71	>71	>71	>71
f_R	71	53	63	56	71	51
	>71	63	67	61	>71	63
	61	50	65	50	67	66
	63	55	64	64	70	65
	28	0	40	12	41	26
	29	0	41	10	42	19
	—	7	43	29	54	30
	—	3	36	27	54	29
	f_L	$2f_L$	$3f_L$	$4f_L$	$5f_L$

Harmonics of f_L

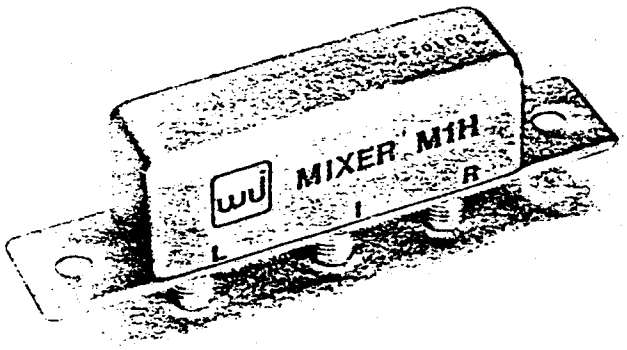
Harmonic Intermodulation Products: Intermodulation signals which result from the mixing of mixer generated harmonics of the input signal are shown above. Mixing product suppression is indicated by the number of dB below the desired output level, f_R-f_L. Products are for the difference frequencies nf_L-mf_R and mf_R-nf_L. The performance was measured with f_R at 300 MHz, −10 dBm; f_L = 299 MHz, +7 dBm for light area and +13 dBm for shaded area.

WJ-M1H

DOUBLE-BALANCED MIXER

LO, RF } 1.8 TO 6.2 GHz
IF DC TO 2 GHz

- HIGH ISOLATION: >35 dB (TYP.)
- LOW NOISE FIGURE: <6.0 dB (TYP.)
- LOW COST



Guaranteed Specifications*

Characteristics	Min.	Max.	Test Conditions
Conversion Loss		7.0 dB	f_L & f_R 1.8 to 4.2 GHz f_I DC to 2 GHz
			f_L & f_R 4.2 to 6.2 GHz
		8.0 dB	f_I DC to 500 MHz
		9.0 dB	f_I 500 MHz to 2 GHz
Noise Figure		7.0 dB	f_L & f_R 1.8 to 4.2 GHz f_I 30 MHz to 2 GHz
			f_L & f_R 4.2 to 6.2 GHz
		8.0 dB	f_I 30 MHz to 500 MHz
		9.0 dB	f_I 500 MHz to 2 GHz
Isolation			
f_L at R	25 dB		f_L 1.8 to 4.2 GHz
f_L at I	15 dB		
f_L at R	20 dB		f_L 4.2 to 6.2 GHz
f_L at I	15 dB		
Mixer Compression		1.0 dB	f_R = −2 dBm f_L at +13 dBm

*Measured in a 50-ohm system, f_L at +7 dBm.

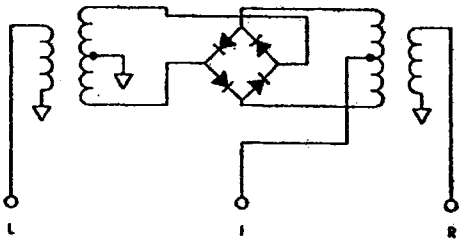
Weight 31 grams (1.1 oz.) maximum

Connectors SMA Female

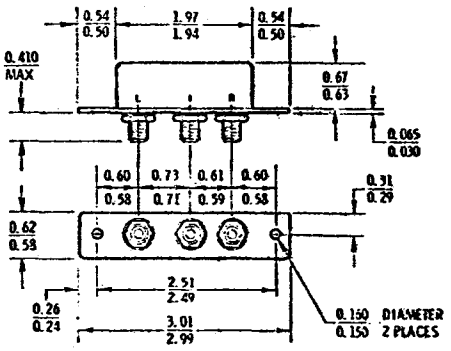
Absolute Maximum Ratings

Storage
Temperature .....−65°C to +100°C
Operating
Temperature .....−54°C to +100°C
Maximum Input Power .....50 mW peak
Maximum Input Current ....50 mA peak

Schematic Diagram

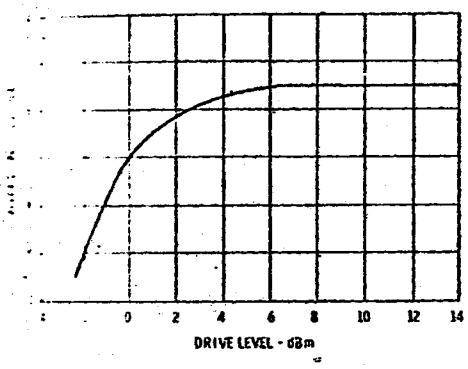


Outline Drawing

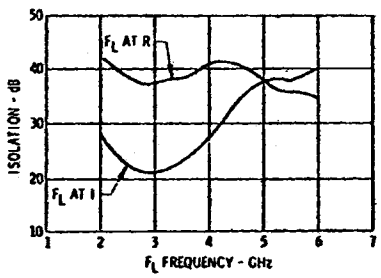


NOTE: DIMENSIONS ARE IN INCHES.

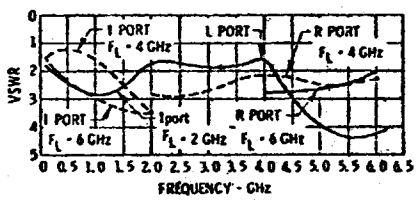
Typical Performance at 25°C



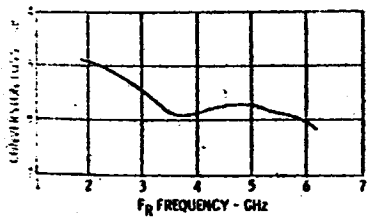
Conversion Loss vs. Drive Level: Conversion loss in a SSB system is a function of drive level (f_L) with f_L and f_R at approximately 3 GHz and f_R level at −6 dBm.



Isolation vs. Frequency: Level of the f_L signal fed through to the R- and I-ports with respect to the level of the f_L signal at the L-port.



VSWR vs. Frequency: VSWR of the L-, I- and R-ports in a 50 ohm system. Some variation in the R-port VSWR will occur as a function of the L-port frequency as shown above. Curves for R-port VSWR are plotted for L-port frequencies of 4 GHz and 6 GHz. A plot of I-port VSWR is also shown with f_L at 2 GHz, 4 GHz and 5 GHz.



Conversion Loss and Noise Figure vs. Input Frequency: The frequency ordinate refers to the f_L and f_R inputs with a f_I frequency of 500 MHz for conversion loss and a f_I frequency of 30 MHz for noise figure.

WATKINS - JOHNSON COMPANY

3333 Hillview Avenue Stanford Industrial Park Palo Alto, California 94304 (415) 493-4141 TWX 910-373-1253

October 18, 1977

Mr. D.S. Bagri
NRAO
Post Office Box O
Socorro, New Mexico 87801

Reference: M1H Intermod data

Dear Mr. Bagri,

The M1H mixer and the M5H mixer are very similar, the primary difference being their packages. The M5H has typical intermod data listed in the catalog.

I hope the data answers your questions.

Regards,

WATKINS-JOHNSON COMPANY

John Follett
Applications Engineer
Relcom Department

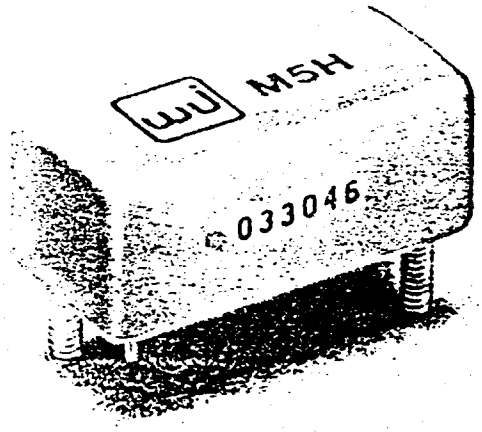
JFF/lmj

WJ-M5H

DOUBLE-BALANCED MIXER

LO, RF } 1.8 TO 6.2 GHz
IF DC TO 2 GHz

- LOW NOISE FIGURE: 5.8 dB (TYP.)
- HIGH ISOLATION: 35 dB (TYP.)
- HERMETICALLY SEALED



Guaranteed Specifications*

Characteristics	Min.	Max.	Test Conditions
SSB Conversion Loss		7.5 dB	f_L & f_R 2.0 to 4.2 GHz, f_I DC to 2 GHz
		8.0 dB	f_L & f_R 4.2 to 6.2 GHz, f_I DC to 0.5 GHz
		8.5 dB	f_L & f_R 1.8 to 6.2 GHz, f_I DC to 2 GHz
SSB Noise Figure		7.5 dB	f_L & f_R 2.0 to 4.2 GHz, f_I 0.03 to 2 GHz
		8.0 dB	f_L & f_R 4.2 to 6.2 GHz, f_I 0.03 to 0.5 GHz
		8.5 dB	f_L & f_R 1.8 to 6.2 GHz, f_I 0.03 to 2 GHz
Isolation			
f_L at R	25 dB		f_L 1.8 to 6.2 GHz
f_L at I	20 dB		
Conversion Compression		1.0 dB	f_R at 0 dBm, f_L at +7 dBm
Desensitization Level		1.0 dB	f_{R2} at −2 dBm, f_L at +7 dBm

*Measured in a 50-ohm system with f_L at +7 dBm.

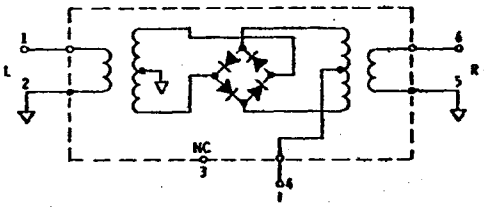
Weight

7 grams (0.247 oz.) maximum

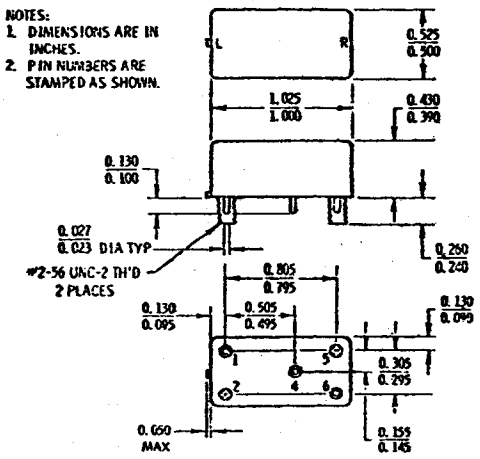
Absolute Maximum Ratings

Operating Temperature .....−54°C to +100°
Storage Temperature .....−65°C to +100°C
Maximum Peak Input Power .....50 mW
Maximum Peak Input Current ....50 mA
Maximum Pin Temperature ...260°C for 10 sec.

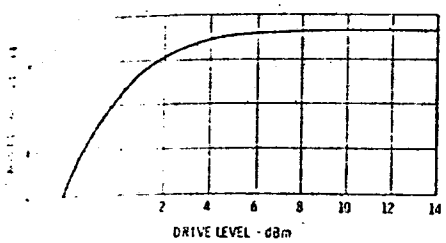
Schematic Diagram



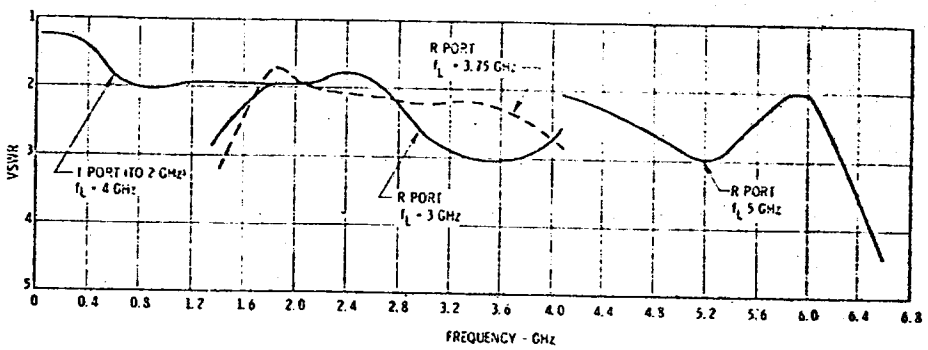
Outline Drawing



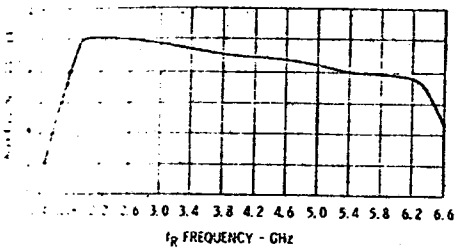
Typical Performance at 25°C



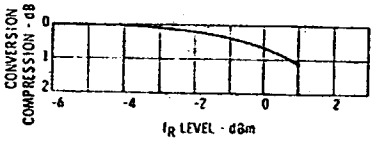
Drive Level: The minimum recom- [illegible] drive level is +4 dBm. [illegible] maximum recommended drive [illegible] +13 dBm.



VSWR vs. Frequency: VSWR of the R- and I-ports in a 50-ohm system with f_L at +7 dBm. Some variation in the R-port VSWR will occur as a function of the L-port frequency. Curves for the R-port VSWR are plotted for L-port frequencies of 3, 3.75 and 5 GHz. Also shown is the I-port VSWR with f_L at 4 GHz.



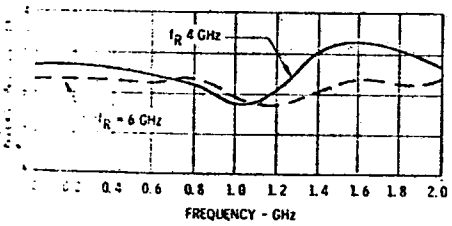
Conversion Loss vs. Input Frequency: Conversion loss of the mixer when used in [illegible] SSB system. The frequency ordinate [illegible] to the R-port (f_R) with f_I at 200 MHz. [illegible] plotted with an f_L level of +7 dBm.



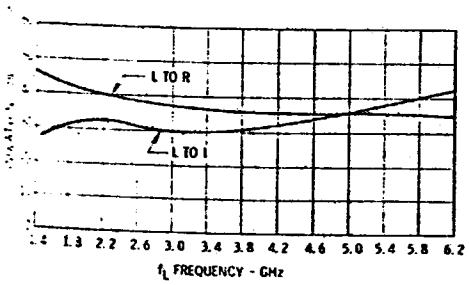
Conversion Compression vs. f_R Drive Level: Conversion compression of the mixer in a 50-ohm system with f_L at +7 dBm.

			$5f_R$	71	56
		$4f_R$	62	65	64
	$3f_R$	63	60	48	$5f_L$
$2f_R$	33	56	46	$4f_L$	
f_R	0	21	$3f_L$		
	f_L	$2f_L$			

Harmonic Intermodulation Products: Intermodulation signals which result from the mixing of mixer generated harmonics of the input signals are shown above. Mixing product suppression is indicated by the number of dB below the desired output level. The performance was measured with f_L and f_R 2 to 4 GHz, f_I 100 to 600 MHz, f_R at −10 dBm and f_L at +7 dBm.

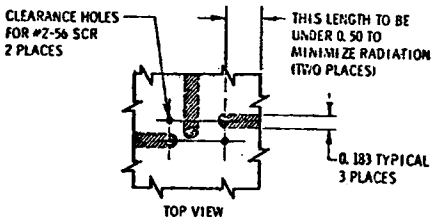


Conversion Loss vs. f_I Frequency: Conversion loss of the mixer when used in a SSB system. The frequency ordinate refers to the I-port (f_I). Curves are shown for [illegible] at 4 GHz with f_L swept from 2 to 4 GHz and f_R at 6 GHz with f_L swept from 4 to 6 GHz.



Isolation vs. Frequency: Level of the f_L signal fed through to the R- and I-ports with respect to the level of the f_L signal at the L-port.

Recommended Mounting Procedure



NOTE:

1. CROSS HATCHED AREA EQUALS COPPER TRACE ON FAR SIDE.
2. BOARD MATERIAL - 3M COMPANY K6098 1/16" THICK.
3. DIMENSIONS ARE IN INCHES.

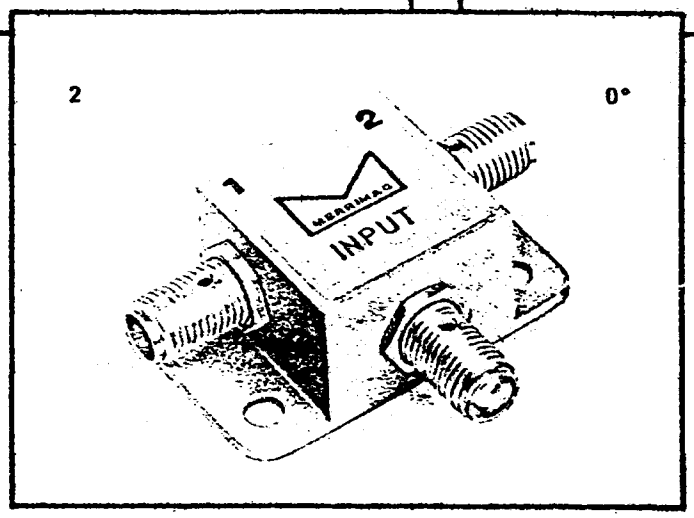
Model Number	Frequency Range MHz		Small Signal Gain dB			Gain Flatness ±dB		Noise Figure dB			Power Output• At 1 dB Compression dBm			Intercept Point dBm	VSWR In/Out		D.C.		U.S. Price Each $1-9
			TYP	Min 0/50C	Min −54/85C	Max 0/50C	Max −54/85C	Typ	Max 0/50C	Max −54/85C	Typ	Min 0/50C	Min −54/85C	Typ	Max 0/50C	Max −54/85C	Volts Nom	MA Typ	
A71	5	200	18.0	16.5	16.0	1.0	1.0	2.1	2.5	2.8	−2.5	−3.0	−3.5	10.0	2.0	2.0	15	9	85
A75-2	5	250	21.5	20.0*	19.0	0.7	1.0	3.8	4.5	5.0	9.0	7.0	7.0	21.0	1.7	2.0	15	24	85
A74-1	5	250	31.0	30.0*	29.0	0.7	1.0	4.0	5.0	5.5	9.0	7.0	7.0	21.0	1.7	2.0	15	40	110
A79	5	250	13.8	13.0	12.5	0.7	1.0	5.5	6.5	7.0	22.0	20.0	19.5	39.0	2.0	2.0	15	88	85
A51	10	400	15.0	14.0	13.0	0.7	1.0	2.7	3.0	3.5	−3.0	−3.5	−3.5	10.0	1.7	2.0	15	6	55
A54	5	400	27.5	26.0	24.0	1.0	1.0	4.5	5.5	6.0	8.0	6.5	5.5	19.0	2.0	2.0	15	34	59
A1	5	500	16.0	15.0	14.5	0.7	1.0	2.5	3.0	3.5	−1.0	−2.0	−3.0	11.0	2.0	2.0	15	9	75
A53	10	400	15.0	14.0	13.5	1.0	1.0	3.0	3.5*	4.0	3.5	2.0	1.5	16.0	2.0	2.0	15	12	59
A3	5	500	15.5	14.0	13.0	0.7	1.0	3.3	4.0	4.5	−1.0	−2.0	−3.0	11.0	1.7	2.0	15	9	65
A4‡	5	500	15.5	14.0	13.0	0.7	1.0	3.3	4.0	4.5	−1.0	−2.0	−3.0	11.0	1.7	2.0	15	9	109
A73	5	500	32.0	30.0	29.0	0.7	1.0	3.5	4.0	4.5	3.5	2.0	2.0	15.0	1.8	2.0	15	18	120
A74-2	5	500	26.0	25.0	24.0	1.0	1.2	3.8	4.3	4.8	−1.0	−2.0	−2.0	10.0	2.0	2.0	5	13	122
A5-5	5	500	15.5	14.0	13.5	0.5	0.7	4.0	5.0	5.5	9.0	7.0	7.0	21.0	1.5	1.6	15	24	70
A5	5	500	14.8	14.0	13.5	0.7	0.7	4.5	5.5	6.0	9.0	7.0	7.0	22.0	2.0	2.0	15	25	65
A6‡	5	500	14.8	14.0	13.5	0.7	0.7	4.5	5.5	6.0	9.0	7.0	7.0	22.0	2.0	2.0	15	25	99
A74	5	500	30.0	28.0	27.0	0.7	1.0	4.7	5.5	6.0	8.5	7.0	7.0	20.0	1.8	2.0	15	40	110
A76	5	500	29.0	27.0	26.0	1.0	1.0	4.7	5.5	6.0	15.0	14.0	13.5	28.0	2.0	2.0	15	62	130
A77	5	500	16.5	16.0*	15.0	0.7	1.0	4.5	6.0†	6.5†	16.5	15.0	14.5	30.0	1.7	2.0	15	50	90
A55	10	400	14.7	14.0	13.5	1.0	1.0	5.0	6.0	6.5	11.0	9.0	8.0	24.0	2.0	2.0	15	30	45
A58	5	500	11.0	10.0	9.5	0.7	1.0	5.0	6.0	6.5	19.0	18.0	17.5	35.0	2.0	2.0	15	65	85
A59	5	500	11.0	10.0	9.5	0.7	1.0	5.5	6.5	7.0	22.0	20.0	20.0	38.0	2.0	2.0	15	68	85
A7 **	5	500	14.9	14.0	13.5	0.7	1.0	5.5	6.5	6.5	14.0	13.0	12.5	26.0	2.0	2.0	24	43	70
A8 **‡	5	500	14.9	14.0	13.5	0.7	1.0	5.5	6.5	6.5	14.0	13.0	12.5	26.0	2.0	2.0	24	43	109
A9 **	5	500	11.0	10.0	9.5	1.0	1.0	8.0	10.0	10.5	22.0	20.0	20.0	35.0	2.0	2.0	24	110	75
A5-6	5	600	16.5	15.0	14.5	0.7	0.7	4.5	5.5	6.0	9.0	7.0	7.0	21.0	2.0	2.0	15	24	70
A77-1	5	600	15.5	15.0	14.5	0.7	1.0	5.0	6.5†	7.0†	16.5	15.0	14.5	30.0	2.0	2.0	15	50	100
A59-1	10	700	10.5	9.5	9.0	1.0	1.0	6.0	7.5	8.0	22.0	20.0	19.5	36.0	2.0	2.0	15	88	95
A18	10	800	14.7	14.0	13.5	0.7	1.0	5.0	6.5	7.0	15.0	14.0	13.5	29.0	2.0	2.0	15	43	100
A11-1	5	1000	14.7	14.0	13.5	1.0	1.2	3.1	3.5	4.0	−2.0	−3.0	−4.0	10.0	2.0	2.0	15	9	115
A11	5	1000	14.7	14.0	13.5	1.0	1.2	3.6	4.0	4.5	−2.0	−3.0	−4.0	10.0	2.0	2.0	15	9	100
A63	5	1000	16.0	15.0	14.5	1.0	1.0	4.0	5.0	5.5	4.0	2.0	2.0	15.0	2.0	2.0	15	14	95
A13	5	1000	14.7	14.0	13.5	1.0	1.2	4.3	5.0	5.5	−2.0	−3.0	−4.0	10.0	2.0	2.0	15	9	88
A15	5	1000	14.5	14.0	13.0	1.0	1.2	5.4	6.5	7.0	8.7	7.0	6.5	21.0	2.0	2.0	15	24	85
A17	10	1000	12.0	10.5	10.0	0.7	1.0	6.1	7.5	8.0	15.3	14.0	13.5	29.0	1.8	2.0	15	44	90
A19	10	1000	7.0	6.0	5.5	1.0	1.3	10.0	12.0	12.5	21.0	20.0	19.0	34.0	2.2	2.2	15	100	95
A64▲	10	1200	26.0	24.0	23.0	1.0	1.0	4.0	4.5	5.0	8.0	7.0	6.5	20.0	2.0	2.0	15	35	160
A65	10	1000	10.5	9.5	9.0	0.7	0.7	6.0	7.5	8.0	10.0	8.0	8.0	24.0	2.0	2.0	15	30	58
A23	5	1500	11.0	10.0	9.5	0.6	1.0	4.8	5.5	6.0	4.0	2.0	2.0	15.0	2.0	2.0	15	14	100
A25	5	1500	10.0	9.0	8.0	0.6	1.0	6.0	7.5	8.0	9.0	7.0	6.5	21.0	2.0	2.0	15	24	95
A27	10	1500	8.5	7.5	7.0	0.6	1.0	7.5	9.0	9.5	15.6	14.0	13.5	28.0	2.0	2.0	15	50	105
A28	10	1500	11.0	10.0	9.5	0.6	1.0	6.0	7.0	7.5	15.0	14.0	13.5	29.0	2.0	2.0	15	45	115
A29	10	1500	5.0	3.5	3.0	1.2	1.2	12.0	13.0	13.5	21.0	20.0	19.0	32.0	2.5	2.5	15	95	115
A29	10	1200	5.0	4.5	4.0	1.0	1.0	12.0	13.0	13.5	21.0	20.0	19.0	32.0	2.5	2.5	15	95	115
A31▲	10	2000	13.0	12.0	10.0	0.7	1.0	3.7	4.5	5.0	−2.0	−3.0	−3.5	10.0	2.0	2.2	15	9	140
A33	10	2000	9.8	8.5	8.0	0.7	1.0	5.2	6.5	7.0	3.0	2.0	2.0	15.0	2.0	2.2	15	14	115
A35	10	2000	10.2	9.0	8.5	0.7	1.0	5.0	6.5	7.0	9.0	7.0	6.5	21.0	2.2	2.2	15	24	105
A37	10	2000	9.3	8.0	7.0	0.7	1.0	6.5	8.0	8.5	15.5	14.0	13.5	28.0	2.2	2.2	15	45	130

*Specification guaranteed at 25°C
**Specification guaranteed to 71°C
†Noise figure guaranteed over 30 to 500 MHz
▲Tentative Specifications
‡Flatpack

•All of the W-J cascadable amplifiers can withstand a maximum of 50 mW of continuous power on the input port at any frequency without damage. Short term overload maximum is 1.0 watt peak power for 3 nsec maximum. Total short term destruct level is a function of time and power level. It can occur in less than 60 seconds for power levels exceeding .5 watt cw. Maximum dc voltage is +17 volts for 15 volts models, +25 volts for 24 volt models. Maximum case temperature is +100°C for all models except the A7, A8, and A9 which have a maximum case temperature of +85°C.

ULTRA-WIDEBAND POWER DIVIDER
MINIATURE TWO-WAY
5 MHz-1000 MHz

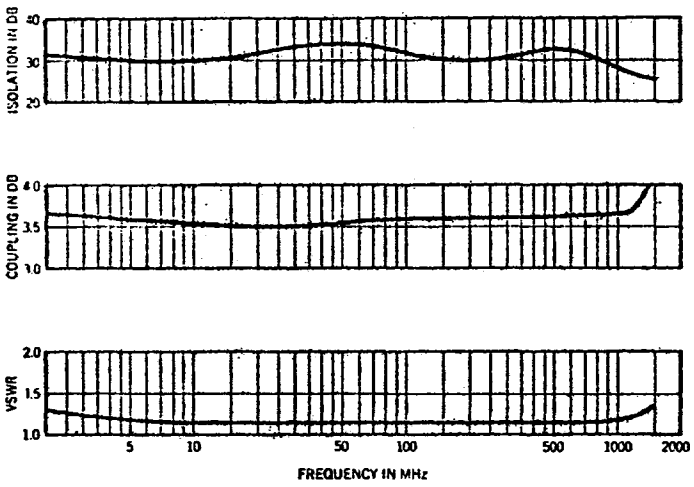
MODEL PDM-20-500



Merrimac's new miniature ultra-broadband power divider is extremely versatile for the following applications:

- HF/VHF/UHF avionics
- LO power division
- VOR/glide slope systems
- Instrument landing systems
- Image reject mixers
- Antenna couplers

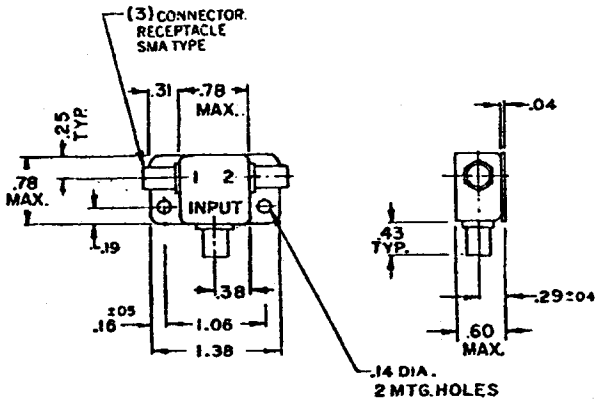
TYPICAL CHARACTERISTICS MODEL PDM-20-500



MINIMUM PERFORMANCE SPECIFICATIONS

MODEL:	**PDM-20-500**
Frequency Range:	5-1000 MHz
Coupling:	—3 db
Isolation:	25 db
Amplitude Balance:	0.2 db
Phase Balance:	2.0°
Insertion Loss:	0.7 db
Impedance:	50 ohms
VSWR:	1.3:1
Power (matched loads):	1 watt
Connectors (3):	SMA Female
Weight:	1 oz. (28 grams)
PRICE:	**$70.00**

OUTLINE OF PDM-20-500



Also available in other configurations, impedances, and with other connectors.

For latest outline details, be sure to contact Merrimac.

Prices and specifications subject to change without notice.

MERRIMAC INDUSTRIES, INCORPORATED
41 FAIRFIELD PLACE, WEST CALDWELL, N. J. 07006 • (201) 228-3890 • TWX 710-734-4314

Operational Amplifiers

LM318 operational amplifier general description

The LM318 is a precision high speed operational amplifier designed for applications requiring wide bandwidth and high slew rate. It features a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

features

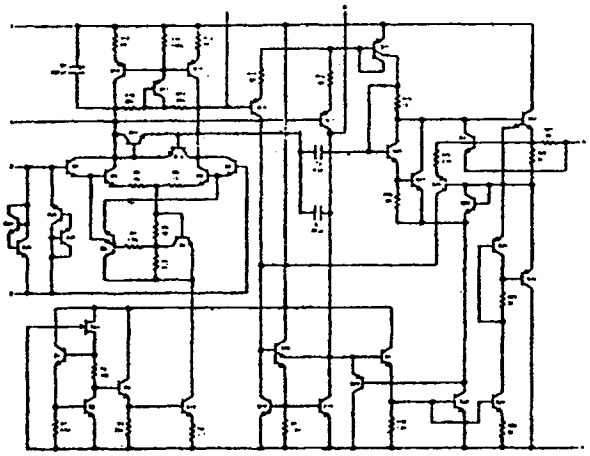
- 15 MHz small signal bandwidth
- Guaranteed 50V/μs slew rate
- Maximum bias current of 500 nA
- Operates from supplies of ±5V to ±20V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

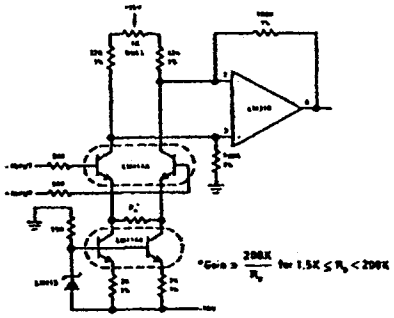
The LM318 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/μs and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μs.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

The LM318 is specified for operation over 0°C to 70°C.

schematic diagram and typical application

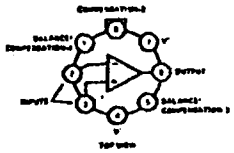




Instrumentation Amplifier

connection diagrams

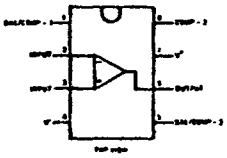
Metal Can Package*



*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

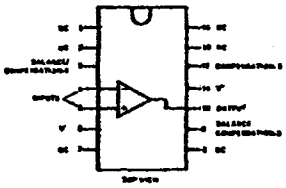
Order Number LM318H
See Package 11

Dual-In-Line Package



Order Number LM318N
See Package 20

Dual-In-Line Package



Order Number LM318D
See Package 1

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25°C$		4	10	mV
Input Offset Current	$T_A = 25°C$		30	200	nA
Input Bias Current	$T_A = 25°C$		150	500	nA
Input Resistance	$T_A = 25°C$	0.5	3		MΩ
Supply Current	$T_A = 25°C$		5	10	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 2\ k\Omega$	25	200		V/mV
Slew Rate	$T_A = 25°C$, $V_S = \pm15V$, $A_V = 1$	50	70		V/μs
Small Signal Bandwidth	$T_A = 25°C$, $V_S = \pm15V$		15		MHz
Input Offset Voltage				15	mV
Input Offset Current				300	nA
Input Bias Current				750	nA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 2\ k\Omega$	20			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 2\ k\Omega$	±12	±13		V
Input Voltage Range	$V_S = \pm15V$	±11.5			V
Common Mode Rejection Ratio		70	100		dB
Supply Voltage Rejection Ratio		65	80		dB

Note 1: The maximum junction temperature of the LM318 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

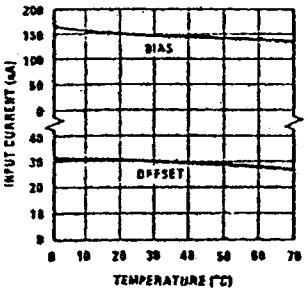
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

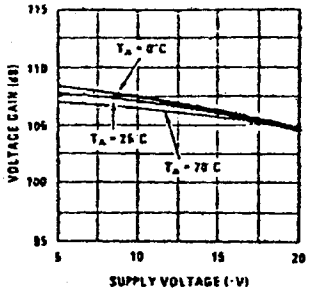
Note 4: These specifications apply for $\pm5V \leq V_S \leq \pm20V$ and $0°C \leq T_A \leq 70°C$, unless otherwise specified. For proper operation, the power supplies must be bypassed with 0.1 μF disc capacitors.

typical performance characteristics

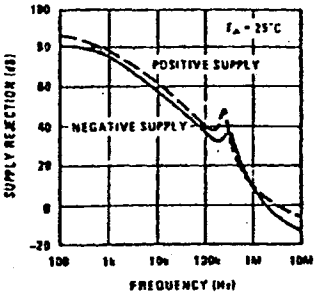
Input Current



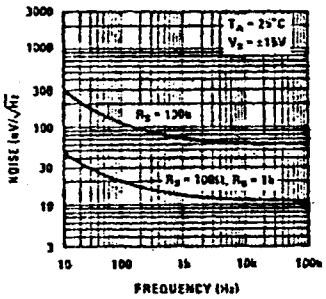
Voltage Gain



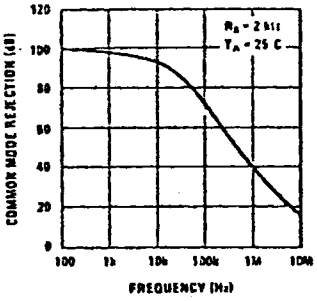
Power Supply Rejection



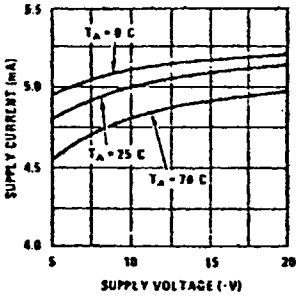
Input Noise Voltage



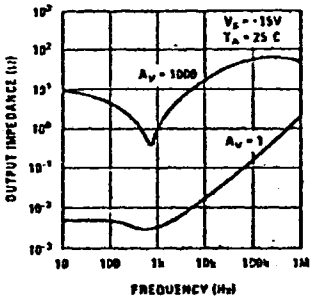
Common Mode Rejection



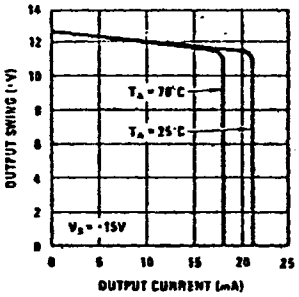
Supply Current



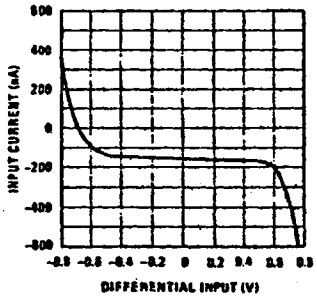
Closed Loop Output Impedance



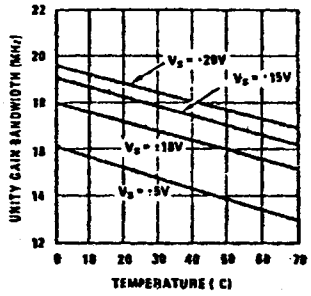
Current Limiting



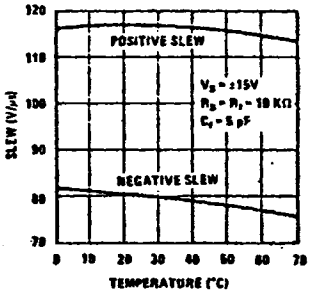
Input Current



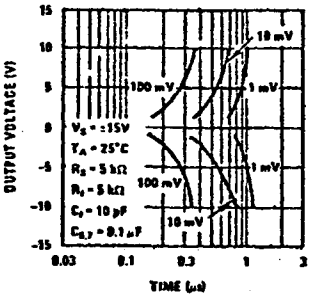
Unit Gain Bandwidth



Voltage Follower Slew Rate

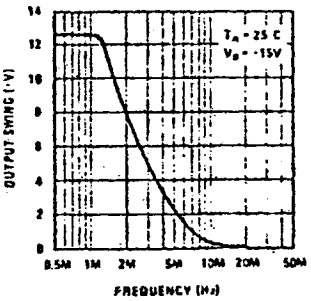


Inverter Settling Time

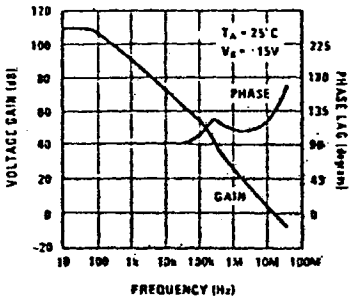


typical performance characteristics (con't)

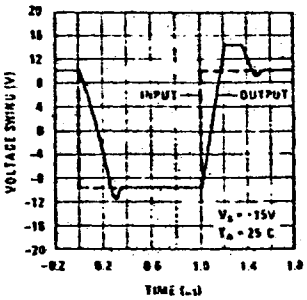
Large Signal Frequency Response



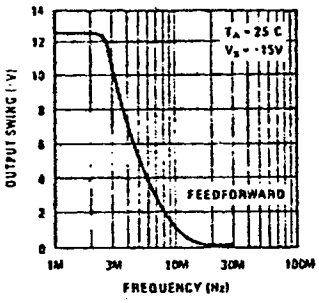
Open Loop Frequency Response



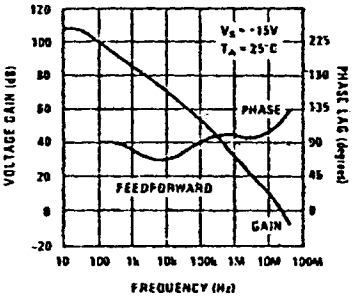
Voltage Follower Pulse Response



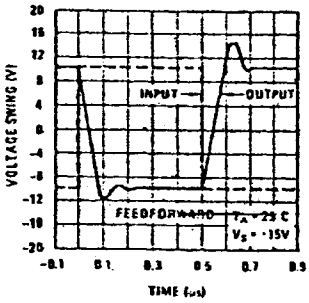
Large Signal Frequency Response



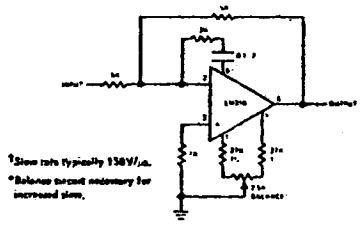
Open Loop Frequency Response



Inverter Pulse Response

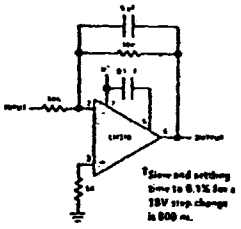


auxiliary circuits



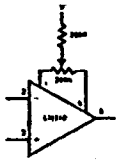
†Slew rate typically 150V/μs.
*Balance current necessary for increased slew.

Feedforward Compensation for Greater Inverting Slew Rate†

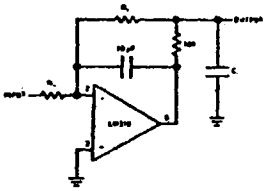


†Slew and settling time to 0.1% for a 10V step change is 800 ns.

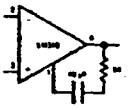
Compensation for Minimum Settling† Time



Offset Balancing

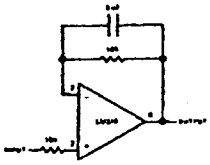


Isolating Large Capacitive Loads

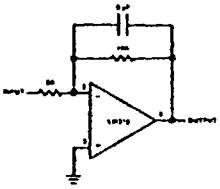


Overcompensation

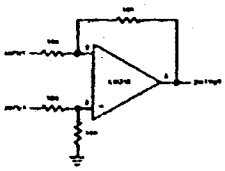
typical applications (con't)



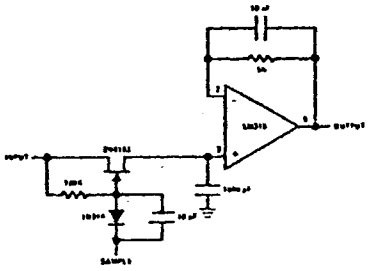
Fast Voltage Follower



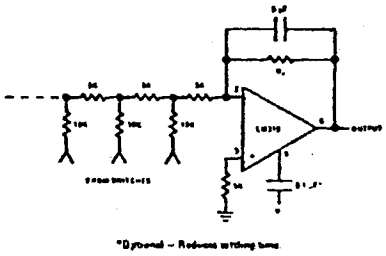
Fast Summing Amplifier



Differential Amplifier

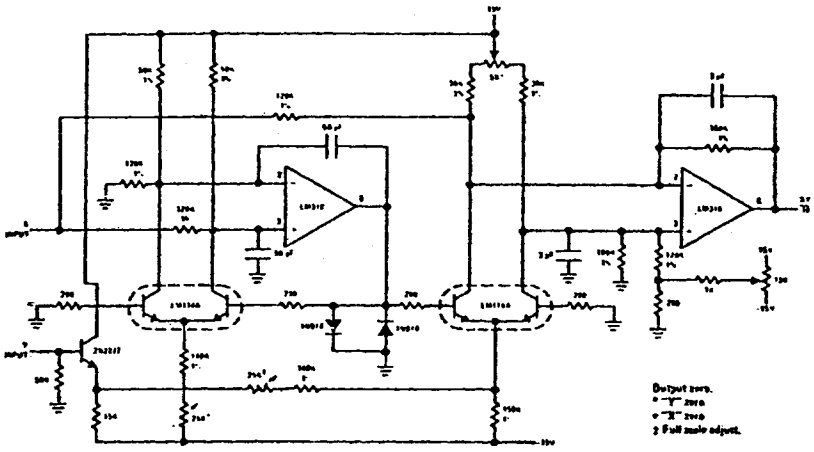


Fast Sample and Hold

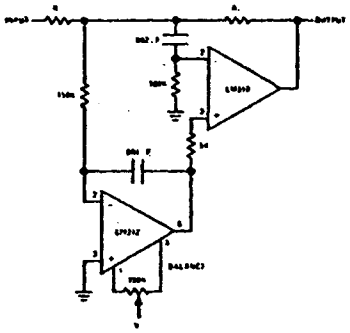


*Optional – Reduces settling time.

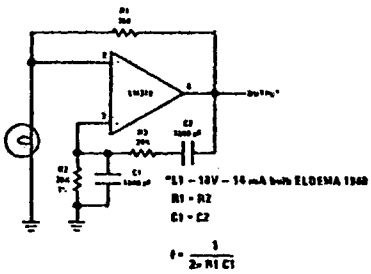
D/A Converter Using Ladder Network



Four Quadrant Multiplier



Fast Summing Amplifier with Low Input Current



Wein Bridge Sine Wave Oscillator

Operational Amplifiers

LH0032/LH0032C ultra fast FET operational amplifier

general description

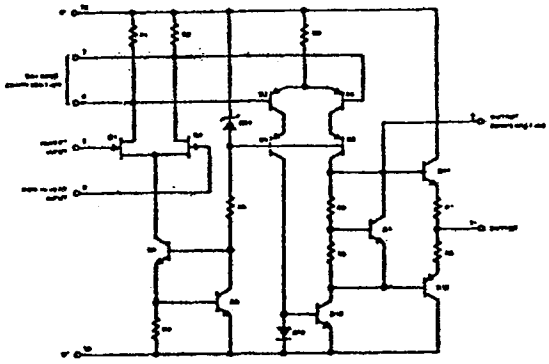
The LH0032/LH0032C is a high slew rate, high input impedance differential operational amplifier suitable for diverse application in fast signal handling. The high allowable differential input voltage, ease of output clamping, and high output drive capability particularly suit it for comparator applications. It may be used in applications normally reserved for video amplifiers allowing the use of operational gain setting and frequency response shaping into the megahertz region.

features

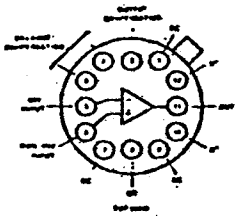
- High slew rate — 500 V/μs
- High bandwidth — 70 MHz
- High input impedance — $10^{12}\Omega$
- Low input bias current — 20 pA max
- Offset null with single pot
- Low input offset voltage — 2 mV max
- No compensation for gains above 50

The LH0032's wide bandwidth, high input impedance and high output capacity make it an ideal choice for applications such as summing amplifiers in high speed D to A's, buffers in data acquisition systems, and sample and hold circuits. Additional applications include high speed integrators and video amplifiers. The LH0032 is guaranteed over the temperature range −55°C to +125°C and the LH0032C is guaranteed from −25°C to +85°C.

schematic and connection diagrams



Metal Can Package

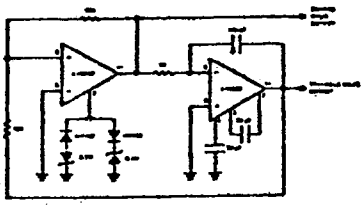


Order Number LH0032G or LH0032CG

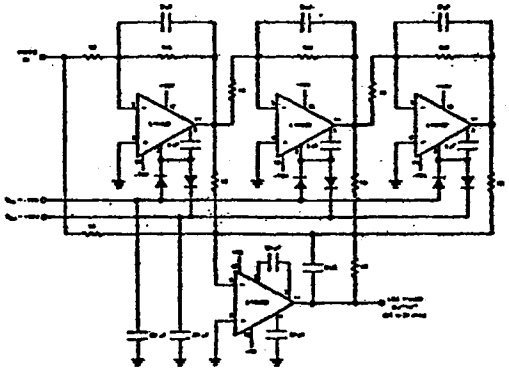
See Package 6

typical applications

1 MHz Function Generator



DC to Video Log Amplifier



absolute maximum ratings

Supply Voltage		±18V
Input Voltage		$\pm V_S$
Differential Input Voltage		±30V
Power Dissipation		See curve
Operating Temperature Range	LH0032	−55°C to +125°C
	LH0032C	−25°C to +85°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0032			LH0032C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_S = ±15V, $R_S \leq$ 100k, T_A = 25°C		2	5		5	15	mV
	V_S = ±15V, $R_S \leq$ 100k			10			20	mV
Average Offset Voltage Drift	$R_S \leq$ 100k		25			25		μV/°C
Input Bias Current	T_A = 25°C		10	100		25	200	pA
				50			15.0	nA
Input Offset Current	T_A = 25°C		5	25		10	50	pA
				25			5	nA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = ±10V, f = 1 kHz R_L = 1 kΩ, T_A = 25°C	60	70		60	70		dB
	V_S = ±15V, V_{OUT} = ±10V, f = 1 kHz R_L = 1 kΩ	57			57			dB
Input Voltage Range	V_S = ±15V	±10	±12		±10	±12		V
Output Voltage Swing	V_S = ±15V, R_L = 1 kΩ	±10	±13.5		±10	±13		V
Power Supply Rejection Ratio	V_S = ±15V, ΔV_S = ±10V	50	60		50	60		dB
Common Mode Rejection Ratio	V_S = ±15V, ΔV_{IN} = 10V	50	60		50	60		dB
Supply Current	V_S = ±15V, T_A = 25°C		18	20		20	22	mA

ac electrical characteristics (Note 2)

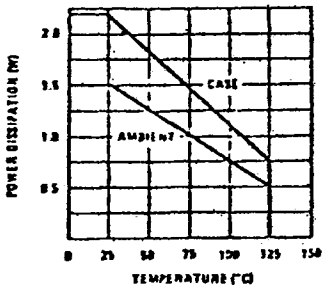
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Slew Rate	A_V = +1, ΔV_{IN} = 20V	350	500		V/μs
Settling Time to 1% of Final Value	A_V = −1, ΔV_{IN} = 20V		100		ns
Settling Time to 0.1% of Final Value	A_V = −1, ΔV_{IN} = 20V		300		ns
Small Signal Rise Time	A_V = +1, ΔV_{IN} = 1V		8	20	ns
Small Signal Delay Time	A_V = +1, ΔV_{IN} = 1V		10	25	ns

Note 1: These specifications apply for ±5V ≤ V_S ≤ ±18V and −55°C to +125°C for the LH0032 and −25°C to +85°C for the LH0032C.

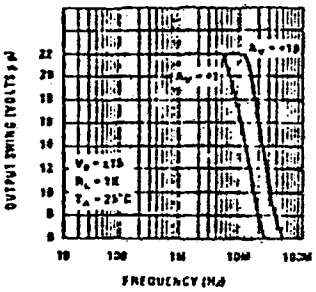
Note 2: These specifications apply for V_S = ±15V, R_L = 1 kΩ and T_A = 25°C.

typical performance characteristics

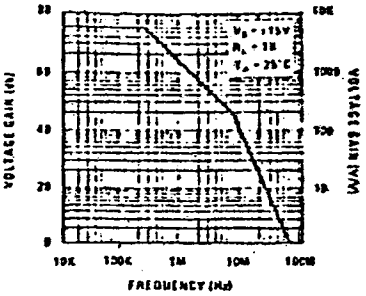
Maximum Power Dissipation



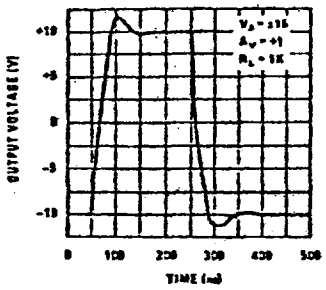
Large Signal Frequency Response



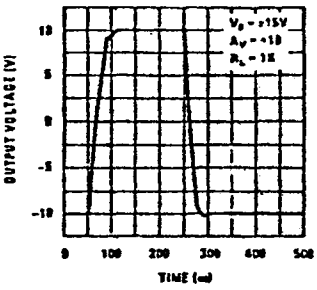
Open Loop Frequency Response



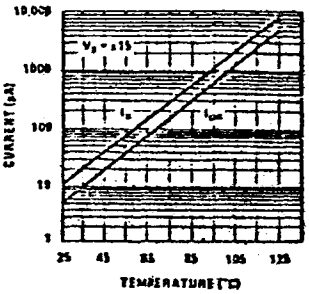
Large Signal Pulse Response



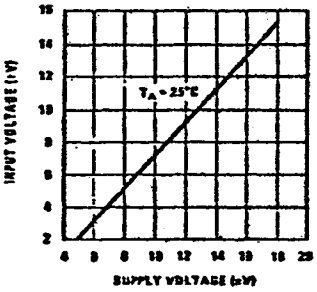
Large Signal Pulse Response



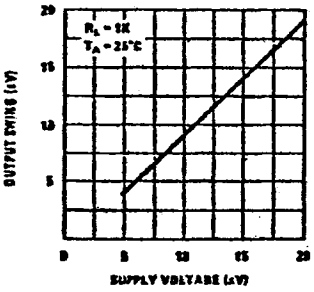
Input Bias and Offset Current vs Temperature



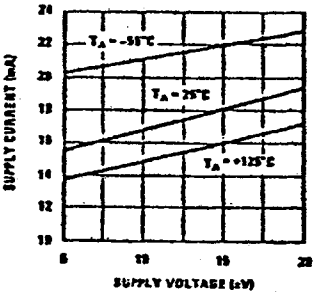
Input Voltage Range



Output Swing



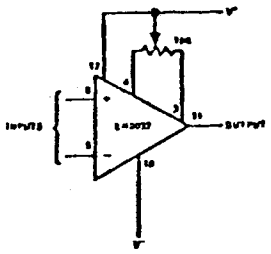
Supply Current vs Supply Voltage



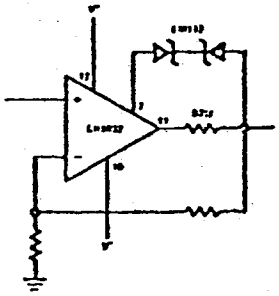
2

auxiliary circuits

Offset Null

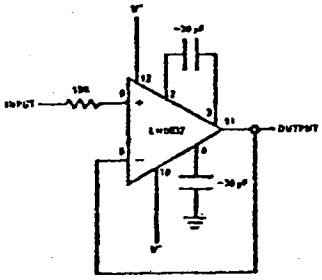


Output Short Circuit Protection

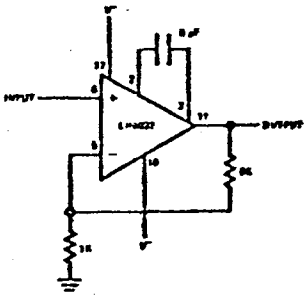


typical applications (con't)

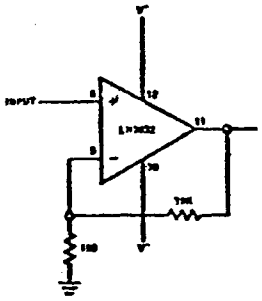
Unity Gain Amplifier



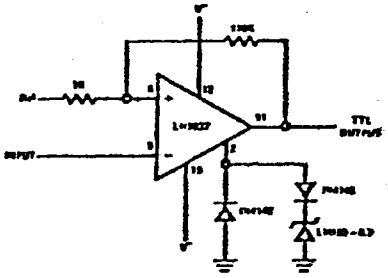
10X Buffer Amplifier



100X Buffer Amplifier

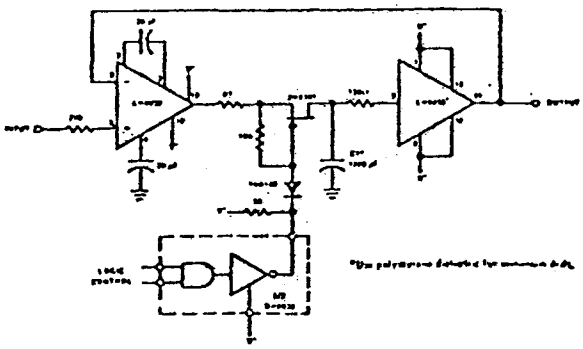


High Impedance, High Speed Comparator

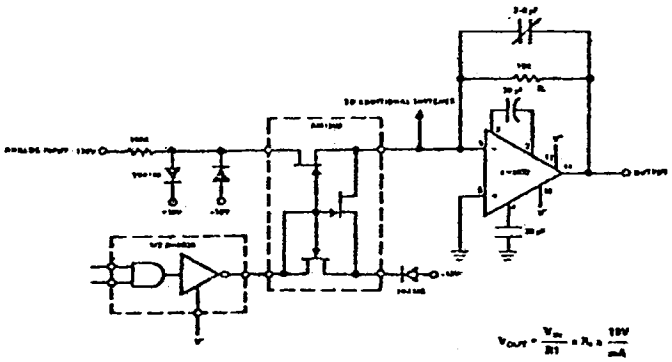


typical applications (con't)

High Speed Sample and Hold



Current Mode Multiplexer



applications information

Power Supply Decoupling

The LH0032/LH0032C like most high speed circuits is sensitive to layout and stray capacitance. Power supplies should be by-passed as near to Pins 10 and 12 as practicable with low inductance capacitors such as 0.01 μF disc ceramics. Compensation components should also be located close to the appropriate pins to minimize stray reactances.

Input Capacitance

The input capacitance to the LH0032/LH0032C is typically 5 pF and thus may form a significant time constant with high value resistors. For optimum performance, the input capacitance to the inverting input should be comperisated by a small capacitor across the feedback resistor. The value is strongly dependent on layout and closed loop gain, but will typically be in the neighborhood of several picofarads.

In the non-inverting configuration, it may be advantageous to bootstrap the case and/or a guard conductor to the inverting input. This serves both to divert leakage currents away from the non-inverting input and to reduce the effective input capacitance. A unity gain follower so treated will have an input capacitance under a picofarad..

Heat Sinking

While the LH0032/LH0032C is specified for operation without any explicit head sink, internal power dissipation does cause a significant temperature rise. Improved bias current performance can thus be obtained by limiting this temperature rise with a small head sink such as the Thermalloy No. 2241 or equivalent. The case of the device has no internal connection, so it may be electrically connected to the sink if this is advantageous. Be aware, however, that this will affect the stray capacitances to all pins and may thus require adjustment of circuit compensation values.

MONOLITHIC DUAL HIGH-GAIN OPERATIONAL AMPLIFIER

4558

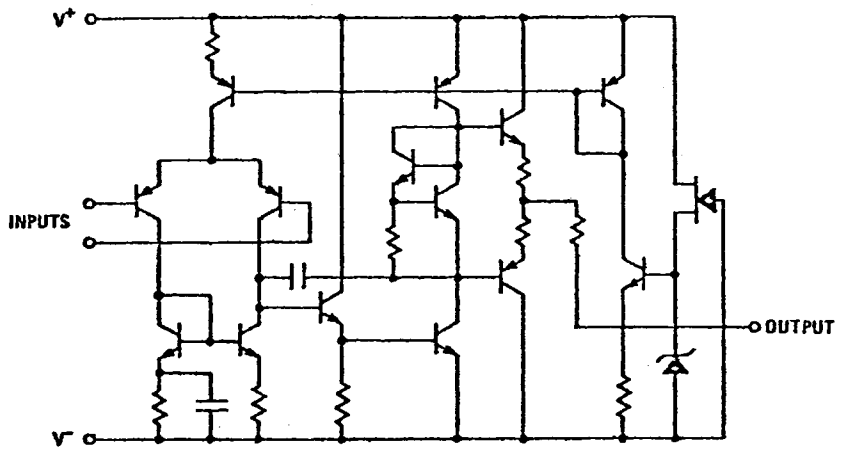
DESIGN FEATURES

- Continuous Short-circuit protection
- No Frequency Compensation Required
- No Latch-up
- Unity Gain Bandwidth 3MHz
- Large Common-mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

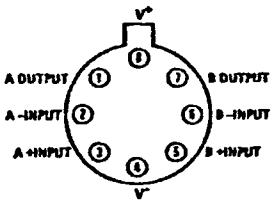
The RC4558 integrated circuit is a high gain operational amplifier internally compensated and constructed on a single silicon chip using the planar epitaxial process. It operates from 0°C to +70°C.

Combining all of the outstanding features of the 741 with the close parameter matching and tracking of a dual device on a monolithic chip results in unique performance characteristics. Excellent channel separation allows the use of the dual device in all single 741 operational amplifier applications providing the highest possible packaging density. It is especially well suited for applications in differential-in, differential-out as well as in potentiometric amplifiers and where gain and phase matched channels are mandatory.

SCHEMATIC DIAGRAM

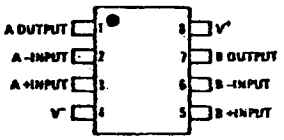


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part No.:
RC4558T



DN Dual In-line
Plastic Package
(Top View)

Order Part No.:
RC4558DN

MONOLITHIC DUAL HIGH-GAIN OPERATIONAL AMPLIFIER

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Internal Power Dissipation (Note 1)	500mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 60s)	300°C
Output Short-circuit Duration (Note 3)	Indefinite

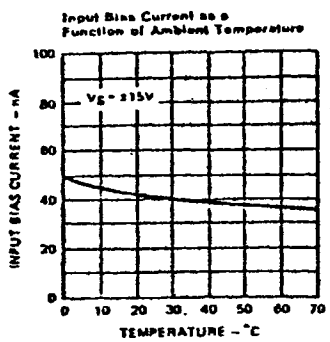
ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_{CC} = ±15V unless otherwise specified)

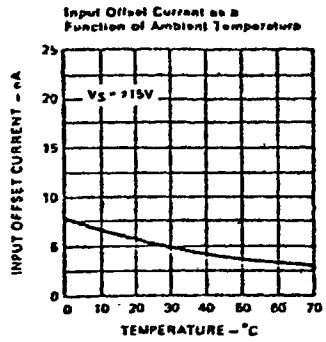
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S \leq 10$ kΩ		0.5	6.0	mV
Input Offset Current			5.0	200	nA
Input Bias Current			40	500	nA
Input Resistance		0.3	5.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ V_{out} = ±10V	20,000	300,000		
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±14		V
	$R_L \geq 2$ kΩ	±10	±13		V
Input Voltage Range		±12	±14		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10$ kΩ		30	150	μV/V
Power Consumption			105	170	mW
Transient Response (unity gain) Risetime	V_{in} = 20 mV R_L = 2 kΩ $C_L \leq 100$ pF		0.13		μs
Transient Response (unity gain) Overshoot	V_{in} = 20 mV R_L = 2 kΩ $C_L \leq 100$ pF		5.0		%
Slew Rate (unity gain)	$R_L \geq 2$ kΩ		1.0		V/μs
Channel Separation	f = 10 kHz R_S = 1 kΩ		105		dB
Equivalent Noise Voltage Referred to Input	A_V = 100 R_S = 1 kΩ BW = 1 Hz		10		nV(Hz)½
Unity Gain Bandwidth (open-loop)			3.0		MHz
The following specifications apply for 0°C ≤ T_A ≤ 70°C unless otherwise specified.					
Input Offset Voltage	$R_S \leq 10$ kΩ			7.5	mV
Input Offset Current				300	nA
Input Bias Current				800	nA
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ V_{out} = ±10V	15,000			
Output Voltage Swing	$R_L \geq 2$ kΩ	±10			V
Power Consumption	V_S = ±15V				mW
	T_A = 70°C		90	150	
	T_A = 0°C		120	200	

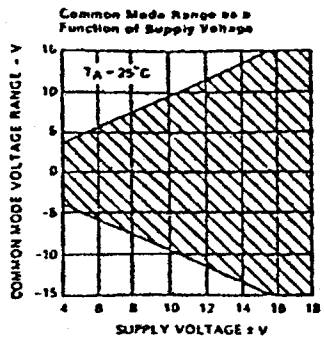
NOTES:

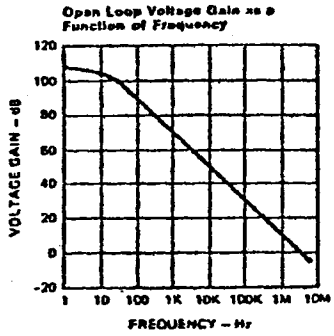
1. Rating applies for ambient temperatures to +25°C; derate linearly at 6.4 mW/°C for ambient temperatures above +25°C.
2. For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground, one amplifier only. I_{SC} = 45mA (typical).

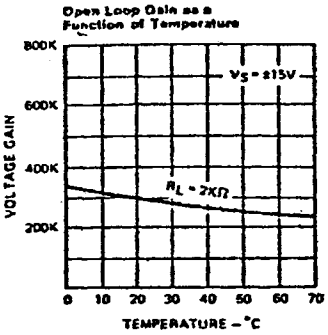
TYPICAL ELECTRICAL DATA

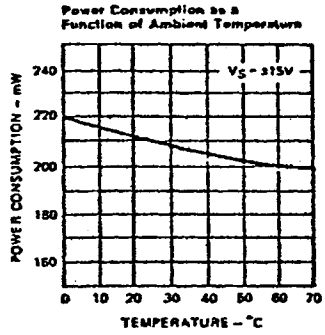


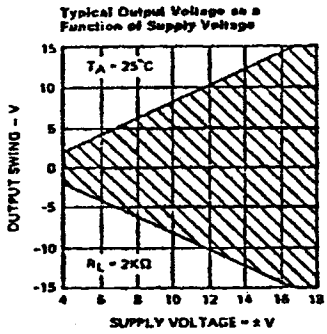


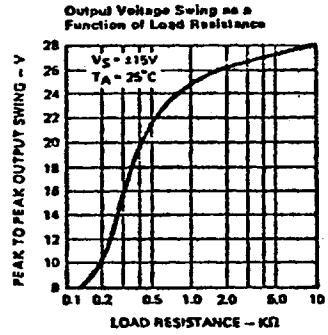


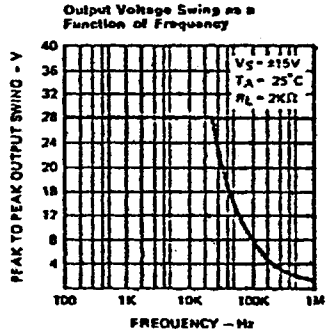


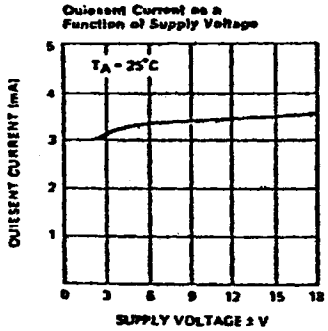


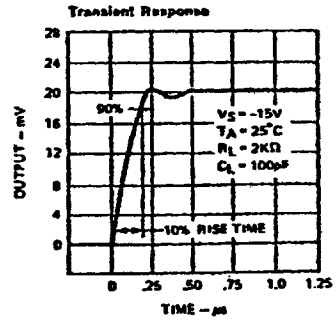


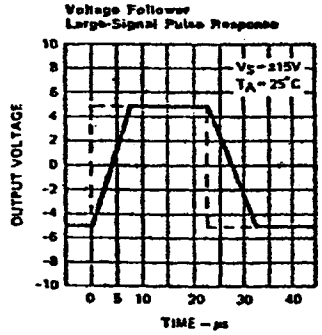






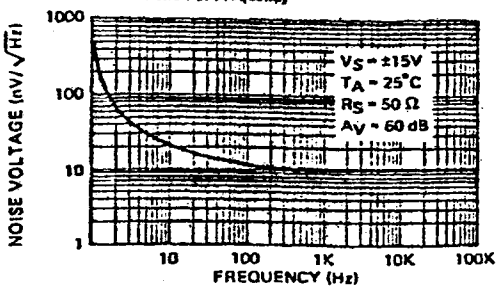




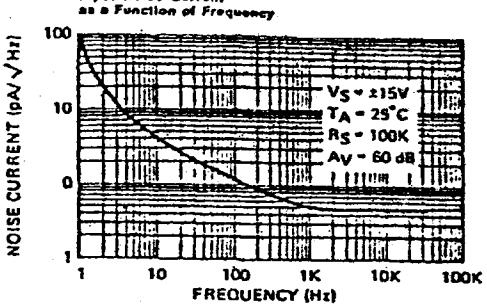


TYPICAL ELECTRICAL DATA

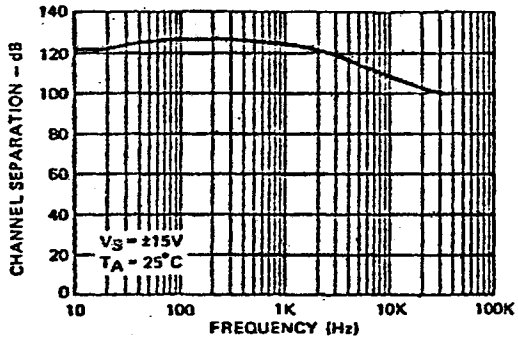
Input Noise Voltage as a Function of Frequency



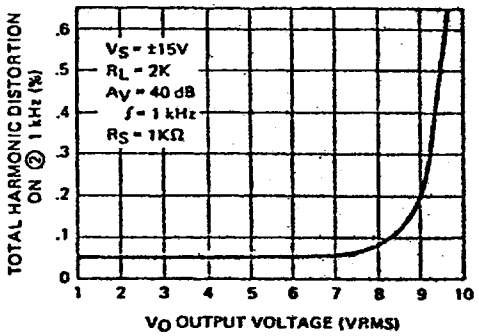
Input Noise Current as a Function of Frequency



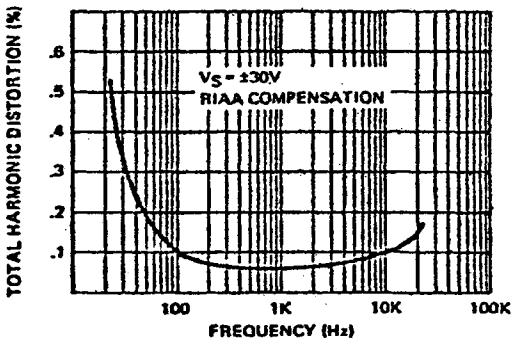
Channel Separation



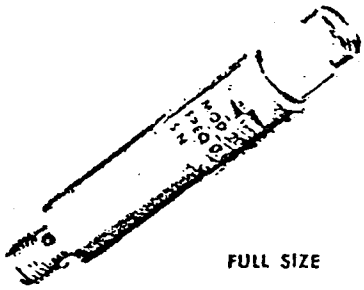
Total Harmonic Distortion vs Output Voltage



Distortion vs Frequency
V_O = 1vrms



CRYSTAL DIODE DETECTOR
MODEL 20090



FULL SIZE

OSM Model 20090 Miniature Coaxial Crystal Detectors are designed for the detection of CW, square wave, pulse and frequency-modulated microwave signals. They may be used to monitor power level or modulation wave shape; as constant level or sensitive null indicator; or as general purpose indicator of microwave signals.
Model 20090 is an ultra-compact, untuned detector which mates with all OSM miniature connectors. These units are supplied with replaceable crystals. The untuned mount allows operation over a very wide frequency range without any adjustment. Video output capacitance is less than 15 picofarads. A 50 ohm dc return path for the detector current is integral with the mount. The output is negative with respect to the housing. The units are supplied with an Omni Spectra part number 5447-4 diode.

ELECTRICAL SPECIFICATIONS

Frequency Range:	10 MHz - 12.4 GHz
Sensitivity:	300 mV/mW Typical
Output Capacitance:	15 Picofarads Maximum
Output Polarity:	Negative
Temperature Range:	- 30°C to + 70°C

Usable to 18GHz

MECHANICAL SPECIFICATIONS

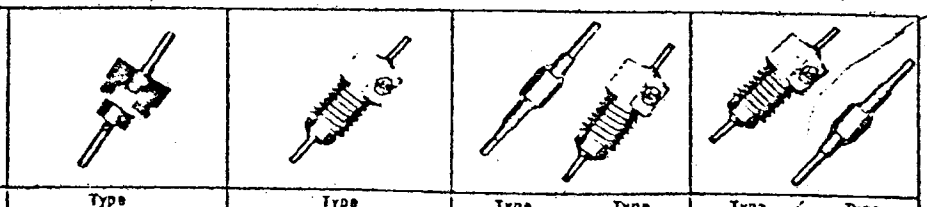
Weight:	0.6 ounces (17.0 g)
Overall Length:	2.0 inches (50.8 mm)
Diameter:	3/8 inches (9.5 mm)
Connectors:	Input - OSM Plug Output - OSM Jack
Finish:	Gold

Omni Spectra, Inc.
24600 Hallwood Ct. • Farmington, Michigan 48024 • Tel. (313) 477-1234 • TWX 810-242-1463

EMI/RFI SUPPRESSION FILTERS

THREAD BUSHING

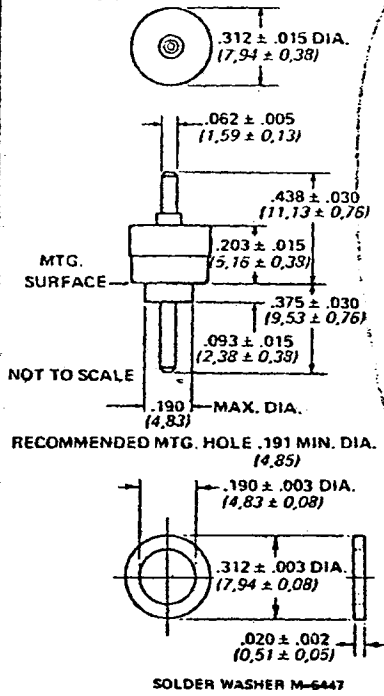
SPECTRUM CONTROL



Specifications	Type FCS-C	Type SMFB-A4	Type SMFO-1 / Type SMFB-A1	Type SMFB-A2 / Type SMFO-2
Attenuation See explanation below table.	25 dB @ 25°C 20 dB @ 85°C	50 dB @ 25°C 45 dB @ 125°C	35 dB @ 25°C 35 dB @ 125°C	60 dB @ 25°C 50 dB @ 85°C
Operating Temperature Range	−55°C to +85°C	−55°C to +125°C	−55°C to +125°C	−55°C to +85°C
DC Working Voltage Includes summation of the DC and lower level AC peak voltages.	500 Volts	500 Volts	200 Volts	200 Volts
Feed-Thru Current DC and/or low frequency AC RMS.	25 Amperes	10 Amperes	10 Amperes	10 Amperes
Capacitance (pF) Minimum values at 25°C, 0.5 to 2.5 volts RMS, at 1 KHz.	1000	2500	1300	5500
Feed-Thru Terminal Resistance	0.01 Ohm Maximum			

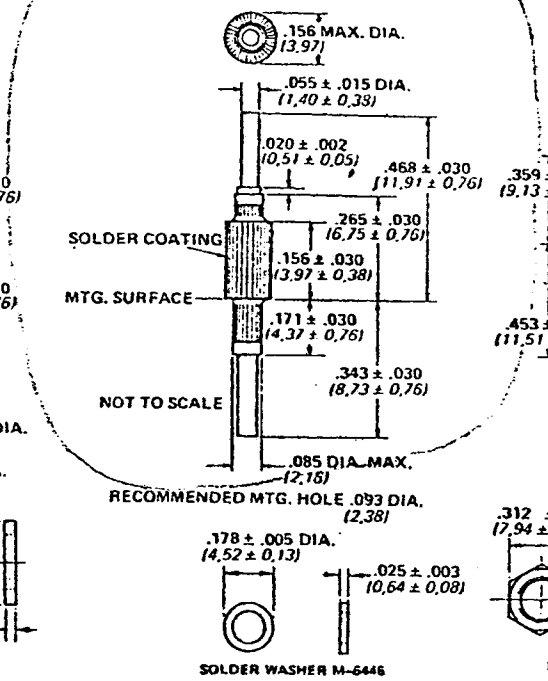
Attenuation: Minimum attenuation values from 100 MHz to 10 GHz, when measured with an input 50 ohm series resistor (except FCS-C which is determined without 50 ohm series resistor), and at 0 volts DC and 0 amperes DC.

Type FCS-C



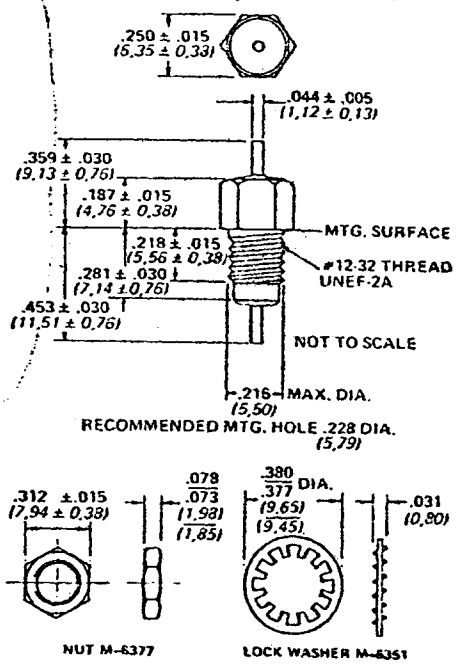
SOLDER WASHER M-6447

Types SMFO-1, SMFO-2



SOLDER WASHER M-6446

Types SMFB-A1, SMFB-A2, SMFB-A4



NUT M-6377 LOCK WASHER M-6351

Allen Bradley Type Number	Spectrum Control Inventory Code Number
FCS-C	51-722-001 51-722-022 with solder mounting washer
SMFB-A1	51-719-022 with nut and lockwasher
SMFB-A2	51-719-021 with nut and lockwasher
SMFB-A4	51-719-011 with nut and lockwasher
SMFO-1	51-723-303 51-723-304 with solder mounting washer
SMFO-2	51-723-301 51-723-302 with solder mounting washer

SPECTRUM ACQUIRES ALLEN BRADLEY LINE

In May of 1973, Spectrum Control, Inc. and Allen Bradley Company entered into a long term agreement whereby Spectrum Control acquired all patents, technology and machinery to manufacture the Allen Bradley line of filters and capacitors. These devices can be ordered by the Allen Bradley part number or by the Spectrum Control inventory code number.

SPECTRUM CONTROL INC.

152 EAST MAIN STREET, FAIRVIEW, PA. 16415 PHONE (814) 474-5593

K&L MICROWAVE, INC.

408 COLES CIRCLE • SALISBURY, MARYLAND 21801 • 301-749-2424 TWX 710-864-9683

SPECIFICATION AND TEST DATA REPORT

K & L Part No. 4MC10-600/50-0

K & L Order No. 5636

Cust. Part No.

Test Eng. J.P.

Ser. No. 8158-1,2

Q.C. Inspector B.B.

Date 7-19-77

SPECIFICATIONS		TEST RESULTS Ser. No. 1	2					
1.0 Center Frequency	600 MHz	✓	✓					
2.0 Relative Bandwidth								
2.1 3dB BW	575 MHz	573	573.3					
	625 MHz	627	626					
2.2 ____ dB	____ MHz							
	____ MHz							
3.0 Insertion Loss								
600 MHz	____ dB	1.1	1.1					
____ MHz	____ dB							
4.0 VSWR 1.5:1								
TYP MHz		581	580					
____ MHz		619.5	616					
5.0 Stopband Rejection								
curve MHz	____ dB							
____ MHz	____ dB							
____ MHz	____ dB							
____ MHz	____ dB							

6.0 Impedance 50 Ohms

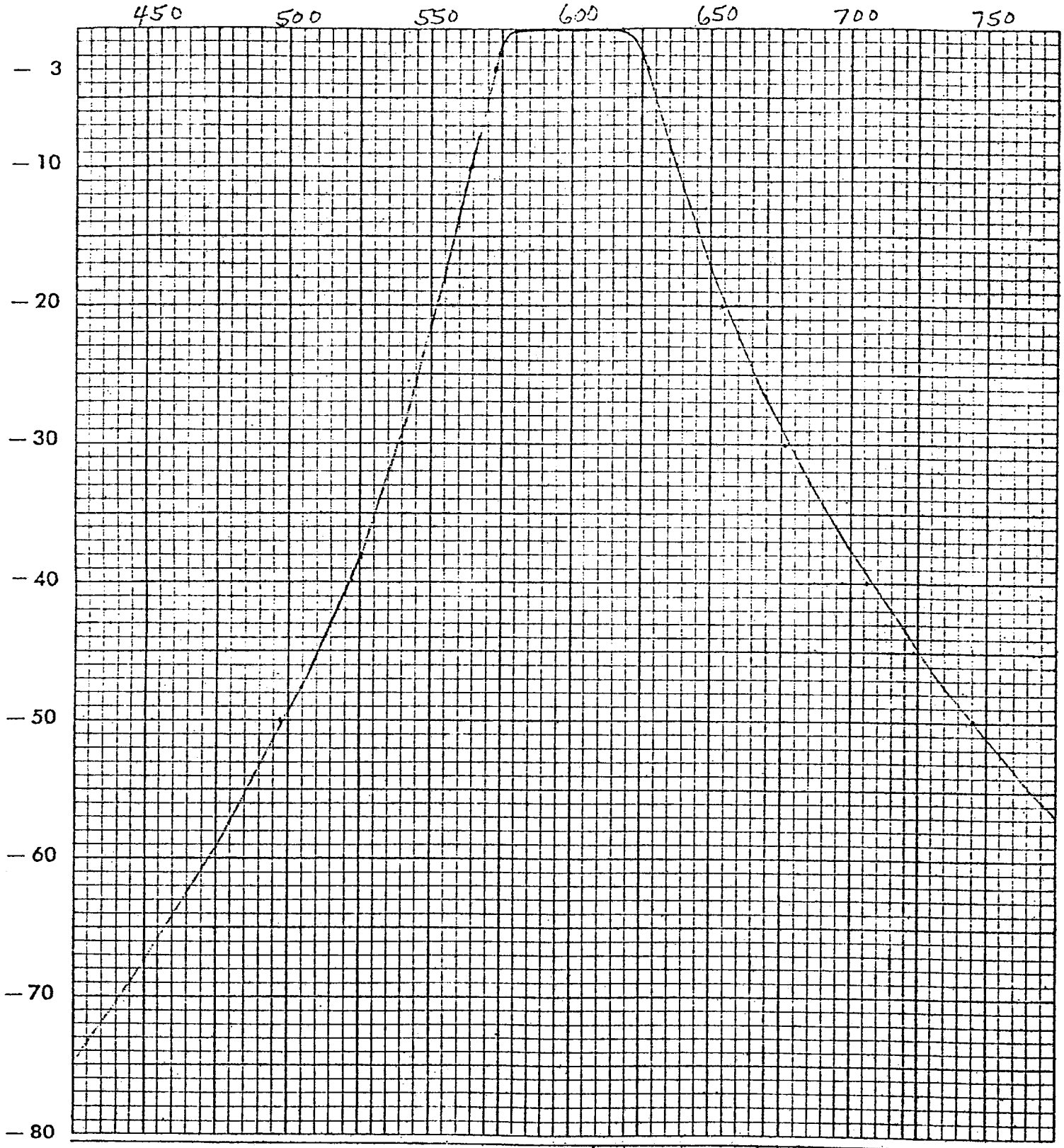
8.0 Connectors SMA-f

7.0 Size

9.0 Weight

K&L MICROWAVE, INC.

408 COLES CIRCLE • SALISBURY, MARYLAND 21801 • 301-749-2424 TWX 710-864-9583



PART NO. 4MC10-600/50-0

SERIAL NO. 8158-1 JOB NO. 5636

TEST ENG. J.P.

QUALITY CONTROL B.B. (K&L 3)

DATE 7-19-77

FREQ. MHz	LOSS D.B. ABSOLUTE	VSWR
f_0 600	1.1	1.5:1
f_1 573	4.1	581
f_2 627	4.1	619.5
f_3		
f_4		

REQUISITIONER - 5

BUYER: Jorgensen

PURCHASE ORDER NO. S-04341

SHEET 1 OF 1

PURCHASE ORDER

xx

DATE June 15, 1977

VENDOR

K & L Microwave
408 Coles Circle
Salisbury, MD 21801

SHIP TO

xx

NATIONAL RADIO ASTRONOMY OBSERVATORY
RECEIVING DEPARTMENT
1000 BULLOCK BLVD.
SOCORRO, NEW MEXICO 87801
TELE 505-835-2924
TELEX 910-988-1710

NATIONAL RADIO ASTRONOMY OBSERVATORY
RECEIVING DEPARTMENT

VENDOR BEST DELIVERY:	TERMS	F.O.B. POINT	SHIP VIA	TRANSPORTATION CHARGES
N.R.A.O. REQUESTED DELIVERY 7/31/77	Net 30	Shp. Pt.	UPS	Prepay and add

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT	ITEM NO	RECEIVED PARTIAL QTY.	RECEIVED PARTIAL DATE	RECEIVED COMPLE QTY.	RECEIVED COMPLE DAT
		K & L Microwave, Inc., make 3/8" coaxial tubular band pass filter center frequency 3750 MHz 3 db BW ~~XXXXXXX~~ 630 MHz							
1	4	K & L Type 4B 380-3750-630-0	$99.00	$396.00					
		K & L Microwave, make miniatur cavity filter loaded helical resonator — Center Freq. 600 MHz; Band width 50 MHz; No. of section 4; Connector SMA Jack - Axially; Temp. coeff. 20 ppm/$^{o}_{c}$							
2	2	K & L Type 4MC10 - 600/50-0	200.00	400.00					
		TOTAL		$796.00					
		DO NOT DUPLICATE Confirming Phone order 6-16-77 - Jorgensen/Schavb							

ACCOUNT/PROJECT NO. 493/13110 - Item #1
13210 Item #2

R.F.Q. NO.
DELIVER TO LOCATION D. Bagri - Site

N.R.A.O. TECHNICAL INSPECTION APPROVAL REQUIRED BEFORE PAYMENT.
YES ☐ NO ☐

9.0 MODULE PHOTOGRAPHS

FIGURE 7: FRONT PANEL

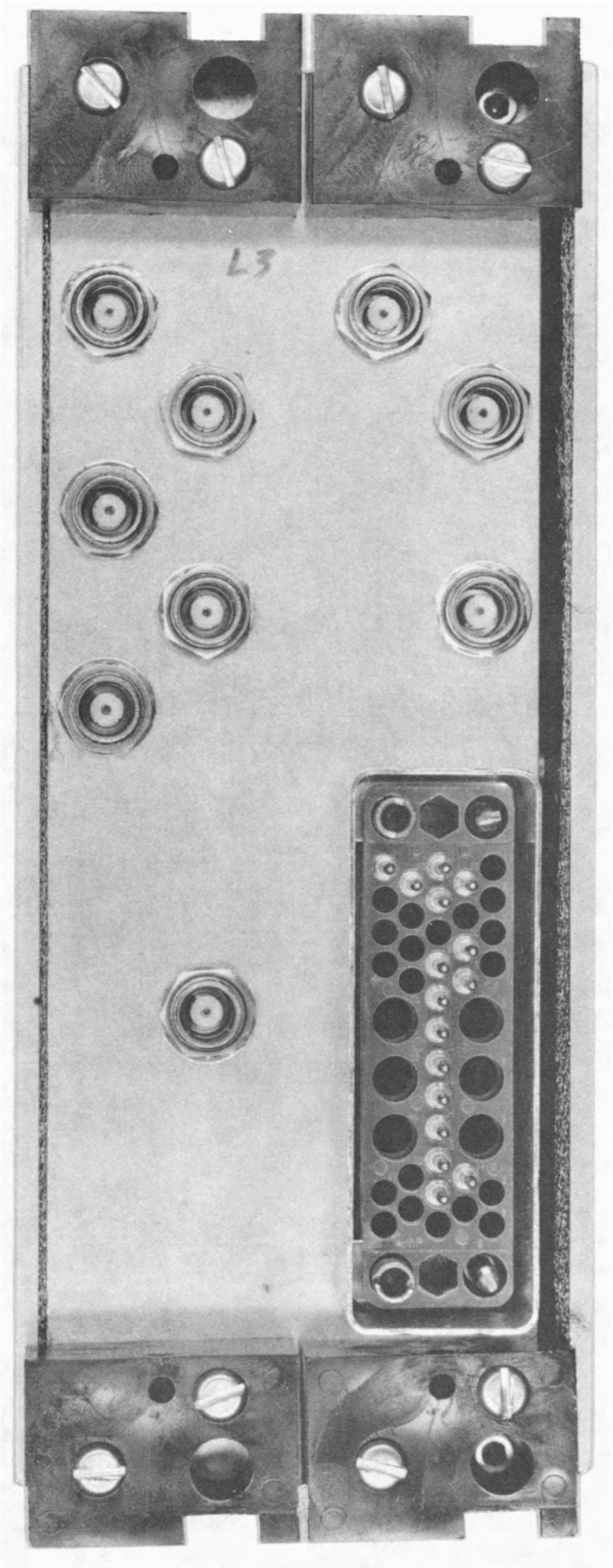


FIGURE 8: REAR PANEL

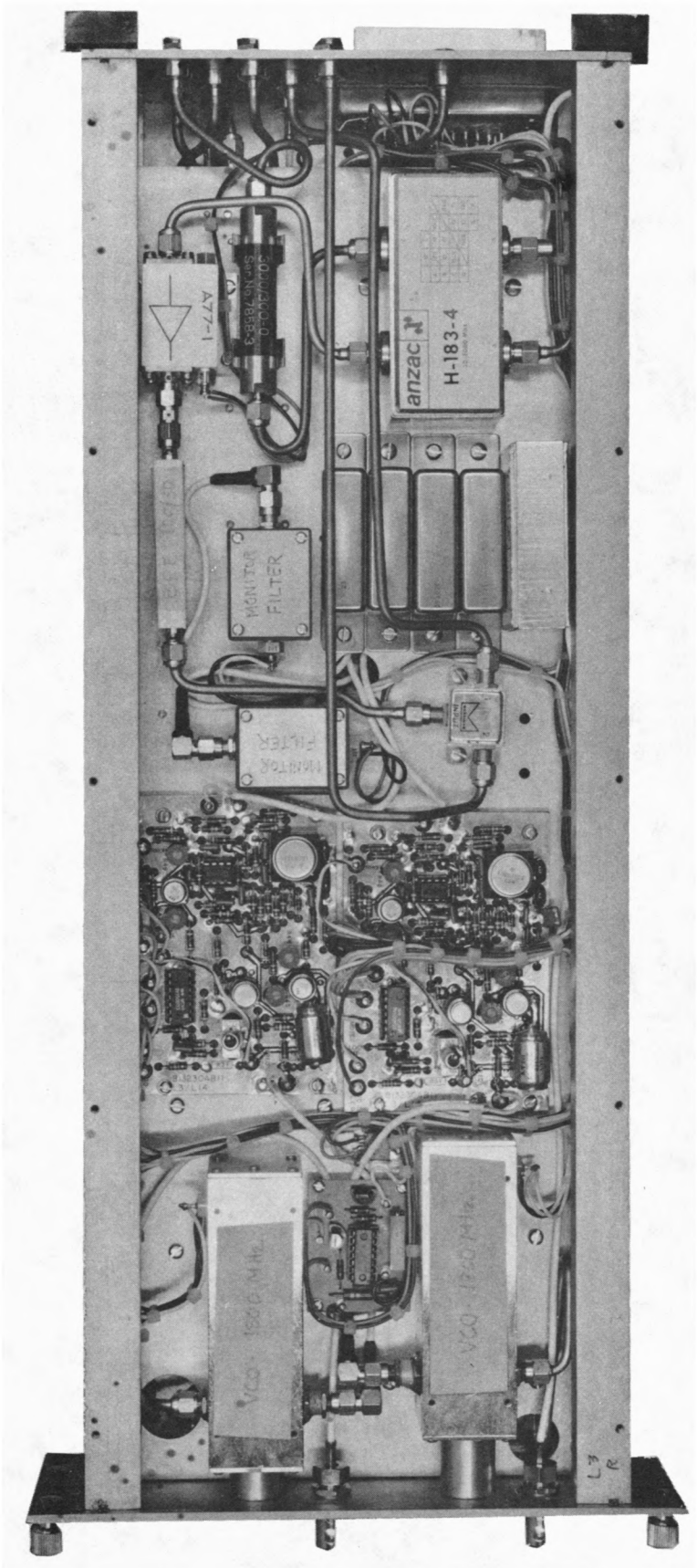


FIGURE 9: RIGHT-HAND SIDE VIEW

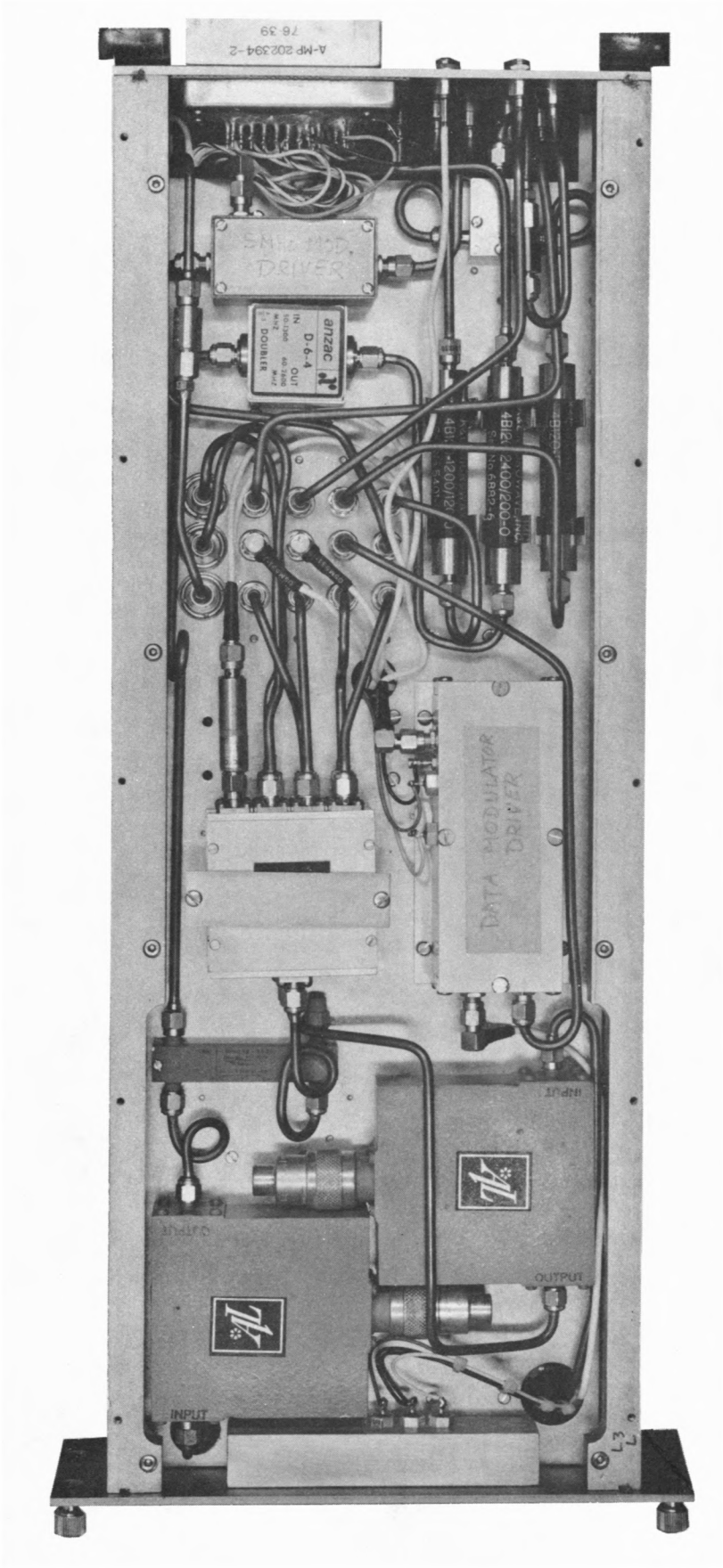


FIGURE 10: LEFT-HAND SIDE VIEW