

VLA Technical Report No. 35

ANTENNA L.O. RECEIVER L4

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- Figure 2 5 MHz Receiver Circuit Schematic**
- Figure 3 Data Receiver Circuit Schematic**
- Figure 4 Level Indicator Circuit Schematic**
- Figure 5 Buffer Amplifier Circuit Schematic**

1.0 L.O. RECEIVER (L4C) MODULE DRAWINGS, ARTWORKS, AND BILLS OF MATERIALS

Block Diagram D13230B23

5 MHz Receiver Schematic B13230S3

Data Receiver Schematic C13230S4

Level Indication Circuit Schematic B13230S25

Buffer Amplifier Schematic B13230S8

Bills of Materials

L.O. Receiver A13230Z04

5 MHz Receiver A13230Z19, Z18

Data Receiver A13230Z16, Z17

Buffer Amplifier A13230Z24, Z25

Level Indication Circuit A13230Z71

Assembly Drawings

5 MHz Receiver B13230P23

Data Receiver B13230P28, P29

Level Indication Circuit B13230P61

Buffer Amplifier B13230P24

Printed Circuit Boards, etc.

	<u>Art Work</u>	<u>Silk Screen</u>	<u>Mechanical</u>
Front Panel		B13230AA21	C13230M31
5 MHz Receiver	B13230AB04		C13230M55
Data Receiver	B13230AB09		B13231M15
Buffer Amplifier	B13230AB06		
Level Indication Circuit	B13230AB33		B13230M19
L.O. Receiver Wire List			A13230W05

Mechanical

Partition Plate D13230M24

Guide B13050M04

Bar Support, Top and Bottom	B13050M23
Right and Left Side Plates	B13050M18
Bar Support, Top and Bottom Left	B13230M36
Panel, Rear	C13210M04
Mixer Mount	A13050M33
Data Receiver/5 MHz Receiver	B13230M89, M90
Data Receiver/5 MHz Receiver	B13230M30
Data Receiver/Side Panel	B13230M39
Data Receiver/Side Panel	B13230M27
Data Receiver	B13230M29
5 MHz Receiver	B13230M54
Terminal Turret	B13230M98
Buffer Amplifier Enclosure	B13230M40

## 2.0 FUNCTION

The Antenna Local Oscillator Receiver (L4) Module is located in Rack B at the antenna Vertex Room. It receives the combined 1200 and 1800 MHz modulated signals from the Modem (T1) and IF Combiner (T2) during approximately one milli-second period of transmission (for details see L8 Manual, VLA Technical Report No. 12 ) from the Central Electronics Room to the Vertex Room. It separates the 1200 and 1800 MHz signals. The separated 1200 and 1800 MHz signals are used to recover 5 MHz and digital commands respectively. The beginning of the 1200 MHz signal in every 1 ms reception period provides synchronizing pulses for Timing Generator (L8). Also the 1200 and 1800 MHz are mixed to recover 600 MHz. The recovered 5 MHz is phase compared with 5 MHz from the 5 to 50 MHz VCXO (L1) Module, and the recovered 600 MHz is phase compared with the 600 MHz produced in the L.O. Transmitter (L3). The resulting phase error signals at both 5 MHz and 600 MHz go to the L.O. Control (L5) Module and are used to phase lock the 5 MHz voltage controlled crystal oscillator in L1. The recovered digital commands are provided to the Antenna Buffer (M4).



### 3.0 THEORY OF OPERATION

A block diagram of the Antenna L.O. Receiver (L4) Module indicating the signal levels is shown in Figure 1. The input L.O. signal at J1 is first amplified using a combination of an attenuator AT1 followed by an amplifier AR1 to provide a net gain of 13 dB. Typical value of AT1 is 6 dB and that of the amplifier mean gain is 19 dB. The output of the amplifier is divided using a two way power divider PD1. The two outputs are filtered using 10% bandwidth band pass filters to separate 1200 and 1800 MHz signals. These signals are further amplified using variable gain amplifiers AR2 and AR3, each of which consists of a voltage controlled attenuator followed by two stages of gain.\* The gain of the amplifiers AR2 and AR3 can be adjusted by varying bias voltage to the voltage controlled attenuators (VCA's) inside the amplifier boxes. The potentiometers for adjusting the bias voltages are mounted on the module front panel.

The total power output from the T2 module is adjusted so that the total L.O. signal at the input of the module is - 4 dBm. However, the power level at each of the 1200 and 1800 MHz may vary by several dB (by as much as 6 dB) from the nominal values due to the pass band ripple in the Modems and the IF combiners. By adjusting gains of the amplifier AR2 and AR3 the signal levels at 1200 and 1800 are adjusted to + 11 dBm at the outputs of the two amplifiers.

The 1800 MHz signal from the output of the amplifier AR2 is given to a 10 dB directional coupler DC1 and the 1200 MHz signal from the output of the amplifier AR3 is given to a 6 dB attenuator (AT2) and then to a 10 dB directional coupler DC2. A - 5 dBm signal at (i) 1.8 GHZ from the coupled port of DC1 and a 6 dB attenuator (AT3) is given to Data Receiver (A1) and (ii) 1.2 GHz from DC2 is given to 5 MHz Receiver (A2).

\* These are Watkins-Johnson cascadable TO-8 devices G1, A35 and A37 respectively, with the assembly conforming to NRAO Specification A13230N3.

In the Data Receiver (A1) the 1.8 GHz signal from DC1 is envelope detected. The DC output of the detector provides indication of the 1800 MHz signal level and the AC output represents the digital commands. The DC signal is given to the level indicator circuitry. The data signal is amplified and given to the Monitor and Control system.

In the 5 MHz receiver (A2) the 1.2 GHz signal from DC2 is envelope detected. The DC output from the detector provides indication of the 1200 MHz signal level and is given to the level indication circuitry. The AC output of the detector is amplified and provided to the Timing Generator Module (L8), which makes use of the sharp rising edge in the detected signal when the 1200 MHz carrier turns on (the time of turn-on of this carrier is closely controlled in the Central L.O. Transmitter, L10). The AC detector output also contains the demodulated 5 MHz, which is phase compared with the 5 MHz reference from the L1 module. The phase error signal is amplified and given to the L.O. Control Module (L5).

The direct port outputs from the directional couplers DC1 and DC2 are mixed in a balanced mixer M1 to produce 600 MHz. The output of DC1 is passed through a 1800/180 MHz BPF (FL3) and is given to the L port of the mixer. The output from the directional coupler DC2 is passed through a 1200/120 MHz BPF (FL4), a 20 dB attenuator (AT4) and is given to the R port of the mixer M1. The 1200/120 BPF is used to filter out any harmonics of 1200 MHz and intermodulation components due to 5 MHz sidebands on the 1200 MHz carrier generated in the amplifier AR3. The 1800/180 BPF is put basically to retain symmetry though it also helps to remove any intermodulation components due to data sidebands on the 1800 MHz carrier. The input signal levels to both L and R ports of the mixer M1 (Watkins-Johnson type M1J) as well as applying 1800 MHz signal to L port and 1200 MHz signal to R port have been chosen to keep down the spurious signals around 600 MHz compared to the desired signal at 600 MHz. The spurious signals are generated by higher order products  $mf_L \pm nf_R$

where m and n are integers other than 1 and  $f_L$  and  $f_R$  are frequencies of the L.O. and RF port signals respectively. Signal levels, the  $2f_L - f_R$  response (the worst one) should be less than -40 dB with respect to the desired  $f_L - f_R$  response.

The 600 MHz output from the mixer M1 is given to a 3 dB attenuator (AT 5), a 600/100 MHz BPF (FL5), a 28 dB gain amplifier (AR4) and a 10 dB directional coupler (DC3). The coupled port output from the directional coupler DC3 is terminated in SMA connector on the module front panel and can be used for monitoring and troubleshooting purposes. The direct port output from DC3 is + 2 dBm. It is phase compared with the 600 MHz signal from the L.O. Transmitter (L3C) Module. The + 2 dBm signal from DC3 is given to R port of the mixer M2. A + 9 dBm signal from L3C Module is passed through a 3 dB attenuator (AT6) and is given to L port of the mixer M2. Output of the mixer M2 is amplified using a buffer amplifier A3 and is given to L.O. Control Module.

The DC outputs representing the 1200 and 1800 MHz signal levels to the 5 MHz Receiver and the Data Receiver respectively are given to the level indication circuitry. The circuit consists of (i) a Level Monitor Board having DC offset bias network, (ii) a 2 pole 3 position center off switch and (iii) a 50-0-50  $\mu$ A meter. To get appropriate output level of + 11 dBm from the amplifiers AR2 and AR3 the gain of each of the amplifiers is adjusted using the level indication circuitry and the VCA control bias ports located on the front panel of the module.



#### 4.0 CIRCUIT DESCRIPTION

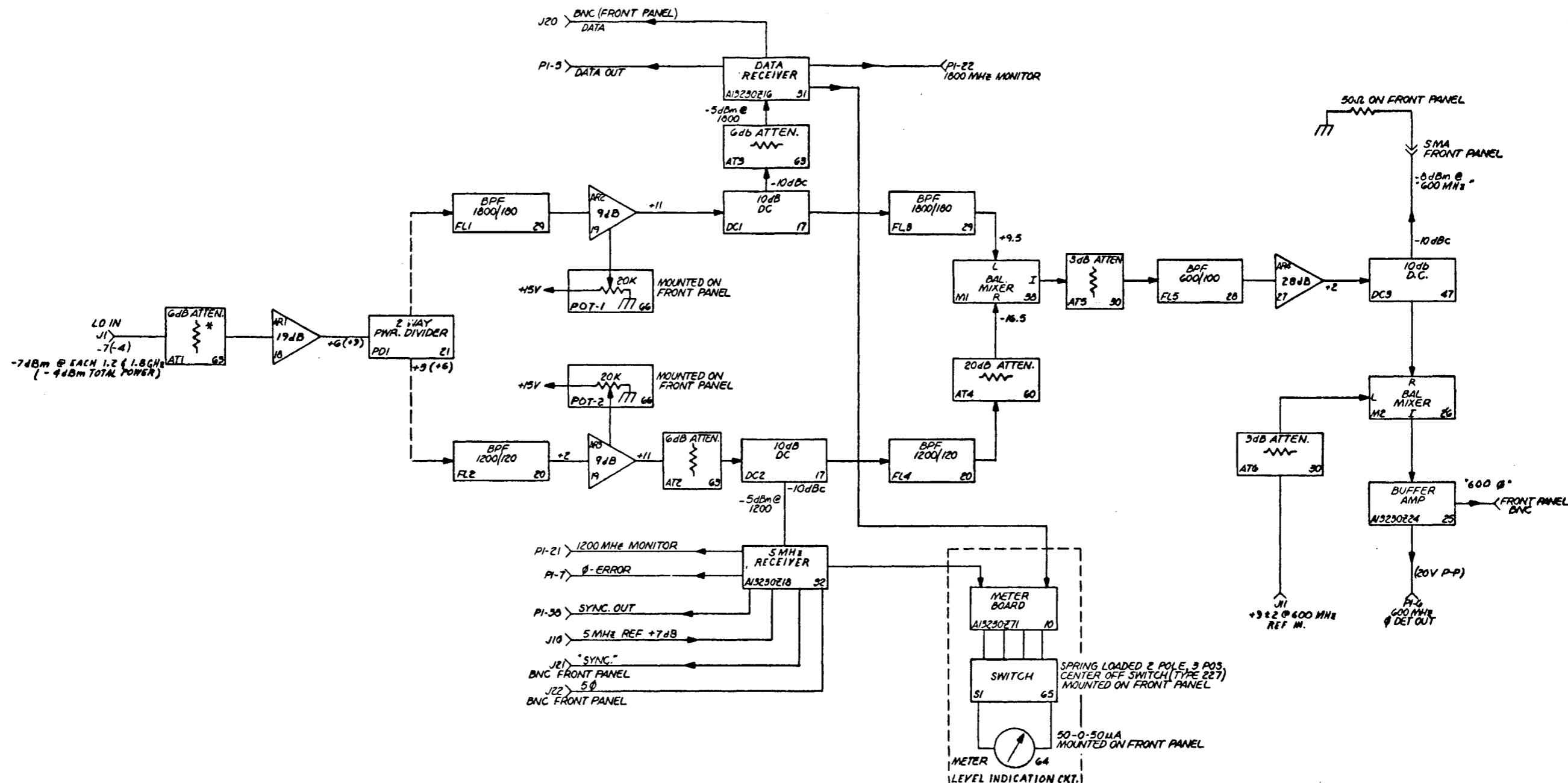
##### 4.1 5 MHz Receiver - Ref. Circuit Schematic C13230S4, Figure 2

The 1.2 GHz signal from directional coupler DC2 (Figure 1) is envelope detected by Schottky Barrier diode CR2 (Hewlett-Packard type 5082-2824) biased at about 0.3 mA as shown in the schematic. At this bias and with an RF input of - 5 dBm, the detector law is linear; it remains linear down to about - 10 dBm. Linear rather than square-law detection is used to obtain low distortion of the demodulated signals. The detector output is dc coupled to the level indicator circuit through an 8.2 K resistor; the indicator circuit (discussed below) is arranged so that no dc current flows through this resistor when the input level is correct (- 5 dBm), so the biasing is not disturbed. The detector output is ac coupled through C8 to video amplifier U2, which provides a broadband gain of about 5, adjustable by R22.

U2 provides a non-inverted output at pin 7 to drive emitter follower Q1, which supplies the received 5 MHz to double-balanced mixer U3 (Mini Circuits type SRA-1), where it is phase compared with the 5 MHz reference signal brought from module L1 via J3. The reference level is + 7 ± 1 dBm and the received signal is about + 4 dBm at the mixer. The mixer output is 300 to 500 mV P-P for a  $2\pi$  radian phase change. Output amplifier U1 provides an adjustable gain to give an output swing of ± 10 V for a  $2\pi$  radian phase change; the gain is adjusted by R16. DC offset pot R16 is used to cancel the combined offset of the mixer and the amplifier.

Amplifier U2 also provides an inverted output at pin 8 to drive emitter follower Q2, which supplies the synchronizing signal to L8 as discussed earlier. Note that the negative output polarity of CR2 combined with the inversion in U2 provides a





NOTES: (ALL FOR REF. INFORMATION ONLY)

1. PI-POWER CONNECTOR
  2. [ ]

ITEM NUMBERS PER BOM A13230265  
REF. DESIG. PER IEEE NO. 315 & NRAO SPEC

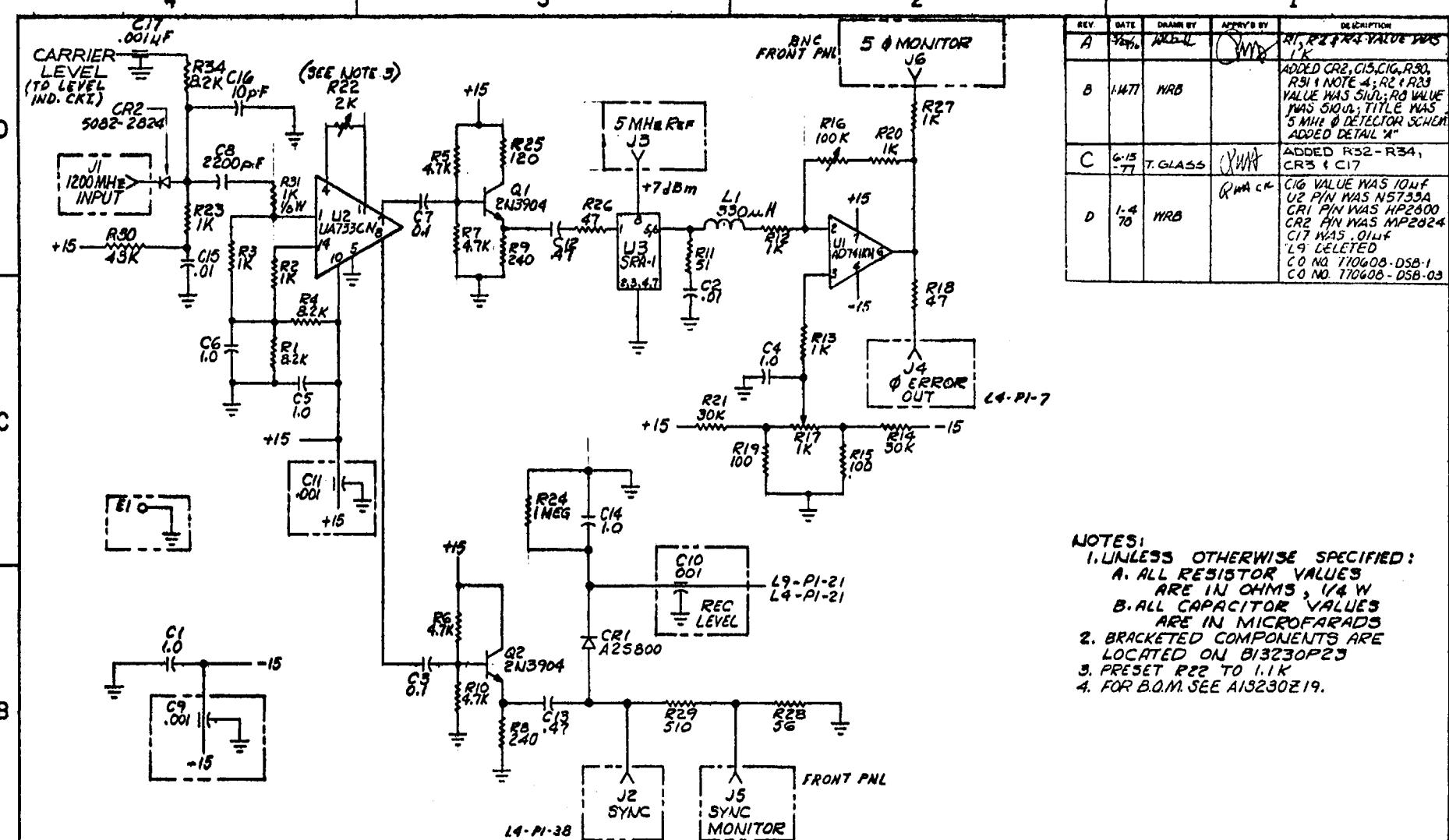
\* NOMINAL 6dB. ADJUST TO GIVE NET GAIN OF 13dB  
FROM ATI AND ARI AT LEVELS INDICATED.

## FIGURE I

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		PROJECT NO. LA	L.O. RECEIVER		NATIONAL RADIO ASTRONOMY OBSERVATORY CHARLOTTESVILLE, VA 22901	
TOLERANCES: ANGLES ± 3 PLACE DECIMALS: X.XXX ± 2 PLACE DECIMALS: X.XX ± 1 PLACE DECIMALS: X.0 ±	BLOCK DIAGRAM			DRAWN BY DATE DES. AND BY DATE APPROVED BY DATE		
MATERIAL:	30204 FINISH: ED ON		D-117 NUMBER D13230823	REV. 0	SCALE	



FIGURE 2



LAST COMPONENT DESIGN USED						
R	C	CR	U	Q	L	J
34	17	3	3	2	1G	

UNLESS OTHERWISE SPECIFIED  
DIMENSIONS ARE IN INCHES  
TOLERANCE: ANGLES ±  
1 PLACE DECIMALS (.1,.00)  
2 PLACE DECIMALS (.1,.01)  
3 PLACE DECIMALS (.1,.001)

MATERIAL:

FINISH:

L4  
L.O. RECEIVER  
A

5 MHz RECEIVER SCHEMATIC

NATIONAL RADIO  
ASTRONOMY  
OBSERVATORY  
CHARLOTTESVILLE, VA 22901

DRAWN BY

DATE 7/6

REVISED BY

DATE 7/6

APPROVED BY

DATE

SHEET NUMBER

DRAWING NUMBER

REV'D

SCALE

positive-going edge for L8 when the 1200 MHz carrier comes on. The height of this edge is measured by a peak detector consisting of C11, C14, and R24. This provides a monitor of the received carrier level during actual operation. The 1 sec time constant C14R24 results in averaging over about 20 waveguide cycles. The peak detector output is given to the Data Set via the L.O. Control Module, L5. The synchronizing edge and the received 5 MHz are made available for monitoring at the front panel via the 10:1 divider R29R28. Correct gain settings will result in 200 mV P-P at 5 MHz at the front panel BNC; this corresponds to + 10 dBm to L8 and + 4 dBm to mixer U3. The non-inverted output from the emitter follower Q1 is phase compared with the reference 5 MHz signal coming from L1 module in a balanced mixer (U3). The signal level is about 0 dBm and the reference level is about + 7 dBm. The phase error output is 300 to 500 mV P-P for a  $2 \pi$  rad. phase change. An output amplifier U1 provides adjustable gain to give output swing of  $\pm 10$  V for the  $2 \pi$  rad. phase change. Gain of the amplifier U1 can be adjusted by R16 and its DC offset by R17. The output from U1 goes to L.O. Central Module and can also be monitored on a BNC jack mounted on the module front panel and labeled "5φ."

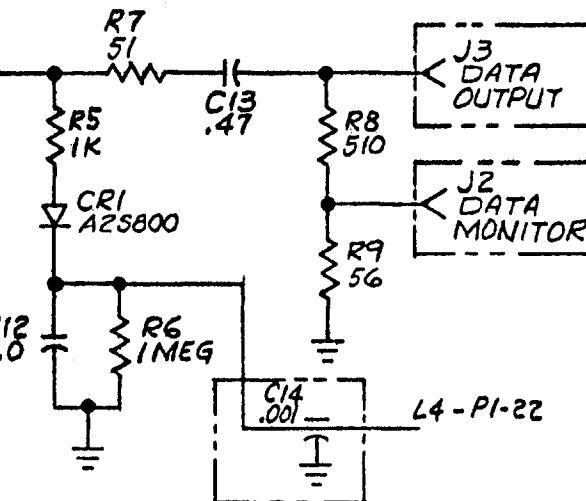
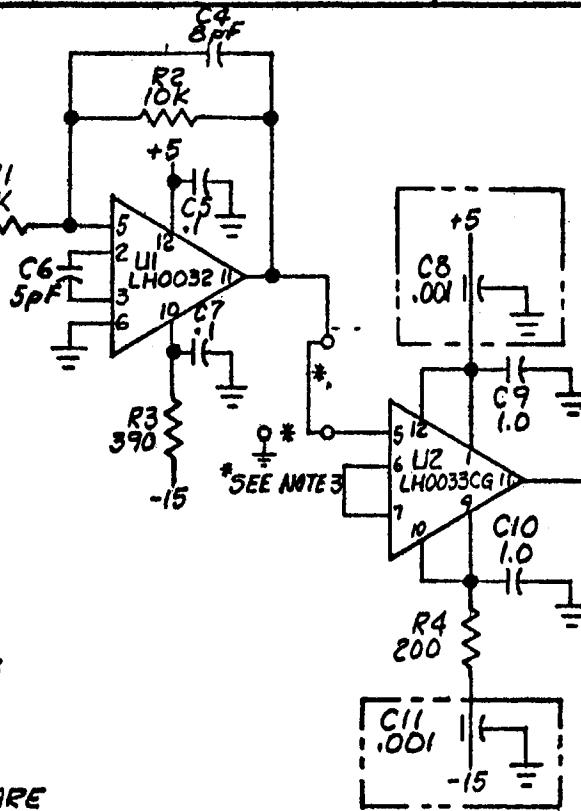
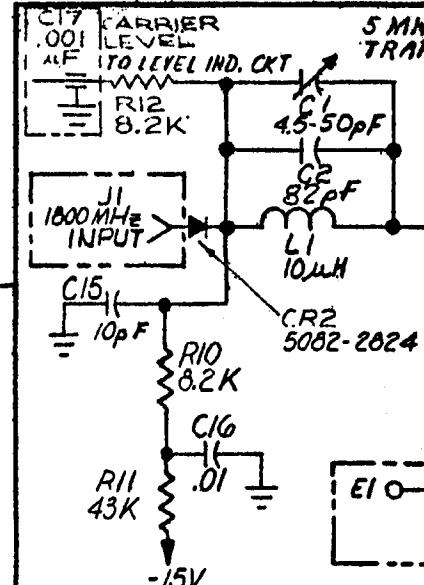
**4.2 Data Receiver - Ref. Circuit Schematic B13230S3, Figure 3**  
The - 5 dBm signal at 1.8 GHz from the directional coupler DC1 and a 6 dB attenuator AT3 (see Block Diagram, Figure 1) is envelope detected by a Schottky Barrier diode (Hewlett-Packard 5082-2824) biased at about 0.3 mA. The bias point and the RF levels are selected to provide linear detection as in the 5 MHz Receiver. Also, as in the case of the 5 MHz Receiver, output of the detector is provided to the Level Indicator Circuit to adjust gain of the 1800 MHz amplifier AR2.

4

3

2

1



REV.	DATE	DRAWN BY	APPR'D BY	DESCRIPTION
A	7/21/75			C2 VALUE WAS 75 pF
B	1-13-77			C3 VALUE WAS .017nF R1 VALUE WAS 3.30nA; ADDED C4,C5,C16,R10,R11, AND ASSOC. CIRCUITRY; ADDED NOTES 4 & 5; REMOVED L2, A70UH; TITLE WAS "ALC.FINFR DATA AMP.SCH." ADDED C17 & R12
C	1-5 78			C1 VALUE WAS 7-50 pF CRI WAS HP2000 C17 VALUE WAS .01 nF C15 VALUE WAS 10 pF 'L9' DELETED C.O. # 710608-DSB-1

## NOTES:

1. UNLESS OTHERWISE SPECIFIED:
  - A. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W
  - B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. BRACKETED COMPONENTS ARE LOCATED ON B13230P28
3. JUMPER AND OPEN PAD POSITION FOR FUTURE COMPONENTS IF NEEDED.
4. FOR B.O.M. SEE A13230Z17.

## LAST COMPONENT DESIGN USED

C	CR	J	L	R	U
17	2	3	1	12	2

A 40-22-24984

NEXT ASSY      USED ON

UNLESS OTHERWISE SPECIFIED  
DIMENSIONS ARE IN INCHESTOLERANCES: ANGLES  $\pm$   
3 PLACE DECIMALS (.XXX);  $\pm$   
2 PLACE DECIMALS (.XX);  $\pm$   
1 PLACE DECIMALS (.X);  $\pm$ 

MATERIAL:

FINISH:

PL4 L.O. RECEIVER

PROJECT

DATA RECEIVER  
SCHEMATICNATIONAL RADIO  
ASTRONOMY  
OBSERVATORY  
CHARLOTTESVILLE, VA. 22901DRAWN BY DATE 6/17/75  
DESIGNED BY DATE 6/16/75  
APPROVED BY DATE

SHEET NUMBER DRAWING NUMBER B13230S3 REV. C SCALE

4

3

2

1

The output of the detector is AC coupled to the inverting amplifier U1. The parallel trap L1, C1 and C2 reduces the gain of the amplifier to less than one at 5 MHz. A buffer amplifier U2 and R7 provide a 51 ohm source to drive the data output line which connects to the Antenna Buffer, M4. Note that the positive output connection of CR2 combined with the inversion in U1 provides a net inversion, which is required for proper operation of the Antenna Buffer. A 10:1 resistive divider provides monitoring of the data on a BNC jack mounted on the module front panel and marked "Data." Correct signal levels will result in about 200 mV P-P at this point, corresponding to 2 V P-P to M4. The peak detector CR1, C12, R6 allows monitoring of the 1800 MHz carrier level in the same way as the similar circuit in the 5 MHz receiver allows monitoring of the 1200 MHz carrier.

#### 4.3 Level Indicator Circuit - Ref. Circuit Schematic B13230S25 Figure 4

The DC signals representing the 1200 and the 1800 MHz signal levels to the 5 MHz Receiver and the Data Receiver respectively are connected to the Level Monitor Circuit as shown in the schematic. The two signals are given to one side of a 2 pole-3 position center off spring loaded switch mounted on the module front panel. Also mounted on the front panel is a 50-0-50  $\mu$ A meter connected between the two poles of the switch. On the other side of the switch two independently adjustable bias outputs are connected. The bias pots R1 and R2 are adjusted so that for the nominal signal of + 11 dBm present full time (not just 1 msec every 50 msec) at the outputs of the amplifiers AR2 and AR3 will indicate meter readings of zero when the switch is appropriately connected. When the signal is absent the meter will read negative and for the signal larger than the nominal value the meter should indicate positive. In the vicinity of the meter zero the meter calibration is approximately 5  $\mu$ A/dB.

4

3

2

1

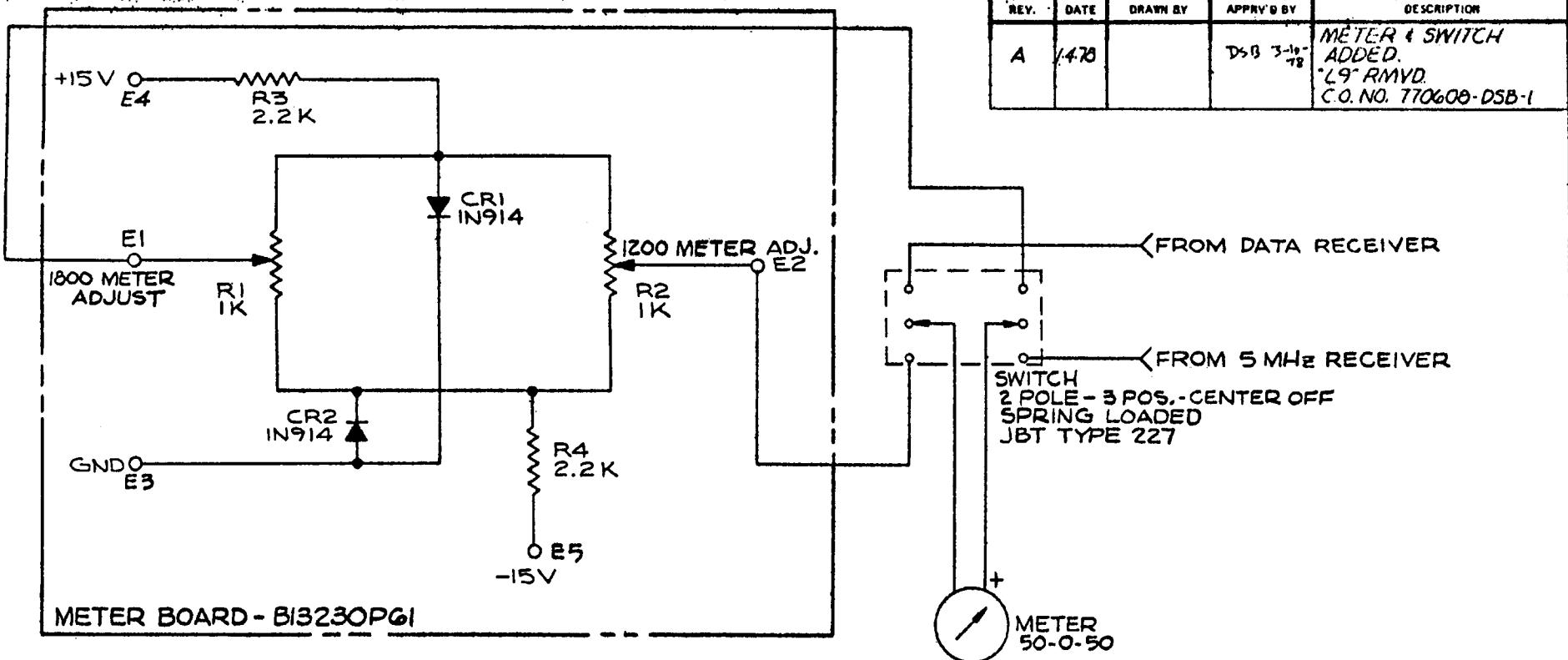
D

C

FIGURE  
4

B

A

DRAWING  
40-22 24944

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

MATERIAL:

FINISH:

PROJECT  
A

TITLE  
LEVEL INDICATION  
CIRCUIT  
SCHEMATIC

NATIONAL RADIO  
ASTRONOMY  
OBSERVATORY  
CHARLOTTESVILLE, VA. 22901

DRAWN BY	DATE
	3-4-77
DESIGNED BY	DATE
	6-6-77
APPROVED BY	DATE
	1-16-78

SHEET NUMBER 1 OF 1 DRAWING NUMBER B13230S25 REV. A SCALE

4

3

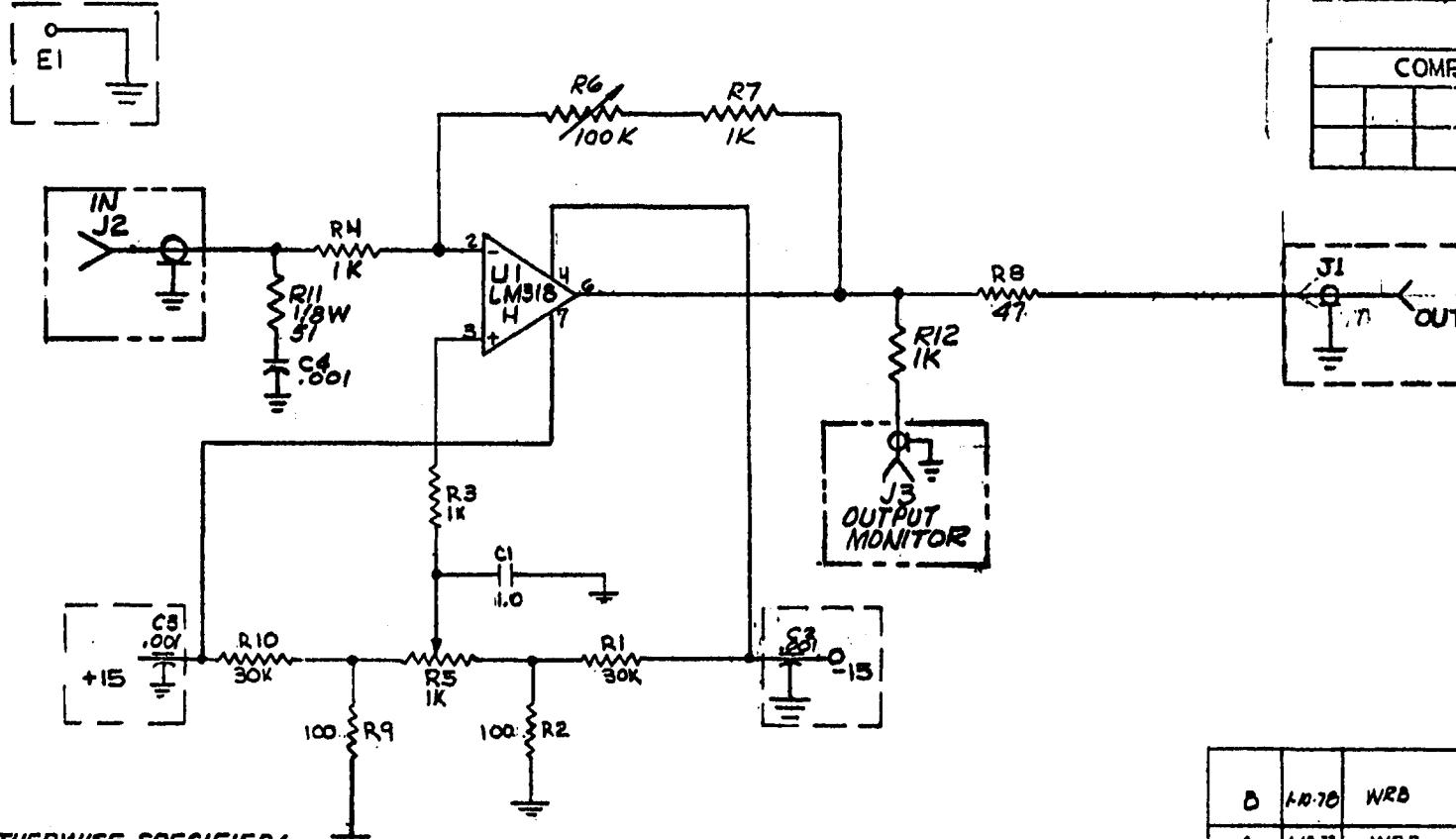
2

1

**4.4 Buffer Amplifier - Ref. Circuit Schematic B13230S8 (Figure 5)**

Output of the balanced mixer M2 (Block Diagram D13230B23) is connected to the buffer amplifier. The buffer amplifier input is terminated by a  $51 \Omega$  (R11) in series with a  $0.001 \mu F$  (C4). The balance-mixer M2 looks about  $50 \Omega$  at the sum frequency and  $1 K$  (due to R4) at the difference frequency (DC) term. The output of the balance-mixer should be about 300 to 500 mV for a  $2 \pi$  rad. phase variation. This is amplified to  $\pm 10 V$  P-P by amplifier U1 employing operational amplifier LM318. R6 is adjusted to give output of the amplifier  $\pm 10 V$  for a  $2 \pi$  rad. phase variation and the pot R5 is used to adjust DC offset to zero. Output of U1 is given to the Antenna L.O. Control Module. Also, it can be monitored at the module front panel BNC jack labeled "600 MHz  $\phi$ ."

FIGURE 5



## NOTES:

1. UNLESS OTHERWISE SPECIFIED:
  - A. ALL RESISTOR VALUES ARE IN OHMS,  $\frac{1}{4}$  WATT.
  - B. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. BRACKETED COMPONENTS LOCATED ON B13230P24.
3. FOR B.O.M. SEE A13230Z24 & A13230Z25.

LAST COMPONENT DESIGN USED			
R	C	U	
12	4	1	

COMP DESIGN NOT USED			

D	1-10-70	WRB		RMVD. DI (IN4733) & R13(1K)
A	1-10-71	WRB		R8 WAS 2.2K ADDED R6 & R7
REV	DATE	DRAWN BY	APPRV'D BY	ADDED U1, R13; RMVD R6, R7; R8 WAS 47.0
				DESCRIPTION
V	L4			NATIONAL RADIC
L	LO RECEIVER			ASTRONOMY
A				OBSERVATORY
T				CHARLOTTESVILLE, VA. 22901
T				
E				
V L4 LO RECEIVER				
A T BUFFER AMPLIFIER				
SCHEMATIC				
SHEET NUMBER	DRAWING NUMBER	B1323058	REV B	SCALE -



## 5.0 ADJUSTMENTS

### 5.1 5 MHz Receiver - Ref. Schematic Cl3230S4

- (a) Apply a total of - 5 dBm power at 1200 MHz with normal sidebands (- 10 dBc at  $\pm$  5 MHz from carrier at 1200 MHz) to the Receiver input from a  $50 \Omega$  source (DC return is required).
- (b) Set pot R22 on U2 to provide 2 V P-P output at emitter of Q1.
- (c) Apply a + 7 dBm 5 MHz reference signal at the 5 MHz reference input of the Receiver.
- (d) Set the potentiometers R16 and R17 on amplifier U1 to give the out of 20 V P-P (at about 50 Hz difference frequency) and DC off-set of zero.

### 5.2 Data Receiver - Ref. Schematic Bl3230S3

- (a) Apply - 5 dBm power at 1200 MHz with normal  $\pm$  5 MHz - 10 dBc sidebands from a  $50 \Omega$  DC return source to the input of the Data Receiver.
- (b) Tune capacitor C1 in 5 MHz trap to observe minimum 5 MHz output at the Data Receiver output. It should be less than 50 mV P-P.

### 5.3 Level Monitor Circuit - Ref. Block Diagram Dl3230B23 and Schematic Bl3230S25

- (a) Connect nominal input signal at the module OMQ jack J1 with nominal modulation on both 1800 and 1200 MHz carrier (total power in the two carriers with normal modulation = - 4 dBm).

(b) Adjust gain of the 1800 and 1200 MHz amplifiers AR2 AR3 by adjusting front panel potentiometers POT-1 and POT-2 respectively such that the signal level at the input of each of the Data Receiver and the 5 MHz Receiver is - 5 dBm.

(c) Adjust potentiometer R1 (R2) on the level monitor board with the meter switch connected towards 1800 (1200) MHz side so that the meter reads zero.

(d) Check by varying the input signal at L4J1 by + 1 dB that the meter reading indicates about + 5  $\mu$ A for both 1800 and 1200 MHz connections of the meter switch.

**5.4 Buffer Amplifier - Ref. Block Diagram D13230B23 and Schematic Bl3230S8**

(a) Connect nominal input signal at L4J1 as described in 5.3 (a) and adjust 1800 and 1200 MHz amplifier gains as described in 5.3 (b).

(b) Check the 600 MHz output at the module front panel "600 MHz" SMA jack. It should be about - 8 dBm.

(c) Connect a + 9 dBm 600 MHz signal to L4J11.

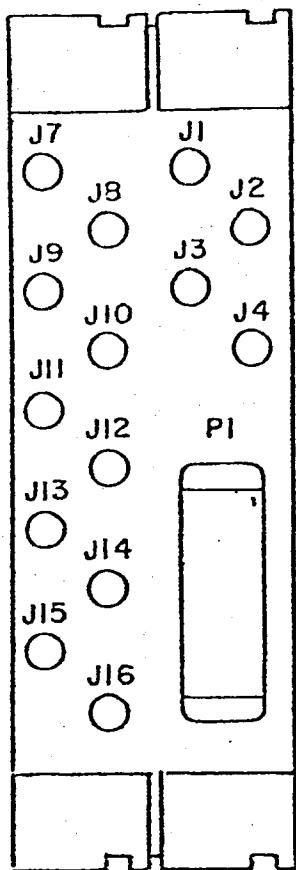
(d) Adjust gain pot R6 and DC offset pot R5 to give 20 V P-P for  $2 \pi$  rad. phase change zero D.C. offset as measured at module front panel BNC jack "600  $\phi$ ." For checkup 20 V P-P output for a  $2 \pi$  rad. phase change it may be convenient to test the module in the system and open the L1-5 MHz VCXO phase lock. The beat frequency should not be more than a few kHz.

5.5 1800 and 1200 MHz Amplifier Gains in the System

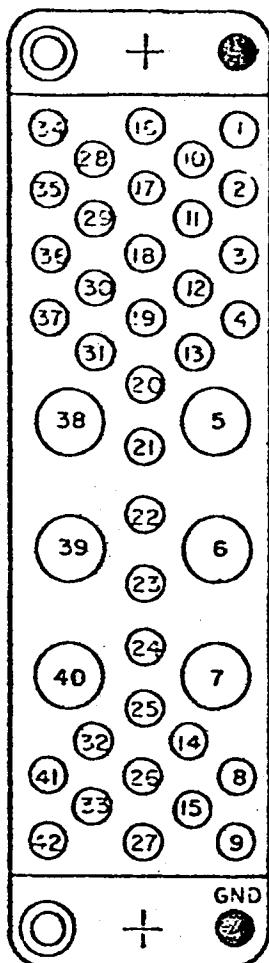
- (a) Connect the module in a normal system
- (b) Put Central Electronics Room Modem in full transmit and the Vertex Room Modem in full receive.
- (c) With the module front panel switch on 1800 (1200) MHz side adjust the front panel potentiometer Pot-1 (Pot-2) to give the meter reading zero.
- (d) Normalize the two modems to Auto Mode.



## 6.0 INPUT OUTPUT CONNECTIONS



CONN	FUNCTION	
J1	1.2 & 1.8 GHz -7 (4) dBm	Input
J2		
J3		
J4		
J7		
J8		
J9		
J10	+7 ± 1 dBm @ 5 MHz	Input
J11	+9 ± 2 dBm @ 600 MHz	Input
J12		
J13		
J14		
J15		
J16		



DOUBLE WIDE MODULE  
(REAR VIEW)

PI (REAR VIEW)

PI

PIN	FUNCTION	WIRE COLOR	PIN	FUNCTION	WIRE COLOR
1			22	RCV. 1800 MHz Level	
2			23		
3			24		
4			25		
5	Digital Data Out		26		
6	600 MHz Phase Det Out		27		
7	5 MHz Phase Det Out		28	-28VDC *	GREEN
8			29	+28VDC *	GREY
9			30		
10	+5VDC	ORANGE	31		
11	-5VDC *	BROWN	32		
12			33		
13			34	PWR. GROUND	BLACK
14			35		
15			36		
16	+15VDC	RED	37		
17	-15VDC	YELLOW	38	SYNC OUT	
18			39		
19			40		
20			41		
21	RCV. 1200 MHz Level		42	HIGH QUAL. GROUND	

\* INDICATES A FUNCTION NOT FOUND IN THIS MODULE.



**7.0 BILLS OF MATERIALS**



## VLA DATA LISTING

MODULE: L04  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230ZC4  
BCM: LO RECEIVER

0

MOD-Q/S-O/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NST		A13230Z04	NRAO	1	A13230Z04	LO RECEIVER	0 0.00
L04	1	MPM	D13230M24	NRAO	2	A13230Z04	PARTITION PLATE	M 35.56
L04	4	MPM	B13050M04	NRAO	3	A13230Z04	GUIDE	Z 0.20
L04	4	MPM	A13050M33	NRAO	4	A13230Z04	MIXER MOUNT	M 1.73
L04	2	MPM	B13050M23	NRAO	5	A13230Z04	BAR, SUP. TCP & BOTTOM	G 13.46
L04	2	MPM	B13050M18	NRAO	6	A13230Z04	RIGHT & LEFT SIDE PLATES	H 8.78
L04	4	H	47-10-204-10	SCUTHCO	7	A13230Z04	FASTNER, CAPTIVE	0.67
L04	1	MPM	C13230M31	NRAO	8	A13230Z04	PANEL, FRONT	A 55.00
L04	2	MPM	B13230M36	NRAO	9	A13230Z04	BAR SUP TOP & BTM LEFT	G 16.91
L04	01	NSA	A13230Z71	NRAO	10	A13230Z04	METER BOARD PCB ASSY	O 0.00
L04	2	MPM	C13050M22-1	NRAO	11	A13230Z04	COVER, PERFORATED	K 1.38
L04	04	P	KC-19-153	KINGS	12	A13230Z04	CONNECTOR, PAL BNC	2.35
L04	1	MPM	C13210M04	NRAO	13	A13230Z04	PANEL, REAR	E 15.93
L04	01		B13230AA21	NRAO	14	A13230Z04	FRONT PANEL SILKSCREEN	5 0.00
L04	2	DC 01	20063-10	OMNI-SPECTRA	17	A13230Z04	CPLR 10DB 1-2GHZ	66.60
L04		DC 02	20063-10	OMNI-SPECTRA	17	A13230Z04	CPLR 10DB 1-2GHZ	66.60
L04	01	AR 01	6203-313	WATKINS JOHN	18	A13230Z04	SPEC A13230N4	282.00
L04	02	AR 02	6203-8	WATKINS JOHN	19	A13230Z04	SPEC A13230N3	391.00
L04		AR 03	6203-8	WATKINS JOHN	19	A13230Z04	SPFC A13230N3	391.00
L04	2	FL 02	4B120-1200/120-0	K&L MICROWAVE	20	A13230Z04	FILTER, TUBULAR BP	45.00
L04		FL 04	4B120-1200/120-0	K&L MICROWAVE	20	A13230Z04	FILTER, TUBULAR BP	45.00
L04	01	PD 01	20493	OMNI-SPECTRA	21	A13230Z04	POWER DVDR, 2 WAY, 1-2GHZ	126.00
L04	J 11		OMQ-3043-75	OMNI-SPECTRA	22	A13230Z04	JACK, BLKHD RF MOUNT 141SR	1.50
L04	J 10		OMQ-3043-75	OMNI-SPECTRA	22	A13230Z04	JACK, BLKHD RF MOUNT 141SR	1.50
L04	3	J 01	OMQ-3043-75	OMNI-SPECTRA	22	A13230Z04	JACK, BLKHD RF MOUNT 141SR	1.50
L04	1	P	204186-5	AMP SPEC IND	23	A13230Z04	BLOCK, PIN 42 MIXED	1.68
L04	1	P	202394-2	AMP SPEC IND	24	A13230Z04	HOOD, PIN(42 AND 50 BLOCK)	0.87
L04	1	NSA	A13230Z24	NRAO	25	A13230Z04	BUFFER AMPLIFIER	O 0.00
L04	1	M 02	M1A	WATKINS JOHN	26	A13230Z04	MIX, DBL BAL CC-1GHZ SMA CON	72.00
L04	1	AR 04	UTA-8418M	AVANTEK	27	A13230Z04	AMPLIFIER (2-UTO-1002)	242.00
L04	07	MPP	M12-A	K&L MICROWAVE	28	A13230Z04	Mounting CLIP	0.05
L04	01	FL 05	4B120-6C0/100-0	K&L MICROWAVF	28	A13230Z04	FILTER, TUBULAR BP	45.00
L04	02	FL 03	4B120-1800/180-0	K&L MICROWAVE	29	A13230Z04	FILTER, TUBULAR RP	45.00
L04		FL 01	4B120-1800/180-0	K&L MICROWAVE	29	A13230Z04	FILTER, TUBULAR BP	45.00
L04	02	AT 05	FP87-03	TEXSCAN	30	A13230Z04	3DB ATTENUATOR	35.00
L04		AT 06	FP87-03	TEXSCAN	30	A13230Z04	3DB ATTENUATOR	35.00
L04	1	NSA	A13230Z16	NRAO	31	A13230Z04	DATA LINE DRIVER AMP.	O 0.00
L04	1	NSA	A13230Z18	NRAO	32	A13230Z04	5 MHZ PHASE DETECTOR	O 0.00
L04	3	P	OSM-511-3	CMNI-SPECTRA	33	A13230Z04	CONNECTOR, PLUG RG188	1.96
L04	5	P	OSM-531-3	CMNI-SPECTRA	34	A13230Z04	PLUG RT ANGL RG188	3.57
L04	18	P	OSM-201-1A	CMNI-SPECTRA	35	A13230Z04	CONNECTOR, PLUG 141SR	0.85
L04	4	W	UT-141A	UNIFORM TUBES	36	A13230Z04	CABLE, PF SEMIRIGID	0.45
L04	4	P	OSM-218	CMNI-SPECTRA	37	A13230Z04	ADAPTER, STRGHT PLUG/PLUG	4.56
L04	1	M 01	M1J	WATKINS JOHN	38	A13230Z04	MIX, DBL BAL CC-1GHZ SMA CON	73.00
L04	34	P	OSM-201-1	CMNI-SPECTRA	40	A13230Z04	CONNECTOR, PLUG 141SR	0.94
L04	4	P	201143-5	AMP SPEC IND	42	A13230Z04	COAX PIN	2.48
L04	07	P	204188-1	AMP SPEC IND	43	A13230Z04	CONTACT, PIN	0.23
L04	2	P	203964-6	AMP SPEC IND	44	A13230Z04	GUIDE SOCKET	0.21
L04	1	P	200833-4	AMP SPEC IND	45	A13230Z04	GUIDE PIN	0.23
L04	01	P	202514-1	AMP SPFC IND	46	A13230Z04	GROUND GUIDE PIN	0.42
L04	01	DC 03	DRG-10-4	ANZAC	47	A13230Z04	COUPLER, 10DB 30MHZ-1GHZ	64.00
L04		DSH	D13230R23	NRAO	48	A13230Z04	BLOCK DIAGRAM	7 0.00



MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	DWW		A13230W05	NRAO	49	A13230Z04	LO RECEIVER WIRE LIST 8	0.00
L04	16 H		PHSS 6-32 X 0.375	HW	50	A13230Z04	FLAT HEAD SLCTFD SS SCREW	0.02
L04	16 H		PHSS 6-32 X 0.250	HW	51	A13230Z04	PAN HEAD SLCTED SS	0.02
L04	14 H		PHSS 4-40 X 0.250	HW	52	A13230Z04	PAN HEAD SLCTFD SS	0.02
L04	3 H		PHSS 4-40 X 0.187	HW	53	A13230Z04	PAN HEAD SLCTED SS	0.02
L04	3 H		PHSS 2-56 X 0.500	HW	54	A13230Z04	PAN HEAD SLCTED SS	0.02
L04	2 H		PHSS 2-56 X 0.875	HW	55	A13230Z04	PAN HEAD SLCTED SS	0.02
L04	4 H		PHSS 6-32 X 0.625	HW	56	A13230Z04	PAN HEAD SLCTFD SS	0.02
L04	4 H		PHSS 6-32 X 0.875	HW	57	A13230Z04	PAN HFAD SLCTED SS	0.02
L04	2 H		PHSS 6-32 X 0.250	HW	58	A13230Z04	FLAT HEAD SLOTTED SS SCREW	0.02
L04	2 H		HSMS 6-32 X 0.250	HW	59	A13230Z04	HEX-SOCKET HC SLCTED SS	0.02
L04	01 AT 04		FP87-20	TEXSCAN	60	A13230Z04	20DB ATTENUATOR	35.00
L04	1 AT		8018-6009	SOLITRON	61	A13230Z04	TERM,50 OHM W/CHAIN	12.05
L04	1 J		OSM-208A	OMNI-SPECTRA	62	A13230Z04	JACK/JACK BLKHD FCTHRU	8.94
L04	03 AT 01		FP87-06	TEXSCAN	63	A13230Z04	6DB ATTENUATOR	35.00
L04	AT 02		FP87-06	TEXSCAN	63	A13230Z04	6DB ATTENUATOR	35.00
L04	AT 03		FP87-06	TFXSCAN	63	A13230Z04	6DB ATTENUATOR	35.00
L04	01 M	50.0	111-5622750	WESTON	64	A13230Z04	50-0-50 UACC VERT MT	18.00
L04	01 S 01		227	JBT	65	A13230Z04	SWITCH, TOGGLE 2 POLE	6.00
L04	R 02	20.0	K 534-20K	SPECTROL	66	A13230Z04	10 TURN PCT	6.00
L04	02 R 01	20.0	K 534-20K	SPECTROL	66	A13230Z04	10 TURN PCT	6.00
L04	02 H		1702	KEYSTONE	68	A13230Z04	SHAFT LOCK	0.35

\*\*\* TOTAL COST= 2586.59 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230Z16  
BOM: DATA LINE CRIVFR AMP

0

MAN-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NSA		A13230Z16	NRAO	1	A13230Z16	DATA LINE DRIVER AMP	0.00
L04	1 MPN		B13230M89	NRAO	2	A13230Z16	RCVR DATA AMP END PANEL J	0.00
L04	1 MPN		B13230M30	NRAO	3	A13230Z16	RECEIVER DATA AMPLIFIER J	3.71
L04	1 MPN		B13230M39	NRAO	4	A13230Z16	RECVR DATA AMP SIDE PANELJ	0.00
L04	1 MPN		B13230M27	NRAO	5	A13230Z16	RECEIVER DATA AMPLIFIER J	2.73
L04	8 H		PHSS 4-40 X 0.500	HW	6	A13230Z16	PAN HEAD SLCTTED SS	0.02
L04	04 H		FHSS 4-40 X 0.375	HW	7	A13230Z16	FLAT HEAD SLCTTED SS SCREW	0.02
L04	1 MPN		B13230M29	NRAO	8	A13230Z16	RECEIVER DATA AMPLIFIER J	6.72
L04	1 MPN		B13230M90	NRAO	9	A13230Z16	RCVR DATA AMP END PANEL J	0.00
L04	01 DSA		B13230P28	NRAO	10	A13230Z16	RCVR DAT AMPLIFIER ASSY I	0.00
L04	04 H		PHSS 4-40 X 0.250	HW	12	A13230Z16	PAN HEAD SLCTTED SS	0.02
L04	1 NSB		A13230Z17	NRAO	16	A13230Z16	DATA LINE DRIVER AMP	0.00
L04	J 02		OSM-211	OMNI-SPECTRA	17	A13230Z16	JACK BLKHC FCTHRU	2.15
L04	J 03		OSM-211	OMNI-SPECTRA	17	A13230Z16	JACK BLKHD FCTHRU	2.15
L04	3 J 01		DSM-211	CMNI-SPECTRA	17	A13230Z16	JACK BLKHC FOTHRU	2.15
L04	C 11	0.001UF	F83810F102W	SPEC CONTROL	18	A13230Z16	CAPACITOR,FEEDTHRU SCREW MT	0.66
L04	C 08	0.001UF	F83810F102W	SPEC CONTPOL	18	A13230Z16	CAPACITOR,FEEDTHRU SCREW MT	0.66
L04	01 C 17	0.001UF	F83810F102W	SPEC CONTROL	18	A13230Z16	CAPACITOR,FEEDTHRU SCREW MT	0.66
L04	C 14	0.001UF	F83810F102W	SPEC CONTROL	18	A13230Z16	CAPACITOR,FEEDTHRU SCRFW MT	0.66
L04	1 E 01		1587-1	KEYSTONE	19	A13230Z16	TERMINAL,TURRET .125 4-40THD	0.09
L04	E 01		B13230M98	NRAO	19	A13230Z16	TERMINAL, TURRET MCD N	0.00
L04	DSH		B13230S03	NRAO	20	A13230Z16	PCVR DATA AMP SCHEMATIC	2.00

\*\*\* TOTAL COST=

20.68 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SFT: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A1323CZ17  
BOM: DATA LINE DRIVER AMP

0

MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NSA		A13230Z17		01	A13230Z17	DATA LINE DRIVER AMP	0 0.00
L04	01 EPCD	1.0	K B13231M15	NRAO	02	A13230Z17	LG RCVR DRILL DIAGRAM	6 0.00
L04	01 FPCP		B13230P29	NRAO	03	A13230Z17	DATA LINE CRIVER AMP	1 0.00
L04	01 R 02	10.0	K RCR07 103-5S		04	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 03	390.0	K RCR07 391-5S		05	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 04	200.0	K RCR07 201-5S		06	A13230Z17	RESISTOR 1/4W	0.06
L04	R 01	1.0	K RCR07 102-5S		07	A13230Z17	RESISTOR 1/4W	0.06
L04	02 R 05	1.0	K RCR07 102-5S		08	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 06	1.0	M RCR07 105-5S		09	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 07	51.0	K RCR07 510-5S		10	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 08	510.0	K RCR07 511-5S		11	A13230Z17	RESISTOR 1/4W	0.06
L04	01 R 09	56.0	K RCR07 560-5S		12	A13230Z17	CAPACITOR, VARIABLE 4.5-50PF	1.85
L04	01 C 01	4.5 PF	DVJ305A	JFD	13	A13230Z17	CAPACITOR MICA 500VDC	0.11
L04	01 C 02	82.0 PF	CM04ED820J03	ARCO	14	A13230Z17	0.01UF, 50VDC, CAP. (RED CAP)	.39
L04	02 C 03	0.01 UF	8121-050-651-103M	EPIE	14	A13230Z17	0.01UF, 50VDC, CAP. (RED CAP)	.39
L04	C 16	0.01 UF	8121-050-651-1C3M	ERIE	15	A13230Z17	CAPACITOR MICA 500VDC	0.09
L04	01 C 04	8.0 PF	CM05CD0080J03	ARCO	16	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	0.19
L04	02 C 05	0.1 UF	8121-050-651-104M	ERIE	16	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	0.11
L04	C 07	0.1 UF	8121-050-651-104M	ERIE	17	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	0.11
L04	01 C 06	5.0 PF	CM04CD050D03	ARCO	18	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	1.23
L04	03 C 09	1.0 UF	8131-050-651-105M	ERIE	18	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	1.23
L04	C 10	1.0 UF	8131-050-651-105M	ERIE	18	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	1.23
L04	C 12	1.0 UF	8131-050-651-105M	FRTE	18	A13230Z17	CAPACITOR, MONOLYTHIC 50VDC	1.23
L04	01 C 13	0.47 UF	8131-050-651-474M	ERIE	19	A13230Z17	CAPACITOR, MCNOLYTHIC 50VDC	0.35
L04	01 U 01		LH0032CG	NAT SEMICOND	20	A13230Z17	OP AMP, FET ULTPA FAST	17.38
L04	01 U 02		LH0033CG	NAT SEMICOND	21	A13230Z17	AMPLIFIER, OP FET	14.49
L04	01 L 01	10.0 UH	9230-44	MILLER	22	A13230Z17	CHOKE, 10MH 10%	0.60
L04	01 CP 01		A25800	AERTECH	24	A13230Z17	DIODE, SHOTTKY	1.05
L04	02 X		MP12100S	ROB NUGENT	25	A13230Z17	SOCKET, 12 PIN TO-8 SQUARE	0.28
L04	DSH		B13230S03	NRAO	26	A13230Z17	RCVR DATA AMP SCHEMATIC	0.00
L04	EPCA		B13230AB09	NRAO	27	A13230Z17	RECEIVER DATA AMPLIFIER	0.00
L04	01 W		297	ALPHA	28	A13230Z17	WIRE, BUS 20AWG	0.18
L04	02 R 10	8.2	K RCR07 822-5S		29	A13230Z17	RESISTOR 1/4W	0.06
L04	R 12	8.2	K RCR07 822-5S		29	A13230Z17	RESISTOR 1/4W	0.06
L04	1 R 11	43.0	K RCR07 433-5S		30	A13230Z17	PF-SISTOR 1/4W	0.06
L04	01 C 15	10.0 PF	ATC100B-160-J-P-50	AMER TECH CER	31	A13230Z17	CAPACITOR, CHIP	4.00
L04	01 CR 02		5082-2824	HEWLETT PACK	32	A13230Z17	DIODE, HOT CARRIER	7.90

\*\*\* TOTAL COST=

54.24 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A1323CZ18  
BOM: 5 MHZ PHASE DETECTOR

0

MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NSA		A13230Z18	NRAO	1	A13230Z18	5 MHZ PHASE DETECTOR	0.00
L04	1 MPN		B13230M89	NRAO	2	A13230Z18	RCVR DATA AMP END PANEL	0.00
L04	1 MPN		B13230M30	NRAO	3	A13230Z18	RECEIVER DATA AMPLIFIER	3.71
L04	1 MPN		B13230M54	NRAO	4	A13230Z18	5MHZ PHASE DETECTOR	0.00
L04	1 MPN		R13230M27	NRAO	5	A13230Z18	RECEIVER DATA AMPLIFIER	2.73
L04	8 H		PHSS 4-40 X 0.500	HW	6	A13230Z18	PAN HEAD SLOTTED SS	0.02
L04	4 H		FHSS 4-40 X 0.375	HW	7	A13230Z18	FLAT HEAD SLCTEC SS SCREW	0.02
L04	1 MPN		B13230M90	NRAO	8	A13230Z18	RCVR DATA AMP END PANEL	0.00
L04	01 MPN		B13230M29	NRAO	09	A13230Z18	RECEIVER DATA AMPLIFIER	6.72
L04	01 DSA		B13230P23	NRAO	10	A13230Z18	5MHZ PHASE DET FACL	1.00
L04	04 H		PHSS 4-40 X 0.350	HW	12	A13230Z18	PAN HEAD SLOTTED SS	0.02
L04	01 C 17	0.001UF	FB3810F102W	SPEC CONTROL	16	A13230Z18	CAPACITOR, FEEDTHRU SCREW MT	0.66
L04	C 11	0.001UF	FR3810F102W	SPEC CONTROL	16	A13230Z18	CAPACITOR, FEEDTHRU SCREW MT	0.66
L04	C 10	0.001UF	FB3810F102W	SPEC CONTROL	16	A13230Z18	CAPACITOR, FEEDTHRU SCREW MT	0.66
L04	04 C 09	0.001UF	FB3810F102W	SPEC CONTROL	16	A13230Z18	CAPACITOR, FEEDTHRU SCREW MT	0.66
L04	E 01		B13230M98	NRAO	17	A13230Z18	TERMINAL, TURRET MCD	0.00
L04	1 E 01		1587-1	KEYSTONE	17	A13230Z18	TERMINAL, TURRET .125 4-40THD	0.09
L04	J 02		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	J 06		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	J 04		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	J 03		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	J 05		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	6 J 01		OSM-211	OMNI-SPECTRA	18	A13230Z18	JACK BLKHD FDTHRU	2.15
L04	1 NSB		A13230719	NRAO	19	A13230Z18	5 MHZ PHASE DETECTOR	0.00
L04	1 DSH		C13230S04	NRAO	21	A13230Z18	5MHZ DETECTOR SCHEMATIC	0.00

\*\*\* TOTAL COST= 29.77 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230Z19  
BOM1 5 MHZ PHASE DETECTOR

0

MOD-Q/S-Q/N	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04		NSA	A13230Z19	NRAO	01	A13230Z19	5 MHZ PHASE DETECTOR	0 0.00
L04	01	EPCD	C13230M55	NRAO	02	A13230Z19	5 MHZ PHASE DETECTOR	6 3.65
L04	08	R 20	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		P 23	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		R 27	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		R 12	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		R 13	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		R 02	1.0 K RCR07 102-5S		03	A13230Z19	RFSISTOR 1/4W	0.06
L04		P 03	1.0 K RCR07 102-5S		03	A13230Z19	RESISTOR 1/4W	0.06
L04		R 10	4.7 K RCR07 472-5S		04	A13230Z19	RESISTOR 1/4W	0.06
L04		R 06	4.7 K RCR07 472-5S		04	A13230Z19	RESISTOR 1/4W	0.06
L04		P 07	4.7 K RCR07 472-5S		04	A13230Z19	RESISTOR 1/4W	0.06
L04	04	R 05	4.7 K RCR07 472-5S		04	A13230Z19	RESISTOR 1/4W	0.06
L04	01	R 29	510.0 PCR07 511-5S		05	A13230Z19	RESISTOR 1/4W	0.06
L04	02	R 08	240.0 PCR07 241-5S		06	A13230Z19	RESISTOR 1/4W	0.06
L04		P 09	240.0 PCR07 241-5S		06	A13230Z19	RESISTOR 1/4W	0.06
L04	01	R 11	51.0 RCR07 510-5S		07	A13230Z19	RESISTOR 1/4W	0.06
L04		R 21	30.0 K RCR07 303-5S		08	A13230Z19	RFSISTOR 1/4W	0.06
L04	02	R 14	30.0 K RCR07 303-5S		08	A13230Z19	RESISTOR 1/4W	0.06
L04	02	R 15	100.0 RCR07 101-5S		09	A13230Z19	RESISTOR 1/4W	0.06
L04		R 19	100.0 RCR07 101-5S		09	A13230Z19	RESISTOR 1/4W	0.06
L04	01	R 16	100.0 K 3339P-1-104	BOURNS	10	A13230Z19	POT.CERMET,4 TURN,+-10%	1.98
L04	01	R 17	1.0 K 3339P-1-102	BOURNS	11	A13230Z19	POT.CERMET,4 TURN,+-10%	2.50
L04		P 26	47.0 RCR07 470-5S		12	A13230Z19	RESISTOR 1/4W	0.06
L04	02	R 18	47.0 RCR07 470-5S		12	A13230Z19	RESISTOR 1/4W	0.06
L04	01	P 22	2.0 K 3339P-1-202	BOURNS	13	A13230Z19	POT.CERMET,4 TURN,+-10%	1.98
L04	01	R 24	1.0 M RCR07 105-5S		14	A13230Z19	RESISTOR 1/4W	0.06
L04	01	R 25	120.0 RCR07 121-5S		15	A13230Z19	RFSISTOR 1/4W	0.06
L04	01	R 28	56.0 RCP07 560-5S		16	A13230Z19	RESISTOR 1/4W	0.06
L04		C 14	1.0 UF 8131-050-651-105M	ERIE	17	A13230Z19	CAPACITOR,MONOLYTIC 50VDC	1.23
L04		C 05	1.0 UF 8131-050-651-105M	ERIE	17	A13230Z19	CAPACITOR,MONOLYTIC 50VDC	1.23
L04	05	C 01	1.0 UF 8131-050-651-105M	ERIE	17	A13230Z19	CAPACITOR,MONOLYTIC 50VCC	1.23
L04		C 06	1.0 UF 8131-050-651-105M	ERIE	17	A13230Z19	CAPACITOR,MONOLYTIC 50VCC	1.23
L04		C 04	1.0 UF 8131-050-651-105M	ERIE	17	A13230Z19	CAPACITOR,MONOLYTIC 50VDC	1.23
L04	02	C 02	0.01 UF 8121-050-651-103M	ERIE	18	A13230Z19	0.01UF,50VCC,CAP.(RED CAP)	.39
L04		C 15	0.01 UF 8121-050-651-103M	ERIE	18	A13230Z19	0.01UF,50VDC,CAP.(RED CAP)	.39
L04		C 07	0.1 UF 8131-050-651-104M	ERIE	19	A13230Z19	CAPACITOR,MONOLYTIC 50V	0.19
L04	02	C 03	0.1 UF 8131-050-651-104M	ERIE	19	A13230Z19	CAPACITOR,MONOLYTIC 50V	0.19
L04	01	C 08	2200.0 PF 8111-050-651-222M	ERIE	20	A13230Z19	CAPACITOR,MONOLYTIC 50V	0.11
L04		C 13	0.47 UF 8131-050-651-474M	ERIE	21	A13230Z19	CAPACITOR,MONOLYTIC 50VDC	0.35
L04	02	C 12	0.47 UF 8131-050-651-474M	ERIE	21	A13230Z19	CAPACITOR,MONOLYTIC 50VDC	0.35
L04	01	CR 01	A2S800	AERTECH	22	A13230Z19	CIOCE,SHCTTKEY	1.05
L04	01	U 01	AD741KN	ANALOG DEV	23	A13230Z19	OP AMP,LC CCST DIP	2.50
L04	01	U 02	UA733CA	SIGNETICS	24	A13230Z19	AMPLIFIER,DIFF VIDEO	1.00
L04	01	U 03	SRA-1	MINI CKT LABS	25	A13230Z19	MIXER,DBL BAL	9.45
L04		U 02	2N3904	MOTOROLA	26	A13230Z19	TRANSISTOR,AMPLIFIER NPN	0.12
L04	02	Q 01	2N3904	MOTOROLA	26	A13230Z19	TRANSISTOR,AMPLIFIER NPN	0.12
L04	01	L 01	330.0 UH 9230-80	MILLER	27	A13230Z19	CHOKE,PF MICRO MINATURE	0.85
L04	01	X	ICN-143-S3	ROB NUGENT	28	A13230Z19	SOCKET,14 PIN DIL	0.27
L04	01	X	ICN-083-S3	ROB NUGENT	29	A13230Z19	SOCKET,8 PIN DIL	0.25
L04	02	X	3-LPS-B	CINCH	30	A13230Z19	SOCKET,TRANSISTOR TO-5,TO-18	0.17
104		DSH	C13230S04	NRAO	31	A13230Z19	5MHZ DETECTOR SCHEMATIC ?	0.00



MOD-O/S-Q/M	DESCP	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	EPCA		813230A804	NRAO	32	A13230Z19	5 MHZ O DETECTOR	4 0.00
L04	R 34	8.2	K RCR07 822-5S		33	A13230Z19	PESISTOR 1/4W	0.06
L04	R 01	8.2	K RCR07 822-5S		33	A13230Z19	RESISTOR 1/4K	0.06
L04	03 P 04	8.2	K RCR07 822-5S		33	A13230Z19	RESISTOR 1/4W	0.06
L04	01 FPCP		B13230P30	NRAO	34	A13230Z19	5 MHZ PHASE DETECTOR	1 0.00
L04	P 31	1.0	K RCR07 105-5S		39	A13230Z19	RESISTOR 1/4W	0.06
L04	01 R 30	43.0	K RCR07 433-5S		40	A13230Z19	RESISTOR 1/4W	0.06
L04	01 C 16	10.0	PF ATC100B-100-J-P-50	AMER TECH CER	41	A13230Z19	CAPACITOR,CHIP	4.00
L04	01 CR 02		5082-2824	HEWLETT PACK	42	A13230Z19	DIODE,HOT CARRIER	7.90

\*\*\* TOTAL COST= 47.72 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230Z24  
BOM: BUFFER AMPLIFIER

0

MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NSA		A13230Z24	NRAO	1	A13230Z24	BUFFER AMPLIFIER	0 0.00
L04	01	NSB	A13230Z25	NRAO	2	A13230Z24	BUFFER AMPLIFIER	0 0.00
L04	02	J 01	OSM-211	OMNI-SPECTRA	3	A13230Z24	JACK BLKHD FCTHRU	2.15
L04		J 02	OSM-211	OMNI-SPECTRA	3	A13230Z24	JACK BLKHD FCTHRU	2.15
L04	03	J 03	OSM-211	OMNI-SPECTRA	3	A13230Z24	JACK BLKHD FCTHRU	2.15
L04	02	C 02	0.001UF FB3R10F102W	SPEC CONTROL	4	A13230Z24	CAPACITOR,FFEDTHRU SCREW MT	0.66
L04	C 03	0.001UF	FR3R10F1C2W	SPEC CONTROL	4	A13230Z24	CAPACITOR,FEFTHRU SCREW MT	0.66
L04	01	E 01	1587-1	KEYSTONE	5	A13230Z24	TERMINAL,TURRET .125 4-40THD	0.09
L04	DSH		B13230S08	NRAO	6	A13230Z24	BUFFER AMPLIFTER SCH	2 0.00
L04	01	DSA	B13230P24	NRAO	7	A13230Z24	BUFFER AMPLIFTER ASSY	1 0.00
L04	01	MPZ	B13230M40	NRAO	16	A13230Z24	BUFFER AMPLIFER ENCLOSURE	1.61
L04	01	MOP	2400(NRAO)	PAMONA	16	A13230Z24	ENCLOSURE,RF	1.55
L04	02	H	FHSS 2-56 X 0.250	HW	17	A13230Z24	FLAT HEAD SLCTTED SS SCREW	0.02

\*\*\* TOTAL COST= 15.36 \*\*\*



## VLA DATA LISTING

MODULE: LO4  
DATA SET: LO RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230Z25  
BOM: BUFFER AMPLIFIER

0

MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
LO4	NSA		A13230Z25					
LO4	02 R 01	30.0	K RCR07 303-5S	NRAO	1	A13230Z25	BUFFER AMPLIFIER	0 0.00
LO4	P 10	30.0	K RCR07 303-5S		2	A13230Z25	RFSISTOR 1/4W	0.06
LO4	02 R 02	100.0	K RCR07 101-5S		2	A13230Z25	RFSISTOR 1/4W	0.06
LO4	R 09	100.0	K RCR07 101-5S		3	A13230Z25	RESISTOR 1/4W	0.06
LO4	R 04	1.0	K RCR07 102-5S		3	A13230Z25	RESISTOR 1/4W	0.06
LO4	R 07	1.0	K RCR07 102-5S		4	A13230Z25	RESISTOR 1/4W	0.06
LO4	04 R 03	1.0	K RCR07 102-5S		4	A13230Z25	RESISTOR 1/4W	0.06
LO4	01 R 08	47.0	K RCR07 470-5S		5	A13230Z25	RESISTOR 1/4W	0.06
LO4	R 05	1.0	K 3339H-1-102	BOURNS	6	A13230Z25	POTENTIOMETER 4 TURN	1.53
LO4	R 06	100.0	K 3339H-1-104	BOURNS	7	A13230Z25	POTENTIOMETER 4 TURN	1.53
LO4	C 01	1.0	UE 8131-050-651-105M	ERIE	8	A13230Z25	CAPACITOR, MONOLYTIC 50VDC	1.23
LO4	01 U 01		LM318H	NAT SEMICONO	9	A13230Z25	OP AMP	1.88
LO4	R 12	1.0	K RCR07 102-5S		10	A13230Z25	RFSISTOR 1/4W	0.06
LO4	EPCD		B13230M58	NRAO	11	A13230Z25	BUFFER AMPLIFIER	6 1.75
LO4	X		DP-5178	ROB NUGENT	12	A13230Z25	SOCKET, 8 PIN TO-5	1.98
LO4	C 04	0.001UF	8101-050-651-102M	ERIE	13	A13230Z25	CAPACITOR, MONOLYTIC 50VDC	0.10
LO4	R 11	51.0	K RCR05 510-5S		14	A13230Z25	RESISTOR 1/8W	0.22
LO4	02 E		1589-2	KEYSTONE	15	A13230Z25	STANDOFF, SWAGE 2-56 1/8H	0.06
LO4	DSH		B13230S08	NRAO	16	A13230Z25	BUFFER AMPLIFIER SCH	2 0.00
LO4	EPCA		B13230AB06	NRAO			BUFFER AMPLIFIER	4 0.00

\*\*\* TOTAL COST= 10.88 \*\*\*



## VLA DATA LISTING

MODULE: L04  
DATA SET: LC RECEIVER

PROJECT NO. 13230

DRAWING NO.: A13230Z71  
BOM#: METER BOARD PCB ASSY 0

MOD-Q/S-Q/M	DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L04	NSA		A13230Z71	NRAO	01	A13230Z71	METER BOARD PCB ASSY	0 0.00
L04	01 EPCP		B13230P61	NRAO	02	A13230Z71	METER BOARD PCB ASSY	1 0.00
104	01 EPCD		B13231M19	NRAO	03	A13230Z71	METER BOARD ARTWCPK	6 0.00
L04	01 DSH		B13230S25	NRAO	04	A13230Z71	METER BOARD SCHEMATIC	2 0.00
L04	02 R 01	1.0	K 3339P-1-102	BOURNS	05	A13230Z71	POT,CERMET,4TURN,+-10%	2.50
L04	R 02	1.0	K 3339P-1-102	BOURNS	05	A13230Z71	POT,CERMET,4TURN,+-10%	2.50
L04	02 CR 01		IN914B	GE	06	A13230Z71	DIODE,GENL PUR	0.07
L04	CR 02		IN914B	GE	06	A13230Z71	DIODE,GENL PUR	0.07
L04	02 R 03	2.2	K PCR07 222-5S		07	A13230Z71	RESISTOR 1/4W	0.06
L04	R 04	2.2	K RCR07 222-5S		07	A13230Z71	RESISTOR 1/4W	0.06
L04	05 P		1502-2	KEYSTONE	08	A13230Z71	TERMINAL,TURRET 1/16 STK	0.02
L04	04 P		1589-2	KFYSTONE	09	A13230Z71	STANDOFF,SWAGE 2-56 1/RH	0.06
L04	01 EPCA		B13230AB33	NRAO	10	A13230Z71	METER BOARD ARTWCPK	4 0.00

\*\*\* TOTAL COST= 5.60 \*\*\*

\*\*\* TOTAL COST FOR MODULE L04 IS 2770.84 \*\*\*



**8.0 SPECIFICATIONS AND MANUFACTURERS' DATA SHEETS**

NATIONAL RADIO ASTRONOMY OBSERVATORY  
SOCORRO, NEW MEXICO  
VERY LARGE ARRAY PROJECT

SPECIFICATION: A13230N2, N3 DATE: October 25, 1977

TITLE: 0.1-2 GHz Gain-Controlled Amplifiers

PREPARED BY: \_\_\_\_\_ APPROVED BY: \_\_\_\_\_

1.0 GENERAL DESCRIPTION

Two types of solid state power amplifier incorporating voltage-controlled attenuators are required. All specifications shall be met at frequencies between 0.1 and 2.0 GHz, and temperatures between 0 and 50 C, except as noted.

A13230N2 A13230N3

2.0 SMALL SIGNAL GAIN, with attenuator

control set for maximum gain >6.0 >14.0 dB

3.0 GAIN VARIATION WITH FREQUENCY, peak-to-peak

(3.1) Attenuator at any setting from maximum gain to 15 dB lower; 0.1-2.0 GHz <4.0 <4.0 dB

(3.2) Attenuator set for gain of 0 dB at 1.5 GHz; 1.0-2.0 GHz <2.0 -- dB

(3.3) Attenuator set for gain of +10 dB at 1.5 GHz; 1.0-2.0 GHz -- <3.0 dB

4.0 VSWR, input and output ports

(4.1) Attenuator at maximum gain to 15 dB lower; 0.1-2.0 GHz <2.5 <2.5

(4.2) Attenuator set for gain of 0 dB at 1.5 GHz; 1.0-2.0 GHz <2.0 --

(4.3) Attenuator set for gain of +10 dB at 1.5 GHz; 1.0-2.0 GHz -- <2.0

A13230N2 A13230N3

5.0 OUTPUT AT 1.0 dB GAIN COMPRESSION  $\geq +7.0$   $\geq +14.0$  dBm

6.0 NOISE FIGURE with attenuator at maximum gain  $\leq 10.0$   $\leq 10.0$  dB

7.0 ATTENUATOR RANGE for control voltage  
variation of 0 to +15 V (maximum gain  
shall be obtained at +15 V)  $\geq 15$   $\geq 15$  dB

8.0 POWER REQUIREMENTS

(8.1) Supply voltage at which all specifica-  
tions shall be met  $+15\pm 1$   $+15\pm 1$  Vdc  
(8.2) Supply current at +15.0 volts  $\leq 45$   $\leq 90$  mA

9.0 CONNECTORS

(9.1) RF SMA female  
(9.2) DC (power and attenuator control) solder terminals

10.0 CASE SIZE, excluding base plate and  
connectors  $1.4 \times 1 \times 0.7$   $2.4 \times 1 \times 0.7$  in.

11.0 TESTING

For each type of amplifier, the manufacturer shall perform tests on each unit sufficient to ensure that all specifications are met, including at least the following: small signal gain, VSWR at each RF port, and 1 dB gain compression point. Each quantity is to be measured at frequencies of 0.1, 0.6, 1.2, 1.8, and 2.0 GHz, and at fixed attenuator settings of maximum gain, approximately 5 dB lower, and approximately 15 dB lower. (For these tests, attenuator control voltages may be chosen from typical device characteristics at 1.0 GHz.) The results of all tests shall be supplied with the unit.

NATIONAL RADIO ASTRONOMY OBSERVATORY  
SOCORRO, NEW MEXICO  
VERY LARGE ARRAY PROJECT

SPECIFICATION: A13230N4 DATE: October 21, 1977  
TITLE: 0.1-2.0 GHz Amplifier  
PREPARED BY: \_\_\_\_\_ APPROVED BY: \_\_\_\_\_

1.0 GENERAL DESCRIPTION

A solid state, broadband power amplifier is required. All specifications shall be met at frequencies between 0.1 and 2.0 GHz and temperatures between 0 and 50 C, except as noted below.

2.0 SMALL-SIGNAL GAIN >17.0 dB

3.0 GAIN VARIATION WITH FREQUENCY, peak-to-peak

(3.1) 0.1 to 2.0 GHz ≤4.0 dB  
(3.2) 1.0 to 2.0 GHz ≤2.0 dB

4.0 VSWR, input and output

(4.1) 0.1 to 2.0 GHz ≤2.5  
(4.2) 1.0 to 2.0 GHz ≤2.0

5.0 OUTPUT AT 1.0 dB GAIN COMPRESSION >+14.0 dBm

6.0 NOISE FIGURE <7.0 dB

7.0 POWER REQUIREMENTS

(7.1) Supply voltage at which all specifications shall be met +15±1 Vdc  
(7.2) Supply current at +15.0 volts ≤75 mA

8.0 CONNECTORS

(8.1) RF SMA female  
(8.2) DC (power) solder terminals

## 9.0 TESTING

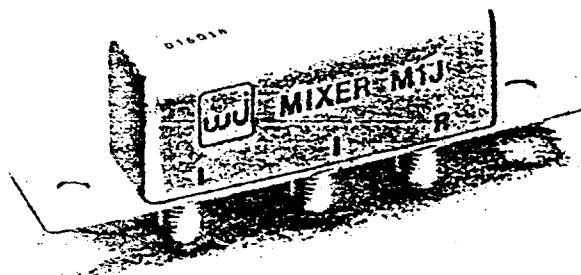
The manufacturer shall perform tests on each unit sufficient to ensure that all specifications are met, including at least the following: small signal gain, VSWR at each RF port, and 1 dB gain compression point; each quantity is to be measured at frequencies of 0.1, 0.6, 1.2, 1.8, and 2.0 GHz. The results of all tests shall be supplied with each unit.

# WJ-M1J

## DOUBLE-BALANCED MIXER

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

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



### Guaranteed Specifications\*

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

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

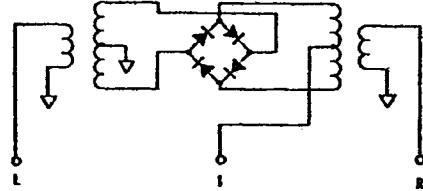
**Weight** 31 grams (1.1 oz.) maximum

**Connectors** SMA Female

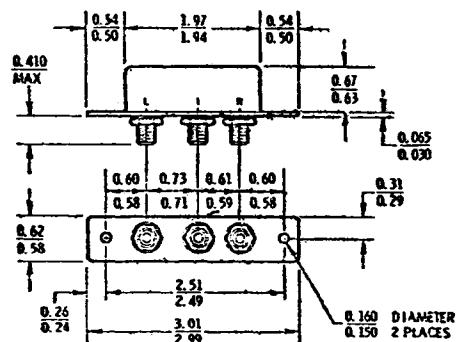
### Absolute Maximum Ratings

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

### Schematic Diagram

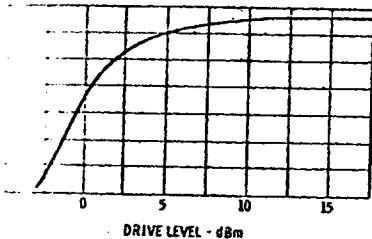


### Outline Drawing



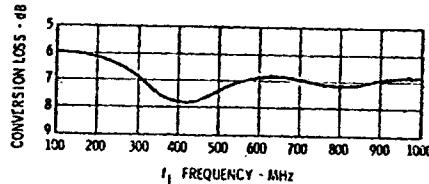
NOTE: DIMENSIONS ARE IN INCHES.

## Typical Performance at 25°C



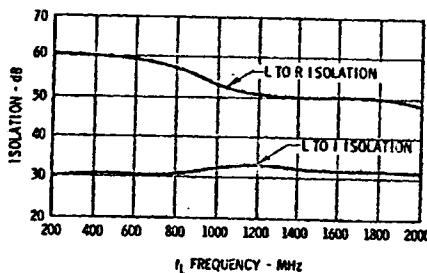
**Drive Level:** The minimum recommended drive level is +4 dBm.

The maximum recommended drive level is +13 dBm.



### Conversion Loss vs. $f_i$ Frequency:

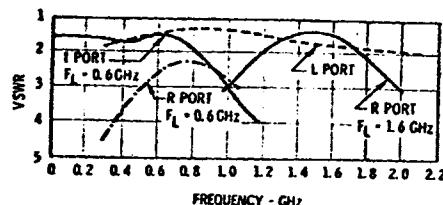
Conversion loss of the mixer when used in a SSB system. The frequency ordinate refers to the I-port ( $f_i$ ) with  $f_R$  at 1200 MHz and  $f_L$  swept from 200 to 1100 MHz.



### Conversion Loss vs. Input Frequency:

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

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



**VSWR vs. Frequency:** VSWR of the L-, I- and R-ports in a 50-ohm system with  $f_L$  at +7 dBm. Some variation in the R-port

VSWR will occur as a function of the L-port frequency. Curves for the R-port VSWR are plotted for L-port frequencies of 0.6 and 1.6 GHz. Also shown are the L-port VSWR and the I-port VSWR with  $f_L$  at 0.6 GHz.

	Harmonics of $f_R$						
$5f_R$	>71	>71	>71	>71	>71	>71	>71
$4f_R$	>71	>71	>71	>71	>71	>71	>71
$3f_R$	>71	>71	>71	>71	>71	>71	>71
$2f_R$	53	68	56	71	51		
$f_R$	63	67	61	>71	69		
	61	55	50	67	66		
	63	55	64	70	66		
	28	0	40	12	41	26	
	29	0	41	10	42	19	
	—	7	43	29	54	33	
	—	3	36	27	54	29	

Harmonics of  $f_L$

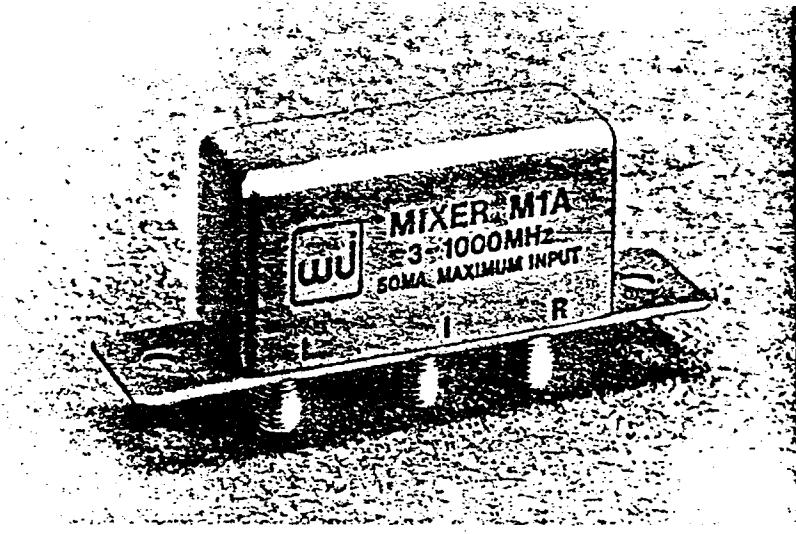
**Harmonic Intermodulation Products:** Intermodulation signals which result from the mixing of mixer generated harmonics of the input signal are shown above. Mixing product suppression is indicated by the number of dB below the desired output level,  $f_R-f_L$ . Products are for the difference frequencies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

# WJ-M1A

## DOUBLE-BALANCED MIXER

LO } 3 TO 1000 MHz  
 RF }  
 IF DC TO 1000 MHz

- HIGH ISOLATION: >45 dB (TYP.)



### Guaranteed Specifications\*

Characteristics	Min.	Max.	Test Conditions
Conversion Loss (SSB)		7.5 dB	$f_L$ & $f_R$ 10 MHz to 100 MHz $f_I$ dc to 100 MHz
		10 dB	$f_L$ & $f_R$ 3 MHz to 1000 MHz $f_I$ 1000 MHz
Noise Figure (SSB)		7.5 dB	$f_L$ & $f_R$ 10 MHz to 100 MHz $f_I$ .4 MHz to 100 MHz
		10 dB	$f_L$ & $f_R$ 3 MHz to 1000 MHz $f_I$ .4 MHz to 1000 MHz
Mixer Isolation			
$f_L$ at R	40 dB		3 - 100 MHz
$f_L$ at I	40 dB		
$f_L$ at R	30 dB		100 - 1000 MHz
$f_L$ at I	20 dB		

\*These specifications apply to a mixer used in a 50-ohm system with an  $f_L$  source of +7 dBm available. A short circuit at the I-port for the unwanted sideband will usually improve CL and NF by 0.5 dB. The 1000 MHz upper frequency range may be extended to 1200 MHz by ordering option 11 (M1A-11).

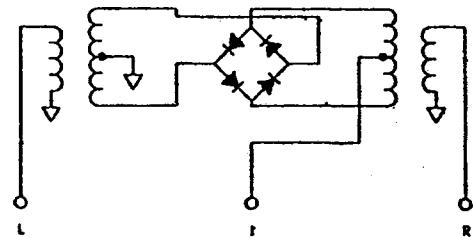
**Weight** 45 grams (1.6 oz.) maximum

**Connectors** BNC, TNC, SMA

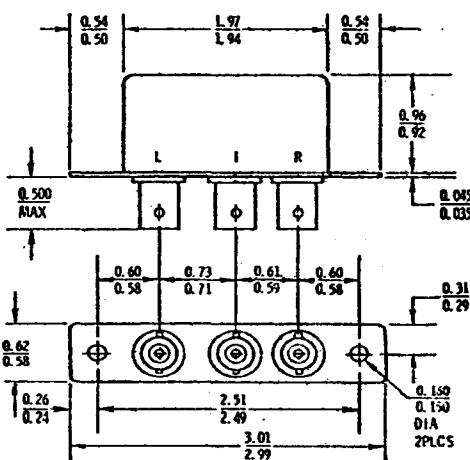
### Absolute Maximum Ratings

Storage Temperature .... -65°C to +100°C  
 Operating Temperature .... -54°C to +100°C  
 Peak Input Power ..... 50 mW  
 Peak Input Current ..... 50 mA

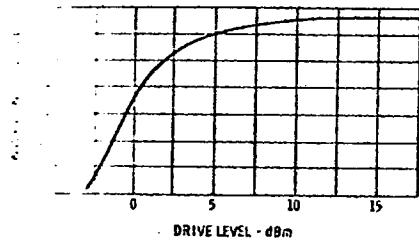
### Schematic Diagram



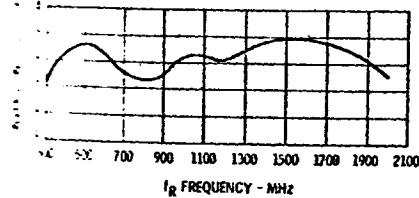
### Outline Drawing



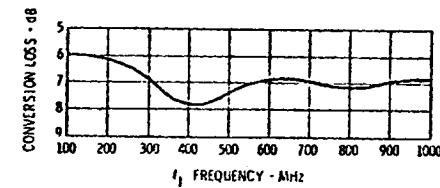
## Typical Performance at 25°C



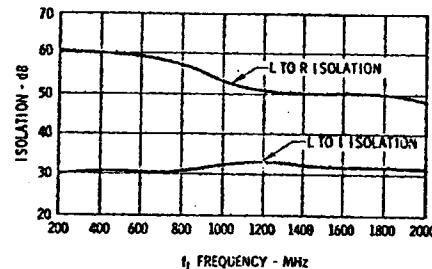
**Drive Level:** The minimum recommended drive level is +4 dBm. The maximum recommended drive level is -13 dBm.



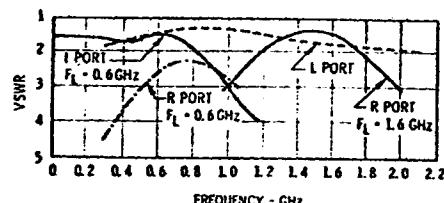
**Conversion Loss vs. Input Frequency:** Conversion loss of the mixer when used in an SSB system. The frequency ordinate refers to the R-port ( $f_R$ ) with  $f_L$  at 150 MHz. Data plotted with an  $f_L$  level of +7 dBm.



**Conversion Loss vs.  $f_1$  Frequency:** Conversion loss of the mixer when used in an SSB system. The frequency ordinate refers to the I-port ( $f_I$ ) with  $f_R$  at 1200 MHz and  $f_L$  swept from 200 to 1100 MHz.



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



**VSWR vs. Frequency:** VSWR of the L-, I- and R-ports in a 50-ohm system with  $f_L$  at +7 dBm. Some variation in the R-port

VSWR will occur as a function of the L-port frequency. Curves for the R-port VSWR are plotted for L-port frequencies of 0.6 and 1.6 GHz. Also shown are the L-port VSWR and the I-port VSWR with  $f_L$  at 0.6 GHz.

	Harmonics of $f_R$	Harmonics of $f_L$
$3f_R$	>71	>71
$4f_R$	>71	>71
$3f_L$	>71	53
$2f_L$	61	50
$f_L$	63	55
—	28	0
—	—	7
—	—	3
$2f_R$	>71	64
$3f_R$	>71	40
$4f_R$	>71	10
$2f_L$	64	41
$f_L$	70	42
—	55	43
—	30	54
—	29	54
$2f_L$	66	27
$3f_L$	67	54
$4f_L$	68	29
$5f_L$	71	51
$6f_L$	69	27
$7f_L$	66	29
$8f_L$	66	27
$9f_L$	66	29
$10f_L$	66	27
$11f_L$	66	29
$12f_L$	66	27
$13f_L$	66	29
$14f_L$	66	27
$15f_L$	66	29
$16f_L$	66	27
$17f_L$	66	29
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$97f_L$	66	29
$98f_L$	66	27
$99f_L$	66	29
$100f_L$	66	27

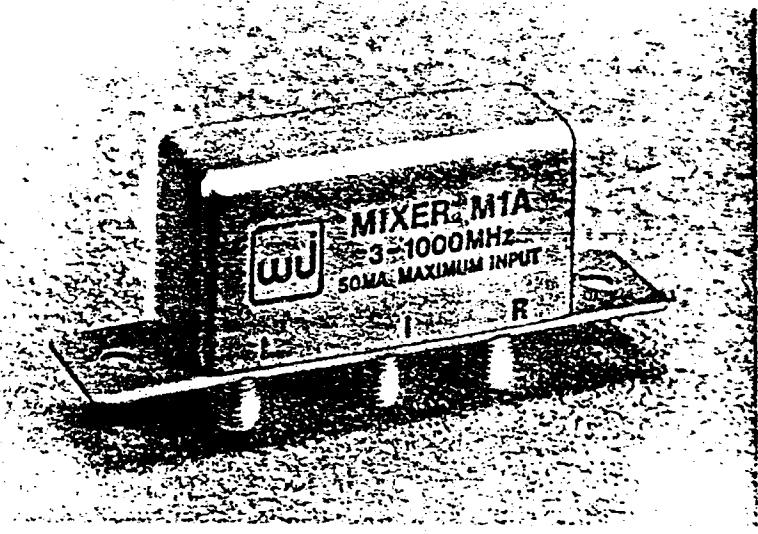
**Harmonic Intermodulation Products:** Intermodulation signals which result from the mixing of mixer generated harmonics of the input signal are shown above. Mixing product suppression is indicated by the number of dB below the desired output level,  $f_R - f_L$ . Products are for the difference frequencies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

# WJ-M1A

## DOUBLE-BALANCED MIXER

LO } 3 TO 1000 MHz  
 RF }  
 IF DC TO 1000 MHz

- HIGH ISOLATION: >45 dB (TYP.)



### Guaranteed Specifications\*

Characteristics	Min.	Max.	Test Conditions
Conversion Loss (SSB)		7.5 dB	$f_L$ & $f_R$ 10 MHz to 100 MHz $f_I$ dc to 100 MHz
		10 dB	$f_L$ & $f_R$ 3 MHz to 1000 MHz $f_I$ 1000 MHz
Noise Figure (SSB)		7.5 dB	$f_L$ & $f_R$ 10 MHz to 100 MHz $f_I$ .4 MHz to 100 MHz
		10 dB	$f_L$ & $f_R$ 3 MHz to 1000 MHz $f_I$ .4 MHz to 1000 MHz
Mixer Isolation			
$f_L$ at R	40 dB		3 - 100 MHz
$f_L$ at I	40 dB		
$f_L$ at R	30 dB		100 - 1000 MHz
$f_L$ at I	20 dB		

\*These specifications apply to a mixer used in a 50-ohm system with an  $f_I$  source of +7 dBm available. A short circuit at the I-port for the unwanted sideband will usually improve CL and NF by 0.5 dB. The 1000 MHz upper frequency range may be extended to 1200 MHz by ordering option 11 (M1A-11).

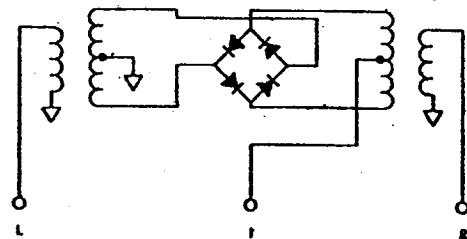
**Weight** 45 grams (1.6 oz.) maximum

**Connectors** BNC, TNC, SMA

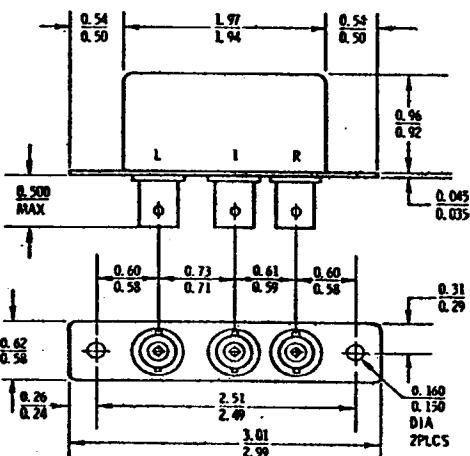
### Absolute Maximum Ratings

Storage  
 Temperature .... -65°C to +100°C  
 Operating  
 Temperature .... -54°C to +100°C  
 Peak Input Power ..... 50 mW  
 Peak Input Current ..... 50 mA

### Schematic Diagram

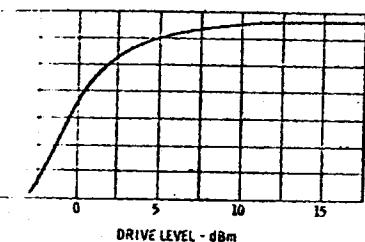


### Outline Drawing

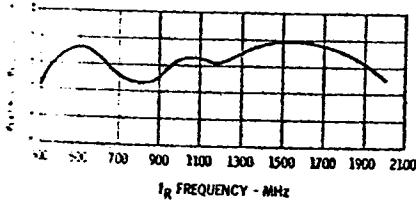


NOTE: DIMENSIONS ARE IN INCHES.

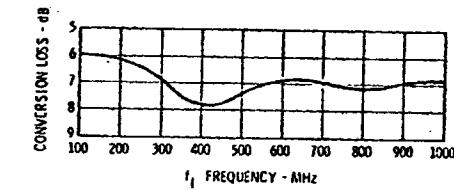
## Typical Performance at 25°C



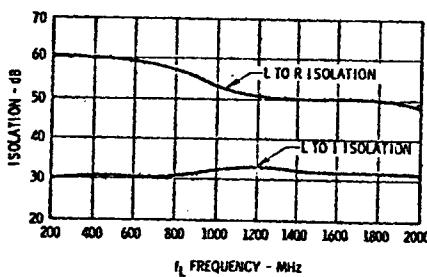
**Drive Level:** The minimum recommended drive level is +4 dBm. The maximum recommended drive level is -13 dBm.



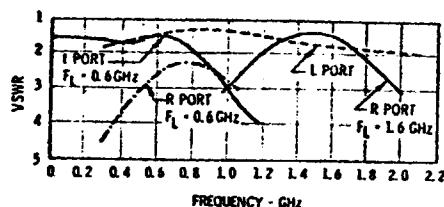
**Conversion Loss vs. Input Frequency:** Conversion loss of the mixer when used in a SSB system. The frequency ordinate refers to the R-port ( $f_R$ ) with  $f_L$  at 150 MHz. Data plotted with an  $f_L$  level of +7 dBm.



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



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



**VSWR vs. Frequency:** VSWR of the L-, I- and R-ports in a 50-ohm system with  $f_L$  at +7 dBm. Some variation in the R-port

VSWR will occur as a function of the L-port frequency. Curves for the R-port VSWR are plotted for L-port frequencies of 0.6 and 1.6 GHz. Also shown are the L-port VSWR and the I-port VSWR with  $f_L$  at 0.6 GHz.

Harmonics of $f_R$						
$5f_R$	$>71$	$>71$	$>71$	$>71$	$>71$	$>71$
$4f_R$	$>71$	$>71$	$>71$	$>71$	$>71$	$>71$
$3f_R$	$>71$	$>71$	$>71$	$>71$	$>71$	$>71$
$2f_R$	53	68	55	71	51	51
$f_R$	63	67	61	>71	69	68
$-$	50	65	59	67	66	66
$-$	55	64	64	70	58	58
$-$	0	40	12	41	26	26
$-$	0	41	10	42	13	13
$-$	7	43	29	54	33	33
$-$	3	36	27	54	29	29

Harmonics of $f_L$						
$f_L$	$2f_L$	$3f_L$	$4f_L$	$5f_L$	$6f_L$	$7f_L$

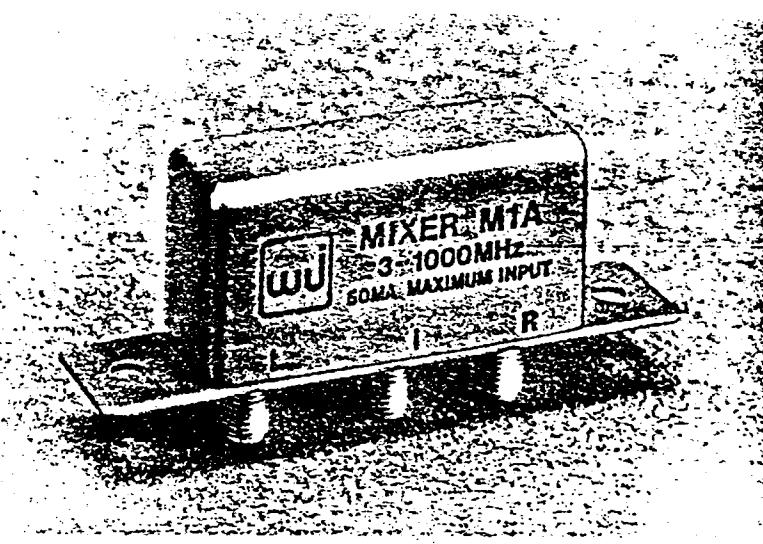
**Harmonic Intermodulation Products:** Intermodulation signals which result from the mixing of mixer generated harmonics of the input signals are shown above. Mixing product suppression is indicated by the number of dB below the desired output level,  $f_R-f_L$ . Products are for the difference frequencies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

# WJ-M1A

## DOUBLE-BALANCED MIXER

LO } 3 TO 1000 MHz  
 RF }  
 IF DC TO 1000 MHz

- HIGH ISOLATION: >45 dB (TYP.)



### Guaranteed Specifications\*

Characteristics	Min.	Max.	Test Conditions
Conversion Loss (SSB)	7.5 dB	f <sub>L</sub> & f <sub>R</sub> 10 MHz to 100 MHz f <sub>I</sub> dc to 100 MHz	
		10 dB	f <sub>L</sub> & f <sub>R</sub> 3 MHz to 1000 MHz f <sub>I</sub> 1000 MHz
Noise Figure (SSB)	7.5 dB	f <sub>L</sub> & f <sub>R</sub> 10 MHz to 100 MHz f <sub>I</sub> .4 MHz to 100 MHz	
		10 dB	f <sub>L</sub> & f <sub>R</sub> 3 MHz to 1000 MHz f <sub>I</sub> .4 MHz to 1000 MHz
Mixer Isolation			
f <sub>L</sub> at R	40 dB		3 - 100 MHz
f <sub>L</sub> at I	40 dB		
f <sub>L</sub> at R	30 dB		100 - 1000 MHz
f <sub>L</sub> at I	20 dB		

\*These specifications apply to a mixer used in a 50-ohm system with an f<sub>I</sub> source of +7 dBm available. A short circuit at the I-port for the unwanted sideband will usually improve CL and NF by 0.5 dB. The 1000 MHz upper frequency range may be extended to 1200 MHz by ordering option 11 (M1A-11).

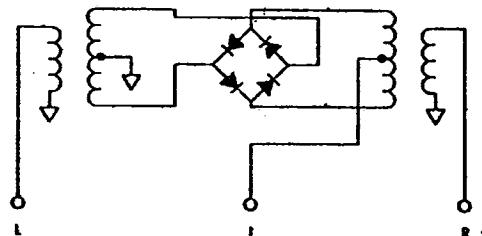
**Weight** 45 grams (1.6 oz.) maximum

**Connectors** BNC, TNC, SMA

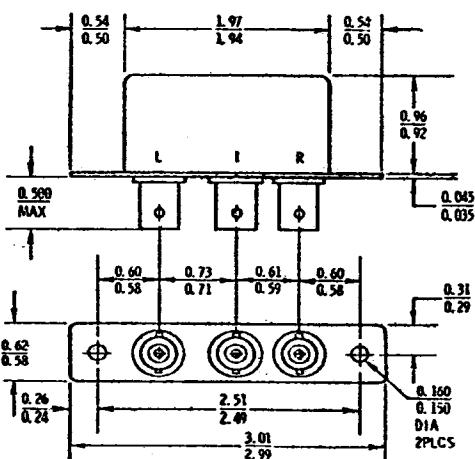
### Absolute Maximum Ratings

Storage Temperature .... -65°C to +100°C  
 Operating Temperature .... -54°C to +100°C  
 Peak Input Power ..... 50 mW  
 Peak Input Current ..... 50 mA

### Schematic Diagram



### Outline Drawing



NOTE: DIMENSIONS ARE IN INCHES.

# 10db BI-DIRECTIONAL COUPLER

■ 30 MHz - 1 GHz

## FEATURES

- Wide Frequency Range - 30 MHz - 1 GHz
- Constant Coupling Within  $\pm 0.5$  db (Output to Output)
- Small Size, Light Weight
- Standard Connectors: BNC, TNC, SMA or N

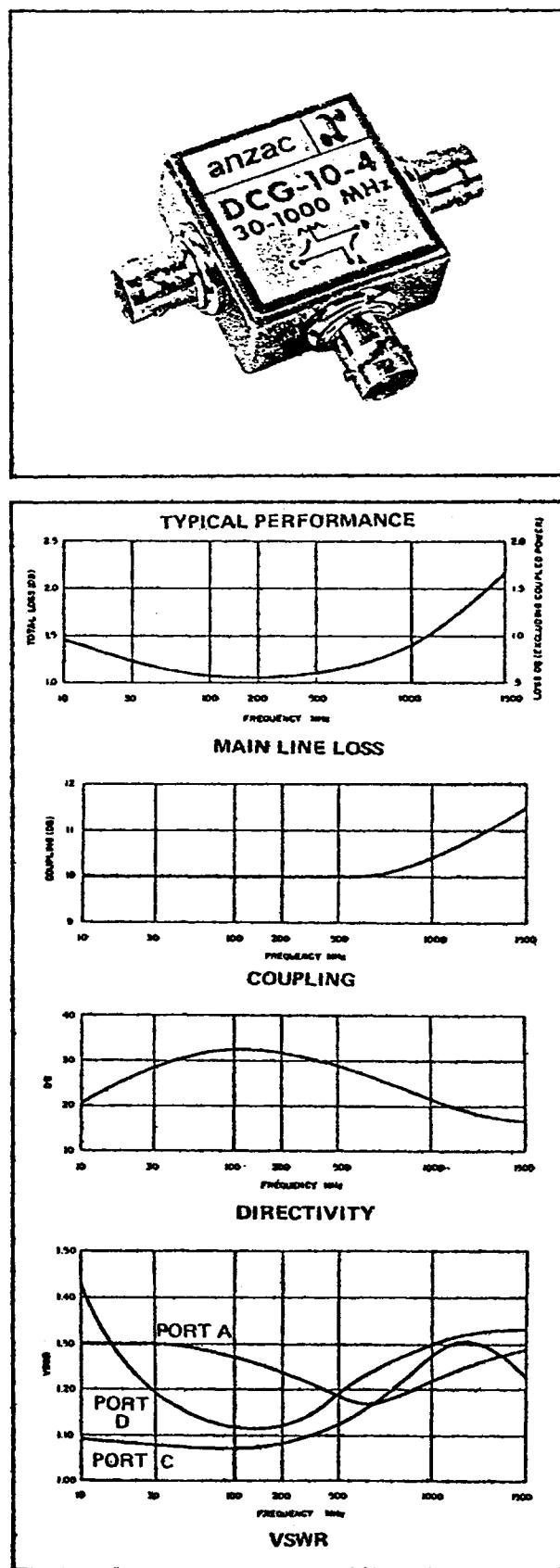
## GUARANTEED SPECIFICATIONS

Frequency Range:	30 MHz - 1 GHz
VSWR:	1.35 : 1 Max.
Impedance:	50 ohms
Main Line Loss (above theoretical 0.46 db power split):	1.0 db Max.
Coupling (Output to Output):	10.0 $\pm 0.5$ db Max.
Directivity:	20 db Min.
Input Power:	5 Watts Max.
Operating Temperature Range:	-55°C to +85°C

## ENVIRONMENTAL

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

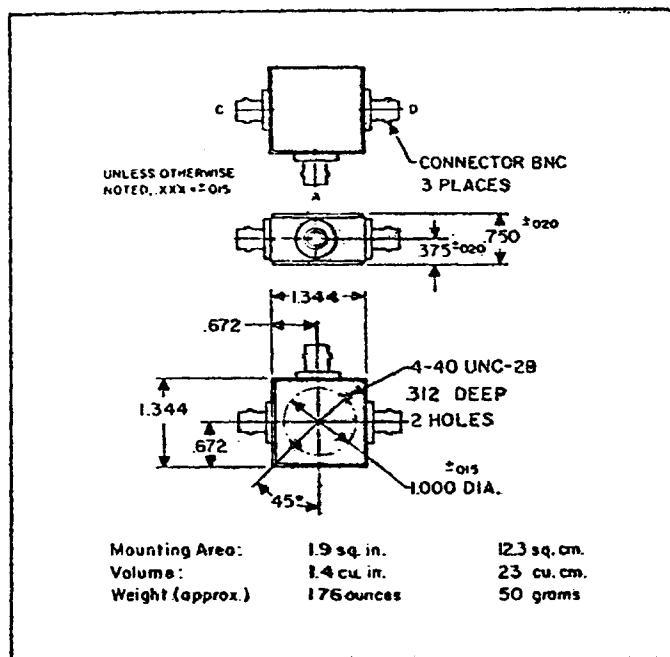
Thermal Shock:	Method 107, Test Condition A -55°C to +85°C, 30 minutes at temperature extremes, 5 cycles
Humidity:	Method 103, Test Condition B (96 hours)
Barometric Pressure:	Method 105, Test Condition D 100,000 feet
Moisture Resistance:	Method 106
Life Test:	Method 108, Test Condition B (250 hours)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



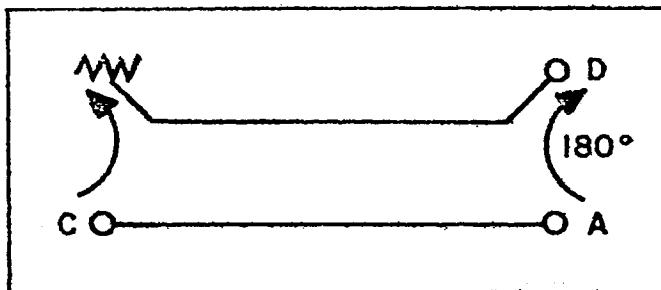
## DESCRIPTION

The Model DCG-10-4 directional coupler operates over a frequency range of 30 MHz - 1 GHz. Its main line loss of only 1.0 db Max. (above the theoretical 0.46 db power split) makes this device superior to a 3 db hybrid when used as a reference for levelling radio frequency sources.

## MECHANICAL DATA



## SCHEMATIC



## ORDERING INFORMATION

Please specify Model No. and Connector Type when ordering.

Model DCG-10-4: \$75.00 (1-5 Qty.)

Connector Types: BNC, TNC, SMA or N

Availability: Stock

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

Printed in U.S.A.

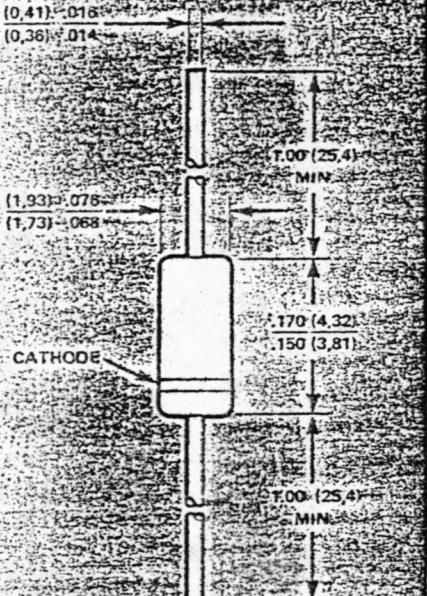


39 Green Street, Waltham, Massachusetts 02154 • (617) 899-1900 • TWX 710-324-6484

# SCHOTTKY DIODES FOR MIXING AND DETECTING

1-2 GHz

5082-2817
5082-2818
5082-2819
5082-2824
5082-2825



## Features

- **High Burnout**  
4.5 Watt burnout capability makes these diodes ideal for shipboard, airborne, or other systems where high power interference signals are present.
- **Low I/f Noise**  
8kHz noise corner frequency for 1mA dc current for Doppler mixing and low video frequency detecting.
- **Low NF for Mixer Applications**  
6dB at 2GHz and below allows this series to be used in sensitive receiver systems.
- **High TSS for Detector Applications**  
-56dBm at 2GHz makes this series a prime choice for those receivers which require high sensitivity in signal reception.
- **Excellent Environmental Capabilities**  
200° C operating temperature, 20,000 G shock capability and overall ruggedness make this family ideal for any military or other high reliability program.

## Description

These microwave silicon Schottky diodes are epitaxial, planar, passivated devices of hybrid construction which utilize a unique combination of a conventional pn junction and a Schottky barrier.

This manufacturing process (Patent No. 3463971) results in a diode with greatly increased ruggedness and burnout reliability without sacrificing low noise properties.

## Applications

This series is designed for use in video and super-heterodyne receivers up to S-Band. They are especially useful in airborne or other severe environmental applications due to their high burnout and 20,000 G shock capabilities. Because of their high sensitivity, they are eminently suited for high performance receivers. This ruggedness and sensitivity is now available for high volume applications.

## Absolute Maximum Ratings at $T_A=25^\circ\text{C}$

Pulse Power Dissipation .....	4.5W (Notes 1,2)
CW-Power Dissipation .....	1W (Notes 1,3)
Peak Inverse Voltage .....	15V
Operating Junction Temperature Range .....	-65°C to +200°C
Storage Temperature Range ..	-65°C to +200°C

## Typical Electrical Characteristics at $T_A=25^\circ\text{C}$

Chip Capacitance, at $V_f = 0\text{V}$ .....	0.8pF
Package Capacitance .....	0.17pF
Series Resistance .....	9Ω
Series Inductance .....	2.3nH (Note 4)

# Electrical Specifications at $T_A=25^\circ\text{C}$

5082-2817, 2818, 2819

Parameter	Min.	Typ.	Max.	Unit	Notes
Noise Figure		5.8	6.0	dB	5,6
VSWR		1.3	1.5	—	6
IF-Impedance	250	330	400	$\Omega$	6

Model Number	Description	Matching Criteria
5082-2817	Single Diode	
5082-2818	Matched Pair	Note 7
5082-2819	Matched Quad	Note 7

5082-2824, 2825

Parameter	Min.	Typ.	Max.	Unit	Notes
Tangential Signal Sensitivity		-58	-56	dBm	8,9
Voltage Sensitivity	6.0	8.5	—	mV/ $\mu\text{W}$	8
Video Output Resistance	1.2	1.35	1.5	k $\Omega$	8

Model Number	Description	Matching Criteria
5082-2824	Single Diode	
5082-2825	Matched Pair	Note 10

## Notes:

- Derate linearly to zero at  $200^\circ\text{C}$ .
- Power absorbed by the diode.  
Frequency 2GHz  
Pulse Width 1 $\mu\text{s}$   
Duty Cycle .001  
Load Resistance 38k $\Omega$
- Power absorbed by the diode, applied for one minute.  
Frequency 2.0GHz  
DC-load Resistance <1 $\Omega$   
The cathode lead is connected to an infinite heat sink at the plane where it leaves the glass body.
- Series inductance of a coaxial line section consisting of the diode with short circuited chip as inner conductor and an outer conductor of 0.28 inch diameter. The geometrical length of the coaxial line is determined by the length of the glass-package body.
- Single sideband receiver noise figure including an IF-amplifier noise figure of 1.5dB (intermediate frequency 30MHz). Noise figure guaranteed at 2GHz and below.

- Measurement conditions are:  
The diode is inserted into a fix tuned coaxial mount.  
Local Oscillator Frequency 2.0GHz  
Local Oscillator Incident Power 1.0mW  
DC-load Resistance 100 $\Omega$
- Noise Figure Match  $\Delta F \leq 0.3\text{dB}$   
IF-Impedance Match  $\Delta Z_{IF} \leq 25\Omega$
- The measurement conditions are:  
The diode is inserted into a fix tuned coaxial mount.  
Signal Frequency  $f_{signal} = 2.0\text{GHz}$   
DC Bias Current  $I_{bias} = 20\mu\text{A}$   
Video Load Resistance  $R_L = 38\text{k}\Omega$
- TSS is defined as incident RF power level which yields a signal to noise power ratio of 8.0dB at the video receiver output.  
Video Bandwidth  $\Delta f_{video} = 2.0\text{MHz}$   
Equivalent Noise Resistance of Video Amplifier  $R_A = 500\Omega$
- Voltage Sensitivity Match  $\Delta y \leq 0.5\text{mV}/\mu\text{W}$   
Video Resistance Match  $\Delta R_v \leq 100\Omega$

## Mechanical Specifications

The HP Outline 15 package has a glass hermetic seal with domet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1.6mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E [4 lb (1.8kg)] tension for 30 minutes. The maximum soldering temperature is  $230^\circ\text{C}$  for five seconds.

Marking is by digital coding with a cathode band.

## Reliability

This series of diodes is suitable for high reliability space applications where maximum performance under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs.

## Environmental Capabilities

### MIL-STD-750 Reference

### Conditions

Temperature, Storage	103T	$-65^\circ\text{C}$ to $+200^\circ\text{C}$
Temperature, Operating	2026	$-65^\circ\text{C}$ to $+200^\circ\text{C}$ $230^\circ\text{C}$ as applicable
Solderability	1051	5 cycles, $-65^\circ\text{C}$ to $+200^\circ\text{C}$
Temperature, Cycling	1056	5 cycles, 0-100 $^\circ\text{C}$
Thermal Shock	1021	10 days, 90-98% RH
Moisture Resistance	2016	5 blows, X <sub>1</sub> , Y <sub>1</sub> , Y <sub>2</sub> at 1500G
Shock	2046	32 hours, X <sub>1</sub> , Y <sub>1</sub> , Z <sub>1</sub> at 20G/mm
Vibration Fatigue	2056	Four 4-min. cycles, X, Y, Z, at 20G/min., 100 to 2000 Hz
Vibration-Variable Frequency	2006	X <sub>1</sub> , Y <sub>1</sub> , Z <sub>1</sub> at 20,000G
Constant Acceleration	2036	See mechanical specifications
Terminal Strength	1041	$35^\circ\text{C}$ fog for 24 hours
Salt Atmosphere		

## TYPICAL PERFORMANCE CURVES AT $T_A = 25^\circ\text{C}$

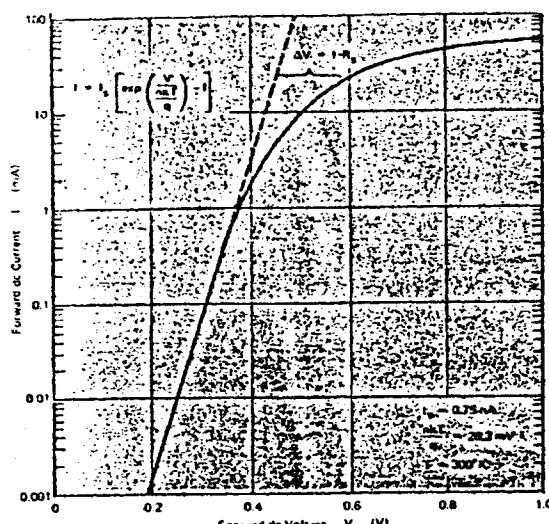


Figure 1. Static forward current versus voltage relationship.

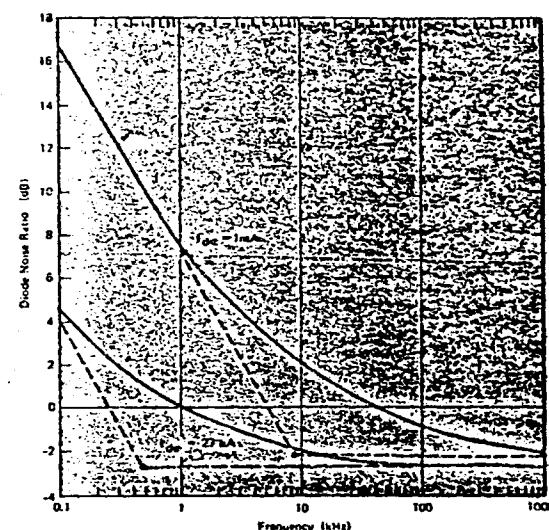


Figure 2. Typical diode noise ratio versus frequency for two dc-current levels.

## TYPICAL MIXER PERFORMANCE CURVES AT $T_A = 25^\circ\text{C}$

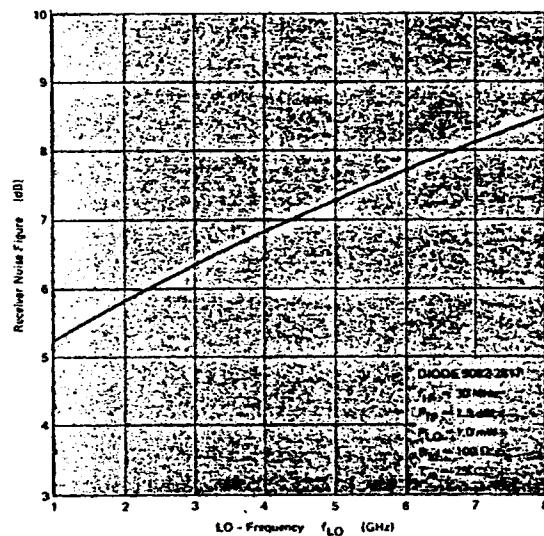


Figure 3. Single sideband receiver noise figure  $F_r$  (including an IF-amplifier noise figure of 1.5dB) versus local oscillator frequency  $f_{LO}$ . The mount is tuned for minimum noise figure at each frequency.

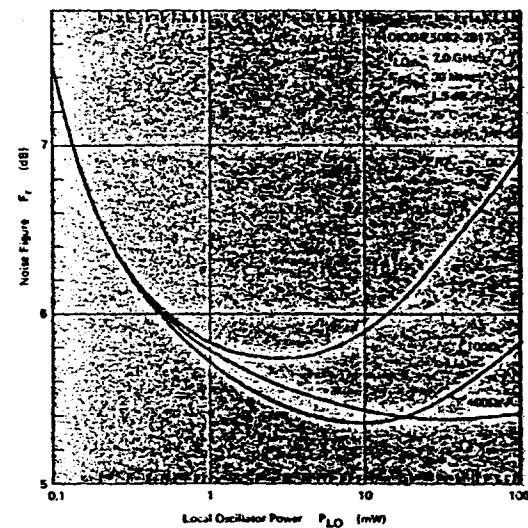


Figure 4. Single sideband receiver noise figure  $F_r$  (including an IF-amplifier noise figure of 1.5dB) versus incident LO-power  $P_{LO}$  for various dc-load resistances  $R_L$ . (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

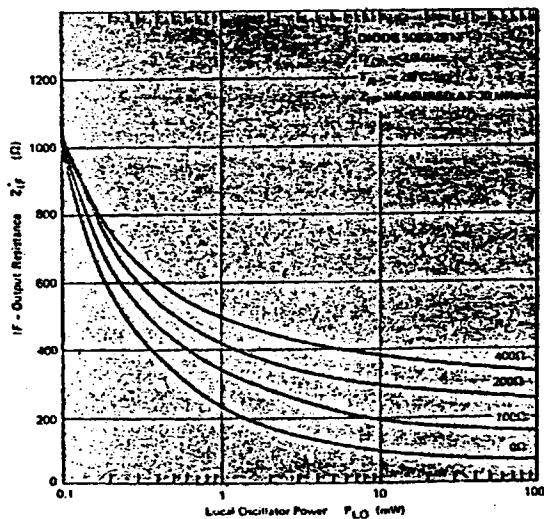


Figure 5. IF-output resistance  $Z_{IF}$  versus incident LO-power  $P_{LO}$  for various dc-load resistances  $R_L$ . (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

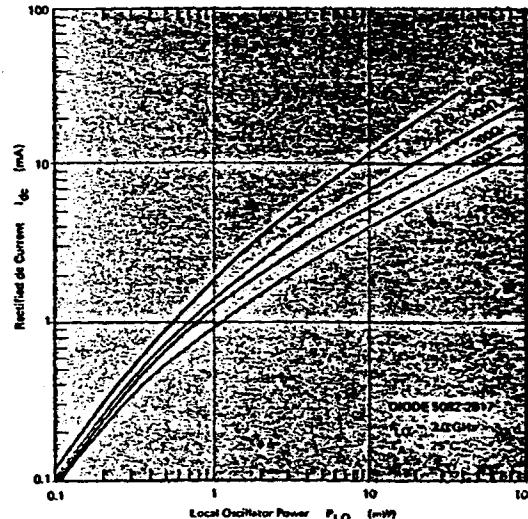


Figure 6. Rectified dc-current  $I_{DC}$  versus incident LO-power  $P_{LO}$  for various dc-load resistances  $R_L$ . (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

## TYPICAL DETECTOR PERFORMANCE CURVES AT $T_A = 25^\circ\text{C}$

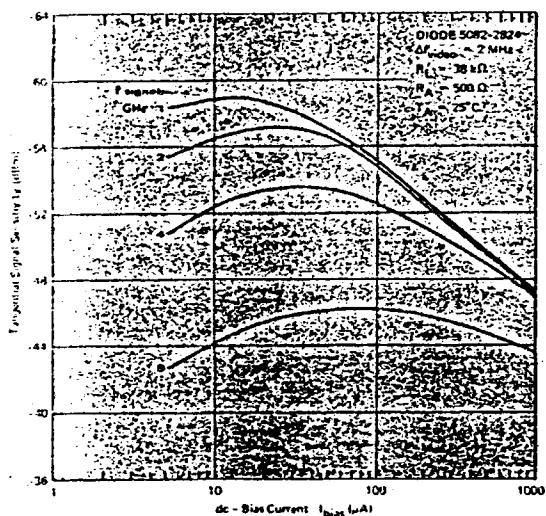


Figure 7. Tangential signal sensitivity versus dc-bias current for various signal frequencies. (At each bias current and frequency the mount was tuned for maximum signal sensitivity.)

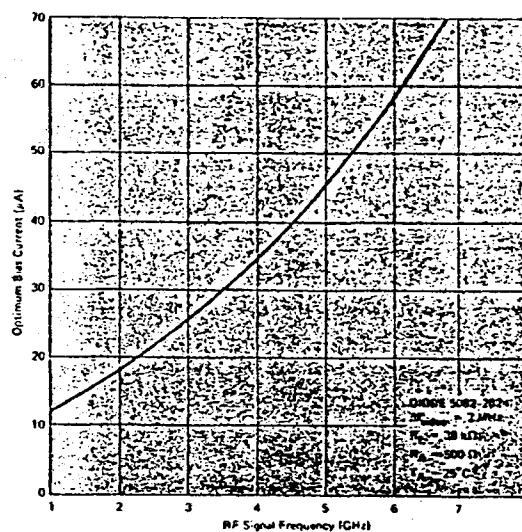


Figure 8. Optimum dc-bias current, which yields maximum signal sensitivity, versus RF-signal frequency.

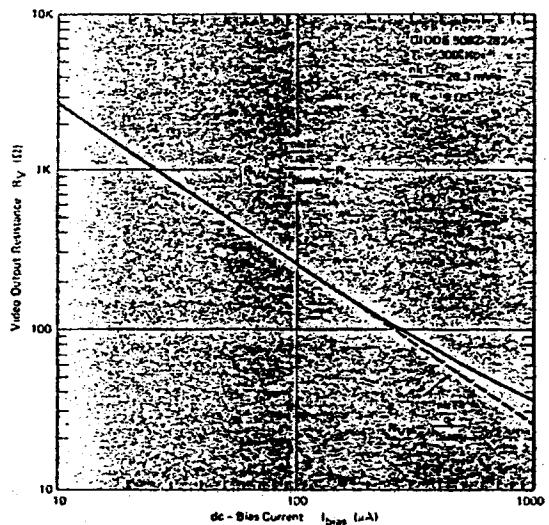


Figure 9. Video output resistance versus dc-bias current.

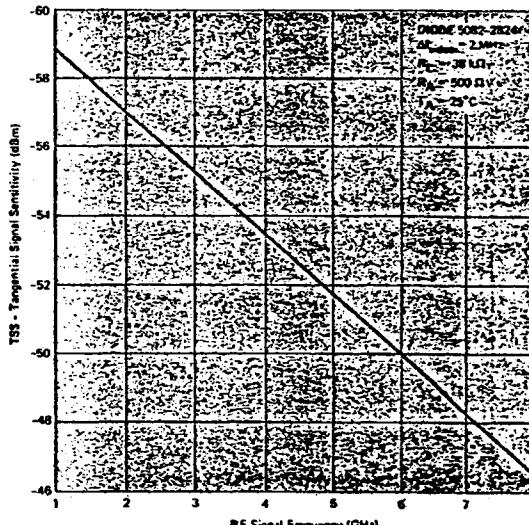


Figure 10. Optimum tangential signal sensitivity versus RF-signal frequency. (At each frequency the bias current was optimized and the mount tuned for maximum signal sensitivity.)

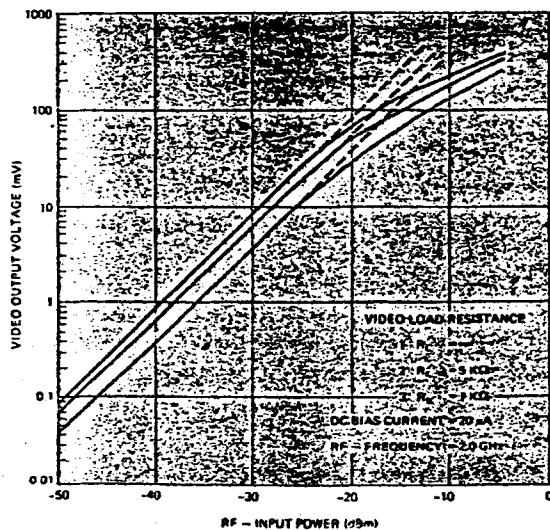


Figure 11. Video output voltage  $V_o$  versus incident RF-signal power  $P_i$  for various video load resistances  $R_L$ .

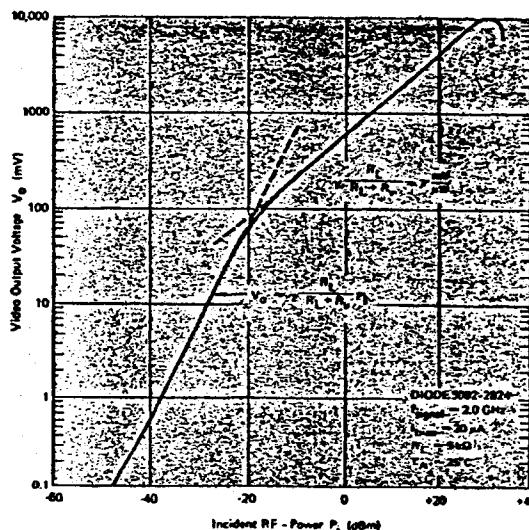


Figure 12. Video output voltage  $V_o$  versus incident RF-signal power  $P_i$ .

FIG. 1: VOLTAGE CONTROLLER

171-1

PHASE SHIFT & ATTENUATION VS. CONTROL VOLTAGE  
FROM 100 MHz TO 2 GHz  
(SMOOTHED DATA)

W-T MODEL G-1

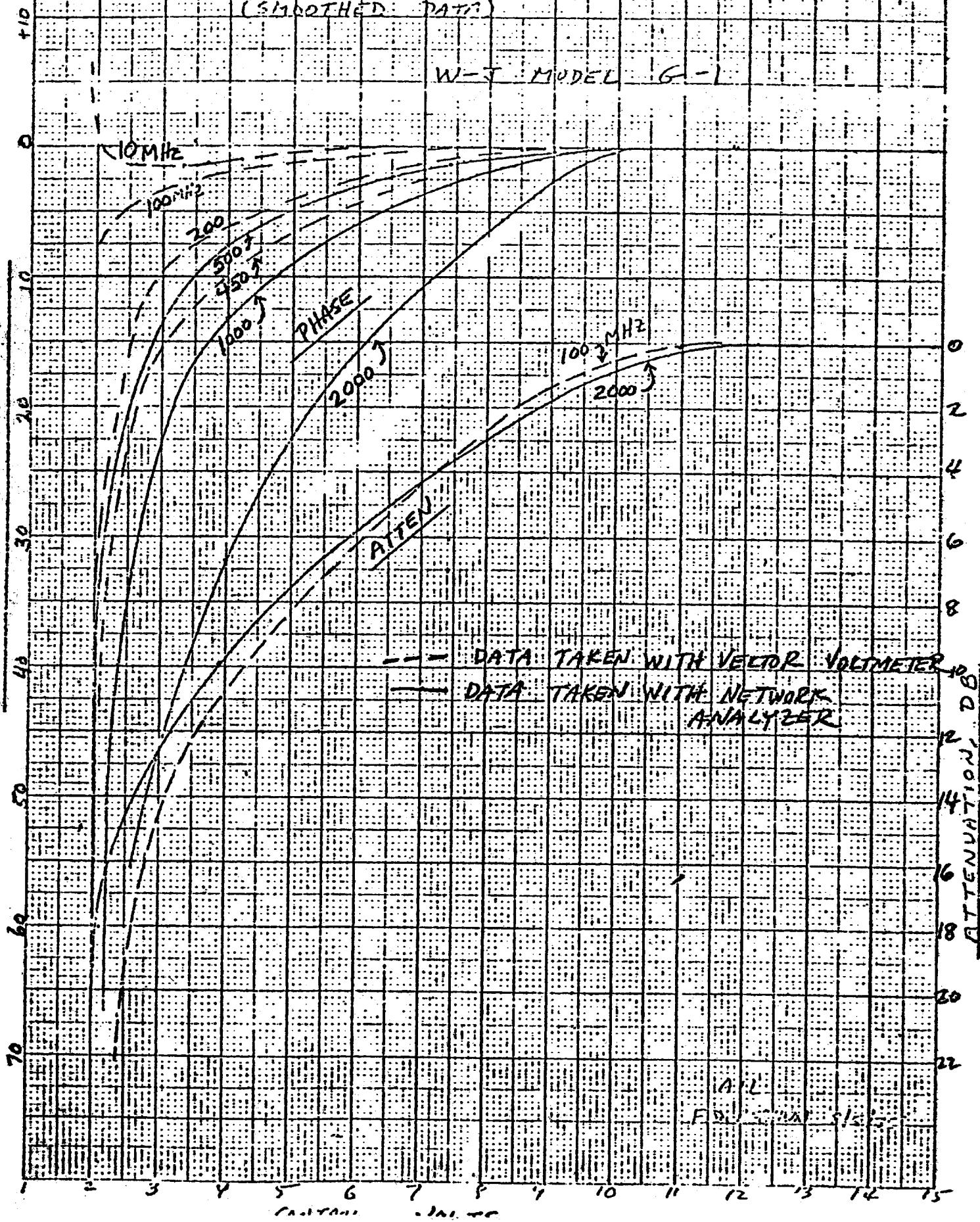
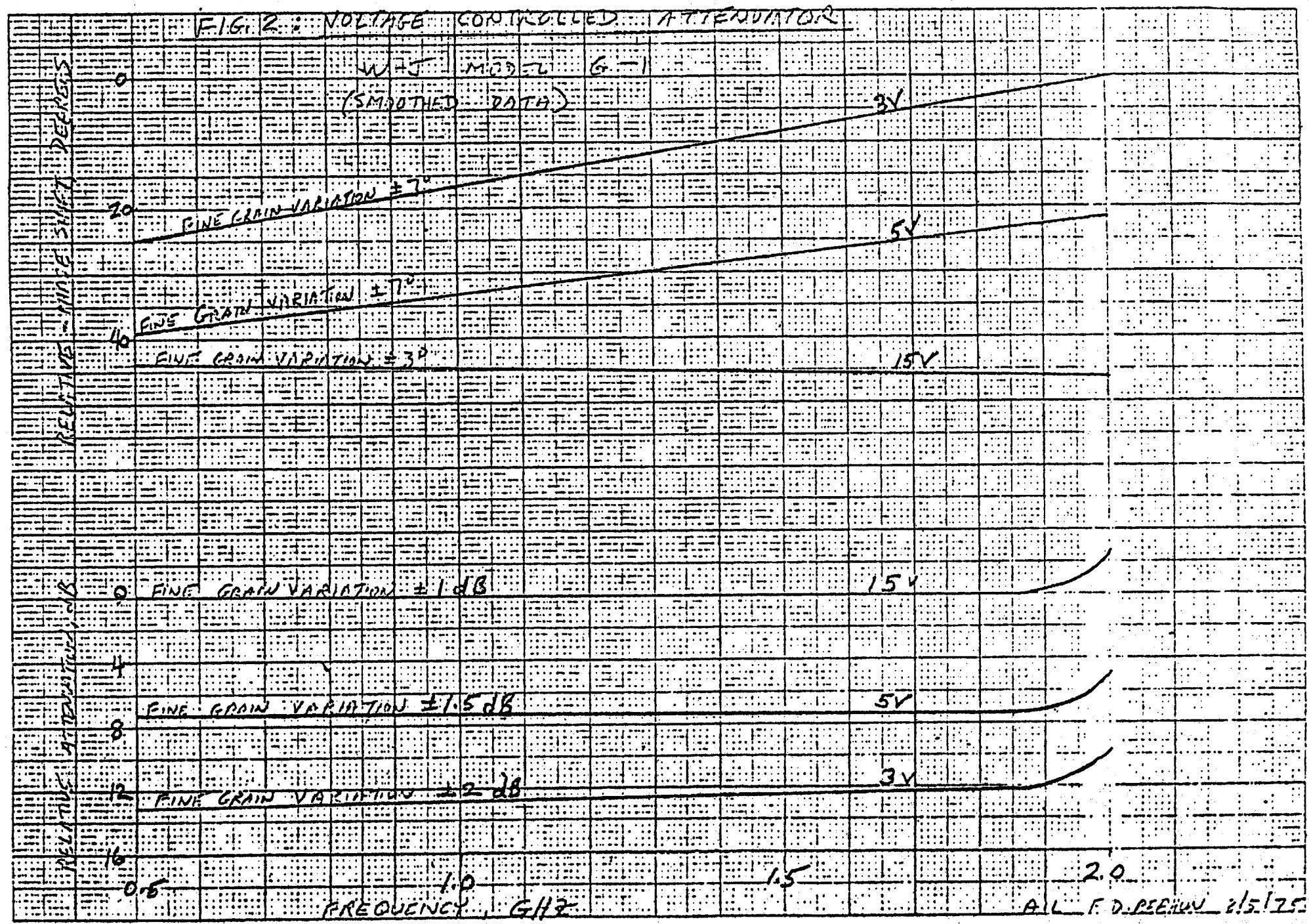


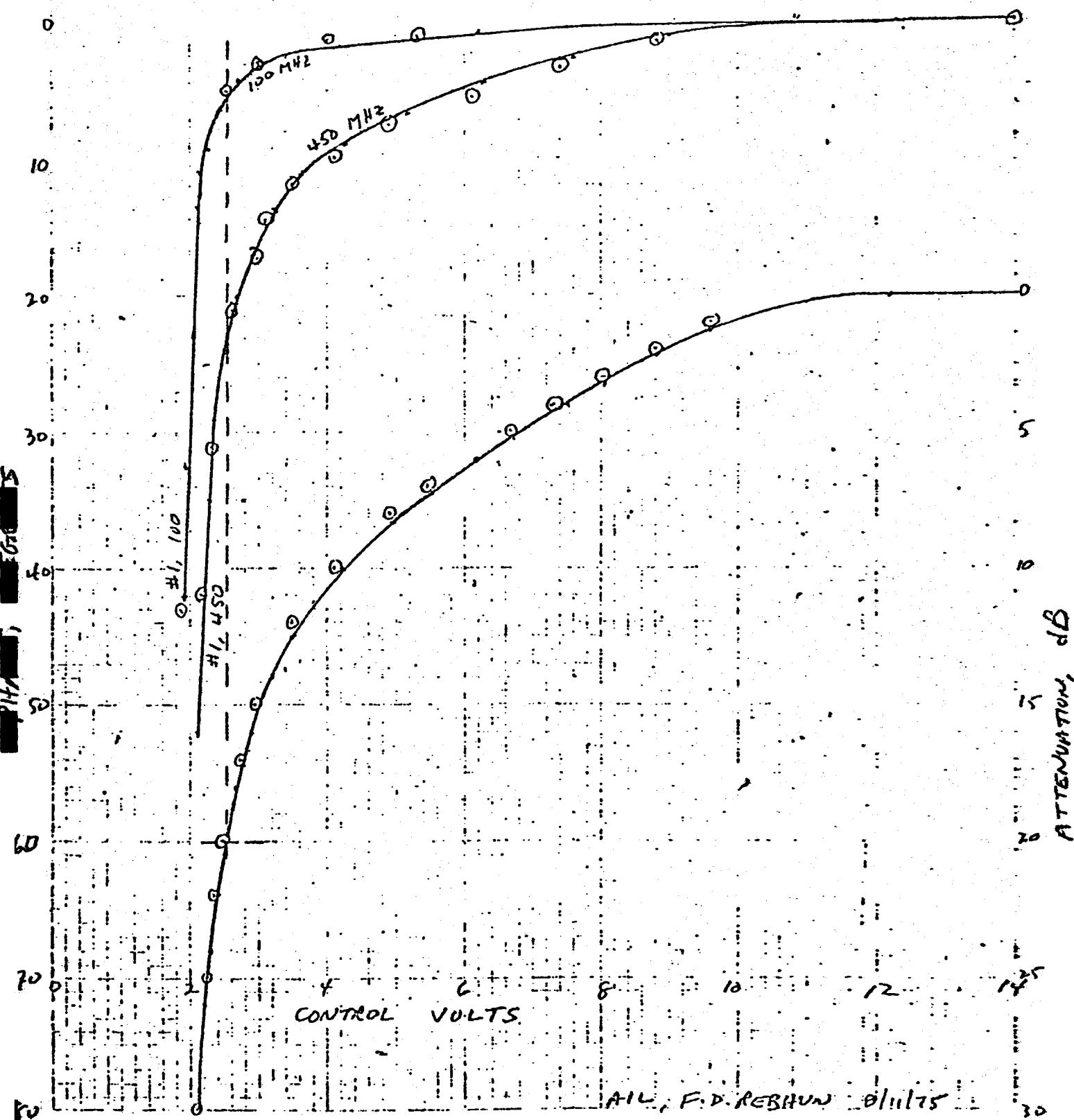
FIG. 2: VOLTAGE CONTROLLED ATTENUATOR



PHASE & ATTENUATION VS. CONTROL VOLTAGE  
100 MHZ & 450 MHZ

WJ VCA MODEL G-1

• #1 DATA POINTS  
○ #2 DATA POINTS





# Consumer Circuits

## LM733/LM733C differential video amp

### general description

The LM733/LM733C is a two-stage, differential input, differential output, wide-band video amplifier. The use of internal series-shunt feedback gives wide bandwidth with low phase distortion and high gain stability. Emitter-follower outputs provide a high current drive, low impedance capability. Its 120 MHz bandwidth and selectable gains of 10, 100, 400, without need for frequency compensation, make it a very useful circuit for memory element drivers, pulse amplifiers, and wide band linear gain stages.

The LM733 is specified for operation over the -55°C to +125°C military temperature range. The LM733C is specified for operation over the 0°C to +70°C temperature range.

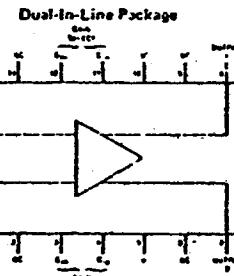
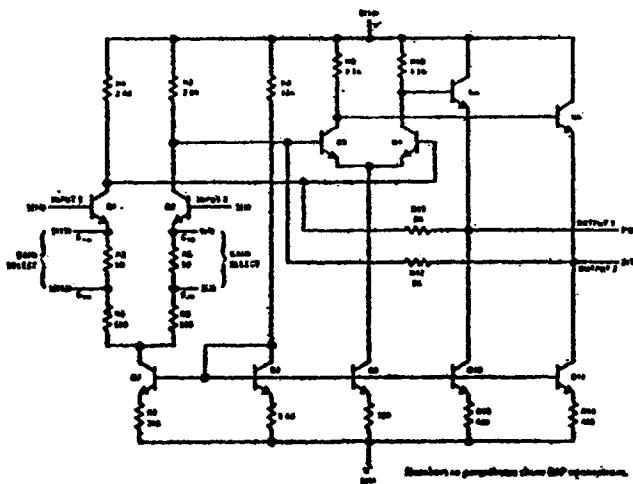
### features

- 120 MHz bandwidth
- 250 k $\Omega$  input resistance
- Selectable gains of 10, 100, 400
- No frequency compensation
- High common mode rejection ratio at high frequencies.

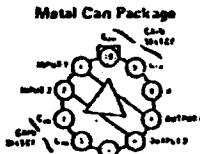
### applications

- Magnetic tape systems
- Disk file memories
- Thin and thick film memories
- Woven and plated wire memories
- Wide band video amplifiers.

### schematic and connection diagrams



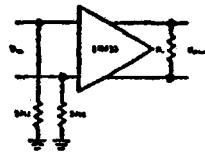
Order Number LM733 or LM733CD  
See Package 1  
Order Number LM733CN  
See Package 22



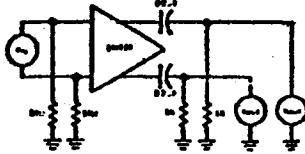
Note Pin 5 connected to case.  
NPN = 1  
Order Number LM733H or LM733CH  
See Package 14

### test circuits

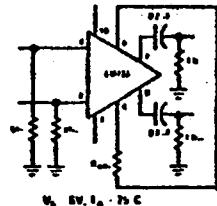
Test Circuit 1



Test Circuit 2



Voltage Gain Adjust Circuit



V<sub>1</sub> 8V, I<sub>1</sub> = 75 C  
Pin numbers apply to DIP package

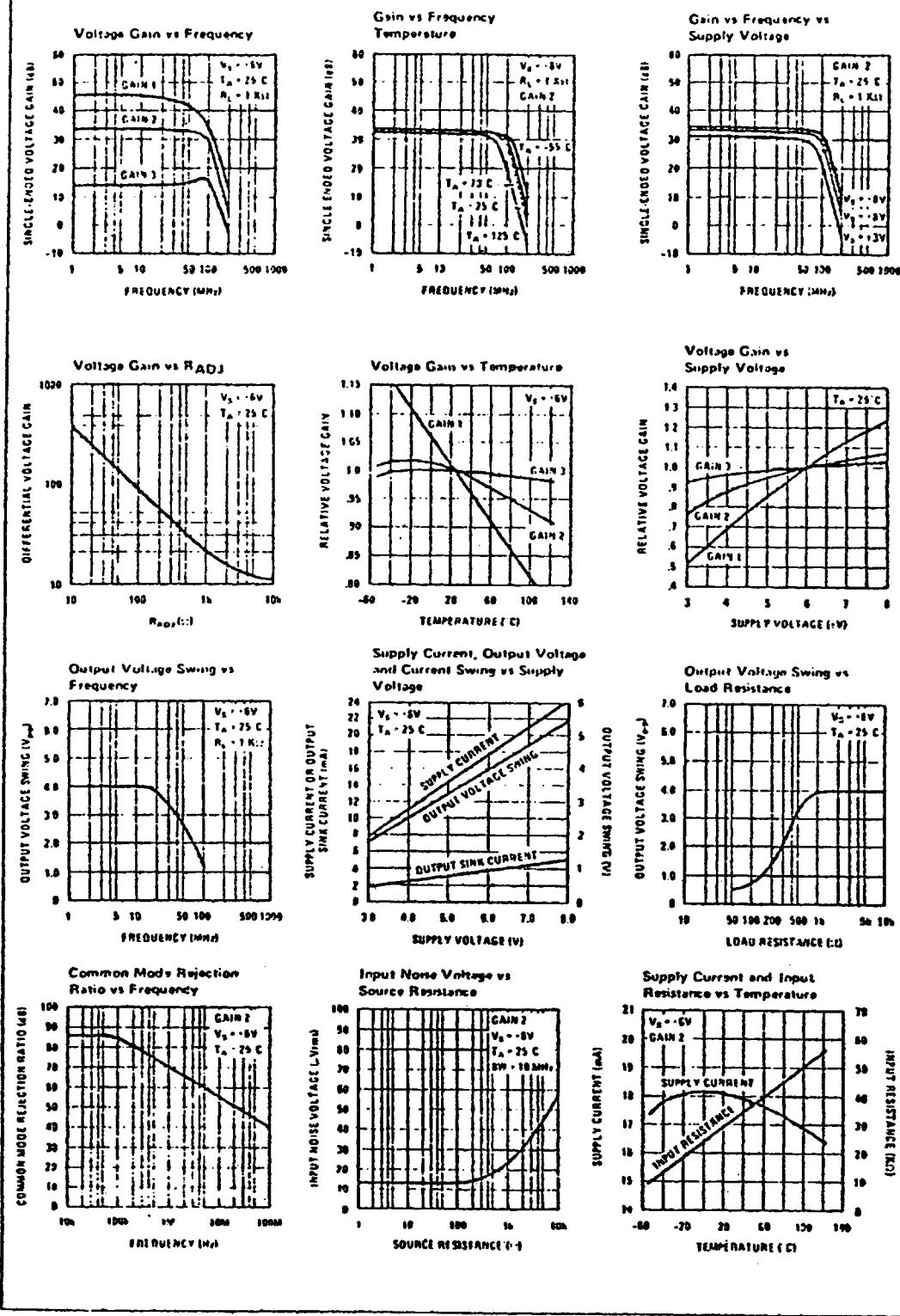
### absolute maximum ratings

Differential Input Voltage	$\pm 5V$
Common Mode Input Voltage	$\pm 6V$
$V_{CC}$	$\pm 8V$
Output Current	10 mA
Power Dissipation (Note 1)	500 mW
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range LM733	-55°C to +125°C
LM733C	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

### electrical characteristics ( $T_A = 25^\circ C$ , unless otherwise specified, see test circuits, $V_g = \pm 6.0V$ )

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1 (Note 2)			300	400	500	250	400	600	
Gain 2 (Note 3)	1	$R_L = 2k\Omega$ $V_{OUT} = 3V_{DD}$	90	100	110	80	100	120	
Gain 3 (Note 4)			9.0	10	11	8.0	10	12	
Bandwidth									
Gain 1				40			40		MHz
Gain 2	2			90			90		MHz
Gain 3				120			120		MHz
Rise Time									
Gain 1		$V_{OUT} = 1V_{DD}$		10.5			10.5		ns
Gain 2	2			4.5	10		4.5	12	ns
Gain 3				2.5			2.5		ns
Propagation Delay		$V_{OUT} = 1V_{DD}$							
Gain 1				7.5			7.5		ns
Gain 2	2			6.0	10		6.0	10	ns
Gain 3				3.6			3.6		ns
Input Resistance									
Gain 1			20	4.0			4.0		$\mu S$
Gain 2				30		10	30		$\mu S$
Gain 3				250			250		$\mu S$
Input Capacitance		Gain 2		2.0			2.0		pF
Input Offset Current				0.4	3.0		0.4	5.0	$\mu A$
Input Bias Current				0.0	2.0		0.0	3.0	$\mu A$
Input Noise Voltage		$10W = 1 kHz$ to $10 MHz$		12			17		$\mu V_{rms}$
Input Voltage Range	1			±1.0			±1.0		V
Common Mode Rejection Ratio									
Gain 2	1	$V_{CM} = \pm 1V$ $f \leq 100 kHz$	60	88		60	88		dB
Gain 2		$V_{CM} = \pm 1V$ $f = 5 MHz$	60	60		60	60		dB
Supply Voltage Rejection Ratio									
Gain 2	1	$\Delta V_S = \pm 0.5V$	50	70		50	70		dB
Output Offset Voltage									
Gain 1	1	$R_L = \infty$		0.6	1.5		0.6	1.5	V
Gain 2 and 3				0.35	1.0		0.35	1.5	V
Output Common Mode Voltage	1	$R_L = \infty$	2.4	2.9	3.4	2.4	2.9	3.4	V
Output Voltage Swing	1	$R_L = 2k$	3.0	4.0		3.0	4.0		
Output Sink Current			2.5	3.6		2.5	3.6		mA
Output Resistance				20			20		$\Omega$
Power Supply Current	1	$R_L = \infty$	18	24		18	24		mA

### typical performance characteristics (con't)



### electrical characteristics

(The following specifications apply for  $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$  for the LM733 and  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$  for the LM733C. V<sub>cc</sub> = 16V)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
<b>Differential Voltage Gain</b>									
Gain 1			200		600	250		600	
Gain 2	1	R <sub>1</sub> = 2 kΩ, V <sub>DD</sub> = 3 V <sub>DD</sub>	80		120	80		120	V
Gain 3			8		12	8		12	
<b>Input Impedance Gain 2</b>									
Input Offset Current						5		6	μA
Input Bias Current						40		40	μA
Input Voltage Range	1		±1		±1			±1	V
<b>Common Mode Rejection Ratio</b>									
Gain 2	1	V <sub>DD</sub> = 11V, f = 100 kHz	40		50			50	
<b>Supply Voltage Rejection Ratio</b>									
Gain 2	1	ΔV <sub>DD</sub> = ±5V	50		50			50	
<b>Output Offset Voltage</b>									
Gain 1	1	R <sub>L</sub> = ∞			1.5			1.5	V
Gain 2 and 3					1.7			1.5	V
<b>Output Voltage Swing</b>									
Output Sink Current	1	R <sub>L</sub> = 2k	2.5		2.8			2.5	mA
Power Supply Current	1	R <sub>L</sub> = ∞	2.2		2.7			2.7	mA

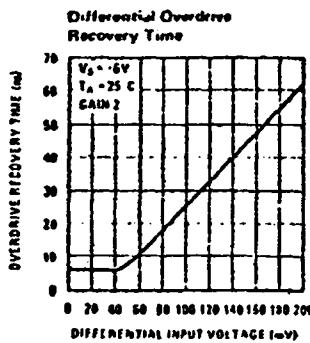
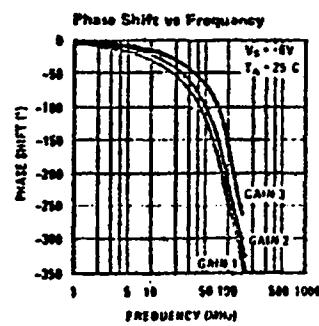
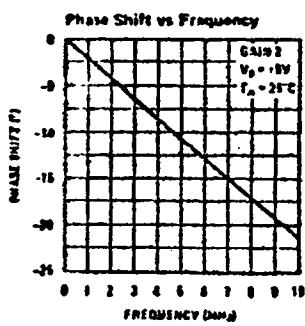
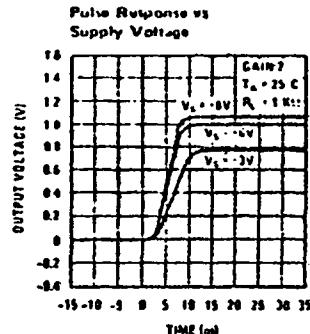
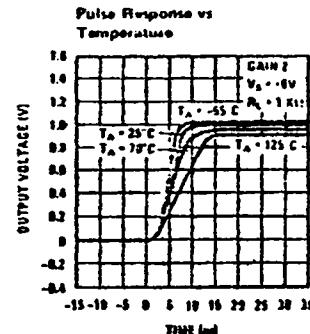
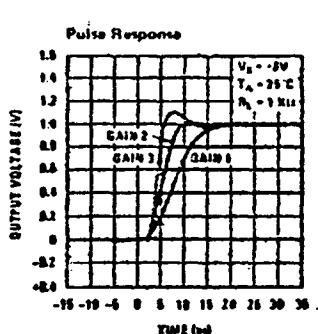
Note 1: The maximum junction temperature of the LM733 is 150°C, while that of the LM733C is 100°C. For operation at elevated temperatures devices in the TO-100 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case. Thermal resistance of the dual-in-line package is 100°C/W.

Note 2: Pins G1A and G1B connected together.

Note 3: Pins G2A and G2B connected together.

Note 4: Gain select pins open.

### typical performance characteristics





# Operational Amplifiers

## LM318 operational amplifier general description

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

### features

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

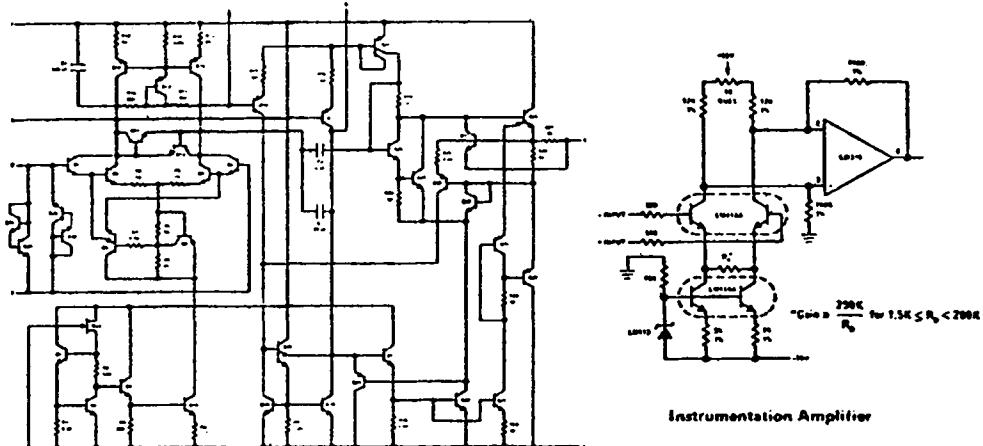
The LM318 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary.

for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/ $\mu$ s and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1  $\mu$ s.

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

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

### schematic diagram and typical application

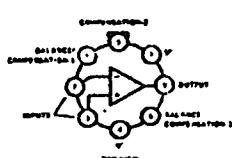


Instrumentation Amplifier



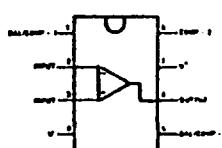
### connection diagrams

#### Metal Can Package\*

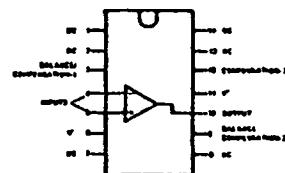


\*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

#### Dual-In-Line Package



#### Dual-In-Line Package



Order Number LM318H  
See Package 11

Order Number LM318N  
See Package 20

Order Number LM318D  
See Package 1

**absolute maximum ratings**

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

**electrical characteristics (Note 4)**

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

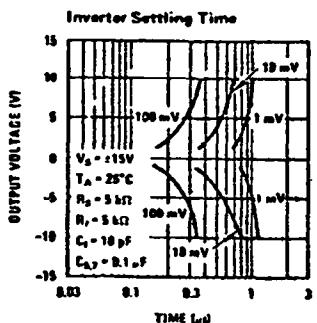
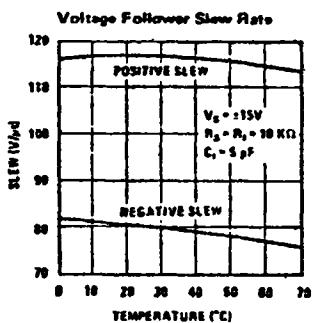
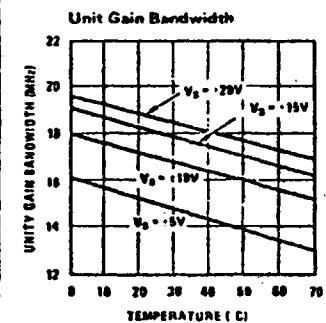
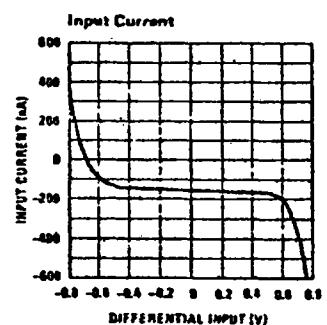
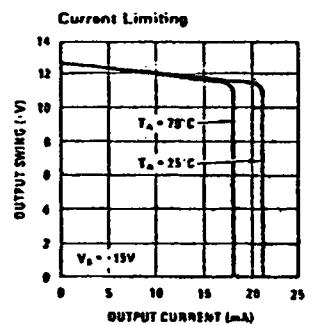
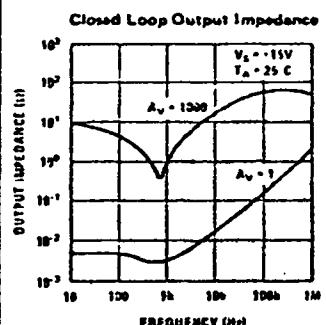
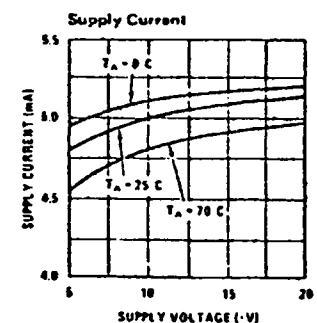
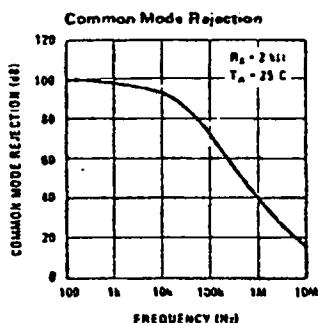
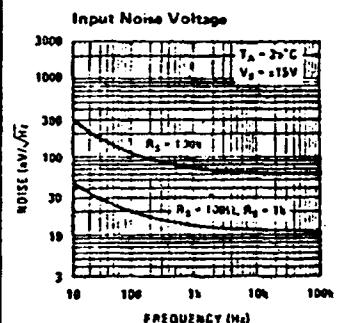
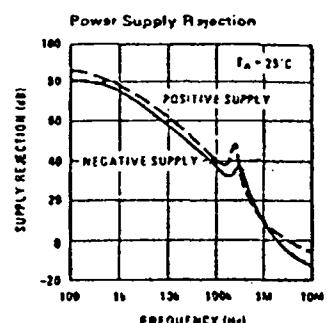
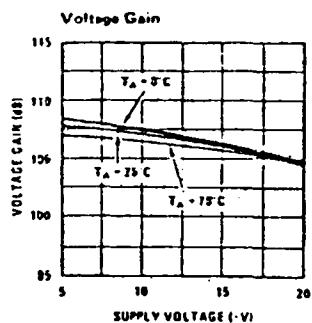
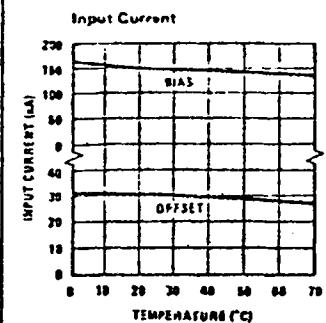
Note 1: The maximum junction temperature of the LM318 is  $85^\circ\text{C}$ . For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of  $150^\circ\text{C/W}$ , junction to ambient, or  $45^\circ\text{C/W}$ , junction to case. The thermal resistance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

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

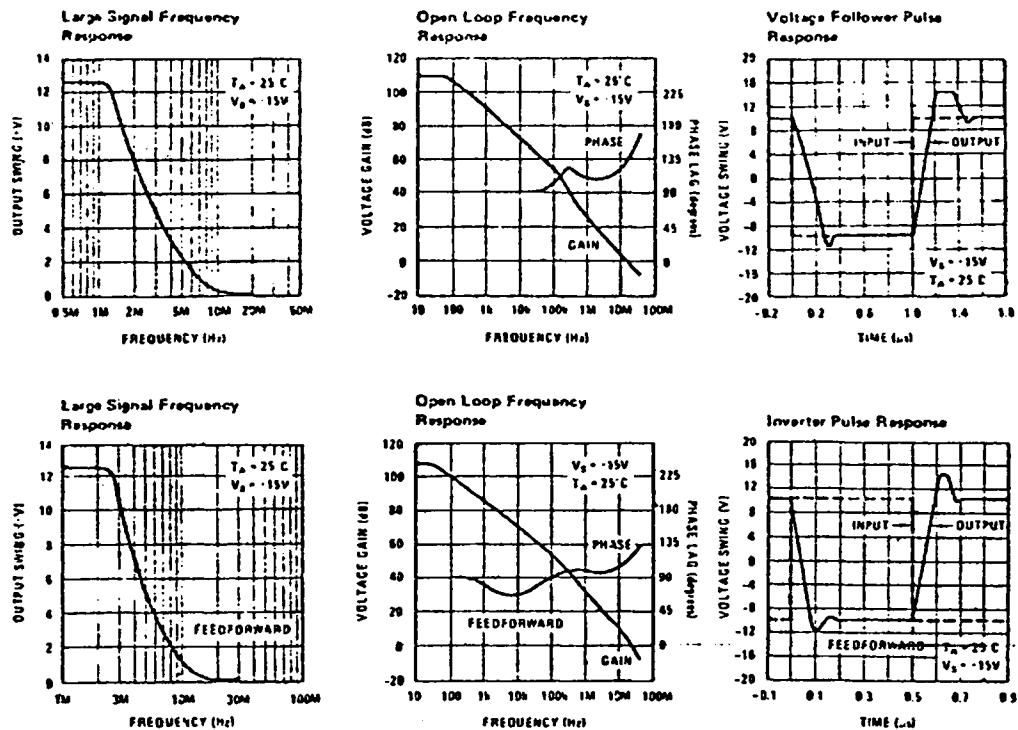
Note 3: For supply voltages less than  $\pm 15V$ , the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for  $\pm 5V \leq V_S \leq \pm 20V$  and  $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ , unless otherwise specified. For proper operation, the power supplies must be bypassed with  $0.1\text{ }\mu\text{F}$  disc capacitors.

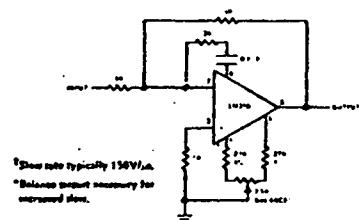
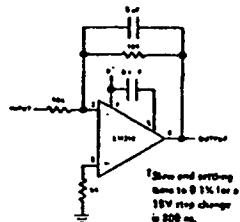
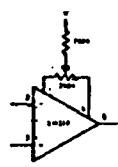
### typical performance characteristics



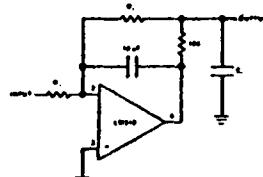
## typical performance characteristics (con't)



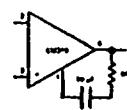
## auxiliary circuits

Feedforward Compensation for Greater Inverting Slow Rate<sup>1</sup>Compensation for Minimum Settling Time<sup>2</sup>

Offset Balancing

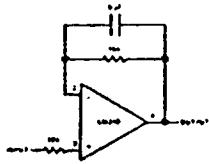


Isolating Large Capacitive Loads

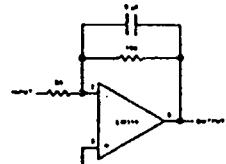


Overcompensation

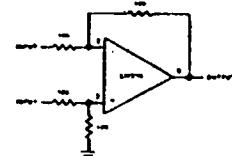
## typical applications (con't)



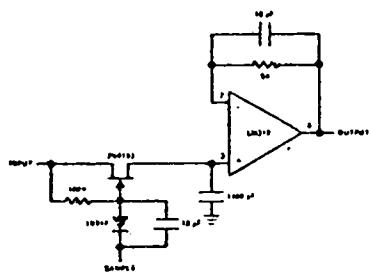
Fast Voltage Follower



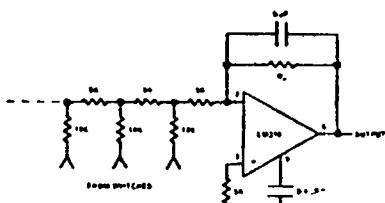
Fast Summing Amplifier



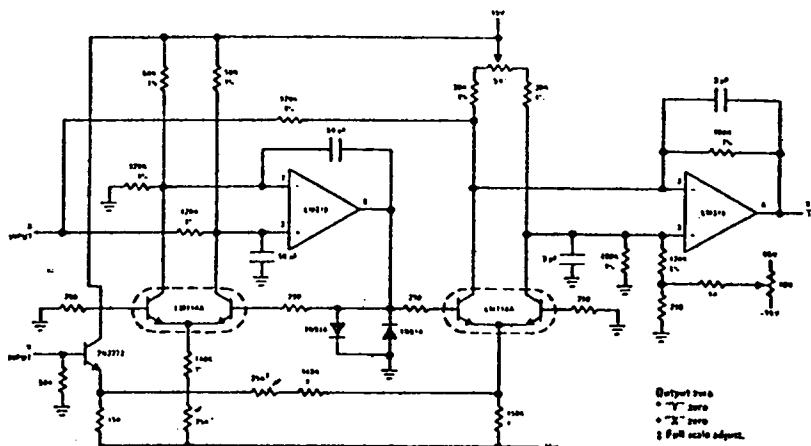
Differential Amplifier



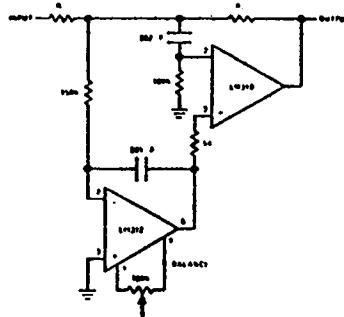
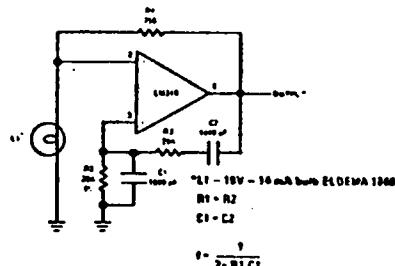
Fast Sample and Hold



\*Optional - Reduces settling time.

D/A Converter Using  
Ladder Network

Four Quadrant Multiplier

Fast Summing Amplifier  
with Low Input CurrentWein Bridge Sine Wave  
Oscillator

**9.0 MODULE PHOTOGRAPHS**



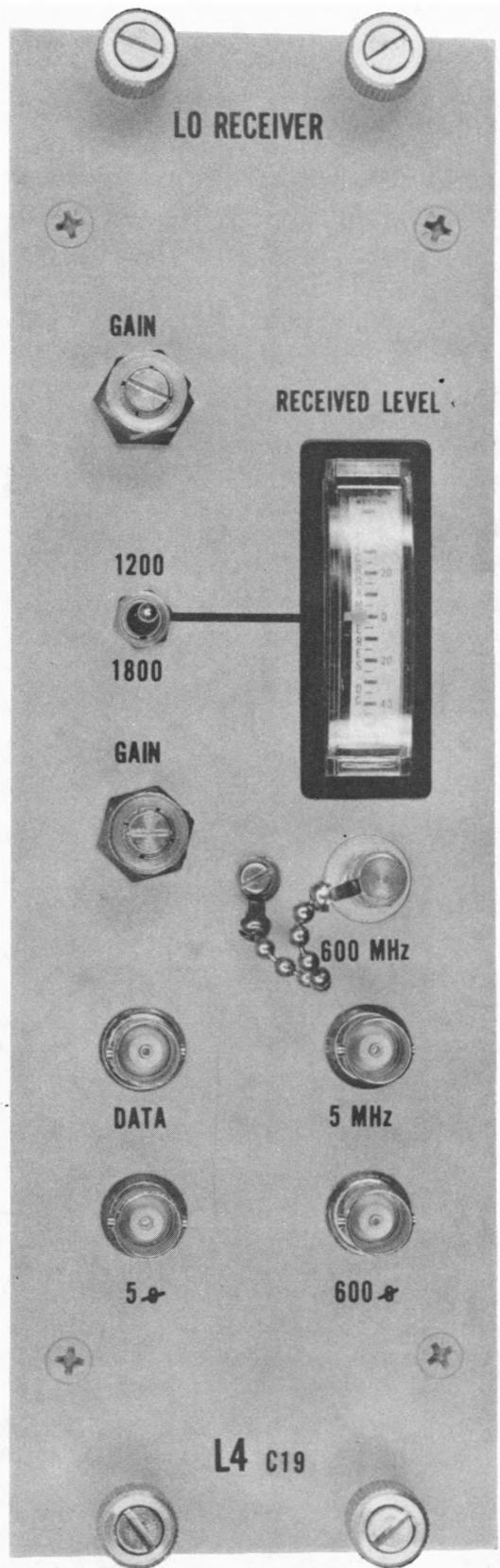


Figure 6 - Front Panel



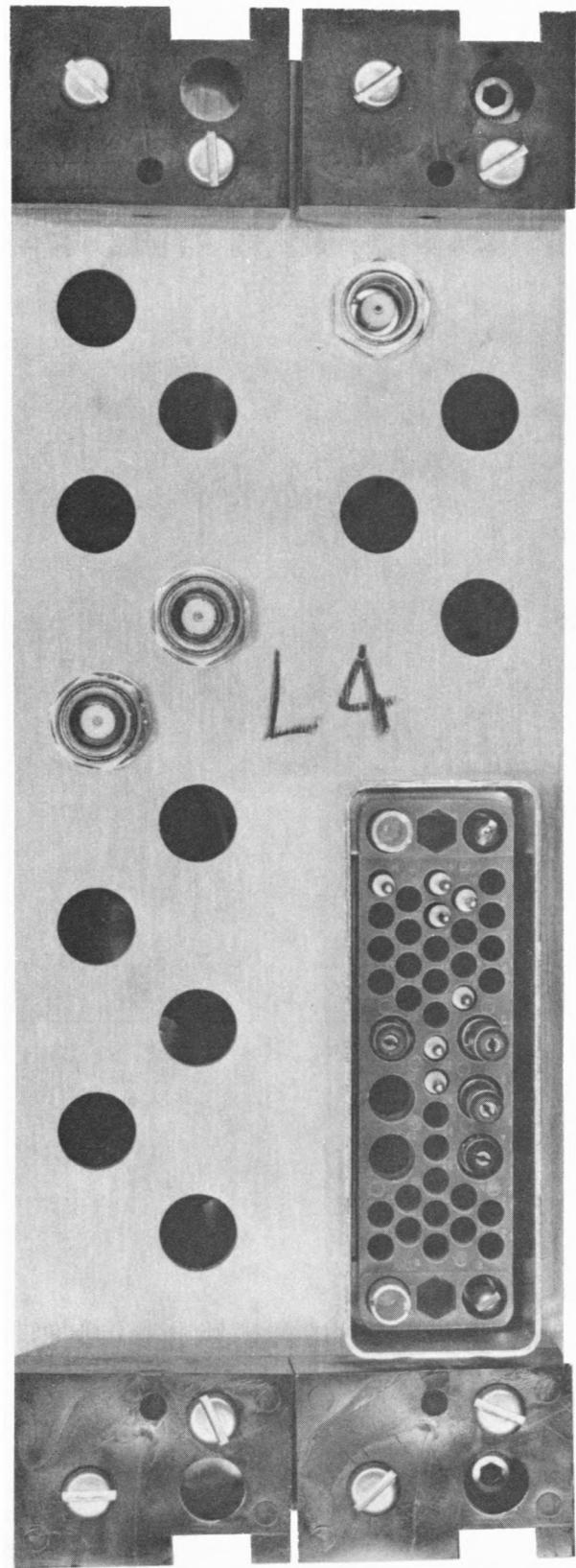


Figure 7 - Rear Panel



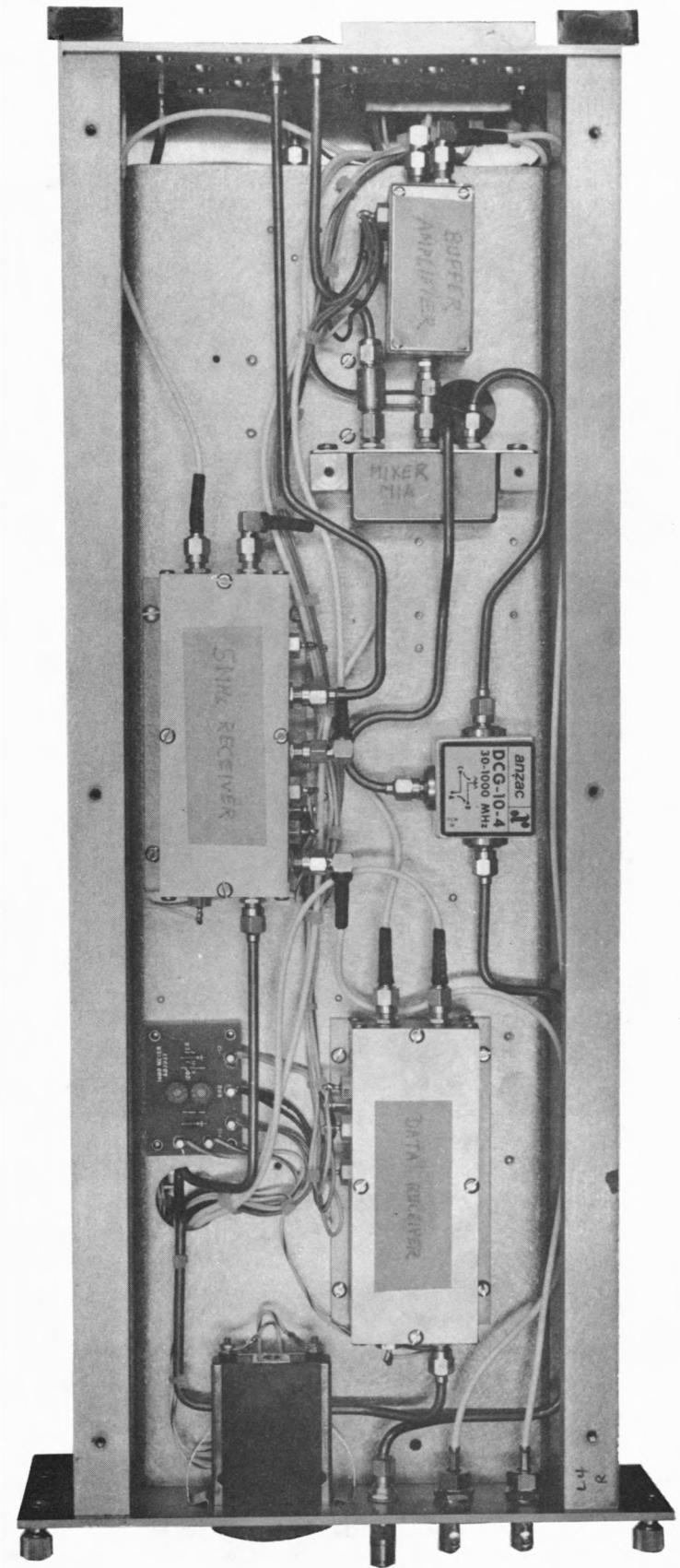
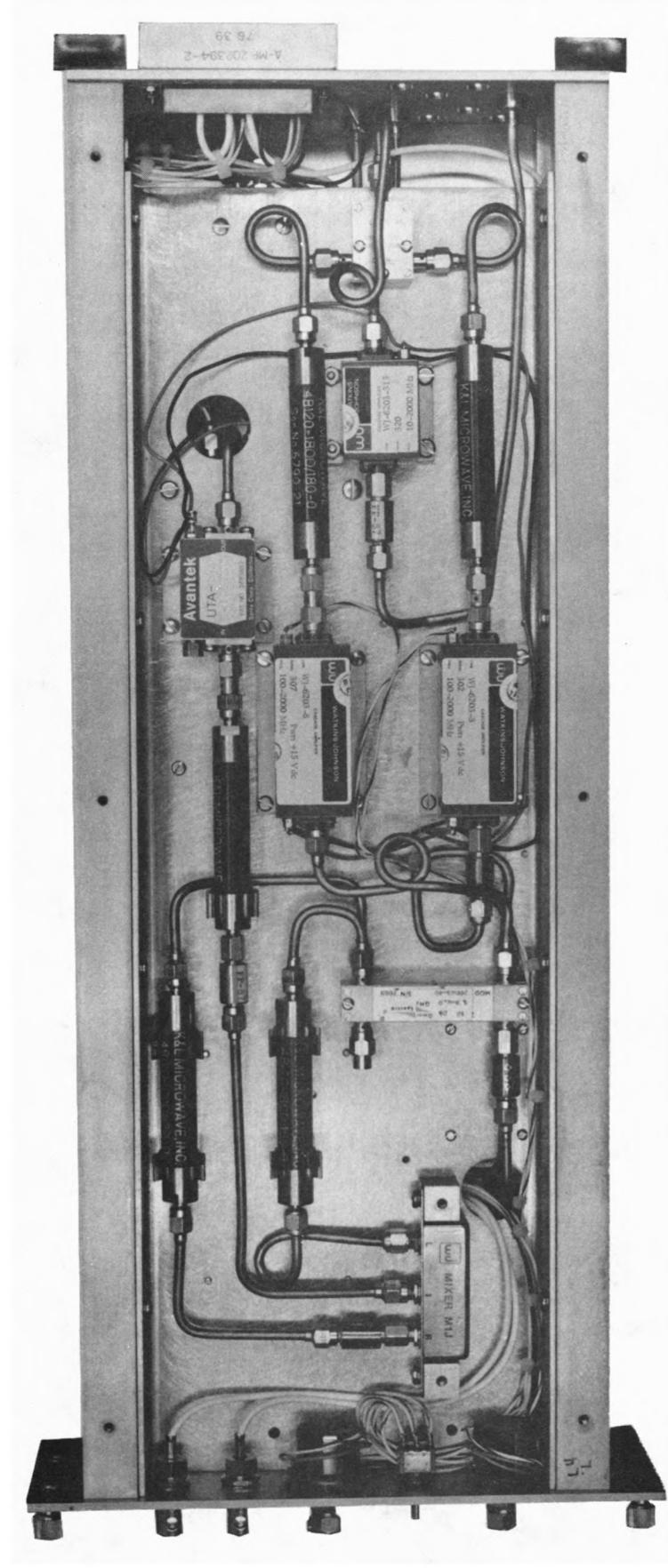


Figure 8 - Right-Hand Side View





**Figure 9 - Left-Hand Side View**

