VLA Technical Report No. 27

MODULE T2
IF COMBINER

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August 1976

CONTENTS

FIGURES

I. GENERAL DESCRIPTION

The "IF Combiner" T2 module performs a support function for the "Modem" T1 module. Its primary role is to combine the signals from various modules into a single 1-2 GHz passband for transmission via the modem, as well as to distribute the received 1-2 GHz passband from the modem to various modules in the rack. The receive function has a front panel level setting adjustment to compensate for waveguide loss variation and component gain variations. The IF combiner also interfaces itself and the modem T1 module with the digiatl communications system.

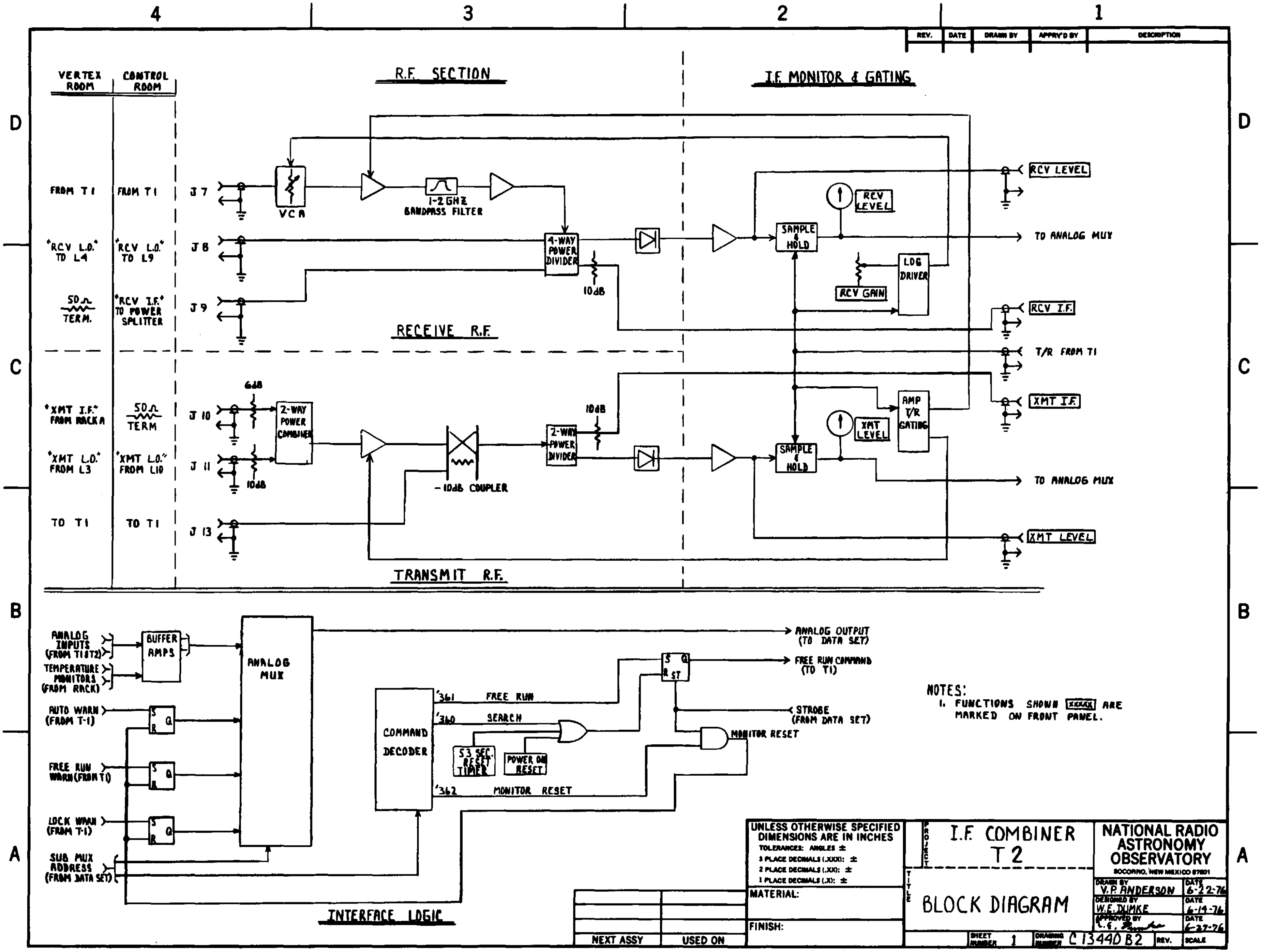
II. THEORY OF OPERATION

Refer to the IF combiner T2 block diagram Figure II-1.

A. Transmit RF section - The IF combiner receives the 1200 MHz and 1800 MHz "LO" signals from the LO system at Port J11. If the module is placed at the antenna vertex room, IF signals from the front end rack will also be present at J10. Attenuator pads at these ports help with level setting and provide good terminations to minimize passband ripple due to VSWR and the long lengths of coax feeding the T2 module.

The LO carriers and the IF signals are then combined in a two-way Wilkinson power combiner and subsequently amplified. The amplifier's supply voltage is gated on and off with the T/R signal to help provide isolation of the transmitted signals from the receive RF section during the receive time period. A 10 dB coupler at the output of the amplifier provides a sample of the combined IF and LO signals to another 2-way power divider for monitoring purposes. One output of the divider, isolated by a 10 dB pad, feeds a front panel BNC jack for use with a spectrum analyzer or power meter for trouble-shooting and level adjustment.

A simple diode detector and amplifier are connected to the other port of the power divider to monitor total IF passband power. Because the duty cycle of the T/R timing varies from vertex room to control room, a sample and hold circuit at the amplified detector output permits the "XMT Level" meter reading on the front panel to be independent



REV.
DATE
DRAWN BY
APPR'D BY
DESCRIPTION
VERTEX ROOM
CONTROL ROOM
R.F. SECTION
I.F. MONITOR & GATING
FROM T1
FROM T1
J 7
VCA
1-2 GHZ BANDPASS FILTER
"RCV L.O." TO L4
"RCV L.O." TO L9
J 8
4-WAY POWER DIVIDER
10dB
50Ω TERM.
"RCV I.F." TO POWER SPLITTER
J 9
RECEIVE R.F.
SAMPLE & HOLD
RCV LEVEL
LOG DRIVER
RCV GAIN
RCV LEVEL
TO ANALOG MUX
RCV I.F.
T/R FROM T1
"XMT I.F." FROM RACK A
50Ω TERM
J 10
6dB
2-WAY POWER COMBINER
"XMT L.O." FROM L3
"XMT L.O." FROM L10
J 11
10dB
-10dB COUPLER
2-WAY POWER DIVIDER
10dB
SAMPLE & HOLD
XMT LEVEL
AMP T/R GATING
XMT I.F.
TO ANALOG MUX
TO T1
TO T1
J 13
XMT LEVEL
TRANSMIT R.F.
ANALOG INPUTS (FROM T1 & T2)
TEMPERATURE MONITORS (FROM RACK)
BUFFER AMPS
ANALOG MUX
ANALOG OUTPUT (TO DATA SET)
FREE RUN COMMAND (TO T1)
AUTO WARN (FROM T-1)
FREE RUN WARN (FROM T1)
LOCK WARN (FROM T-1)
SUB MUX ADDRESS (FROM DATA SET)
COMMAND DECODER
'361 FREE RUN
'360 SEARCH
'362 MONITOR RESET
53 SEC. RESET TIMER
POWER ON RESET
STROBE (FROM DATA SET)
MONITOR RESET
NOTES:
1. FUNCTIONS SHOWN [XXXX] ARE MARKED ON FRONT PANEL.
INTERFACE LOGIC
NEXT ASSY
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:
PROJECT
I.F. COMBINER T2
TITLE
BLOCK DIAGRAM
NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801
DRAWN BY V.P. ANDERSON
DATE 6-22-76
DESIGNED BY W.E. DUMKE
DATE 6-14-76
APPROVED BY
DATE 6-27-76
SHEET NUMBER 1
DRAWING NUMBER C13440B2
REV.
SCALE

FIGURE II-1

of this duty cycle. Thus the module can be used at both the antenna and control rooms without any changes in the module itself. This feature also permits the module to be used in full transmit or receive for test purposes without affecting meter calibration. The "XMT Level" meter is precalibrated by use of a gain trimpot on the IF monitor and gating PC card to read 1/2 full scale when the proper level of total input power is provided. The "XMT Level" meter will read linearly with input power level and may be used as a check on the levels arriving at the input of the T2. However, no adjustment of transmit power level to the modem T1 module is available. With correct input levels at the T2 module the power supplied to the T1 module via J13 is -6.5 dBm. Modem system levels are given in Figure III-1. The "XMT Level" BNC connector monitors the voltage before the sample and hold circuit that feeds the meter. A scope may be attached to this point to check T/R gating as well as gated receive level precalibrated at +5 VDC.

B. <u>Receive RF Section</u> - The IF combiner receives a 1-2 GHz passband from the modem T1 module at J7. A voltage controlled attenuator (VCA) connected to J7 can be varied by a front panel screwdriver adjustment potentiometer to provide a standard output level to the modules connected to the receive output ports of T2. The 35 dB dynamic range of the attenuator permits a wide range of input levels without compression in the receive amplifiers. The attenuator is normally set at mid range for a waveguide loss of 46 dB.

Two amplifiers provide gain following the VCA. The first of these amplifiers has its supply voltage gated off during the transmit interval. A 1-2 GHz bandpass filter between the two amplifiers is used to minimize 600 MHz and 2400 MHz feedthrough.

A 4-way power divider after the amplifiers distributes the received passband to the LO system via J8 and the "IF Receiver" power splitter via J9, if the module is at the control room. Monitor outputs are also provided identical to those described in the transmit RF section. Again the "RCV IF" BNC connector on the front panel may be used with a spectrum analyzer or power meter for checking levels. The

"RCV Level" meter is precalibrated to read 1/2 full scale for proper level. This level should be set using the "RCV Gain" potentiometer on the front panel. The "RCV Level" BNC connector monitors the voltage before the sample and hold circuit that feeds the meter. A scope may be attached to this point to check T/R gating as well as gated receive level precalibrated at +5 VDC.

C. <u>Interface Logic</u> - The IF combiner T2 module contains the interface to the digital communications system for both the T1 and T2 modules. A list of monitor points and digital commands are given in Figure VII-1 and Figure VII-2. Both digital and analog monitor signals are transmitted through the analog monitor system.

Three digital monitor points from the T1 module are stored in three set-reset flip-flops before transmission via the analog multiplexer. A momentary failure in the modem phase locked loop indicated by a high lock warn or free run warn will be stored in these flip-flops until the telescope operator resets them by the "monitor reset" command. Thus a momentary failure can be indicated to the data set and computer even with a slow monitor sampling rate. The "auto warn" monitor point, also stored in a set-reset flip-flop indicates whether either one of the two manual command switches on the modem has been disturbed.

Because of this storage feature and the operator reset feature, the integrity of the modem system may be checked periodically by the operator without need of continuous monitoring. These three warning flags should remain low throughout an observing run.

Only two other commands are used with the modem system. The "free run" and "search" command inputs feed a set-reset flip-flop for storage. The free-run command is used to disable the phase locked loop in the modem in case of failure. Thus the normal mode is the search condition (free run flip-flop low). To insure this condition when the T2 module is first plugged into the rack or after a power failure, a power-on reset function will place the flip-flop into the search condition. To eliminate the need for an operator to diagnose a transient erroneous free run command and then reset it, a 53 second reset timer will automatically reset the flip-flop every 53 seconds. Therefore, in order to enable the free run backup system, the telescope operator must issue a continuous chain of free run commands, at least one per 53 seconds. The modem free run - search system is described more fully in the T1 manual.

III. MODULE SPECIFICATIONS AND POWER LEVELS

Refer to Figure III-1 for modem system levels. Note that even though the front end "IF" signals are not transmitted by the control room modem, the total power output of the modem is the same as that from the vertex room modem. This is accomplished by an increase in the LO signal levels arriving at the T2 transmit input port. The total power output of the T2 transmit section should in both cases be a constant -6.5 dBm, if all four "IF" channels are in use at the vertex room. If fewer "IF" channels are used, the power output will be correspondingly lower. Thus levels are not changed to compensate for different numbers of channels utilized.

Worst case passband variations are given in Figure III-2.

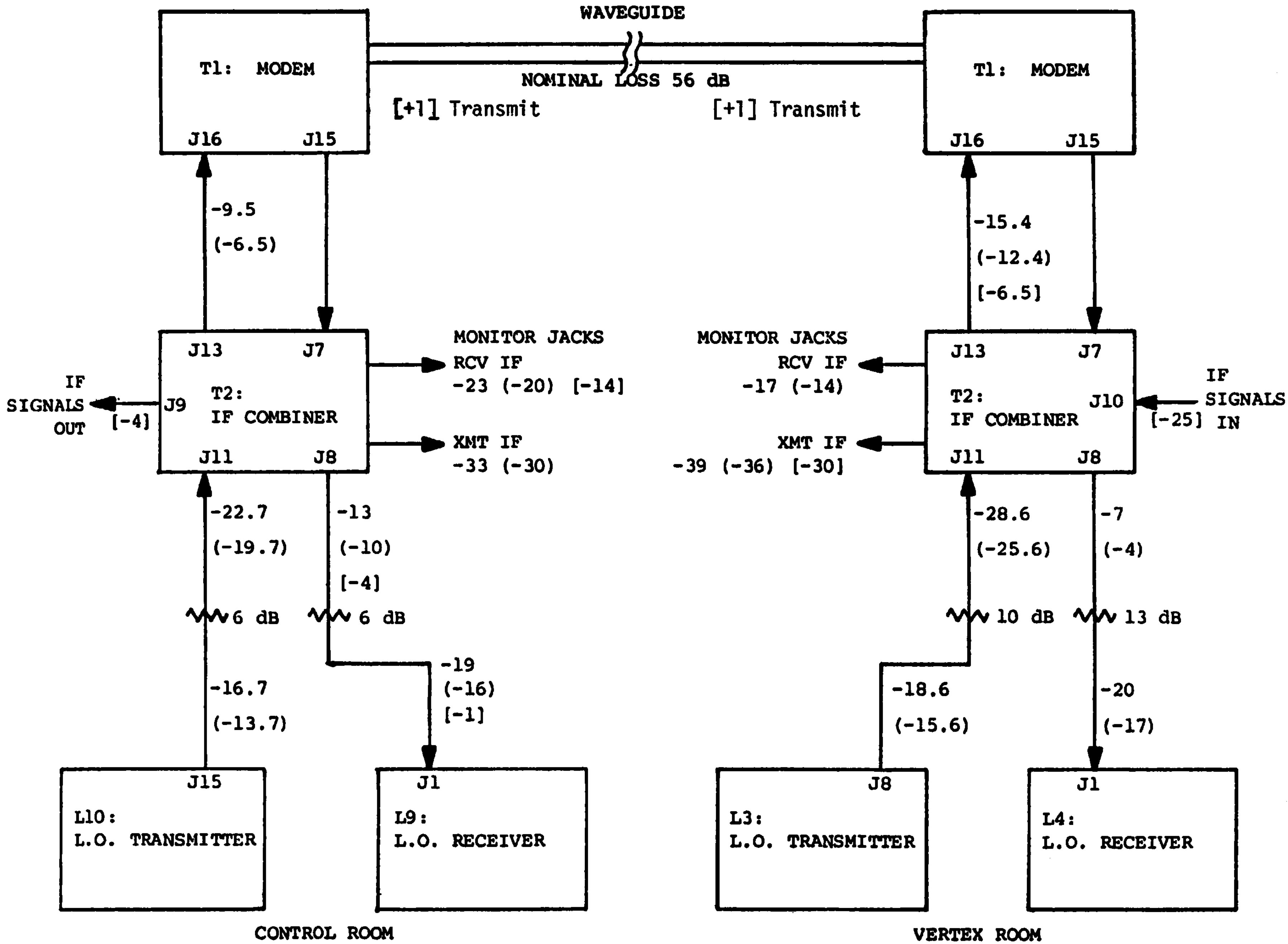


FIGURE III-1 System levels and pads. All power levels in dBm and apply to carrier if no parenthesis, total LO carriers if in parenthesis, and total IF and LO power if in brackets. All signal levels are when the signal is ON; they are not average levels.

T2 PASSBAND AMPLITUDE VARIATION IN RECEIVE

Component		Worst Case Variation Specification
Pin Diode Attenuator		± 0.75 dB
Amplifier		± 1.0
Amplifier		± 1.0
4-way Power Divider		± 0.2
	Total	± 2.95 dB

Total worst case passband variation does not include variations due to the bandpass filter (-3 dB @ 1 and 2 GHz), nor variations due to connectors or reflection coefficients of individual components.

T2 PASSBAND AMPLITUDE VARIATION IN TRANSMIT

Component		Worst Case Variation Specification
Fixed Attenuator		± 0.6 dB
2-way Power Divider		± 0.1
Amplifier		± 1.0
-10 dB Coupler		± 1.0
	Total	± 2.7 dB

Total worst case passband variation does not include variations due to connectors or reflection coefficients of individual components.

T2 PASSBAND AMPLITUDE VARIATIONS

Figure III-2

IV. CIRCUIT DETAILS

A. <u>IF Monitor and Gating Circuit</u> - Refer to the schematic of Figure IV-1.

The monitor circuits for transmit and receive are identical. The RF detector diode connects to a differential input operational amplifier U1A or U2A. Because of the low level of signal from the detector diode, an input-offset adjustment is provided on the amplifier. The amplifier's gain is variable from 10 to 1000 by a poteniometer. The gain is adjustable to compensate for detector differences and to provide a calibrated DC output level for either transmit level checking or for the "RCV Gain" adjustment. This level is set to +5 VDC peak at the front panel "XMT Level" and "RCV Level" BNC connectors, or mid scale on the "XMT Level" and "RCV Level" front panel meters. A scope may be connected to the BNC connectors to observe the T/R timing in the T2 module or to set levels. To prevent damage to a spectrum analyzer accidentally placed at one of these connectors, a 10KΩ resistor is placed in series with each one.

Because of the different T/R duty cycles between the vertex and control rooms, and because of the manual continuous transmit/receive function of the modem, a sample and hold circuit, synchronous with the transmit/receive input signal is used to provide a meter indication as well as an analog input to the DCS system that is independent of T/R duty cycle. An FET analog switch, U3, is used to charge a capacitor to the amplifier's output voltage during the appropriate time period. This capacitor retains its charge during the opposite time period in the case of a normal 1 msec - 49 msec duty cycle. However, if the T2 module is placed into a manual transmit mode, for example, the receive capacitor will decay to zero with a 1 second time constant indicating the modem is not in receive, or that no input RF signal is being received.

A unity gain buffer amplifier provides a high impedance to the sample and hold capacitor and isolates it from the front panel meter and analog multiplexer system. A 100 KΩ series resistor to the 100 μA front panel meter produces a full scale reading of 10 volts, nominal reading mid scale. Because the diode detector is operated in the square law region, the meter reading will be proportional to RF power.

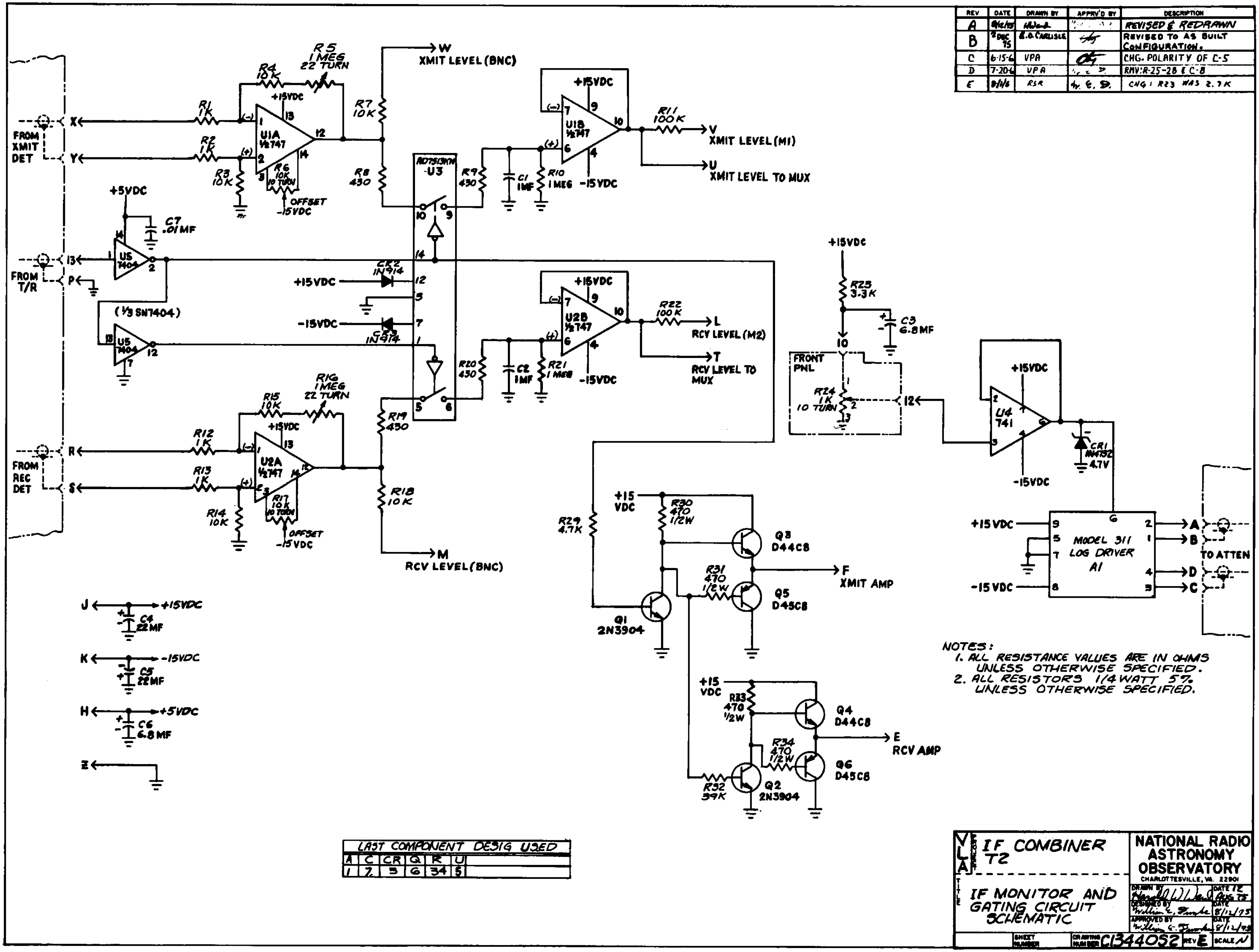

REV | DATE | DRAWN BY | APPRV'D BY | DESCRIPTION
A | REVISED & REDRAWN
B | E.O. CARLISLE | REVISED TO AS BUILT CONFIGURATION.
C | 6-15-6 | VPA | CHG. POLARITY OF C-5
D | 7-20-6 | VPA | RMV: R-25-28 & C-8
E | RSR | CHG: R23 WAS 2.7K
FROM XMIT DET
FROM T/R
FROM REC DET
XMIT LEVEL (BNC)
XMIT LEVEL (M1)
XMIT LEVEL TO MUX
RCV LEVEL (M2)
RCV LEVEL TO MUX
RCV LEVEL (BNC)
XMIT AMP
RCV AMP
FRONT PNL
MODEL 311 LOG DRIVER A1
TO ATTEN
NOTES:
1. ALL RESISTANCE VALUES ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTORS 1/4 WATT 5% UNLESS OTHERWISE SPECIFIED.
LAST COMPONENT DESIG USED
A | C | CR | Q | R | U
1 | 7 | 3 | 6 | 34 | 5
IF COMBINER T2
IF MONITOR AND GATING CIRCUIT SCHEMATIC
NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901
C1344052
REV E

FIGURE IV-1

The IF monitor and gating circuit also contains the logarithmic driver circuit for the 35 dB dynamic range voltage controlled attenuator in the receive section. A 10-turn potentiometer buffered by a unity-gain operational amplifier provides the front panel "RCV Gain" adjustment. The potentiometer provides a 0 to +3.5 VDC control signal to the log driver with maximum attenuation (-35 dB) at +3.5 VDC.

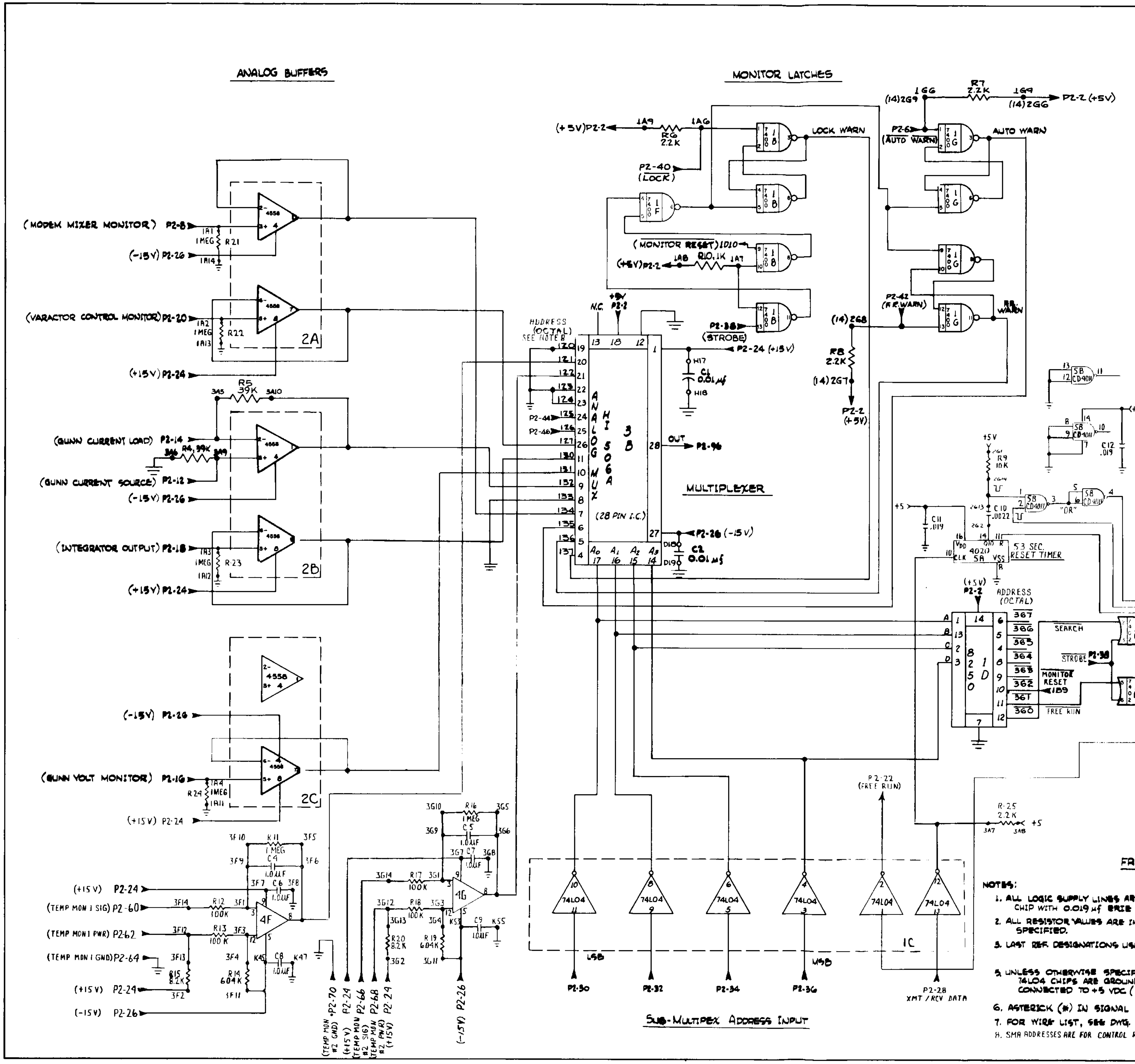
The transmit/receive signal, besides gating the monitor sample and hold circuit, also gates the supply voltages to the T2 transmit amp as well as one of the T2 receive amplifiers for transmit/receive RF signal isolation purposes. To achieve a fast switching time a complementary pair of transistors is used to gate the +15 VDC power supply to each of the two gated amplifiers.

B. Interface Logic - Refer to Figure IV-2.

A single ended analog multiplexer is used to interface both analog and digital monitor signals to the digital communications system. All analog monitor signals originating outside of the T2 module are buffered by operational amplifiers 2A, 2B, 2C, 4F and 4G. All are unity gain buffers with the exception of the Gunn current buffer and the rack temperature buffer amplifiers. The Gunn current amplifier is a differential amplifier with a gain of 4:1 determined by the ratios of the 39KΩ resistors R4 and R5 to 10 KΩ resistors at the output of the modem T1 Gunn voltage regulator board. This normalizes the Gunn oscillator current monitor voltage to read current (amps) corresponding to voltage (volts).

The temperature monitor buffer amplifier intended for use with National Semiconductor Model LX5600A or LX5700A temperature transducers provides a voltage gain of 10:1 with an input voltage offset of 2.73 volts. Thus the output voltage corresponds to temperature at .1 volt/°C with a reference point of 0°C = 0VDC.

Three set-reset flip-flops, 1B and 1G, also interface to the analog multiplexer providing storage for digital warning signals (outputs TTL high) from the modem T1 module. Once these flip-flops are set by a failure in the system, they can only be reset by a telescope operator "monitor reset" command. Integrated circuits 1B and 1F form an "AND" gate with the $\overline{\text{monitor}}$ $\overline{\text{reset}}$ command output from the 8250 command demultiplexer chip, 1D, and the $\overline{\text{strobe}}$ command from the digital communications system to perform this function.



P2	SIGNAL	P1
1		
2	+5 VDC	C
3		
4	+5 VDC (=P2-2)	C
5		
6	AUTO WARN MONITOR	c
7		
8	MODEM MXR VOLT MONITOR	d
9		
10		
11		
12	GUNN CURRENT SOURCE	f
13		
14	GUNN CURRENT LOAD	h
15		
16	GUNN VOLT MONITOR	j
17		
18	INTEGRATOR OUTPUT	k
19		
20	VARACTOR MONITOR	m
21		
22	FREE RUN OUTPUT	n
23		
24	+15 VDC	A
25		
26	-15 VDC	E
27		
28	XMT/RCV DATA	M
29	XMT/RCV DATA GND	N
30	SMA Ø "1" (LSB)	P
31		
32	SMA 1 "2"	S
33		
34	SMA 2 "4"	U
35		
36	SMA 3 "8" (MSB)	W
37		
38	STROBE	Y
39		
40	LOCK WARN MONITOR	a

P2	SIGNAL	P1
41		
42	FREE RUN WARN MONITOR	b
43		
44	XMT I.F. POWER	*
45		
46	RCV. I.F. POWER	*
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60	TEMP MON 1 SIGNAL	t
61		
62	TEMP MON 1 POWER	u
63		
64	TEMP MON 1 GND	v
65		
66	TEMP MON 2 SIGNAL	w
67		
68	TEMP MON 2 POWER	x
69		
70	TEMP MON 2 GND	y
71		
72		
73		
74		
75		
76		
77		
78		
79		
80		
81		
82		
83		
84		
85		
86		
87		
88		
89		
90		
91		
92		
93		
94		
95		
96	ANALOG MUX OUT	EE
97	ANALOG MUX GND	FF
98		
99	GND. (=P2-97)	
100		

NOTES:

1. ALL LOGIC SUPPLY LINES ARE COUPLED AT THE CHIP WITH 0.019 µf ERIE "RED CAP" CAPACITORS.
2. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
3. LAST REF. DESIGNATIONS USED; C12, R25, CR1
5. UNLESS OTHERWISE SPECIFIED, ALL 7400, 7402, AND 74LO4 CHIPS ARE GROUNDED USING PIN 7, AND CONNECTED TO +5 VDC (P2-2) USING PIN 14.
6. ASTERICK (*) IN SIGNAL LIST INDICATES INTERNAL "T2" WIRING.
7. FOR WIRE LIST, SEE DWG. NO. A13440W3
8. SMA ADDRESSES ARE FOR CONTROL ROOM. VERTEX ROOM ADDRESSES ARE 040 THRU 057 (OCTAL)

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
H	7-26-6			RMV: R2 & R3
G	7-20-6			ADD: R25
F	6-29-6			ADD: 5A B C 10-12, R9 - RMV: NOTE 4
E	6-22-6			ADD: R21-24 & LETTERING
D	5/20/76			REVISED PER DESIGN REQMT.
C	9/10/75			REVISED EXTENSIVELY
B	6/17/75			WAS "C" SIZE REVISED & REDRAWN

VLA PROJECT: I.F. COMBINER T2

TITLE: INTERFACE LOGIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY — DATE 6-17-75
DESIGNED BY — DATE 1/17/75
APPROVED BY — DATE 6/18/75

SHEET NUMBER 1 OF 1 | DRAWING NUMBER D13440L1 | REV H | SCALE

FIGURE IV-2

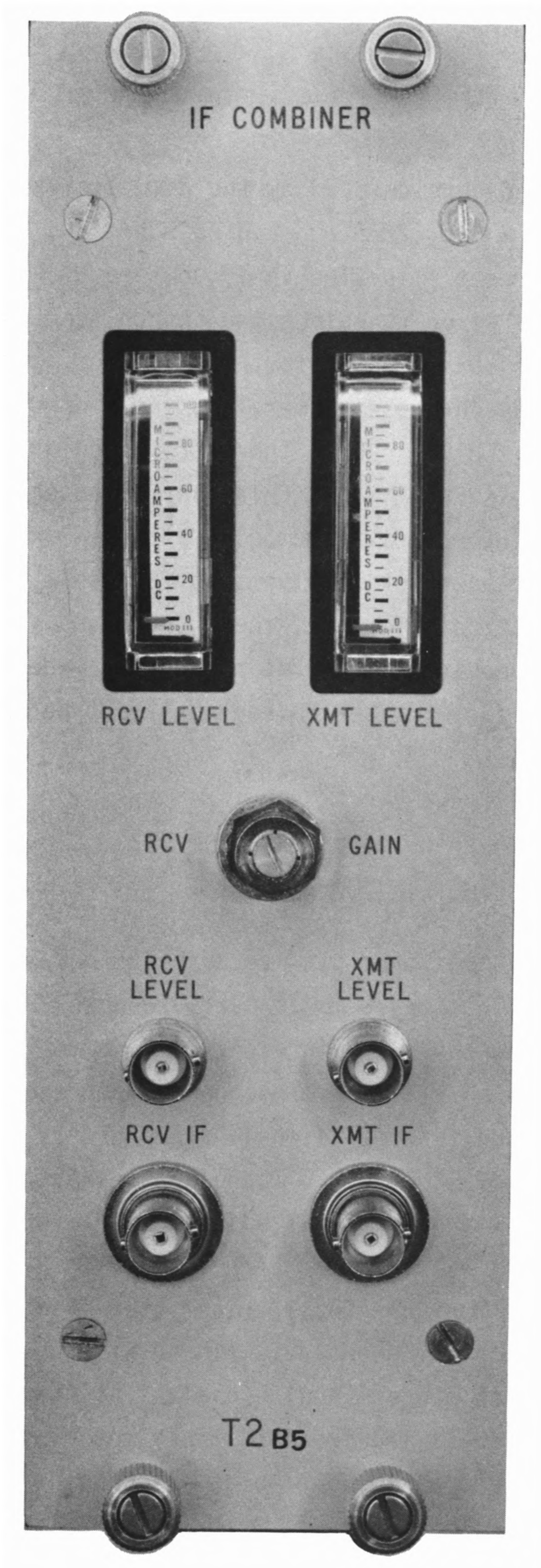


Figure V-1 T2 FRONT PANEL

The analog multiplexer is a single ended output device with address provided through a 74L04 TTL buffer.

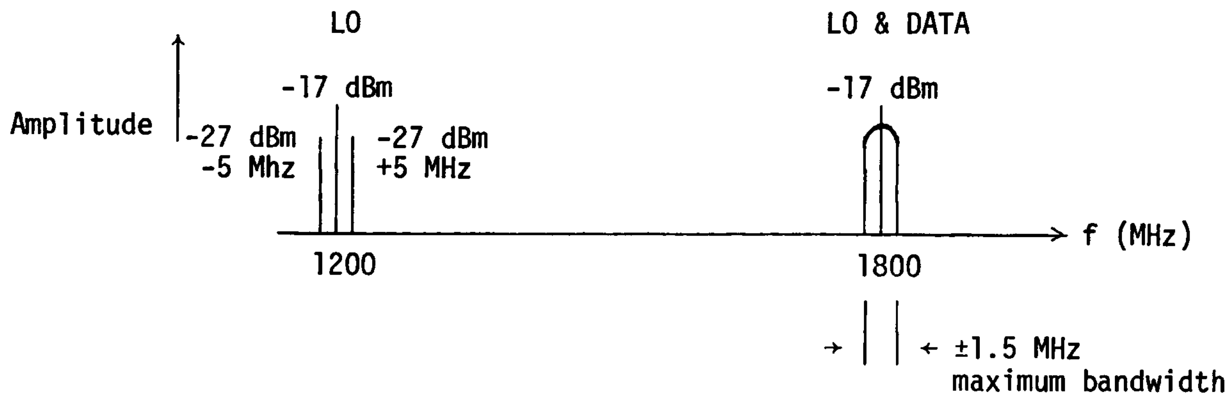
Three commands are decoded by the demultiplexer chip, ID, $\overline{\text{monitor reset}}$, described above, $\overline{\text{free run}}$ and $\overline{\text{search}}$. The latter commands are stored in a set-reset flip-flop in IF, before transmission to the T1 phase locked loop circuit. Since the search function is the normal mode of operation, the search input to the flip-flop is "OR'ed" with an asynchronous 53-second reset timer, 5A, and a power-on reset timer consisting of R1, CR1, and C3. Therefore plugging in the module will incur the proper "search" mode. Also any momentary erroneous free run command will be automatically remedied after a maximum of 53 seconds without telescope operator involvement. Gates 1E and 1F assure priority of these two functions over the free run command. In order to latch the flip-flop continuously in the free run backup mode, a continuous chain of commands (at least one per 53 seconds) must be sent to the T2 module.

V. FRONT PANEL CONTROLS AND ADJUSTMENTS

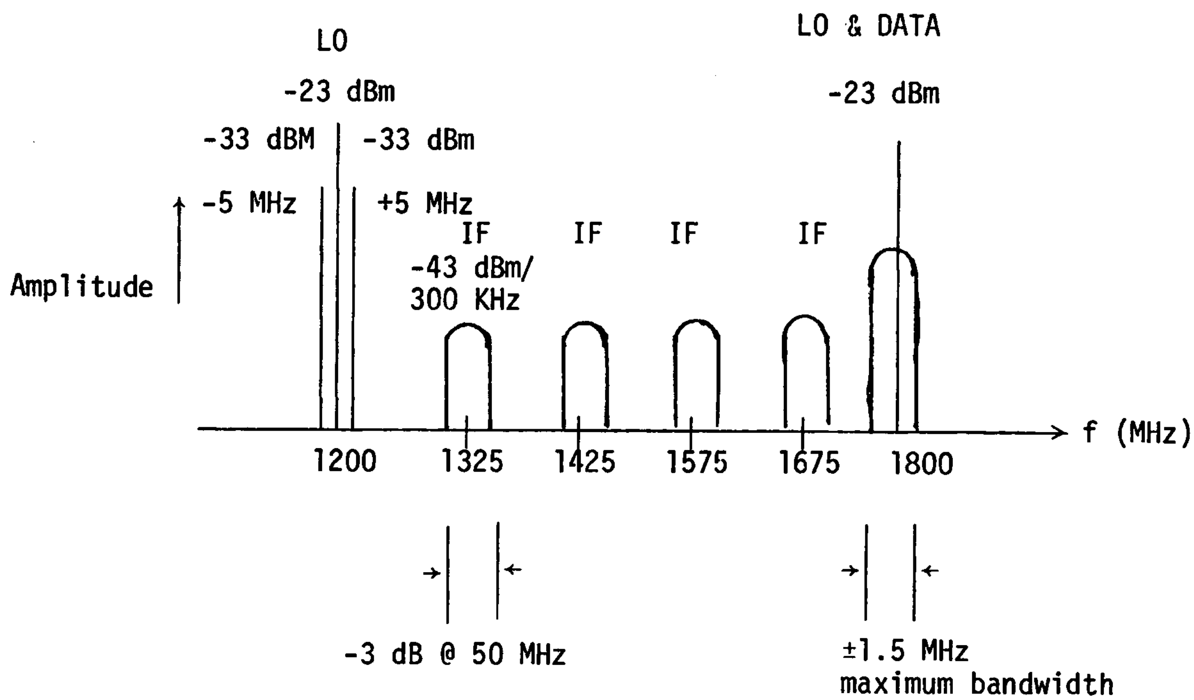
Refer to Figure V-1 "T2 Front Panel".

<u>RCV Level Meter</u>: Monitors total received RF power at the output of the T2 receive amplifiers. This meter is linear with power, precalibrated, and should be set to mid-scale using the RCV Gain front panel adjustment. At the control room this applies only when all four IF signals are present. Note that the meter will read lower when fewer IF signals are present. Also passband ripple may change this reading considerably. Therefore a spectrum analyzer on the RCV IF port may be a better method of final adjustment.

<u>XMT Level Meter</u>: Monitors total transmitted RF power at the output of the T2 transmit amplifiers. The meter is linear with power, precalibrated, and should read mid-scale with proper input signals. At the vertex room this applies only when all four IF signals are present. This meter will read lower when fewer IF signals are present, and passband ripple may change this reading.



VERTEX ROOM



CONTROL ROOM

T2 "RCV IF" Passbands

Figure V-2

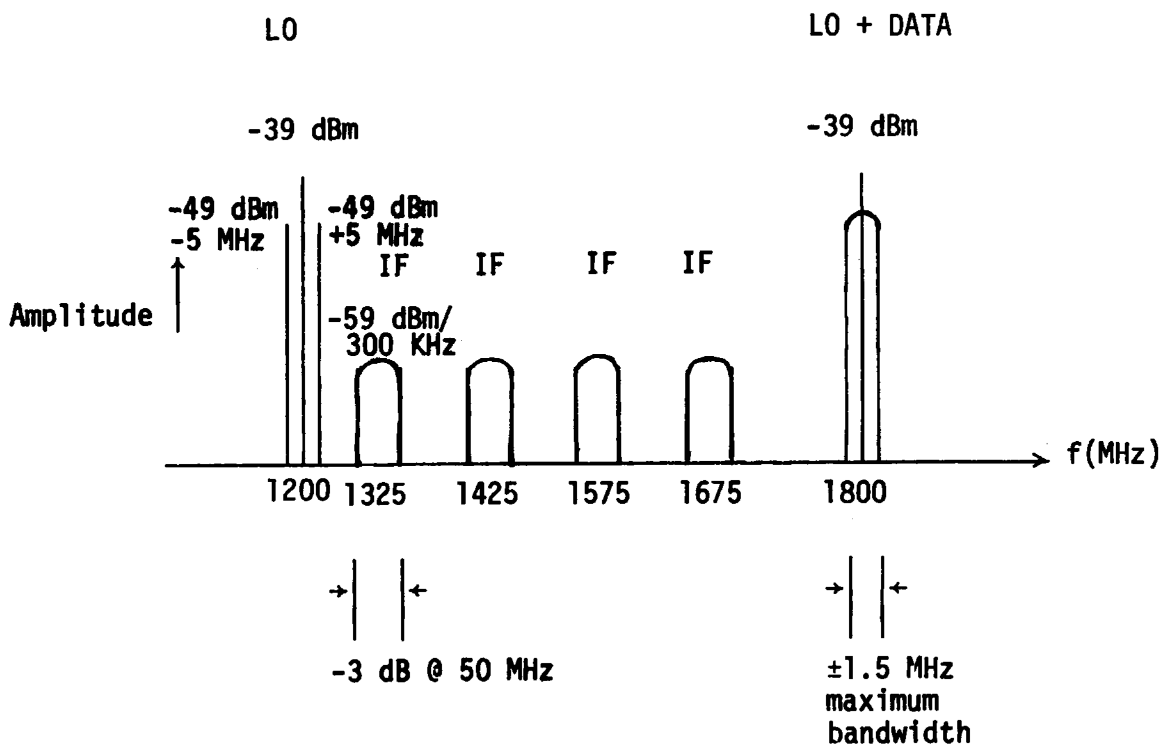
RCV Gain: Controls a voltage-controlled attenuator at the input to the T2 receive section. This potentiometer should be set to provide a RCV level meter mid-scale reading.

RCV Level BNC Connector: Provides a DC monitor point before the sample and hold circuit in the T2 receive output power indication circuit. A gated RCV level indication linear with RF power and set at +5 VDC peak (nominal power) should be observed with a scope. Since the T2 T/R gating is controlled from the transmit/auto/receive switch on the T1 module, the gating observed at this point will be dependent on the position of the switch.

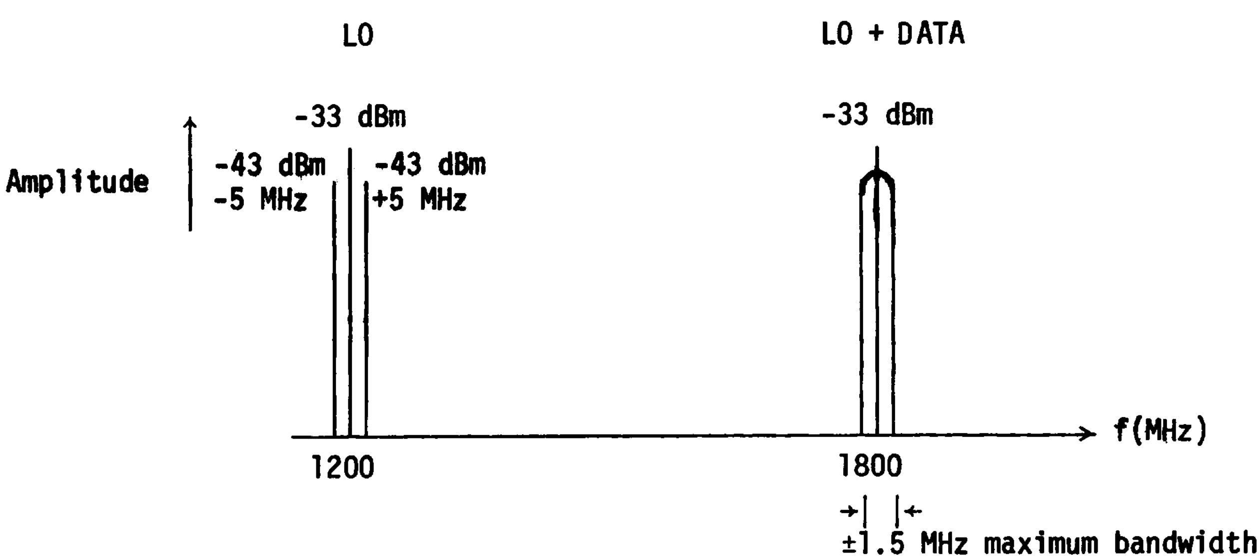
XMT Level BNC Connector: Provides a DC monitor point before the sample and hold circuit in the T2 transmit output power indication circuit. A gated XMT level indication linear with RF power and set at +5 VDC peak (nominal power) should be observed with a scope. Since the T2 T/R gating is controlled from the transmit/auto/receive switch on the T1 module, the gating observed at this point will be dependent on the position of the switch.

RCV IF BNC Connector: Provides an RF monitor point after the T2 receive amplifiers for use with a power meter or spectrum analyzer. Spectrum analyzer waveforms are given in Figure V-2.The modem T1 modules may have to be set to manual transmit or receive in order to take a reading.

XMT IF BNC Connector: Provides an RF monitor point after the T2 transmit amplifier for use with a power meter or spectrum analyzer. Spectrum analyzer waveforms are given in Figure V-3. The modem T1 modules may have to be set to manual transmit or receive in order to take a reading.



VERTEX ROOM



CONTROL ROOM

T2 "XMT IF" Passbands

Figure V-3

VI. TEST PROCEDURE, MONITOR AND CONTROL FUNCTIONS (T1 AND T2), RF CALIBRATION (T2)

A. Connect T1 and T2 to TEST SET.

1. Proper power supply voltages must be connected to the TEST SET.
2. Reference signals, 2400 MHz and 10 MHz, must be connected to the T1.
   a) 2400 MHz at -5 dBm to J4.
   b) 10 MHz at +10 dBm to J14.
3. Place TEST SET switches in the following positions.
   a) ADDRESS SELECT switches up.
   b) S1 in LOCAL.
   c) S2 in CONTROL ROOM.
   d) S3 in AUTO.
4. Place both T1 switches in AUTO.
   a) All LED's on T1 should be out.
5. Momentarily close S9, RESET.
   a) All LED's on TEST SET should be out.

B. Control Function Checkout.

1. Select "1" with ADDRESS SELECT switches (S4 down, free run command).
2. Momentarily close S8, STROBE.
   a) FREE RUN and LOCK WARN LED's on TEST SET and T1 should light.
3. Select "0" with ADDRESS SELECT switches (all switches up, search command).
4. Momentarily close S8, STROBE.
   a) All LED's on T1 should go out.
5. Momentarily close S9, RESET.
   a) All LED's on the TEST SET should go out.
6. Select "1" with ADDRESS SELECT switches (S4 down, free run command).
7. Momentarily close S8, STROBE.
   a) FREE RUN and LOCK WARN LED's on TEST SET and T1 should light.
8. After approximately 53 seconds, FREE RUN and LOCK WARN LED's on T1 should go out.
9. Momentarily close S9, RESET.
   a) FREE RUN and LOCK WARN LED's on TEST SET should go out.

10. Place XMIT/RCV switch (S1) on T1 to either XMIT or RCV.

    a) AUTO WARN LED's on TEST SET and T1 should come on.

11. Place XMIT/RCV switch on T1 to AUTO.

    a) AUTO WARN LED on T1 should go out.

12. Momentarily close S9, RESET.

    a) AUTO WARN LED on TEST SET should go out.

C. <u>Monitor Function Checkout</u>.

1. Starting with test set SUB MUX ADDRESS SELECT switches at "0" (all switches up), select each address, "0" through "15", and compare TEST SET Meter, M1, reading with the following table.

SUB MUX ADDRESS SELECT	TEST SET METER READING (100 = 10 VDC)
"0"	0
1	≈+100
2	≈+100
3	0
4	0
5	0
6	0
7	~0 (should = 1.5 x T1 varactor meter reading)
8	≈ 0
9	+30 to +60 (should = T1 Gunn Volt)
10	≈+10 (should = T1 Gunn Current)
11	0
12	0
13	+40 (TTL High)
14	+40 (TTL High)
15	+40 (TTL High)

2. Select "7" with ADDRESS SELECT switches (S7 down). Remove 10 MHz reference signal from J14, T1.

    a) TEST SET Meter, M1, should alternate from ≈ +25 to ~ -75.

b) LOCK WARN LED's on TEST SET and T1 should light.

c) After ~ 15 seconds, FREE RUN LED should light.

3. Reconnect 10 MHz reference signal to J14, T1.

a) Momentarily throw FREE RUN/SEARCH switch to FREE RUN, then back to SEARCH.

b) LOCK WARN LED on T1 should go out within one complete sweep of the meter voltage.

c) TEST SET Meter, M1, should read ≈ 0.

4. T1 FREE RUN/SEARCH switch to AUTO, momentarily close S9, RESET.

a) All LED's on TEST SET should go out.

5. Select "2" with ADDRESS SELECT switches (S5 down, monitor reset command).

6. Momentarily close S9, STROBE.

7. Select addresses "13", "14" and "15" in turn. TEST SET Meter, M1, should indicate ~0 (TTL Low) for these three steps.

D. <u>RF Calibration Procedure (T2).</u>

NOTE: This procedure can be accomplished in conjunction with the above or as a separate check using a T2 only.

1. TEST SET switches are set according to Step A3.

2. Adjust XMIT OFFSET, R6, on IF Monitor and Gating Circuit for 0 volts as measured with DVM at XMIt LEVEL BNC.

3. Set up Test Oscillator for -19.7 dBm at 1.5 GHz.

4. Connect Test Oscillator to J11 on back panel.

5. Connect Power Meter to J13 on back panel.

a) All unused OMQ Connectors on back panel should be terminated into 50 Ohms at all times.

6. Place T2 into XMIT MODE.

a) If T1 is connected, select XMIT on T1 front panel switch.

b) If T1 is <u>not</u> connected, place TEST SET switch S1 to REMOTE.

7. Adjust XMIT Level, R5, on IF Monitor and Gating Circuit for +5V as measured with DVM at XMT Level BNC.

   a) Power Meter should read approximately -6.5 dBm.

8. Select "5" with ADDRESS SELECT switches (S6 and S4 down).

   a) TEST SET Meter, M1, should read +50.

9. Adjust RCV offset, R17 on IF Monitor and Gating Circuit for 0 volts as measured with DVM at RCV LEVEL BNC.

10. Connect Test Oscillator to J7 in rear panel.

11. Connect Power Meter to J8 on rear panel.

    a) All unused OMQ connectors on back panel should be terminated into 50 Ohms.

12. Place T2 into RCV MODE.

    a) If T1 is connected, select RCV on T1 front panel switch.

    b) If T1 is <u>not</u> connected place S1 to REMOTE and S2 to VERTEX.

13. Adjust RCV LEVEL on front panel for -4 dBm on Power Meter.

14. Adjust RCV LEVEL, R16 on IF Monitor and Gating Circuit for +5V as measured with DVM at RCV LEVEL BNC.

15. Select "6" with ADDRESS SELECT switches (S6 and S5 down).

    a) TEST SET Meter, M1, should read +50.

VII. DIGITAL COMMUNICATIONS SYSTEM ADDRESS ASSIGNMENTS

Address assignments for the modem T1 - IF combiner T2 system are given in Figures VII-1 and VII-2. Note that the monitor addresses are different for the vertex room and control room.

MODEM T1 - IF COMBINER T2 MONITOR POINTS

VERTEX ROOM DATA SET NO. 2

Octal Address	Monitor Point	Voltage
40	Ground	0 VDC
41	Temperature Monitor No. 1	$0.1VDC/^{o}C$, OVDC → $0^{o}C$*
42	Temperature Monitor No. 2	$0.1VDC/^{o}C$, OVDC → $0^{o}C$*
43	Ground	0 VDC
44	Ground	0 VDC
45	Transmit IF Power	5 VDC Nominal
46	Received IF Power	5 VDC
47	Varactor	~OVDC, 1VDC ⇒ 2VDC
50	Integrator Output	~OVDC, 1VDC ⇒ 2VDC
51	Gunn Oscillator Voltage	3 to 6 VDC
52	Gunn Oscillator Current	~1 VDC, 1 VDC = 1 Amp
53	Ground	0 VDC
54	Mixer Voltage	0 VDC
55	Auto Warn	~0 VDC TTL High ⇒ ON
56	Free Run Warn	≈0 VDC TTL High ⇒ ON
57	Lock Warn	~0 VDC, TTL High ⇒ ON

*when connected.

MODEM T1 - IF COMBINER T2 COMMANDS

VERTEX ROOM DATA SET NO. 2

Octal Address	Command
360	Search
361	Free Run
362	Monitor Reset

DCS Addresses - Vertex Room

Figure VII-1

MODEM T1 - IF COMBINER T2 MONITOR POINTS

CONTROL BUILDING DATA SET NO. 5

Octal Address	Monitor Point	Voltage
120	Ground	0 VDC
121	Temperature Monitor No. 1	0.1VDC/^oC, OVDC $\rightarrow$ 0^oC*
122	Temperature Monitor No. 2	0.1VDC/^oC, OVDC $\rightarrow$ 0^oC*
123	Ground	0 VDC
124	Ground	0 VDC
125	Transmit IF Power	5 VDC Nominal
126	Received IF Power	5 VDC
127	Varactor	~0 VDC, 1VDC $\Rightarrow$ 2VDC
130	Integrator Output	~0 VDC, 1VDC $\Rightarrow$ 2VDC
131	Gunn Oscillator Voltage	3 to 6 VDC
132	Gunn Oscillator Current	~1 VDC, 1 VDC = 1 amp
133	Ground	0 VDC
134	Mixer Voltage	0 VDC
135	Auto Warn	$\approx$.1 VDC, TTL High $\Rightarrow$ ON
136	Free Run Warn	$\approx$.1 VDC, TTL High $\Rightarrow$ ON
137	Lock Warn	$\approx$.1 VDC, TTL High $\Rightarrow$ ON

*when connected

MODEL T1 - IF COMBINER T2 COMMANDS

CONTROL BUILDING DATA SET NO. 5

Octal Address	Command
360	Search
361	Free Run
362	Monitor Reset

DCS Addresses - Control Room

Figure VII-2

VIII. "T2", IF COMBINER DRAWING LIST

Title	Drawing
SCHEMATIC & LOGIC DIAGRAMS:	
IF Monitor & Gating Ckt. Schematic	C13440S2
Interface Logic	D13440L1
BILL OF MATERIALS:	
IF Combiner Assembly	A13440Z6
IF Monitor & Gating Ckt. Subassembly	A13440Z7
Interface Logic Subassembly	A13440Z8
ASSEMBLY DRAWINGS:	
Top Assembly Drawing	D13440P6
IF Monitor & Gating Ckt. Subassembly	C13440P3
Interface Logic Subassembly	C13440P5
IF Combiner Wire Harness	C13440P15
BLOCK DIAGRAMS:	
IF Combiner Assembly Block Diagram	C13440B2
WIRE LISTS:	
Interface Logic Board Wire List	A13440W1
Rear Panel Mod. Conn. Wire List	A13440W3
MECHANICAL DRAWINGS:	
Front Panel	C13440M1
Connector Support Block	B13440M20
Partition Plate	D13440M22
Bar Supports, Modified	C13440M24
Guides	B13050M4
Perforated Cover	C13050M22-1
Side Plate	B13050M18
Bar Supports, Top & Bottom	B13050M23
Panel, (10) OMQ Connector	B13050M30
Rear Panel	C13210M4
Panel, 50 Pin Pwr	B13050M29

Title	Drawing
PRINTED CIRCUIT BOARD ARTWORK	
IF Monitor & Gating PC Card	B13440AB1
PRINTED CIRCUIT BOARD SILKSCREEN	
IF Monitor & Gating PC Card	None
PRINTED CIRCUIT BOARD DRILL DRAWINGS	
IF Monitor & Gating PC Card	C13440M26
SPECIFICATIONS	
Assembly/Wiring Operations & Specifications	A13440N10
Solid State Amplifier	A13450N10

IX. SPECIFICATIONS

SPECIFICATION: A13440N10 DATE: December 18, 1975

UNIT: IF Combiner, Module Type T2

TITLE: Assembly/Wiring Operations and Specifications

TOP ASSEMBLY DRAWING:

TOP BILL OF MATERIAL:

PREPARED BY: APPROVED BY:

1.0 GENERAL DESCRIPTION AND SCOPE

This specification defines the work required to assemble and wire prefabricated components into a completed assembly, ready for test.

The scope of this specification covers the operations to be performed, the items supplied by NRAO, assembly and wiring requirements and the associated documentation.

The assembly operations identify the operations to be performed in an orderly assembly sequence. The appropriate drawings and documentation are keyed to the sequence.

If problems of fit or drawing interpretation arise, NRAO should be contacted for resolution of the problem.

2.0 NRAO-SUPPLIED ITEMS

1. NRAO will supply ALL printed circuit boards; drilled, etched and profiled, ready for assembly.
2. NRAO will supply ALL metal and plastic components; plated, painted and engraved. Metal components will be bagged and will have the part number printed on the bag for identification.

3. NRAO will supply ALL hardware items such as screws, nuts, connector pins, connector blocks, insulator spacers, mylar sheets, coax cable, coax connectors, brackets, housings, etc.
4. NRAO will supply ALL electrical components such as integrated circuits, transistors diodes, resistors, capacitors, LED's, IC sockets, potentiometers, RF components, coaxial cable, PC Board connectors, etc.
5. NRAO will not supply wire, ty-wraps or lacing cord.
6. NRAO will not supply any tools, except for OSM and OMQ coax connector assembly kits.
7. All component parts will be bagged and marked but will not be broken out into kits or tagged with assembly drawing part numbers.

3.0 ASSEMBLY OPERATIONS

3.1 Place all components including RF components on front panel. Refer to Figures 1 and 2.

3.2 Mount connector block on rear panel. Refer to Top Assembly Drawing No. D13440P6 for proper assembly.

3.3 Assemble partition plate, bar supports, perforated covers, guides, connector support blocks and P.C. board connectors into one unit. Refer to Figures 3 and 4. Assure that this partition plate and modified support bars are correctly oriented. Refer to Figure 5 for correct orientation of guides. Refer to top assembly drawing No. D13440P6 for proper placement of different length guide machine screws.

The module shall be assembled and handled carefully so as to avoid damage such as nicks and scratches on the panels and metal parts.

If there are fit or alignment problems, consult NRAO for corrective action. In no case shall mating parts be "forced" to fit.

SPECIFICATION: A13440N10 DATE: December 18, 1975

UNIT: IF Combiner, Module Type T2

TITLE: Assembly/Wiring Operations and Specifications

TOP ASSEMBLY DRAWING:

TOP BILL OF MATERIAL:

PREPARED BY: APPROVED BY:

1.0 GENERAL DESCRIPTION AND SCOPE

This specification defines the work required to assemble and wire prefabricated components into a completed assembly, ready for test.

The scope of this specification covers the operations to be performed, the items supplied by NRAO, assembly and wiring requirements and the associated documentation.

The assembly operations identify the operations to be performed in an orderly assembly sequence. The appropriate drawings and documentation are keyed to the sequence.

If problems of fit or drawing interpretation arise, NRAO should be contacted for resolution of the problem.

2.0 NRAO-SUPPLIED ITEMS

1. NRAO will supply ALL printed circuit boards; drilled, etched and profiled, ready for assembly.
2. NRAO will supply ALL metal and plastic components; plated, painted and engraved. Metal components will be bagged and will have the part number printed on the bag for identification.

3. NRAO will supply ALL hardware items such as screws, nuts, connector pins, connector blocks, insulator spacers, mylar sheets, coax cable, coax connectors, brackets, housings, etc.

4. NRAO will supply ALL electrical components such as integrated circuits, transistors diodes, resistors, capacitors, LED's, IC sockets, potentiometers, RF components, coaxial cable, PC Board connectors, etc.

5. NRAO will not supply wire, ty-wraps or lacing cord.

6. NRAO will not supply any tools, except for OSM and OMQ coax connector assembly kits.

7. All component parts will be bagged and marked but will not be broken out into kits or tagged with assembly drawing part numbers.

3.0 ASSEMBLY OPERATIONS

3.1 Place all components including RF components on front panel. Refer to Figures 1 and 2.

3.2 Mount connector block on rear panel. Refer to Top Assembly Drawing No. D13440P6 for proper assembly.

3.3 Assemble partition plate, bar supports, perforated covers, guides, connector support blocks and P.C. board connectors into one unit. Refer to Figures 3 and 4. Assure that this partition plate and modified support bars are correctly oriented. Refer to Figure 5 for correct orientation of guides. Refer to top assembly drawing No. D13440P6 for proper placement of different length guide machine screws.

The module shall be assembled and handled carefully so as to avoid damage such as nicks and scratches on the panels and metal parts.

If there are fit or alignment problems, consult NRAO for corrective action. In no case shall mating parts be "forced" to fit.

3.4 Mount RF components onto partition plate as per Figure 3. Assure that all adapters and in-line pads are connected at this time. Note that the General Microwave M190 (Item No. 70) pin diode attenuator is supported with .250" spacers (Item No. 15). Note that the Vectronics DC9107-10MT directional coupler, -10 dB, (Item No. 75) is mounted with one 2-56 x .400" flat head slotted screw (Item No. 42) from the opposite side of the partition plate. Be certain that the input and output connectors on the Aventek amplifiers (Item No. 69) are oriented as shown in Figure 3.

3.5 Assemble and fit semirigid coax links and connectors. A tool kit for the OSM and OMQ connectors will be provided by NRAO with the appropriate instruction books. Each connector must pass a quality control test using NRAO-provided dial indicators. Instructions on the use of these indicators shall also be provided by NRAO.

All semirigid coax must be handfitted to the appropriate RF components using the bending tool provided in the tool kit. No semirigid coax shall be bent to a radius less than that possible using the bending tool. The finished coax lines shall be free of any kinks or scratches, shall be cleaned of rosin, and shall have good quality solder joints.

The semirigid coax lines shall follow the general layout shown in Figure 3.

Before connection to the RF components, all connectors will be cleaned of any particulate matter and inspected.

A torqued wrench supplied by NRAO shall be used to tighten all OSM connectors.

3.6 Assemble and fit wiring harness. This includes the connectors on the RG-188 flexible coax cable. Instructions on assembly of con-hex connectors (Item Nos. 63 and 64) shall be provided by NRAO. All wire terminations, except those used on the module connector wire pins (Items 29 and 30), shall be fitted with heat shrink tubing. The coax connections on the connector block shall be fitted with heat shrink tubing.

Refer to Figure 4 for general wiring harness layout. Refer to wire list drawing No. A13440W3 and wire harness drawing No. C13440W5

The Wire List defines all wiring in the unit and specifies color codes, size (where appropriate), twisted pair runs, coax runs, signal name, and connector or terminal pin number.

Runs which terminate on a solder pin shall be soldered. In some cases two or three wires may terminate upon a pin (if specified by the wire list). If more than three wires are terminated on a connector solder pin there is either a wiring error or the NRAO wiring documentation is in error. In the event there is a documentation error NRAO should be contacted for corrective action.

Solder terminations of stranded wire shall be neat and free of excess solder and wire whiskers. Cold solder joints are not acceptable. Solder flux residue shall be cleaned.

Handwiring shall be dressed neatly into bundles with orthagonal breakouts to termination points. Wire runs in the neighborhood of the board connectors shall be dressed into bundles between the module rails and the connector pins. Wired subassemblies such as front panels shall be dressed with sufficient service loops to permit the panel to be "folded" open for maintenance access. Wire bundles shall be confined with lacing cord.

ALL wiring residue such as wire whiskers, clippings, solder residue, etc., shall be thoroughly cleaned and removed.

The handwiring error rate shall be less than one error per hundred wires.

3.7 Assemble and install PC card. (NOTE: The wirewrap card will be assembled and installed by NRAO.) Refer to IF monitor and gating card subassembly drawing No. C13440P3 and IF monitor and gating circuit schematic drawing No. C13440S2. Be certain that polarities on components are observed as shown in above drawings. The variable resistors shall be oriented as shown in the above drawing. All integrated circuits shall be mounted with sockets. Transistors Q_1 and Q_2 (Item No. 36) shall be mounted with sockets (Item No. 43). The completed printed circuit board shall be cleaned and free of all rosin and debris. The completed PC card shall be mounted to the partition plate using No. 4x.375" nonthreaded spacers (Item No. 3) and 4-40 x .5" screws (Item No. 5).

3.8 The completed modules shall be packed for shipping.

Each module shall be individually wrapped with a protective covering to prevent scratching damage during shipment.

The modules shall be packed carefully in durable shipping containers to prevent shipment damage.

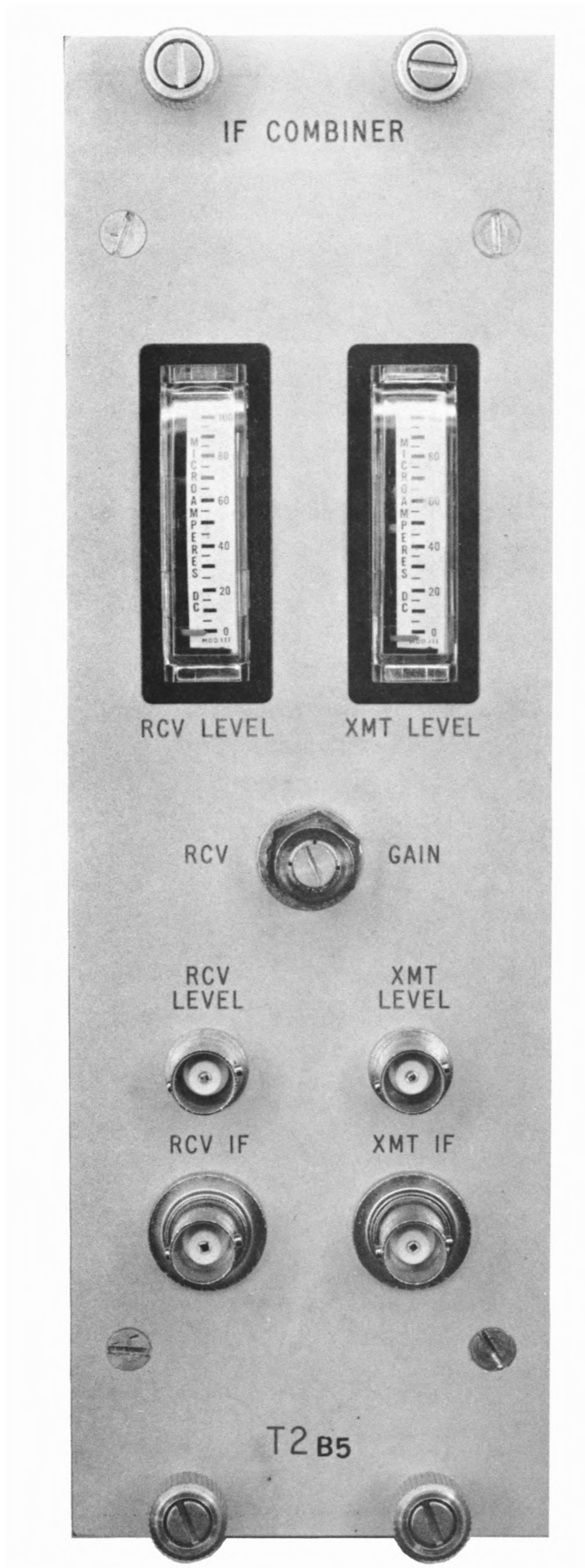


Figure 1: "Front Panel - Front View"

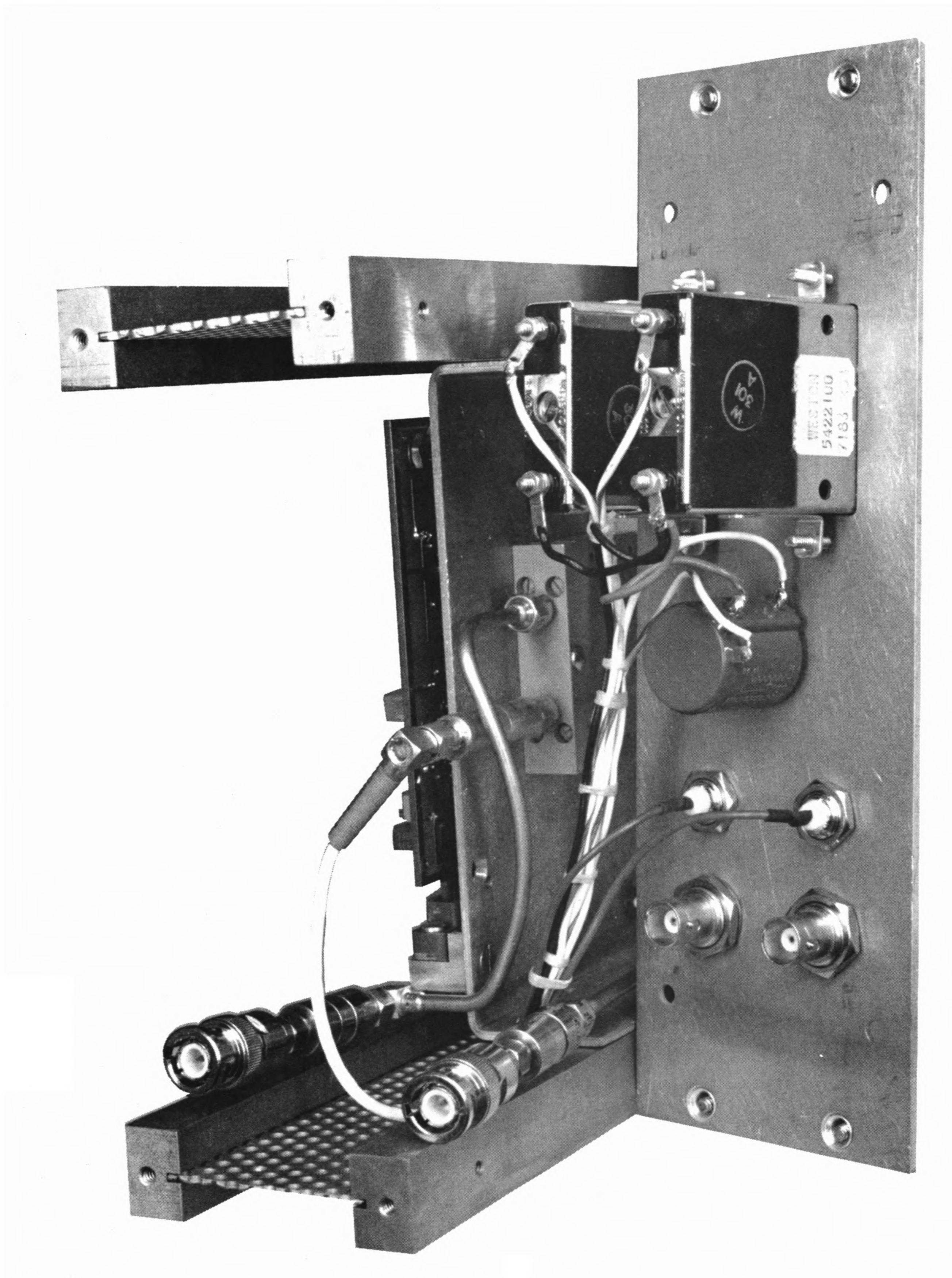


Figure 2: "Front Panel - Rear View"

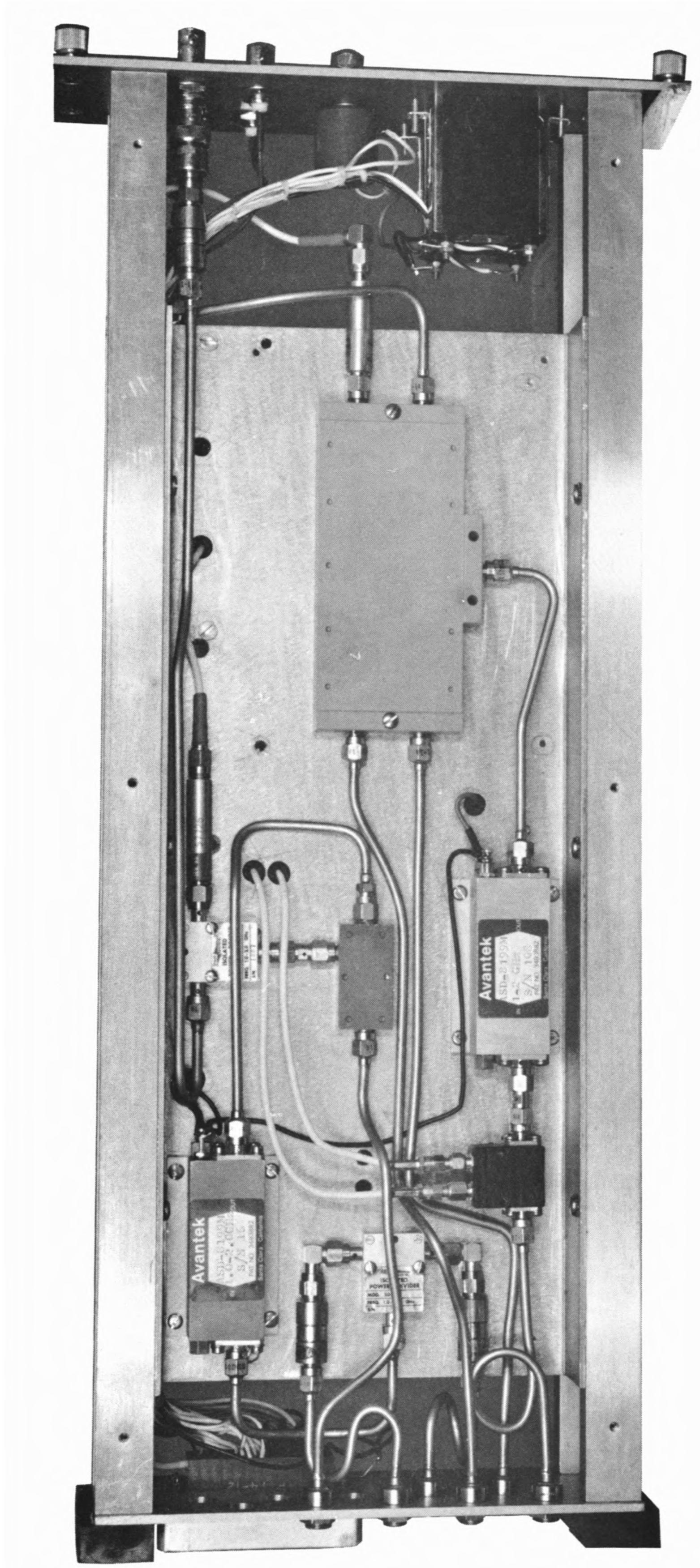


Figure 3: "Right-hand Side View"

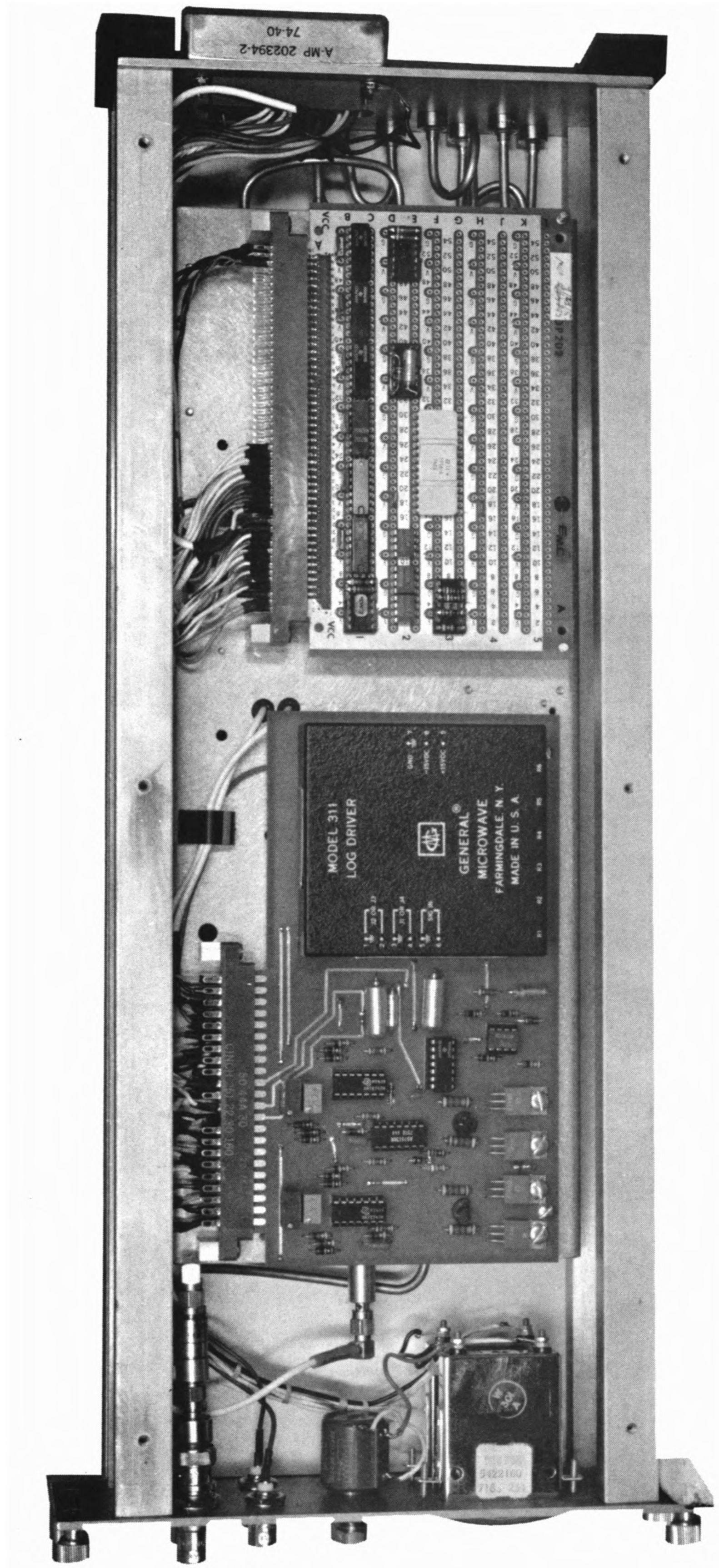


Figure 4: "Left Hand Side View"

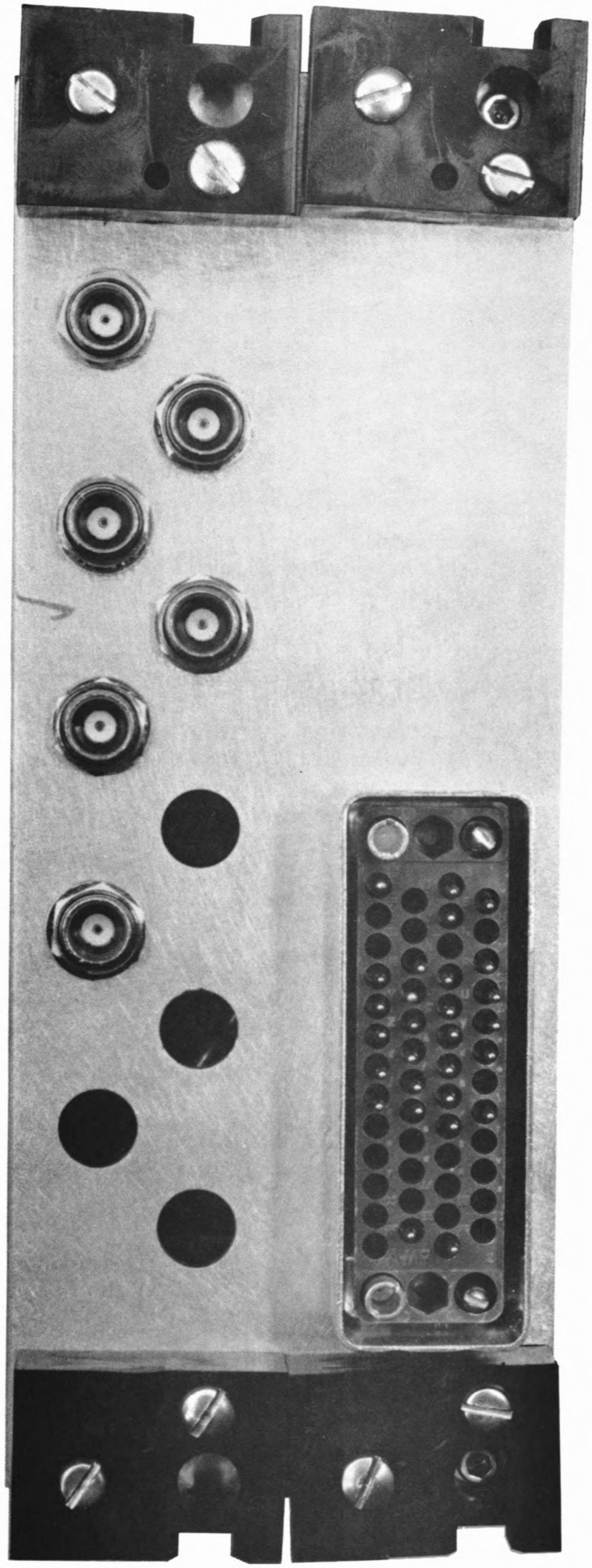


Figure 5: "Rear Panel"

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia
VERY LARGE ARRAY PROJECT

SPECIFICATION NO: A13450N1

NAME: Solid State Amplifier

DATE: February 5, 1974

PREPARED BY: ______________________ APPPROVED BY: ______________________

1. FREQUENCY RANGE: 1.0-2.0 GHz

2. GAIN: 23.5-30 dB (gain of individual units of given type to be equal within ±1 dB).

3. GAIN FLATNESS: ±1 dB

4. POWER OUTPUT: +7 dBm minimum at 1 dB compression

5. NOISE FIGURE: 6 dB max.

6. VSWR: 2.0 max. (input and output)

7. GATING SPEED: The amplifier must switch on or off in less than 10 microseconds when the power supply voltage is gated on and off. Switching time is defined as rise or fall time from 10% to 90% of final RF power. Insertion loss should be greater than 13 dB from 1 to 2 GHz when gated off.

8. INPUT POWER: +15V

9. CONNECTORS: SMA Female

10. Manufacturer is to state whether unit is discrete component construction and whether it is reparable in the event of a transistor failure.

X. DATA SHEETS

TUNNEL DIODE DETECTORS 0.1 to 40 GHz

Series D, DT, DB, DM, DO, DMM, DOM, W812B, W208F, W806F W264F

Aertech's tunnel detector mounts are broadband matched without resistive loading, providing excellent sensitivity and flat response. With both tangential sensitivity and input VSWR optimized, the detectors are available over octave and waveguide bands to 26 GHz. Further performance improvement can be provided in special units matched over narrow bands.

The open circuit voltage sensitivity, K, is approximately 1000 millivolts per milliwatt at 4 GHz. This factor together with the low dynamic video resistance of the diode combine to provide significant improvements in tangential sensitivity (approximately 10 dB for broadband systems) when properly integrated with a low noise video amplifier. This sensitivity improvement is particularly noticeable at low video frequencies (Doppler systems) in which 20-30 dB sensitivity improvements are realized over point contact diodes due to the extremely low 1/f noise corner of the tunnel diode.

The performance of tunnel detectors in wideband video systems requiring fast pulse rise times is particularly noteworthy. The dynamic video resistance of the diodes is on the order of 100 ohms, and enables typical video bandwidths in S band of 100 MHz, with bandwidths up to ½ of the lower RF frequency available on special request.

Detailed diode characterization techniques, precise mechanical design, and low VSWR make possible matched pairs or matched groups of detectors to close tolerances. Applications in amplitude comparator systems, discriminators, and multi-channel receivers are frequent uses of matched tunnel detectors.

Some of the other chief advantages of the tunnel detector include temperature stability, low video impedance, wide dynamic range, and availability in field replaceable mounts.

The tunnel detectors in this catalog are intended to cover the broadest range of system and laboratory applications. However, individual, unique requirements may and do exist, and these types of requirements have created a significant demand for specialized crystal video components. In response to this demand, Aertech engineers have for years specialized in the development of custom detector designs. As a result, a wide range of additional tunnel detectors are available on request.

Frequency response, sensitivity, VSWR, video impedance, square law range, output filtering, connectors, configuration, group matching, burnout, and field replaceable diode mounts are among the detector parameters commonly customized to individual requirements. Contact your local sales representative or Aertech's detector applications group concerning your specific detector needs.

A Technical Note describing tunnel detector features in detail is available upon request.

PART NUMBER CODE

DOM105DPZR-1

Physical Configuration and Connector Options: Refer to Table "A"

Frequency of Operation: Refer to Table "B"

Output Matching:
P = Matched Pair
T = Matched Triplet
Q = Matched Quad
M = Matched Set of 5 or more devices
None = Single Device

Video Bypass:
Z = 50% of Standard Value (Refer to Table B)
None = Standard Value

Output Polarity:
R = Positive Output
None = Negative Output (Standard)

Field Replaceability:
−1 = Field Replaceable Mount
None = Not Field Replaceable

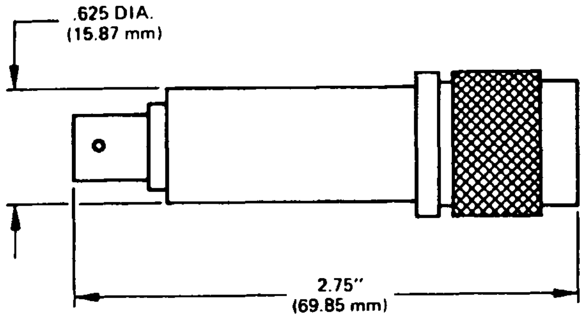
Most detectors are available in several combinations of input and output connectors. RF inputs are available in either type N, TNC, BNC, SMA, or waveguide. Video outputs are available in BNC, TNC, TSM, OSSM, or Sealectro Con-Hex (screw-on, or snap-on) connectors. To specify the model number of the desired detector, add the connector "series" letter(s) (Table A) to the detector "type" number (Table B). Then add any of the desired options listed above in the order they are shown.

TABLE A
STANDARD PHYSICAL CONFIGURATION AND CONNECTOR OPTIONS

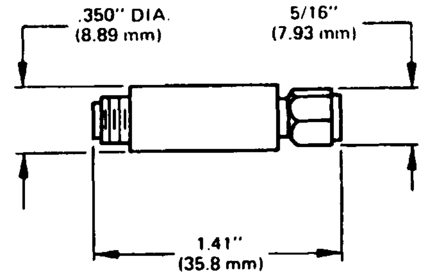
Aertech Connector Series	RF	Video	Maximum RF Frequency GHz	Other Video Connectors Usually Available on Special Request
D	N (M)	BNC (F)	12.4	TNC, Type N (M or F)
DT	TNC (M)	BNC (F)	12.4	TNC, Type N (M or F)
DB	BNC (M)	BNC (F)	4.0	TNC, Type N (M or F)
DM	SMA (M)	Con-Hex*	18.0	Con-Hex (snap-on)
DO	SMA (M)	SMA (F)	18.0	– – –
DMM	SMA (M)	Con-Hex*	26.5	Con-Hex (snap-on)
DOM	SMA (M)	SMA (F)	26.5	– – –
W (for W812B)	RG-52/u	BNC (F)	12.4	Con-Hex, TNC
W (for W208F)	RG-91/u	Con-Hex*	18.0	Con-Hex (snap-on), SMA
W (for W806F)	RG-66/u	Con-Hex*	26.5	Con-Hex (snap-on), SMA
W (for W264F)	RG-96/u	Con-Hex*	40.0	Con-Hex (snap-on), SMA

* Sealectro screw-on Con-Hex Series. Also mates with Amphenol Series 27.

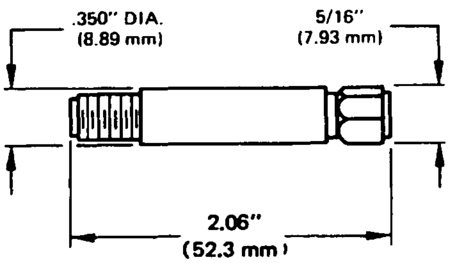
OUTLINES (COAXIAL INPUTS)



D, DT, DB SERIES

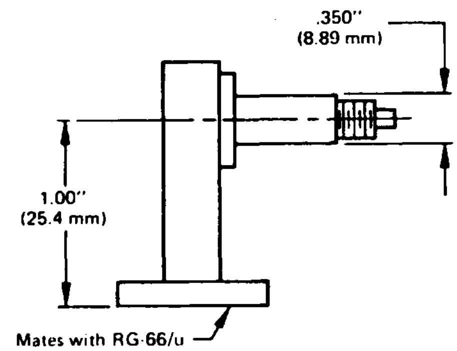


DMM, DOM SERIES

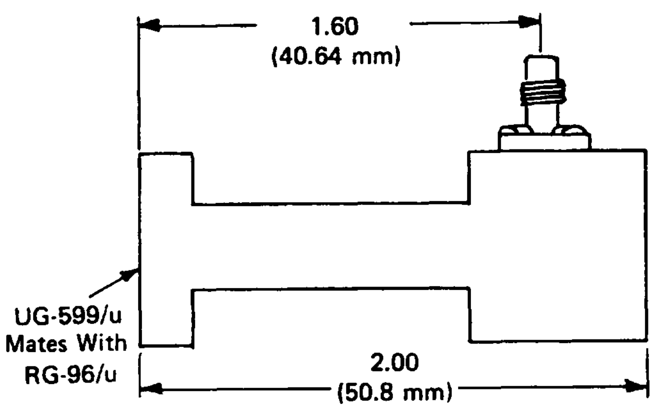


DM, DO SERIES

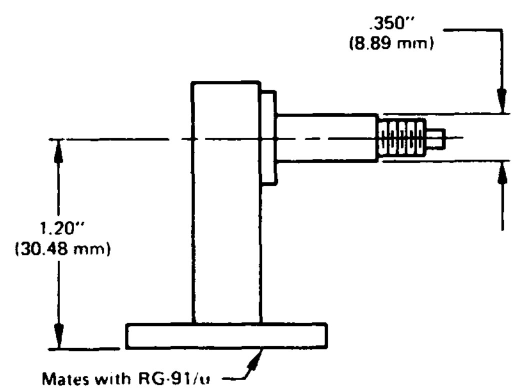
OUTLINES (WAVEGUIDE MOUNTS)



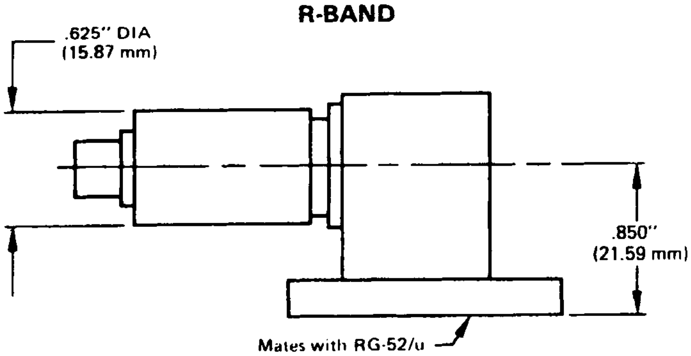
K-BAND



R-BAND



KU-BAND



X-BAND

TABLE B
ELECTRICAL SPECIFICATIONS

	Frequency (GHz)	Type	Cap. (Max.) pF (Cv) [8]	K (Min.) mV/mW	M (Min.)	Flatness Typical (dB)	TSS[7] Typ. (dBm)	VSWR (Max.)	VSWR Typ.
Standard Octaves	0.1-0.5	105D	500	1000	100	±0.2	−51	2.0	1.5
	0.5-1.0	510D	100	1000	100	±0.2	−51	2.0	1.5
	1.0-2.0	102B	50	1000	100	±0.2	−51	2.0	1.5
	2.0-4.0	204B	25	1000	100	±0.2	−51	2.0	1.5
	4.0-8.0	408B	15	700	70	±0.4	−50	2.5	1.7
	8.0-12.0	812B	15	700	70	±0.4	−50	2.5	1.7
	8.0-16.0	816B	15	450	45	±0.6	−48	3.0	2.2
	12.0-18.0	208F*	7	400	40	±0.5	−48	2.5	2.0
	18.0-26.0	806F**†	5	250	25	± 1.0	−46	4.0	2.5
Broad Bands	0.1-1.0	110D	500	700	70	±0.5	−50	3.0	1,8
	0.5-2.0	520D	100	800	80	±0.5	−50	3.0	1,8
	0.7-1.4	714D	50	1000	100	±0.3	−51	2.0	1.5
	1.0-4.0	104B	50	800	80	±0.5	−50	3.0	2.0
	1.0-12.0	112B	25	500	50	±1.5	−50	4.0	2.5
	2.0-8.0	208B	25	600	60	±0.7	−50	3.5	2.0
	2.0-12.0	212B	15	500	50	±1.0	−50	4.0	3.0
	2.0-18.0	218B*	15	400	40	±1.0	−48	4.0	3.0
	4.0-12.0	412B	15	600	60	±0.7	−48	3.5	2.0
	7.0-11.0	711B	15	700	70	±0.4	−50	2.5	1.8
	7.0-12.0	712B	15	600	60	±0.5	−50	3.0	2.0
Waveguide Mounted	8.2-12.4	W812B	15	700	70	±0.4	−50	2.0	1.7
	8.5-9.6	W8596B	15	1000	100	±0.2	−51	1.7	1.4
	12.0-18.0	W208F	7	500	50	±0.5	−48	2.5	2.0
	18.0-26.5	W806F†	5	250	25	± 1.0	−46	4.0	2.5
	26.5-40.0	W264F†	2	250	25	±1.0	−45	4.0	3.0

TECHNICAL NOTES ON SPECIFICATIONS:

1. Detectors can be matched within ±0.25 dB over octave band widths and ±0.4 dB over wider band widths. Add 10% to price per unit for matching in pairs, and add suffix letter "P" to the model number.
2. The 1 dB non-square-law point varies with the value of the video load. Typical values are −17 dBm for open circuit and −12 dBm for a 100-ohm video load.
3. No bias is required to obtain the performance specified. All standard models have a built-in DC return. Detectors can be supplied without DC returns on special request.
4. RF Power Input must be limited to 50 mW, CW or 3 ergs spike. On models specified above 12 GHz, power ratings are 10 mW, CW or 1 erg spike. The video input must be limited to 0.5 volt forward voltage and 10 mA reverse current. Forward voltage is defined as a negative voltage at the video connector for a forward (−) output detector. Voltage and power levels higher than those specified may result in permanent damage to the detector.
5. VSWR, K and flatness ratings are given for input powers from tangential sensitivity to −23 dBm.
6. Flatness is defined as the RF power variation required to maintain a constant voltage output across the frequency range.
7. BW = 2 MHz, NF = 3 dB @ ambient temperature.

* Available only in DM, DO, DMM, and DOM Series.
** Available only in DMM, and DOM Series.
† Not available in field replaceable mount.

8. Capacity, C_V, can be supplied in other values. Add the letter "Z" to the model number to reduce C_V by 50%. Example: D204BZ would have 12 pF. Add 5% to the price for "Z" models.

TANGENTIAL SIGNAL SENSITIVITY

The figure of merit, M, defines the detector parameters and is given by

$$M = \frac{K}{\sqrt{R_v}}$$

where, K = open circuit voltage sensitivity in mV/mW
R_v = video resistance of detector in ohms

However, tangential signal sensitivity (TSS) is a measure of the combined detector-amplifier performance as a video receiver and is a function of temperature, bandwidth, and amplifier noise figure as well as the figure of merit of the detector. TSS has become accepted as being that signal power which produces 8 dB signal-to-noise voltage ratio: and at 300°K

$$P_{TSS} = \frac{3.22\sqrt{BF}}{M} \times 10^{-7}$$

with P in milliwatts, B in Hz, and F expressed as a power ratio.

An important consideration in achieving detector-amplifier sensitivity is optimizing video amplifier noise figure as a function of detector video resistance. Transistor video amplifiers are quite suitable for such application, and noise figures <3.0 dB are easily attainable for the source resistance (75 to 200 ohms) of the tunnel diode detector.

DYNAMIC RANGE

Tunnel detector square-law performance is essentially unaffected by changes in microwave power level at small signal levels ($P_{IN} \leqslant -23$ dBm). At higher power levels there are necessarily deviations, since a strict adherence to square-law performance would require a conversion gain. Proper loading of the tunnel device can, however, extend square-law performance to beyond −15 dBm, and dynamic ranges greater than 40 dB are typically achievable in systems with bandwidths of several MHz.

A particularly convenient application of the tunnel detector is its use in conjunction with narrow band 1 kHz amplifiers such as the HP415E SWR meter. On "low" input, excellent square-law performance is realized, and typical sensitivities are below −65 dBm.

1/f NOISE CHARACTERISTICS

The tunnel diode detector offers significant improvement for low-frequency narrow-band video applications where 1/f noise predominates. Tunnel detectors differ from crystal detectors in that the 1/f noise corner is as much as three decades in frequency below that of the crystal detector. This is due in part to the high doping levels and low resistivity of the back diode semiconductor wafer, and to the fact that no bias is required for normal operation. This physical characteristic of the tunnel detector can improve the sensitivity of video receivers below 100 kHz; e.g., in Doppler radar systems, by 15 to 30 dB, when the detector is properly integrated with a transistor video amplifier.

TEMPERATURE STABILITY

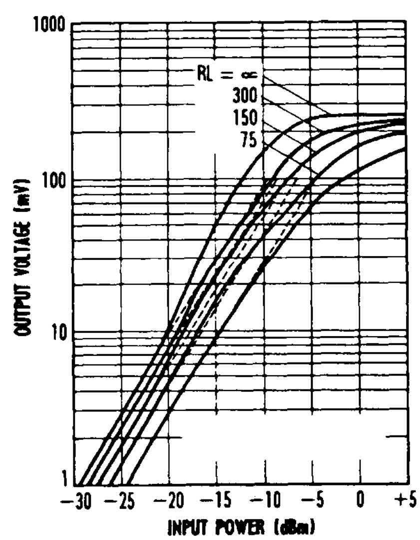
In addition to performing well in systems requiring large dynamic ranges, the tunnel detector displays excellent temperature stability characteristics. Although the I-V characteristic of the tunnel diode is affected by temperature variations, the greatest change occurs in the p-n junction current region beyond the valley voltages; by comparison, the tunneling region (where the detector operates under small signal conditions) is relatively independent of temperature. Typical variation in sensitivity for the tunnel detector is ±0.5 dB over the temperature range from −65° to +85°C. This represents a considerable improvement over competitive crystal devices.

APPLICATION OF BIAS

A further microwave receiver consideration is that the tangential sensitivities mentioned herein are for unbiased tunnel detectors. This operational mode is generally optimal when sensitivity, VSWR, dynamic range, and system simplicity are all considered. When tangential sensitivity is of primary concern, improvements can be obtained by biasing the tunnel device to operate near the peak current. Increasing sensitivities, on the order of 2 to 5 dB, can be realized in this manner, at the expense, however, of reduced dynamic range and increased RF mismatch.

POWER HANDLING CAPABILITIES

The tunnel diode's power handling capabilities are higher than the point-contact crystals; however, because of the low resistance (100 ohms compared to 5,000 ohms) it is much easier to exceed the power ratings through transient voltages. For example, a capacitor charged to 10 volts will generate a peak power of approximately 1 watt when discharged through the tunnel detector and only about 20 milliwatts when discharged through the crystal detector. For high reliability application CW input powers should be kept below 50 mW.



TYPICAL TUNNEL DETECTOR TRANSFER CHARACTERISTICS

CMOS
DUAL SPST ANALOG SWITCH

AD7513

FEATURES

"ON" Resistance	55Ω
Break-Before-Make Switching	
Power Dissipation:	3mW
DTL/TTL/CMOS Compatible	
Switch Current	50mA
Replaces DG-200	

GENERAL DESCRIPTION

The AD7513 is composed of two independent single-pole-single-throw switches on a CMOS chip. State-of-the-art design provides TTL/DTL/CMOS compatibility and a low power dissipation of 3 mW.

The AD7513 is an excellent replacement for reed relays and FET switches due to its low power dissipation, direct logic interface capability and low price. Its high surge current capability makes it ideal for use in integrator or sample/hold circuits.

ABSOLUTE MAXIMUM RATINGS
(T_A = +25°C unless otherwise noted)

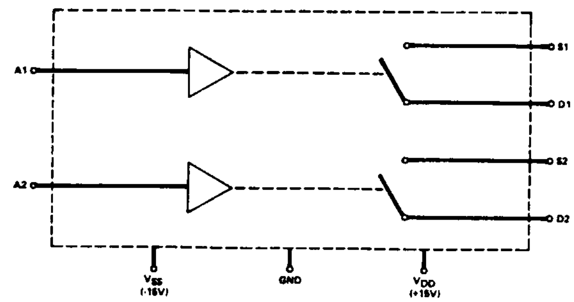
V_{DD} to GND . . . . +17 V
V_{SS} to GND . . . . −17 V
V Between any Switch Terminals . . . . +25 V
Switch Current (I_{DS}, continuous) . . . . 50 mA
Switch Current (I_{DS}, Surge) –
1 ms duration, 10% duty cycle . . . . 150 mA
Digital Input Voltage Range . . . . GND to V_{DD}
Power Dissipation
See page 32

Operating Temperature . . . . −55°C to +125°C
Storage Temperature . . . . −65°C to +150°C

CAUTION:

1. Do not apply voltages higher than V_{DD} and V_{SS} to any other terminal, especially when V_{SS} = V_{DD} = 0V all other pins should be at 0V.
2. The digital control inputs are zener protected; however, permanent damage may occur on unconnected units under high energy electrostatic fields. Keep unused units in conductive foam at all times.

FUNCTIONAL DIAGRAM



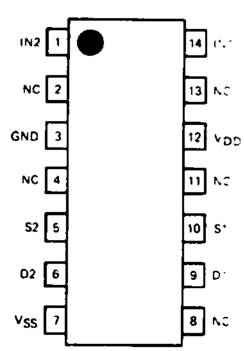
LOGIC
Switch "ON" For Address "LOW".

ORDERING INFORMATION

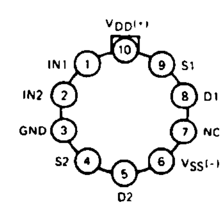
PLASTIC DIP (Suffix N)	TO-100 (Suffix H)	OPERATING TEMPERATURE RANGE
AD7513JN AD7513KN	AD7513JH AD7513KH	0°C to +75°C
	AD7513SH AD7513TH	-55°C to +125°C

PIN CONFIGURATION

PLASTIC DIP
Top View



TO-100
Top View



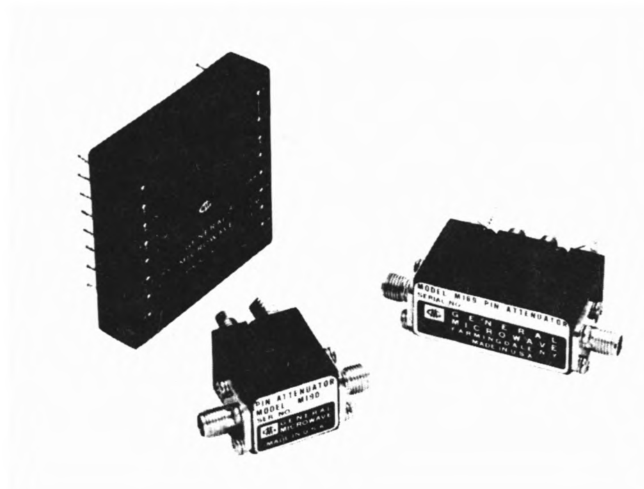
GENERAL MICROWAVE **tech data**

Models M189 and M190

ABSORPTIVE PIN DIODE ATTENUATOR/MODULATORS*

and drivers

- **ULTRA WIDEBAND: 0.2-18.0 GHz**
- **ATTENUATION RANGE: UP TO 65 dB**
- **LOW VSWR AND INSERTION LOSS**
- **FREQUENCY SENSITIVITY: AS LOW AS ±0.5 dB**
- **SMALL SIZE AND WEIGHT**



35 dB ATTENUATOR

The General Microwave Model M190 is an absorptive PIN diode attenuator/modulator which operates over the instantaneous frequency range from 0.2 to 18 GHz. This multi-octave bandwidth uniquely suits the Model M190 to such applications as ECM equipment and wide-band swept power, VSWR and attenuation measuring systems.

Its rf design consists of a T-pad arrangement of shunt and series chip diodes in a microstrip integrated circuit transmission line. (See figure 1.) The arrangement permits operation of the Model M190 as a bilaterally-matched device at all attenuation levels by separately controlling the bias currents through the series and shunt diodes.

Although the Model M190 will safely tolerate input powers up to 2 watts average from −65°C to +25°C, the maximum power level at which it will operate within its specifications is shown in figure 2. For higher power applications, the narrower band Model LM190 is available.

65 dB ATTENUATOR

For applications requiring higher levels of attenuation, the Models M189 and LM189 are available. These units consist of the equivalent of two independently-controlled Model M190 and LM190 attenuators, respectively, in a single rf assembly.

DRIVERS

The proper levels of series and shunt diode currents required for operation of any Model M189 and M190 unit can either be provided by the user's circuitry, or by the GMC Model 311 Driver, which provides voltage controlled linear attenuation with a nominal transfer function of 10 dB per volt. One Model 311 driver is required for each Model M190 and two for each Model M189. When Model 311 drivers are ordered with attenuators, the driver/attenuator assembly is calibrated for optimum linearity at 2 GHz. Calibration at other frequencies within the band is available upon request.

Other drivers are available to permit the use of the Model M189 and M190 units as digitally-programmable step attenuators. Consult the GMC Series 325 data sheet for full technical details

OTHER MODES OF OPERATION

By reducing the series diode current to zero, the Models M189 and M190 can be operated as high-isolation reflective switches for low frequency applications where the isolation provided by the conventional shunt diode switch design (such as that used in the GMC Series M86) is inadequate.

OTHER UNITS

Options for rf and bias connector selection as well as temperature range are described below. Further, GMC offers a 45 dB attenuator, the Model M186B, for applications where the low frequency sensitivity of the Models M189 and M190 is not required. In addition, the Models M189, M190 and M186B can be provided with integrated drivers to function as high-speed ON-OFF absorptive switches, as Models DM189H, DM190H and DM186BH. Technical data sheets for those units are also available.

GENERAL MICROWAVE CORPORATION

[illegible] Farmingdale [illegible] N.Y. [illegible] • Tel 516-694-[illegible] TWX [illegible]

*Patent Nos. 3,812,438 and 3,713,037

SPECIFICATIONS

FEATURE	FREQUENCY (GHz)	MODEL NO. M190	M189	LM190	LM189
MAXIMUM INSERTION LOSS (dB)	0.2- 8.0 8.0-12.4 12.4-18.0	1.5 1.8 2.5	2.5 3.0 5.0	1.5 1.8 –	2.5 3.0 –
MAXIMUM VSWR	0.2- 8.0 8.0-12.4 12.4-18.0	1.5 1.6 2.0	1.5 2.0 2.3	1.5 1.75 –	1.5 2.0 –
MAXIMUM ATTENUATION (dB)	0.2- 8.0 8.0-12.4 12.4-18.0	35 35 30	65 65 60	35 30 –	65 60 –
AVERAGE POWER HANDLING CAPABILITY[1]	OPERATING	–4 to +20 dBm (see fig. 2)		+20 dBm	
	MAXIMUM SAFE	+33 dBm		+33 dBm	

FREQUENCY SENSITIVITY
±dB Variations

ATTEN (dB)	FREQUENCY (GHz) 0.2 to 8.0 M190	M189	LM190	LM189	0.2 to 12.4 M190	M189	LM190	LM189	12.4 to 18.0 M190	M189
10	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.7	1.0	1.0
20	0.5	0.5	0.5	0.5	1.0	1.0	1.2	1.2	1.0	1.0
30	0.7	0.7	1.0	1.0	1.5	1.5	2.0	2.0	1.0	1.5
40	–	1.0	–	1.0	–	1.5	–	2.0	–	1.5
50	–	1.0	–	1.5	–	1.5	–	2.0	–	1.5
60	–	1.0	–	2.0	–	1.5	–	2.5	–	1.5

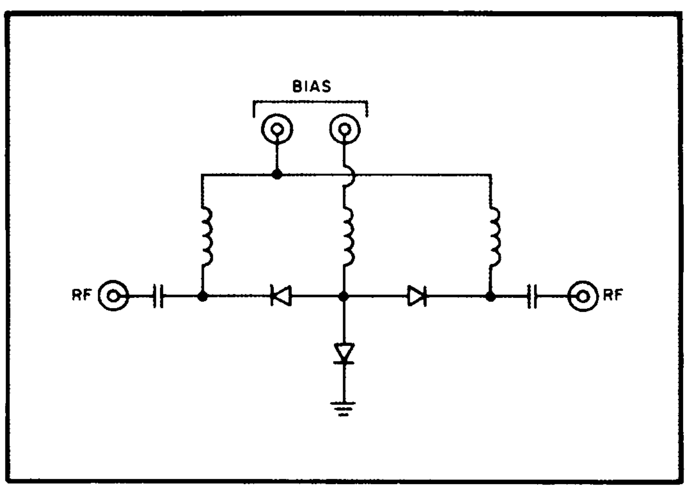


Figure 1. Model M190, Schematic Diagram

[1]At –65°C to +25°C. See figure 3 for derating factors for higher temperatures.

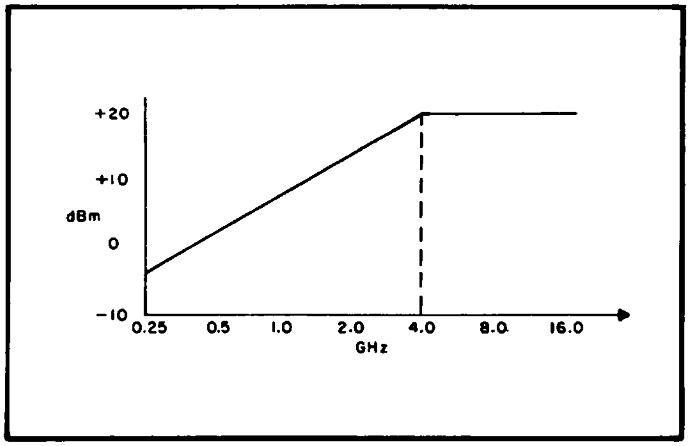


Figure 2. Maximum Average Operating Power From −65°C to +25°C

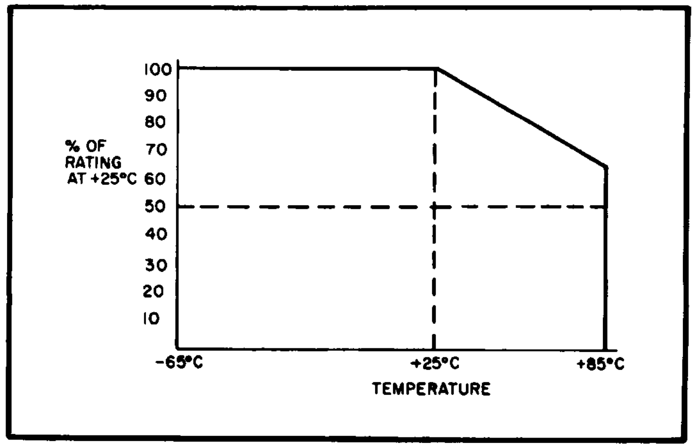


Figure 3. Average Power Derating Factors

BIAS CURRENT REQUIREMENTS

Model M189	±100 mA max.
Model M190	± 50 mA max.

M189 AND M190 ENVIRONMENTAL SPECIFICATIONS

Temperature	OPERATING: −65°C to +85°C[2] NON OPERATING: −65°C to +125°C
Humidity	MIL-STD-202C, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202C, Method 213, Cond. B (75 G, 6 msec)
Vibration	MIL-STD-202C, Method 204A, Cond. B (.06" double amplitude or 15 G, whichever is less)
Altitude	MIL-STD-202C, Method 105C, Cond. B (50,000 ft.)
Temperature Cycling	MIL-STD-202C, Method 102, Cond. D, 5 cycles

MODEL 311 SPECIFICATIONS[3]

Nominal Transfer Function	10 dB/volt
Linearity of Transfer Curve	±1 dB from 5 dB above insertion loss at calibration frequency
Typical Small Signal Bandwidth	500 kHz with M186B 50 kHz with LM186B
Control Signal Input Voltage Range	0 to +5 volts dc
Control Signal Input Impedance	3K ohms (nominal)
Response Time	From 5 to 100 μsec depending on attenuation change
Power Supply Requirements	+15V ±0.1%, 125 mA −15V ±0.1%, 125 mA
Temperature Range	
Operating	−55°C to +75°C
Non-operating	−55C° to +85°C

[2]Attenuators are available for operation to +125°C on special order. See option table below.

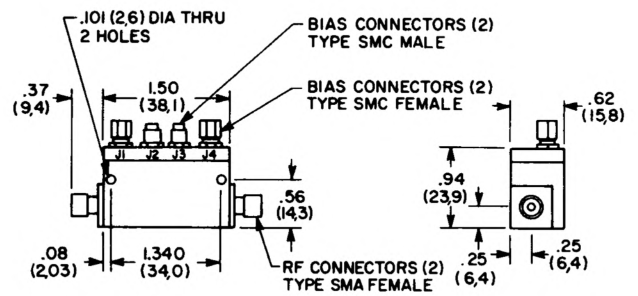
[3]Specifications listed are for each Model 311 Driver in use.

STANDARD ATTENUATOR OPTIONS AVAILABLE

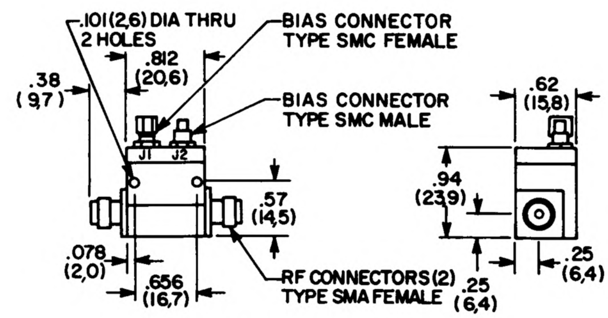
OPTION	DESCRIPTION
4	Solder-type bias terminals
7	Two SMA male rf connectors
10	One SMA male and one SMA female rf connector
33	EMI filter bias terminals
35	High-temperature design (+125°C)

PRICES (QTY 1-9)

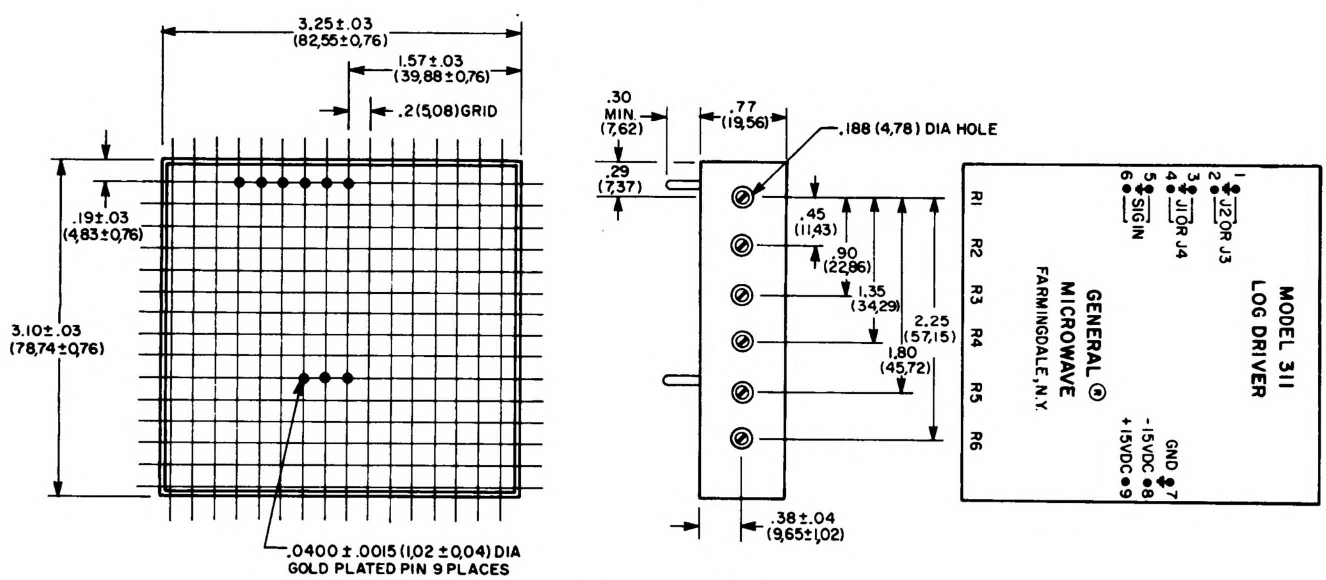
UNIT	PRICE	OPTION SURCHARGE				
		4	7	10	33	35
M190, LM190						
M189, LM189						
311						



MODELS M189 AND LM189
APPROX WT: 2 OZ, 56,8 GM



MODELS M190 AND LM190
APPROX WT: 1 OZ, 28,4 GM



MODEL 311 DRIVER
APPROX WT: 4 OZ, 113,6 GM

Notes: Dimensions are in inches and (mm).
Tolerances unless otherwise indicated:
.XX ±.02 (0,51)
.XXX ±.005 (0,13)

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. 4B120-1500/1000-0
Cust. Part No. ____
Ser. No. 3801-1,7
Date 5-23-75

K & L Order No. 3329
Test Eng. DH
Q.C. Inspector BB (K&L 3)

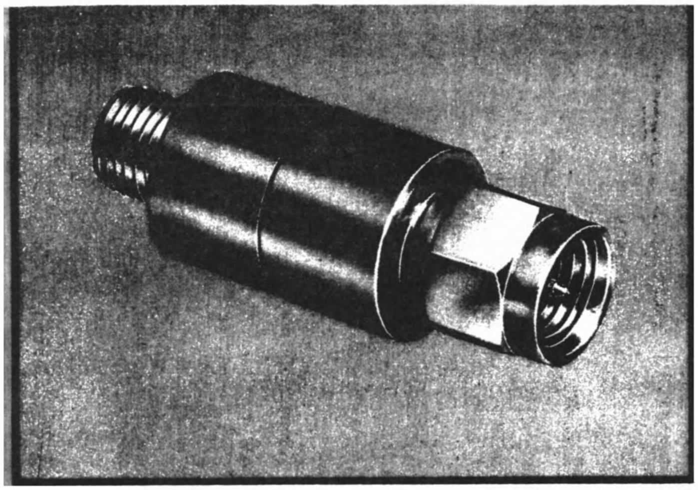
SPECIFICATIONS	TEST RESULTS Ser. No. 1	2	3	4	5	6	7
1.0 Center Frequency 1500 MHz	✓	✓	✓	✓	✓	✓	✓
2.0 Relative Bandwidth							
2.1 3dB BW 1000 MHz	970	970	970	988	970	987	970
2000 MHz	2015	2025	2032	2010	2015	2010	[illegible]
2.2 ____ dB ____ MHz							
____ MHz							
3.0 Insertion Loss							
1500 MHz 0.4 dB	0.2	0.1	0.1	0.1	0.1	0.1	0.1
____ MHz ____ dB							
4.0 VSWR 1.5/1							
Typ. MHz	1155	1192	1170	1190	1160	1175	1160
____ MHz	1923	1935	1903	1920	[illegible]	1910	[illegible]
5.0 Stopband Rejection							
CURVE MHz ____ dB							
____ MHz ____ dB							
____ MHz ____ dB							
____ MHz ____ dB							

6.0 Impedance 50 Ohms

7.0 Size ____

8.0 Connectors SMA-F

9.0 Weight ____



MINIATURE "660" SERIES ATTENUATOR 1 WATT

The Meca "660" series of 50 OHM attenuators are lightweight low power attenuators designed to optimize the volume and weight parameters. Internal electrical construction is of a miniaturized "pi" pad carefully compensated to allow use in the 2000 MCS range. Mating can be made to the OSM, BRM and MICON subminiature connectors. Attenuation values from 1 to 30 db are available from stock. Other values are available upon request.

• •

ELECTRICAL CHARACTERISTICS

New

Frequency	0-2000 MCS
VSWR Maximum	1.30
Power, Average	1 Watt
Power, Peak	500 Watts
Impedence	50 OHMS
Attenuation Accuracy	1 to 10 db ± ~~1.0 db~~ ±0.6
	11 to 20 db ± ~~1.5~~ db ± 1.0
	21 to 30 db ± ~~2.0~~ db ± 1.5

MECHANICAL CHARACTERISTICS

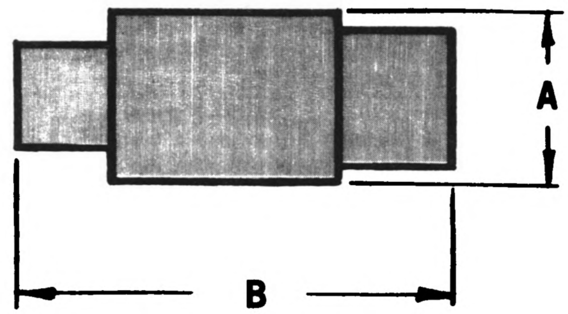
Finish	Stainless Steel
Temperature	—55°C to +150°C
Connectors	Type OSM, BRM Micon
Element	Carbon Composition

When it comes to attenuators come to..... MECA

MINIATURE "660" SERIES ATTENUATOR - 1 WATT

Dimensions-Weight

MODEL	A	B	WEIGHT
660-XX-1	0.45 in.	1.45 in.	0.06 oz.
660-XX-2	0.45 in.	1.45 in.	0.06 oz.
660-XX-3	0.45 in.	1.75 in.	0.06 oz.



INDEX TO MODEL NUMBERS

660-XX-X

Attenuator Series

Attenuation Value
3, 6, 10, 20

Connector Type

Please specify value and type numbers when ordering

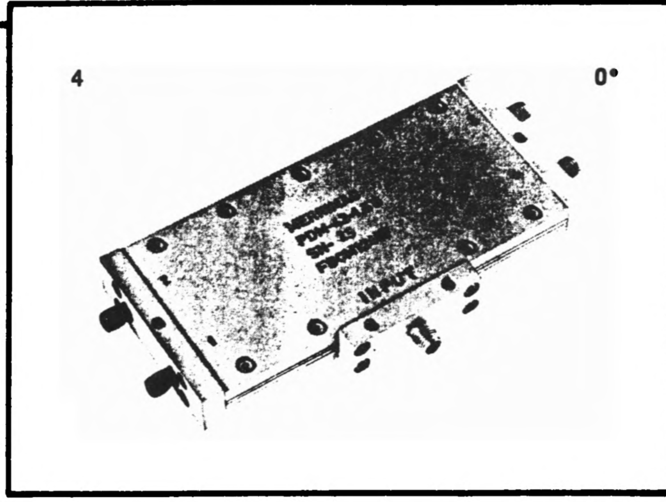
New 1975 Prices
$18.50 each
qty.(1)

PRICING DATA

MODEL NUMBER	CONNECTOR	PRICE
660-XX-1	OSM Male and Female	~~$30.00~~
660-XX-2	BRM Male and Female	~~$30.00~~
660-XX-3	Micon Male and Female	~~$30.00~~

When it comes to attenuators come to..... MECA

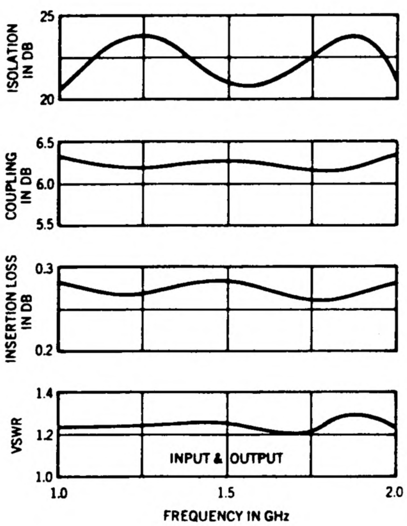
MICROWAVE STRIPLINE POWER DIVIDERS
MINIATURE FOUR-WAY
1.0 GHz -12.4 GHz



Merrimac's new wideband, in-phase, stripline four-way power dividers have many applications in modern microwave systems, such as:

- **Electronic countermeasures**
- **Microwave landing systems**
- **Phased arrays**
- **Data communications**

TYPICAL CHARACTERISTICS MODEL PDM-42-1.5G

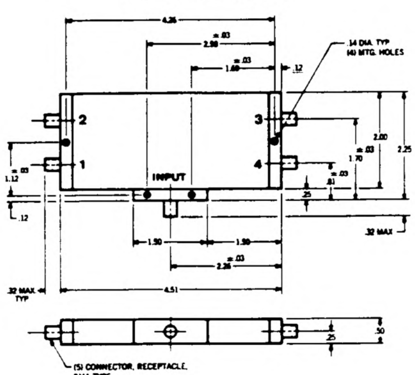


MINIMUM PERFORMANCE SPECIFICATIONS

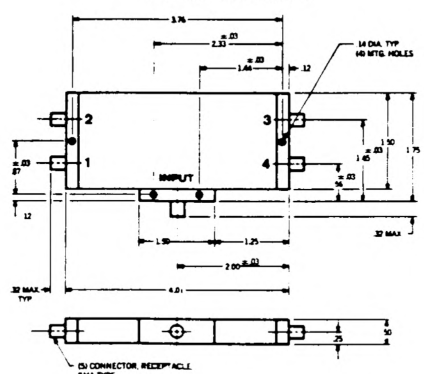
MODEL:	PDM-42-1.5G	PDM-42-3.0G
Frequency Range:	1.0-2.0 GHz	2.0-4.0 GHz
Coupling:	−6 db	−6 db
Isolation:	20 db	18 db
Amplitude Balance:	±0.2 db	±0.3 db
Phase Balance:	±4.0°	±3.0°
Impedance:	50 ohms	50 ohms
Input VSWR:	1.3:1	1.5:1
Output VSWR:	1.3:1	1.5:1
Insertion Loss:	0.3 db	0.5 db
Power (with 1.2:1 loads):	12 watts	12 watts
Connectors (5):	SMA Female	SMA Female
Weight:	14 oz. (392 grams)	9 oz. (252 grams)
PRICE:	**$145.00**	**$145.00**

OUTLINES

PDM-42-1.5G



PDM-42-3.0G



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

LX5600/LX5600A, LX5700/LX5700A temperature transducers

general description

The LX5600/LX5700 series temperature transducers are highly accurate temperature measurement or control systems for use over a −55°C to +125°C temperature range. Fabricated on a single monolithic chip they include a temperature sensor, stable voltage reference and operational amplifier.

The output of the LX5600/LX5700 is directly proportional to temperature in degrees Kelvin at 10 mV/°K. Using the internal op amp with external resistors any temperature scale factor is easily obtained. By connecting the op amp as a comparator, the output will switch as the temperature transverses the set-point making the device useful as an on-off temperature controller.

An active shunt regulator is connected across the power leads to the LX5600/LX5700 to provide a stable voltage reference. In addition to providing a reference, it regulates the operating voltage to 6.8V. This allows the use of any power supply voltage with suitable external resistors.

The op amp can amplify the 10 mV/°K from the sensor to almost any desired output. The input bias current is low and relatively constant with temperature, ensuring high accuracy when high source impedance is used. Further, the output collector can be returned to a voltage higher than 6.8V allowing the LX5600/LX5700 to drive lamps and relays from a 28V supply.

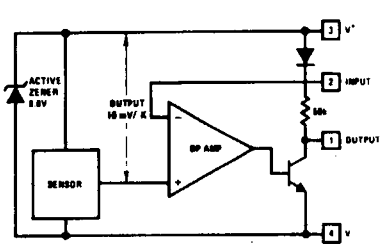
The LX5600 uses the difference in emitter-base voltage of transistors operating at different current densities as the basic temperature sensitive element. Since this output depends only on transistor matching the same reliability and stability as present op amps can be expected.

The LX5600 and LX5600A operate over a −55°C to +125°C range and are available in 4 lead TO-5 package. The LX5700 and LX5700A also operate over the −55°C to +125°C range and are available in the 4 lead TO-46 package.

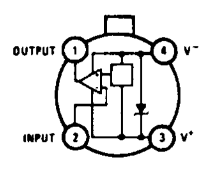
features

- Calibration accuracy of ±4°C over −55°C to +125°C
- Internal op amp with frequency compensation
- Linear output of 10 mV/°K (10 mV/°C)
- Directly calibrated in degrees Kelvin
- Output can drive loads up to 35V
- Internal stable voltage reference
- Four lead device—minimizing wiring

block and connection diagrams



TO-5 Metal Can Package

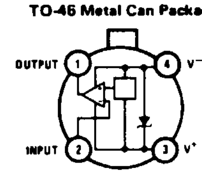


TOP VIEW

NOTE: PIN 4 CONNECTED TO CASE

Order Number LX5600AH or LX5600H

TO-46 Metal Can Package



TOP VIEW

NOTE: PIN 4 CONNECTED TO CASE

Order Number LX5700AH or LX5700H

absolute maximum ratings

Supply Voltage	Internally Regulated	Output Short Circuit Duration	Indefinite
Supply Current (Externally Set)	10 mA	Operating Temperature Range	−55°C to +125°C
Output Collector Voltage	36V	Storage Temperature Range	−65°C to +150°C
Input Voltage Range	0V to +7.0V	Lead Temperature (Soldering, 10 seconds)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LX5600A/LX5700A TYP VOLTS	LX5600A/LX5700A ERROR ±mV	LX5600A/LX5700A ERROR ± % OF SPAN	LX5600/LX5700 TYP VOLTS	LX5600/LX5700 ERROR ±mV	LX5600/LX5700 ERROR ± % OF SPAN	UNITS
Output Voltage (Note 2)	$T_A = +25°C$	2.98	40	2.22	2.98	80	4.44	
Output Voltage (Note 2)	$T_A = -55°C$	2.18	40	2.22	2.18	80	4.44	
Output Voltage (Note 2)	$T_A = +125°C$	3.98	40	2.22	3.98	80	4.44	
Linearity	$\Delta T \leq +180°C$	0.018			0.018			
Long Term Stability	$T_A = 125°C$	±0.002			±0.002			
Repeatability	$T_A = 125°C$	±0.002			±0.002			
VOLTAGE REFERENCE		**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNITS**
Reverse Breakdown Voltage	$1\ mA \leq I_z \leq 5\ mA$	6.68	6.85	7.12	6.55	6.85	7.25	V
Reverse Breakdown Voltage Change With Current	$1\ mA \leq I_z \leq 5\ mA$		10	25		10	35	mV
Temperature Stability			20	60		20	85	mV
Dynamic Impedance	$I_z = 1\ mA$		3.0			3.0		Ω
RMS Noise Voltage	$10\ Hz \leq f \leq 10\ kHz$		30			30		µV
Long Term Stability	$T_A = +125°C$		6.0			6.0		mV
OP AMP								
Input Bias Current	$T_A = +25°C$		35	75		35	150	nA
Input Bias Current			45	150		45	250	nA
Voltage Gain	$R_L = 36k,\ V^{++} = 36V$	2000	15000		1500	15000		V/V
Output Leakage Current	$T_A = 25°C$ (Note 3)		0.2	1.0	2.0	0.2		µA
Output Leakage Current	(Note 3)		1.0	5.0	8.0	1.0		µA
Output Source Current	$V_{OUT} \leq 4.05$	10			10			µA
Output Sink Current	$1V \leq V_{OUT} \leq 36V$	2.0			2.0			mA

Note 1: These specifications apply for $-55°C \leq T_A \leq +125°C$ and $0.9\ mA \leq I_{SUPPLY} \leq 1.1\ mA$ unless otherwise specified.

Note 2: The output voltage applies to the basic thermometer configuration with the output and feedback terminals shorted and a load resistance of $\geq 1.0\ M\Omega$. This is the feedback sense voltage and includes errors in both the sensor and op amp. This voltage is specified for the sensor in a rapidly stirred oil bath.

Note 2: The output leakage current is specified with ≥ 100 mV overdrive. Since this voltage changes with temperature, the voltage drive for turn-off changes and is defined as V_{OUT} (with output and input shorted) −100 mV. This specification applies for $V_{OUT} = 36V$.

application hints

Although the LX5600/LX5700 were designed to be as trouble-free as possible, certain precautions should be taken to insure the best possible performance.

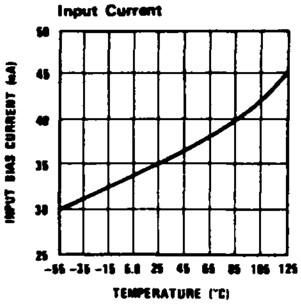
Like any temperature sensor, internal power dissipation will raise the sensor temperature above ambient. Nominal operating current for the shunt regulator is 1.0 mA and causes 7.0 mW of power dissipation. In free, still, air this raises the package temperature by about 1.2°K. Although the regulator will operate at higher reverse currents and the output will drive loads up to 5.0 mA, these higher currents can raise the sensor temperature over 19°K above ambient–degrading accuracy. Therefore, the sensor should be operated at the lowest possible power level.

With moving air, liquid or surface temperature sensing, self heating is not as great a problem since the measured media will conduct the heat from the sensor. Also, there are many small heat sinks designed for transistors which will improve heat transfer to the sensor from the surrounding medium. A small finned clip-on heat sink is quite effective in free-air. It should be mentioned that the LX5600 die is on the base of the package and therefore coupling to the base is preferrable.

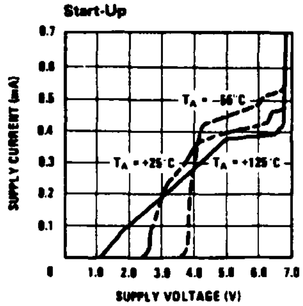
The internal reference regulator provides a temperature stable voltage for offsetting the temperature output or setting a comparison point in temperature controllers. However, since this reference is at the same temperature as the sensor temperature changes will also cause reference drift. For application where maximum accuracy is needed an external reference should be used. Of course, for fixed temperature controllers the internal reference is adequate.

typical performance characteristics

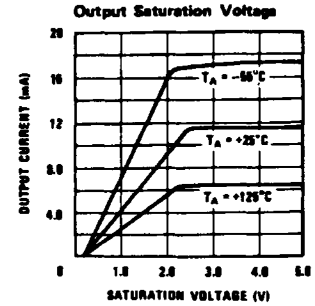
Input Current



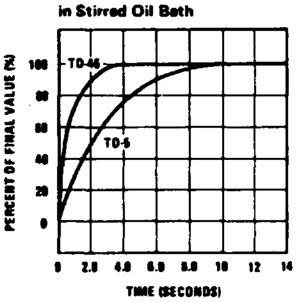
Start-Up



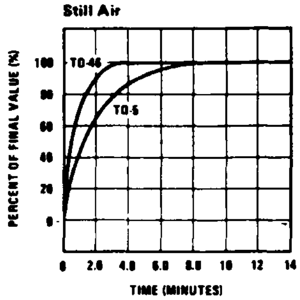
Output Saturation Voltage



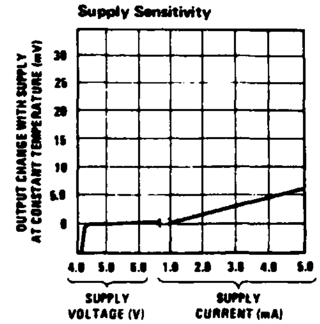
Thermal Time Constant in Stirred Oil Bath



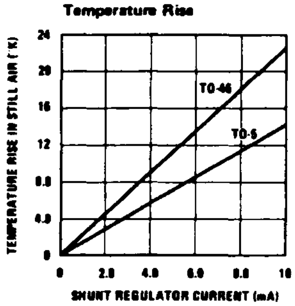
Thermal Time Constant in Still Air



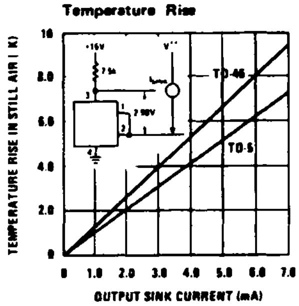
Supply Sensitivity



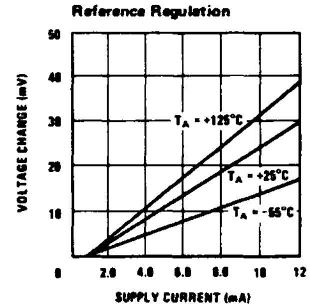
Temperature Rise



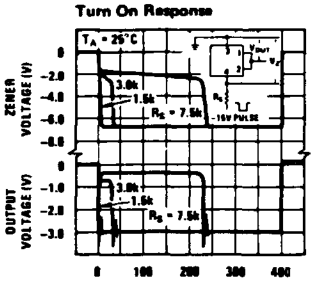
Temperature Rise



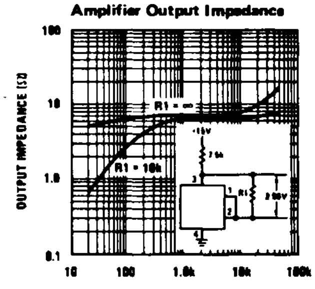
Reference Regulation



Turn On Response



Amplifier Output Impedance



Temperature Conversion

$T_{CENTIGRADE} = T_C$

$T_{FARENHEIT} = T_F$

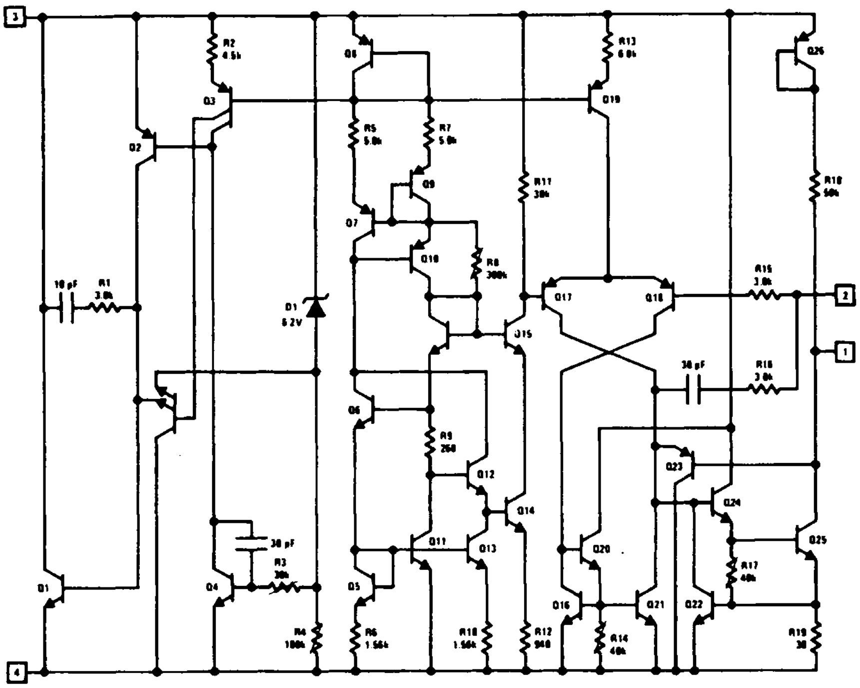
$T_{KELVIN} = T_K$

$T_K = T_C + 273$

$$T_C = (40 + T_F)\ \frac{5}{9} - 40$$

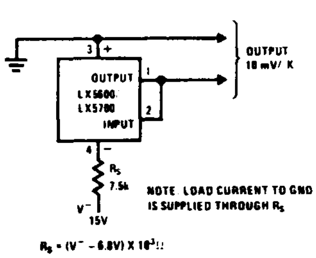
$$T_F = (40 + T_C)\ \frac{9}{5} - 40$$

schematic diagram



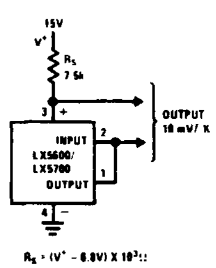
typical applications

Basic Thermometer for Negative Supply



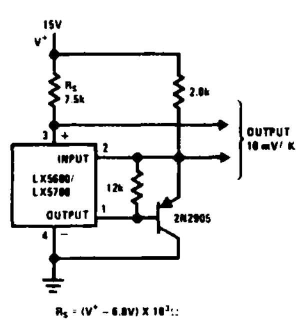
$R_S = (V^- - 6.8V) \times 10^3\Omega$

Basic Thermometer for Positive Supply



$R_S = (V^+ - 6.8V) \times 10^3\Omega$

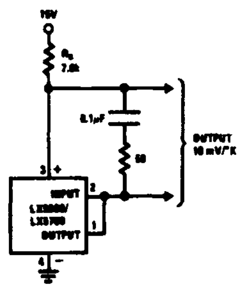
Increasing Gain and Output Drive



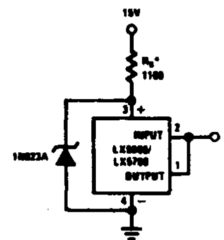
$R_S = (V^+ - 6.8V) \times 10^3\Omega$

typical applications (con't)

External Frequency Compensation for Greater Stability

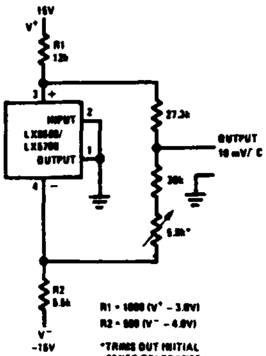


Operating With External Zener for Lower Power Dissipation and Better Reference Stability



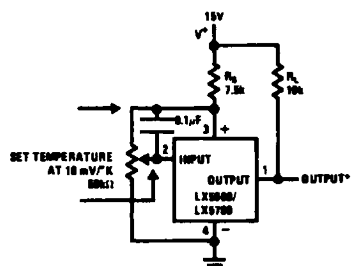
*Depends on Zener current.

Ground Referred Centigrade Thermometer



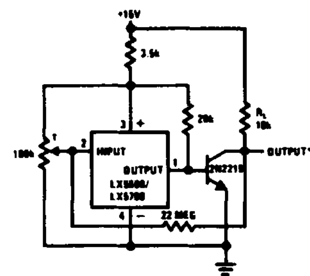
R1 = 1000 (V+ − 3.8V)
R2 = 500 (V− − 4.8V)
*TRIMS OUT INITIAL ZENER TOLERANCE SET OUTPUT TO READ °C

Basic Temperature Controller



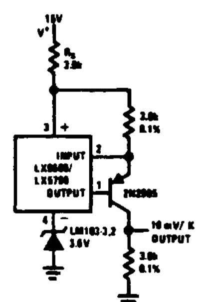
*OUTPUT GOES NEGATIVE ON TEMPERATURE INCREASE
$R_S = (V^+ - 6.8V)\ k\Omega$

Temperature Controller With Hysteresis

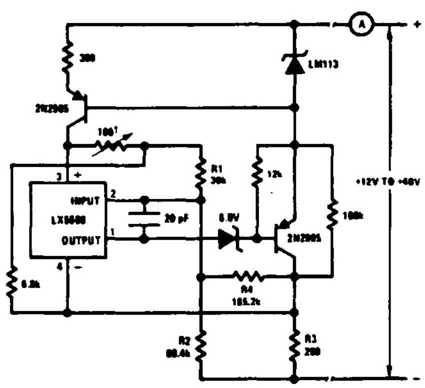


*OUTPUT GOES POSITIVE ON TEMPERATURE INCREASE
†SET TEMPERATURE

Kelvin Thermometer With Ground Referred Output



Two Terminal Temperature to Current Transducer*



$$R2\ (\Omega) = \frac{\left(V_Z - 0.01\,T_L\right)\left(I_H - \frac{0.01\,T_H}{R1}\right) + \left(V_Z - 0.01\,T_H\right)\left(\frac{0.01\,T_L}{R1} - I_L\right)}{\frac{0.01}{R1\,R3}\left|T_H\,(V_Z - 0.01\,T_L) - T_L\,(V_Z - 0.01\,T_H)\right|}$$

$$R3\ (\Omega) \geq \frac{V_Z\left(\frac{T_H}{T_L} - 1\right)}{I_H - \frac{I_L\,T_H}{T_L}}$$

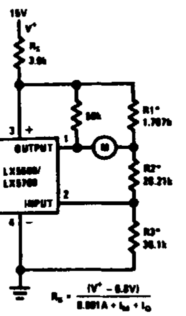
$$\frac{1}{R4} = \frac{1}{(V_Z - 0.01\,T_L)(R2)}\left[\frac{(R2)(0.01\,T_L)}{R1} + \frac{\left(\frac{V_Z - 0.01\,T_L}{R2} - I_L\right)}{\frac{1}{R2} + \frac{1}{R3}} - \frac{1}{R2}\right]$$

T_L = TEMPERATURE FOR I_L (°K)
T_H = TEMPERATURE FOR I_H (°K)
V_Z = ZENER VOLTAGE (VOLTS)
I_L = LOW TEMPERATURE OUTPUT CURRENT (mA)
I_H = HIGH TEMPERATURE OUTPUT CURRENT (mA)

*VALUES SHOWN FOR I_{OUT} = 1 mA TO 10 mA FOR 10°F TO 100°F
†SET TEMPERATURE

typical applications (con't)

Thermometer With Meter Output



*VALUES SHOWN FOR.
T_O = 300 K, ΔT = 100 K,
I_M = 1.0 mA, I_O = 100µA

$$R1^* = \frac{(V_Z)(10\,mV)(\Delta T)}{I_M(V_Z - 0.01\,T_O)}$$

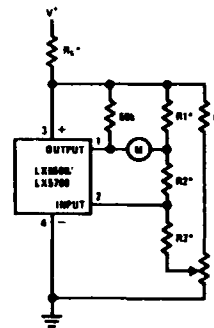
$$R2 = \frac{0.01\,T_O - I_O\,R1}{I_O}$$

$$R3 = \frac{V_Z}{I_O} - R1 - R2$$

$$\left(I_O \leq \frac{2V}{R1}\right)$$

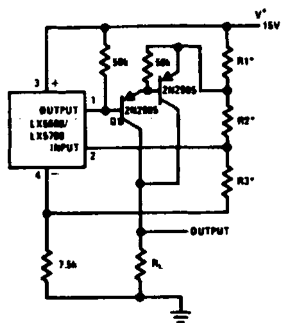
V_Z = SHUNT REGULATOR VOLTAGE (USE 6.85)
ΔT = METER TEMPERATURE SPAN (°K)
I_M = METER FULL SCALE CURRENT (A)
T_O = METER ZERO TEMPERATURE (°K)
I_O = CURRENT THROUGH R1 R2 R3 AT ZERO METER CURRENT (10µA TO 1.0 mA) (A)

Meter Thermometer With Trimmed Output



*SELECTED AS FOR METER THERMOMETER EXCEPT T_O SHOULD BE 5 K MORE THAN DESIRED AND I_O = 100µA.
†CALIBRATES T_O.

Ground Referred Thermometer



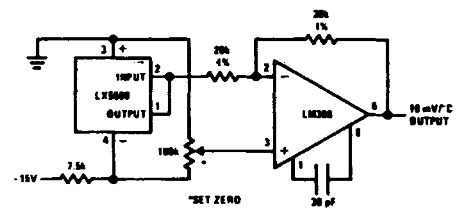
$$R1 = \frac{(V_Z)(10\,mV)(\Delta T)}{\frac{V_O}{R_L}(V_Z - 0.01\,T_O)}$$

$$R2 = \frac{0.01\,T_O - I_O\,R1}{I_O}$$

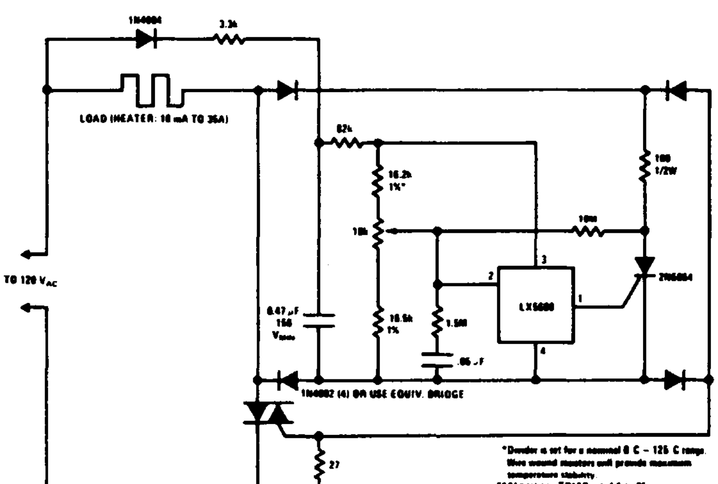
$$R3 = \frac{V_Z}{I_O} - R1 - R2$$

V_Z = SHUNT REGULATOR VOLTAGE
ΔT = TEMPERATURE SPAN (°K)
T_O = TEMPERATURE FOR ZERO OUTPUT (°K)
V_O = FULL SCALE OUTPUT VOLTAGE ≤ 10V
I_O = CURRENT THROUGH R1, R2, R3, AT ZERO OUTPUT VOLTAGE (TYPICALLY 100µA TO 1.0 mA)

Ground Referred Centigrade Thermometer



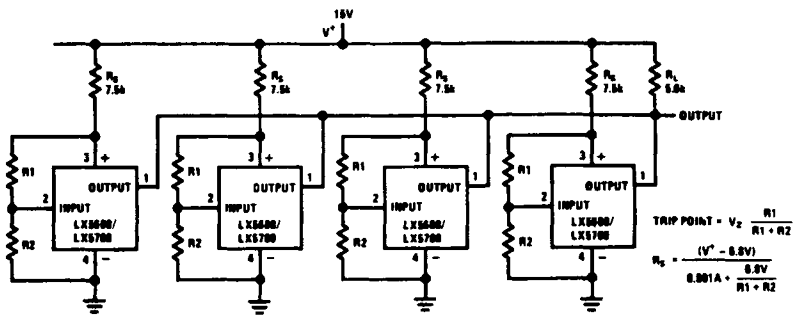
Three Wire Electronic Thermostat



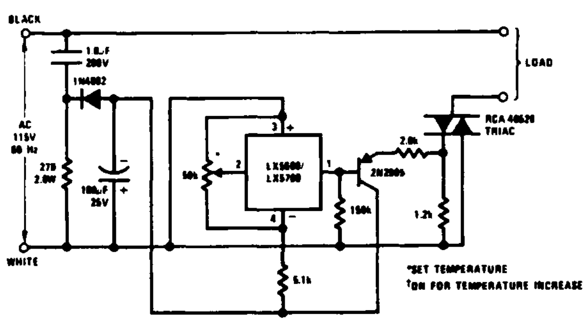
*Divider is set for a nominal 0 C – 125 C range. Wire wound resistors will provide maximum temperature stability.
**Almost any TRIAC rated 1 to 35 amperes usable with appropriate load.

typical applications (con't)

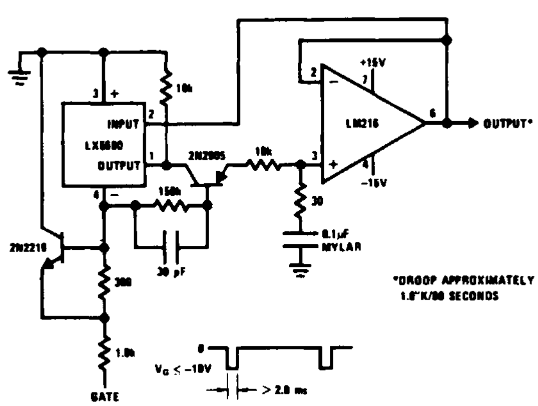
Over Temperature Detectors With Common Output



Temperature Controller Driving TRIAC

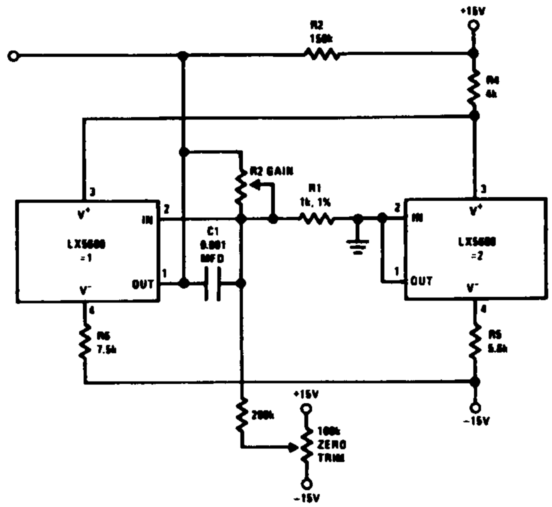


Low Duty Cycle Thermometer



typical applications (con't)

Differential Thermometer



$V_{OUT} = (10\,mV/°C)\left(\frac{R_1 + R_2}{R_1}\right)(T_2 - T_1)$

OUTPUT CAN SWING ±3V AT ±50μA WITH LOW OUTPUT IMPEDANCE.

definition of terms

Output Voltage: The voltage referred to the V+ terminal from the output terminal with the input and output connected. (This voltage is the temperature output of the LX5600 and so includes errors in the sensor section and op amp section.)

Linearity: The deviation in output voltage from a straight line output over a specified temperature excursion.

Reverse Breakdown Voltage: The voltage appearing between the V+ and V− terminals at a specified current.

Temperature Stability: The percentage in output voltage for a thermal variation from room temperature to either temperature extreme.

Output Source Current: The current available to flow into a load from the output to V−, over a specified output voltage range.

Output Sink Current: The current available to flow into a load from a positive supply over a specified output voltage range.

CRYSTAL DIODE DETECTOR
MODEL 20090

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

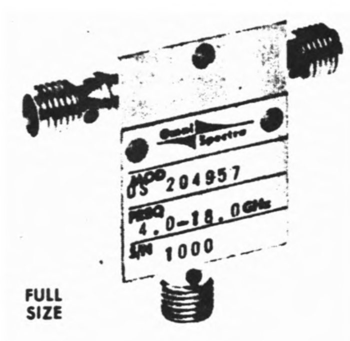
Weight:	0.6 ounces (17.0 g)
Overall Length:	2.0 inches (50.8 mm)
Diameter:	3/8 inches (9.5 mm)
Connectors:	Input - OSM Plug Output - OSM Jack
Finish:	Gold

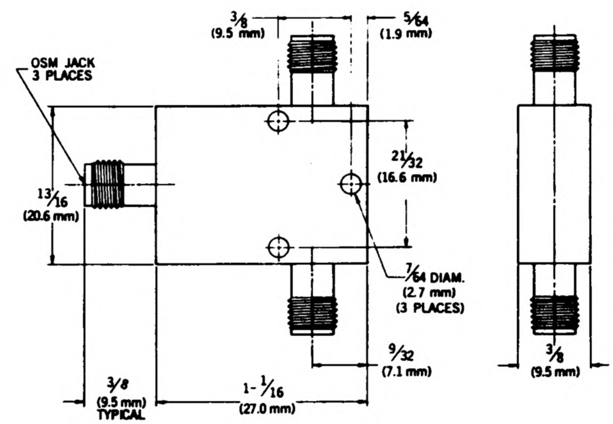
OSI Model 20090R is identical to Model 20090 but has positive output.
OSI Model 20090M is a pair of Model 20090 Detectors that will track within ±0.8dB over any specified octave band.
(Specify band when ordering.)

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

COAXIAL POWER DIVIDERS, TWO-WAY, ISOLATED

MODEL 204924
MODEL 20493
MODEL 20494
MODEL 204957





OSM Miniature Isolated Power Dividers function as sum and difference hybrids, or Magic Tees, with the difference port internally terminated. An input RF signal is divided into two equal amplitude and equal phase outputs. The outputs are highly isolated and all ports are matched.

A ceramic microstrip construction is utilized to achieve small size and high performance.

The units may also be used as power combiners. For complete information send for Application Note No.175.

SPECIFICATIONS

Model No.	Frequency Range (GHz)	Insertion Loss (dB) Max.	Tracking Error (Max.)		VSWR Max.	Isolation (dB) Min.	Temp. Range (°C)	Weight		Finish
			Amplitude (dB)	Phase (Degrees)				oz	g	
204924	0.9 - 4.0	1.0	0.3	5.0	1.5	18	−54 to +85	1.3	37.0	Gold
20493	1.0 - 2.0	0.4	0.2	2.0	1.35	20				
20494	2.0 - 4.0	0.6	0.2	4.0	1.30	20				
204957	4.0 -18.0	0.1 fGHz	0.3	1.0 fGHz	1.60	18				

Power Handling: 2W input, when arbitrarily terminated.
20W input, with output load VSWR ≤ 2.0:1.

8 week

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

MINIATURE DIRECTIONAL COUPLERS
ON ALUMINA SUBSTRATES

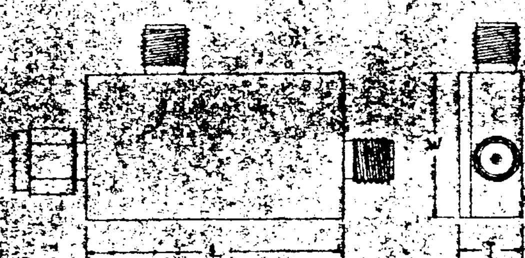
The DC9100 line of Directional Couplers is designed on alumina substrates for smallest size, ruggedness and stable performance over wide ranges of environmental conditions. Standard coupling values are 6 dB, 10 dB and 20 dB for octave-band couplers, 6 dB and 10 dB for double octave couplers. Standard configuration is 3-port with an internal 50 Ohm termination on the decoupled port.

Model No. *	Frequency Range, GHz	Directivity, dB Min.	Directivity, dB Typ.	Dimensions (in.) L	W	T	Price
DC9104-10MT	.25 - .50	20	25	2.3	.85	.32	125.00
DC9105-10MT	.50 - 1.0	20	25	2.0	.75	.32	125.00
DC9106-10MT	.75 - 1.5	20	25	1.5	.75	.32	125.00
DC9107-10MT	1.0 - 2.0	20	25	1.3	.75	.32	125.00
DC9108-10MT	1.5 - 3.0	20	23	1.1	.75	.32	125.00
DC9109-10MT	2.0 - 4.0	18	22	1.1	.75	.32	125.00
DC9110-10MT	4.0 - 8.0	17	20	1.1	.75	.32	125.00
DC9111-10MT	.50 - 2.0	20	25	2.3	.75	.38	175.00
DC9112-10MT	1.0 - 4.0	18	23	1.75	.75	.38	175.00
DC9113-10MT	2.0 - 8.0	17	20	1.2	.75	.38	175.00

* For 6 dB or 20 dB coupling use -6MT and -20MT suffix with part number. For 4-port configuration omit "T" from suffix.

Coupling Accuracy	± 1 dB including frequency sensitivity
VSWR, All Ports	1.25 max.
Insertion Loss	0.3 dB typ. excluding coupling
Connectors	SMA plug input, SMA jacks outputs

These couplers are also available in chip form for use as "drop-in" circuits in microstrip assemblies. Other coupling values and frequency ranges, as well as Dual Directional Couplers can be furnished on special order. Please consult factory for quotations on special requirements.



VMC

VECTRONICS MICROWAVE CORPORATION

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

DC9100/8/74