VLA TECHNICAL REPORT #24

MODULE L4

LO RECEIVER MODULE

Harry Beazell

April 1976

TABLE OF CONTENTS

LIST OF FIGURES

1.0.1 NRAO Drawing List

BILL_OF_MATERIALS

LC RECEIVER	A13230Z04	-06275	4
DATA LINE DRIVER AMP	A13230Z16	A25975	3
DATA LINE DRIVER AMP	A13230Z17	A24775	3
5 MHZ PHASE DETECTOR	A13230Z18	A25971	3
5 MHZ PHASE DETECTOR	A13230Z19	A24775	3
BUFFER AMPLIFIER	A13230Z24	-06275	3
BUFFER AMPLIFIER	A13230Z25	A26175	3

ASSEMBLY_DRAWINGS

5MHZ PHASE DET ENCL	B13230P23	A33674	1
BUFFER AMPLIFIER ASSY	B13230P24	B27475	1
RCVR DAT AMPLIFIER ASSY	B13230P28	B27275	1
DATA LINE DRIVER AMP	B13230P29	A24675	1
5 MHZ PHASE DETECTOR	B13230P30	A24675	1
BUFFER AMPL PC BOARD	B13230P35	-28474	1

SCHEMATIC_DIAGRAMS

RCVR DATA AMP SCHEMATIC	B13230S03	-16875	1
5MHZ DETECTOR SCHEMATIC	C13230S04	-16775	1
BUFFER AMPLIFIER SCH	B13230S08	-26774	1

LOGIC_DIAGRAMS

NONE

PC_BOARD_ARTWORK

5 MHZ C DETECTOR	A13230A804	-18375	2
BUFFER AMPLIFIER	B13230A806	-25175	2

PC_BOARD_SILKSCREEN

NONE

PC_BOARD_MECHANICAL

DATA LINE DRIVER	C13230M52	A25275	1
5 MHZ PHASE DETECTOR	C13230M55	A25275	1

EC_BCARD_MECHANICAL, CONT_

BUFFER AMPLIFIER	B13230M53	-14375	1

BLOCK_DIAGRAMS

BLOCK DIAGRAM	C13230B04	A14275	1
RF INTCON BLK DIAG	D13230B16	C34575	1

WIRE_LISTS

NONE

MECHANICAL_DRAWINGS

GUIDE	B13050M04-L4	D8775	1
RIGHT & LEFT SIDE PLATES	B13050M18-L4	C8775	1
COVER,PERFORATED	C13050M22-1-L4	C5175	1
BAR,SUP. TOP & BOTTOM	B13050M23-L4	C4375	1
MIXER MOUNT	A13050M33-L4	C5075	1
PANEL, REAR	C13210M04-L4	D4275	1
PARTITION PLATE	C13230M24	D28375	1
RECEIVER DATA AMPLIFIER	B13230M27	B4975	1
5MHZ DETECTOR END PANEL	B13230M28	C18375	1
RECEIVER DATA AMPLIFIER	B13230M29	B4975	1
RECEIVER DATA AMPLIFIER	B13230M30	B4975	1
PANEL, FRONT	B13230M31	E31775	1
5MHZ PHASE DET END PANEL	B13230M37	C18375	1
RECVR DATA AMP SIDE PANEL	B13230M39	C18675	1
BUFFER AMPLIFIER ENCLOSUR	B13230M40	D26775	1
5MHZ PHASE DETECTOR	B13230M54	C18375	1
RCVR DATA AMP END PANEL	B13230M89	-18675	1
RCVR DATA AMP END PANEL	B13230M90	-18675	1
TERMINAL, TURRET MOD	B13230M98-L4	-26275	1

2.0 FUNCTIONAL DESCRIPTION

The L.O. Receiver (L4) module is located in the B rack at the antenna. It receives the one millisecond duration transmission from the control room and provides sync control to the L8 module, data output to the data set, and 5 MHz and 600 MHz phase error signals to the L5 module.

3.0 DETAILED CIRCUIT DESCRIPTION

Reference Block Diagram D13230B4

3.0.1 Module Assembly

The input signal to J_1 is in phase divided by DC_4. FL1 selects the 1800 MHz signal for amplification by AR2. FL2 selects the 1200 MHz for amplification by AR1. The specified gain of AR1 and AR2 is 24 dB with 1 dB flatness. This allows a 23.5 dB minimum gain. Current delivered units have been running 27.5 dB. With this as a possible spread, the -6 dB coupled levels (DC_1 and DC_2) delivered to mixer Z_1 are -2 to -6 dBm. The 600 MHz output of Z_1 can be expressed as $(P_L + P_R - 11)$ dBm, P_L, $P_R \leq 0$ dBm. This gives a 600 MHz output level of -15 dBm to -23 dBm. Amplifier AR3 provides a minimum gain of 13 dB. Including the filter loss of FL3, (.5 dB), the coupler DC_3 (.5 dB), and the PAD AT1 (6 dB), the output to R port of Z_2 is -8 dBm to -17 dBm. The 600 MHz reference input to J_{11} is +10 dBm to +7 dBm. With the pad AT2 the L port input to Z_2 is +7 dBm to +4 dBm. The I port of Z_2 is terminated in the Buffer Amplifier A_3 with a series 51Ω and .001 μf. This terminates the mixer sum term in Z_0 and leaves the difference term open. Under these conditions, the phase error voltage peak to peak (0-360°) value is about double the terminated value and at -8 dBm to -17 dBm will be ~200 mV to 70 mV peak to peak. The 1800 MHz carrier from DC_1 is envelope detected by CR_1 to provide the data output signal. A 300 kHz data sideband level of -15 dB from a carrier of +2.75 to -1.25 dBm provides a detected data signal level at the input to A_1 of about 80 mV peak to peak. The 1200 MHz from DC_2 is envelope detected by CR_2 to provide the 5 MHz signal. A sideband level of -10 dBc on the +2.75 to -1.25 dBm carrier provides a signal level of about 50 mV peak to peak to the 51 ohm termination of input of A_2.

3.0.2 Receiver Data Amplifier

Reference Schematic B13230S3

The 300 kHz data input to J_1 is terminated in L_2 to provide a DC return for CR_1 and a high impedance at the data clock frequency. The diode resistance of about 100 ohms plus R_1 produces a gain of about 23 in the inverting op-amp U_1. The parallel trap L_1, C_1, C_2 reduces the gain

to less than one at 5 MHz. A buffer amplifier U_2 and R_7 provide a 51Ω source to drive the data output lines at J_3. A 10:1 divider provides monitoring at J_2. R5, C_{12}, CR_2, and R_6 provide detection and monitor output of the data string with a 1 second time constant.

3.0.3 5 MHz Ø Detector

Reference Schematic C13230S4

The 5 MHz 50 mV input is terminated at J_1 in 51Ω. C_8 and R_3 provide a 2.2 μs time constant for transmission of the "R.F. On" state. U_2 provides broad band gain, adjustable by R_2, of from 5 to 25 to emitter followers Q_1 and Q_2. The inverted output, Q_2, drives the sync J_2 and sync monitor J_5. The nominal 5 MHz sync burst should be 0.8V +1.0V peak to peak. A one second time constant detector CR_1, R_{24}, and C_{14} holds the sync burst level for monitoring by the data set. The non inverted burst emitter follower, Q_1, drives the signal input of a balanced phase detector U_3. The signal level is approximately 0 to -3 dBm. The reference level from J_3 is ±7 to +4 dBm.

The error output is 300 to 500 mV peak to peak for 0 to 360° phase difference. An output amplifier U_1 provides gain to produce ±10V error swing at J_4. R_{17} provides offset correction to balance the output swing and zero point.

3.0.4 Buffer Amplifier

Reference Schematic B13230S8

The Buffer Amplifier terminates the phase comp difference term in 50 ohms (see 3.0.1). Operational Amplifier V1 is gain set and offset adjusted by R_6 and R_5 to provide a standard 20V p-p output for 0-360° phase change.

4.0 ADJUSTMENTS

4.0.1 Receiver Data Amplifier

1. Apply 50 mV 5 MHz signal to J_1.
2. Tune C_1 to produce minimum 5 MHz at J_3 (should be $\leq$50 mV p-p).

4.0.2 5 MHz Phase Detector

1. Apply 50 mV p-p at 5 MHz $\pm$ approximately 50 Hz to J_1.
2. Set R_2 to provide 1V p-p at emitter of Q_1.
3. Apply a +7 to +4 dBm 5 MHz reference signal at J_3.
4. Set R_{16} and R_{17} fro 20V p-p and zero offset of $\sim$ 50 Hz phase difference.

4.0.3 Buffer Amplifier

The buffer amplifier gain (R_6) and offset R_5) pots are set at the system level with nominal 1.2 and 1.8 GHz signals and reference 600 MHz applied. With the VCXO unlocked and offset the standard 20V p-p can be monitored at J_1 or Module J_3 on the front panel.

5.0 SCHEMATIC AND BLOCK DIAGRAMS INCLUDED

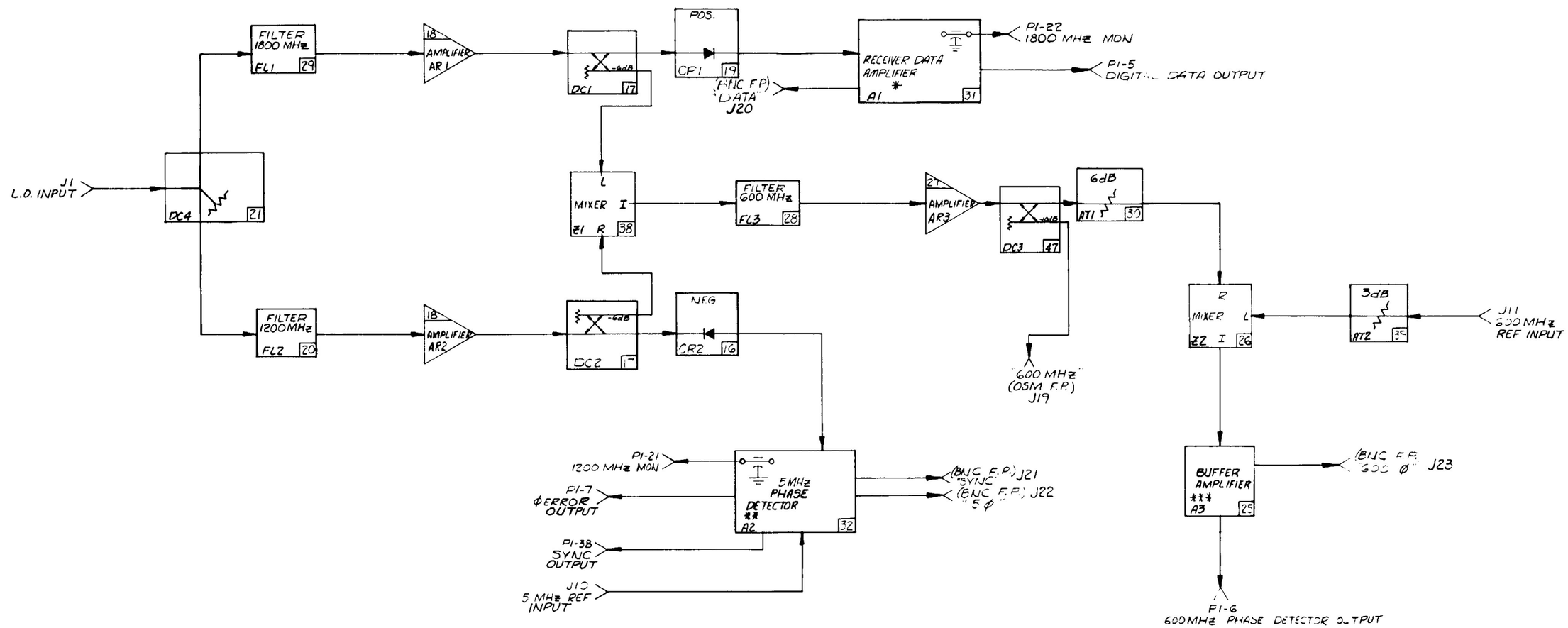
5.0.1 L4 LO Receiver Block Diagram - D13230B4

5.0.2 5 MHz Phase Detector - C13230S4

5.0.3 Receiver Data Amplifier - B13230S3

5.0.4 Buffer Amplifier - B13230S8

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
C	12-5-72	[illegible]	RLS 12-14	REVISED EXTENSIVELY



NOTES:
1. J1, J10 & J11 ARE ON REAR PANEL
2. P1 — 42 PIN CONNECTOR

3. * = ASSY DWG B13230P28, BOM A13230Z16, SCHEMATIC DRAWING B1323053
   ** = ASSY DWG B13230P23, BOM A13230Z18, SCHEMATIC DRAWING C1323054
   *** = ASSY DWG B13230P24, BOM A13230Z24, SCHEMATIC DRAWING B1323058
4. J19 OSM ON FRONT PANEL
   J20-J23 BNC ON FRONT PANEL
5 ——▶ ARROW INDICATES SIGNAL FLOW
6

ITEM NUMBERS REF BOM A13230Z4
REF DESIG PER IEEE NO. 315 & NRAO SPEC

NEXT ASSY	USED ON

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

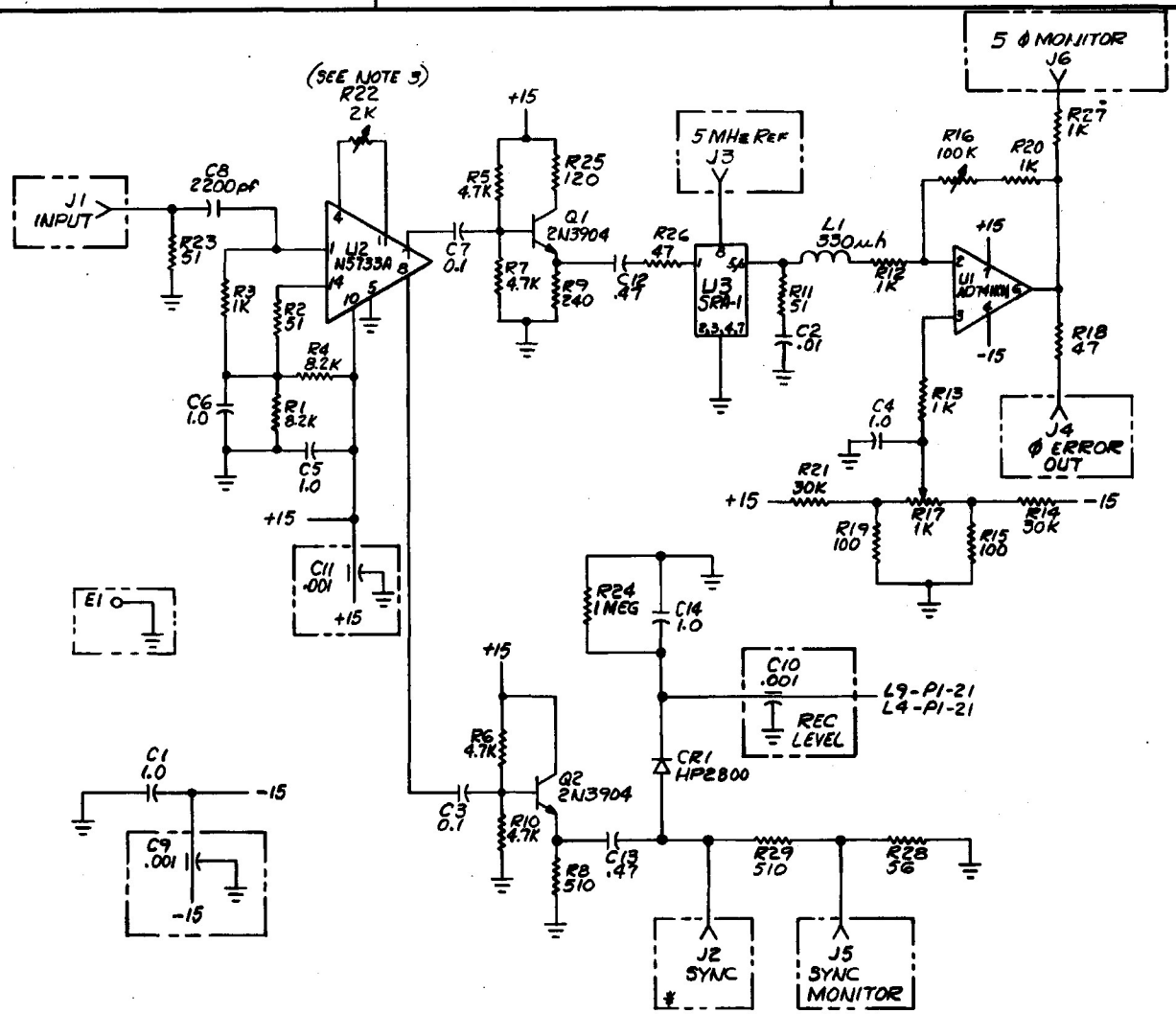
VLA PROJECT: L4 L.O. RECEIVER

TITLE: BLOCK DIAGRAM

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY: [illegible] DATE 22 MAY 70
DESIGNED BY DATE
APPROVED BY: [illegible] DATE 6/7/71

SHEET NUMBER | DRAWING NUMBER D13230B4 | REV C | SCALE



REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	5/20/76	[illegible]	[illegible]	R1, R2 & R4 VALUE WAS 1K

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 813230P23
3. PRESET R22 TO 1.1K

* NOT USED ON "L9"

LAST COMPONENT DESIG USED							
R	C	CR	U	Q	L	J	
29	14	1	3	2	1	6	

NEXT ASSY	USED ON

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

VLA PROJECT: L4, L9 L.O. RECEIVER

TITLE: 5 MHz Φ DETECTOR SCHEMATIC

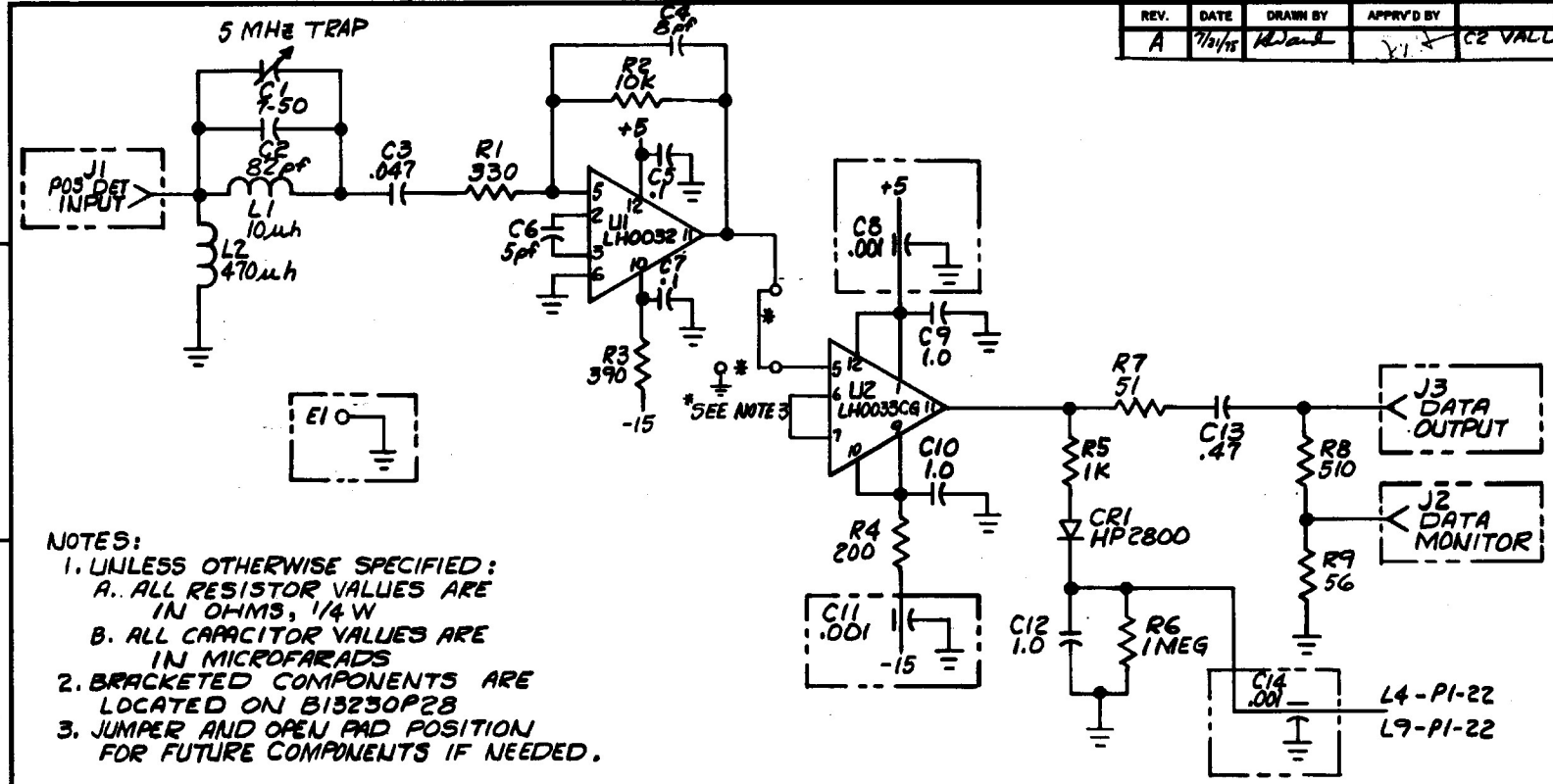
NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY [illegible] DATE 16 June 76
DESIGNED BY J. WEINREB DATE 5/20/76
APPROVED BY [illegible] DATE

SHEET NUMBER | DRAWING NUMBER C1323054 | REV. A | SCALE

DRAWING 40-22 24004

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A	7/21/75			C2 VALUE WAS 75 pf



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.

LAST COMPONENT DESIG USED					
C	CR	J	L	R	U
14	1	3	2	9	2

9/16 REV. LTR A

NEXT ASSY	USED ON

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

VLA PROJECT: L4 L.O. RECEIVER, L9 CENTRAL L.O. RECEIVER

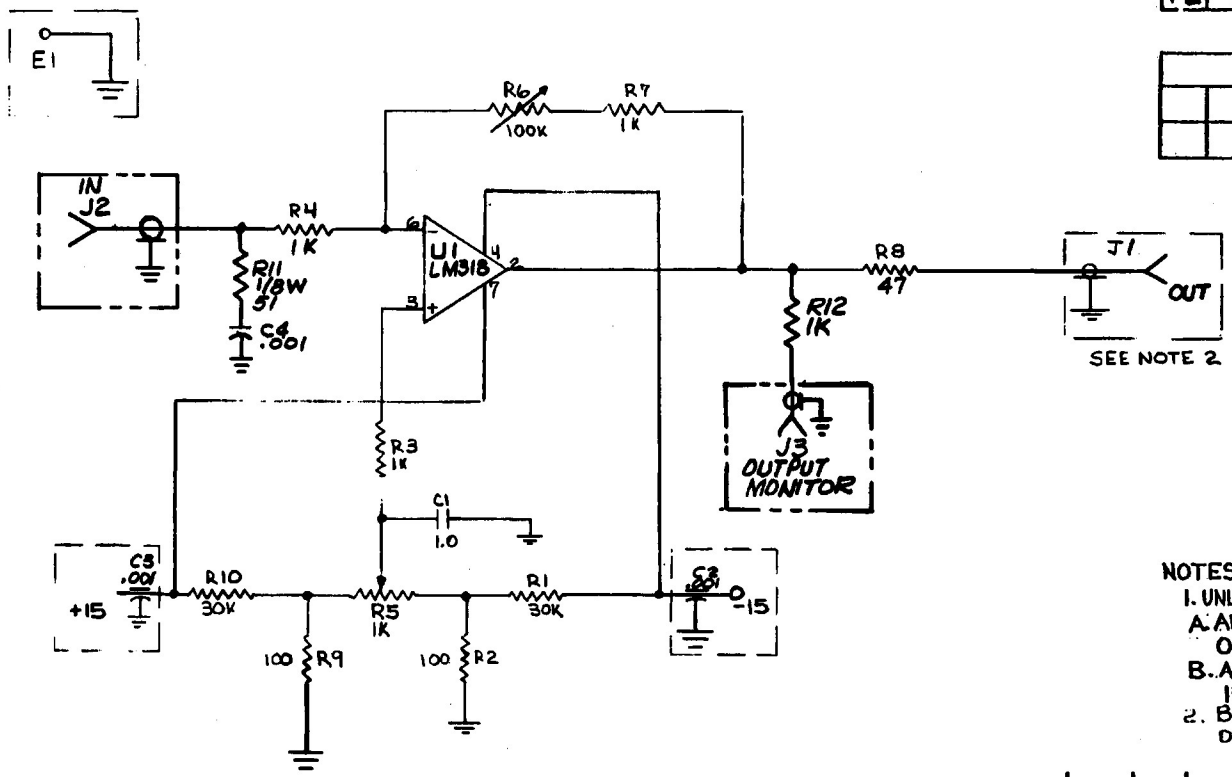
TITLE: RECEIVER DATA AMPLIFIER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY: DeLand DATE 6/17/75
DESIGNED BY: S. WEINREB DATE 6/16/75
APPROVED BY: DATE

SHEET NUMBER | DRAWING NUMBER B13230S3 | REV. A | SCALE

BRUNING 40-22 24984



LAST COMPONENT DESIG. USED								
R	C	U						
12	4	1						

COMP. DESIG. NOT USED								

MISCELLANEOUS
3/1/26

NOTES:
1. UNLESS OTHERWISE SPECIFIED
A. ALL RESISTOR VALUES ARE IN OHMS, 1/4 WATT
B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. BRACKETED COMPONENTS LOCATED ON B1323OP24

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

VLA SYSTEM L4
LO RECEIVER
TITLE: BUFFER AMPLIFIER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY: T. HYZAK — DATE: 10-14-74
DESIGNED BY: — DATE:
APPROVED BY: — DATE: 11/1/05

SHEET NUMBER — DRAWING NUMBER: B1323058 — REV. — SCALE —

6.0 BILLS OF MATERIALS INCLUDED

L.O. Receiver	A13230Z4, pp. 2,3
Data Amplifier	A13230Z16 p.2
Data Amplifier	A13230Z17
5 MHz Phase Detector	A13230Z18 p.2
5 MHz Phase Detector	A13230Z19
Buffer Amplifier	A13230Z24 p.1
Buffer Amplifier	A13230Z25

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A13230Z4 REV B DATE 3/3/75 PAGE 2 OF 4

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16	CR2	AERTECH	D0102B	Crystal Diode Detector, NEG	1	
17	DC1,2	Omni Spectra	20063-6	Coaxial Directional Coupler	2	
18	AR1,2	Aventek	ASD 8199M	3 Stage Amplifier	2	
19	CR1	AERTECH	D0102BR	CRYSTAL DIODE DETECTOR, POS	1	
20	FL2	K & L Microwave	4B120 1200/120-0	Band Pass Filter (with clips)	1	
21	Z1	Omni-Spectra	20493	Isolated Power Divider	1	
22	J1,10,11	Omni-Spectra	OMQ 3043-75	Jack Semi-Rigid Cable	3	
23	P1	AMP	204186-5	Bin/Module Power Connector	1	
24	H	AMP	202394-2	Power Connector Metal Guard	1	
25	A3	NRAO	A13230Z24	Buffer Amplifier (B13230P24)	1	
26	Z3	Wakins Johnson	WJ M1A	Mixer	1	
27	AR3	Aventek	UTA 8712	Amplifier	1	
28	FL3	K & L Microwave	4B120 600-100-0	Band Pass Filter (with clips)	1	
29	FL1	K & L Microwave	4B120 1800-120-0	Band Pass Filter (with clips)	1	
30	AT1	Narda OR (EQUIV)	4772-6	Attenuator Pad	1	
31	A1	NRAO	A13230Z16	RECEIVER DATA AMPLIFIER ASSY (B13230P28)	1	
32	A2	NRAO	A13230Z18	5 MHz Phase Detector ASSY (B13230P23)	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A1323074 REV B DATE 3/3/75 PAGE 3 OF 4

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
33	P	Omni-Spectra	OSM 511-3	Plug/Flex Cable	3	
34	P	Omni-Spectra	OSM 531-3	Right Angle Plug/Flex Cable	5	
35	P	Omni-Spectra	OSM 201-1A	Plug/.141" cable	18	
36	W	Uniform Tubes	UT-141	Semi-Rigid Cable .141 dia.	4 ft	
37	P	Omni-Spectra	OSM-218	Male-Male Connector	4	
38	ZZ	Watkins-Johnson	WJ-MIJ	Mixer	1	
39	AT 2	Narda (OR EQUIV)	4772-3	Attenuator Pad	1	
40	P	Omni-Spectra	OSM 201-1	Plug/.141" cable	9	
41						
42	P	AMP	201143-5	Coax Pin	4	
43	P	AMP	204188-1	Crimp Pin	5	
44	P	AMP	203964-6	Socket, Guide	2	
45	P	AMP	200833-4	Pin, Guide	1	
46	P	AMP	202514-1	Pin, Guide	1	
47	DC 3	ANZAC	DCG-10-4	COUPLER, DIRECTIONAL 10dB	1	
48	DSH	NRAO	D1323084	BLOCK DIAGRAM	REF	
49						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A13230Z16 REV A DATE 11-7-74 PAGE 2 OF 2

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16		NRAO	A13230Z17	P.C. Board Assy (B13230P29)	1	
17	J1, J2, J3	Omni-Spectra	OSM 211	SMA Connector	3	
18	C8, C9 C7	Spectrum Control	FB3B102W	.001MF Feed thru Cap	3	
19	E1	NRAO	B13230M98	Turret Terminal	1	
20		NRAO	B13230S3	Schematic	ref	
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

☒ ELECTRICAL ☐ MECHANICAL BOM # A13230Z17 REV A DATE 9-3-75 PAGE 1 OF 2

MODULE # L4 L9 NAME LO RECEIVER CENTRAL LO RECEIVER DWG # _____ SUB ASMB RECEIVER DATA BOARD ASSY DWG # B13230P29

SCHEMATIC DWG # B13230S3 LOCATION _____ QUA/SYSTEM _____ PREPARED BY Harold Ward APPROVED [illegible]

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	A13230Z17	RECEIVER DATA AMPLIFIER BOARD ASSY (B13230P29)	—	
2		NRAO	C13230M52	RECEIVER DATA AMPLIFIER DRILL DIAGRAM	1	
3	R1		RCR07-331-5S	RESISTOR 1/4W 330 OHMS	1	
4	R2		RCR07-103-5S	10K	1	
5	R3		RCR07-391-5S	390 OHMS	1	
6	R4		RCR07-201-5S	200 OHMS	1	
7	R5		RCR07-102-5S	1K	1	
8	R6		RCR07-105-5S	1MEG	1	
9	R7		RCR07-510-5S	51 OHMS	1	
10	R8		RCR07-511-5S	510 OHMS	1	
11	R9		RCR07-560-5S	RESISTOR 1/4W 56 OHMS	1	
12	C1	JFD	DVJ305D	CAPACITOR, VAR 4.5pf-50pf	1	
13	C2	ARCO	CM04ED820J03	CAPACITOR 5% MICA 82pf	1	
14	C3	ERIE	8121-050-650-473M	CAPACITOR 50V .047μf	1	
15	C4	ARCO	CM04CD080D03	CAPACITOR 5% MICA 8pf	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

☒ ELECTRICAL ☐ MECHANICAL BOM # A13230217 REV A DATE 9/3/75 PAGE 2 OF 2

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16	C5, 7	ERIE	8121-050-650-104M	CAPACITOR 50V .1μf	2	
17	C6	ARCO	CM04CD050D03	CAPACITOR 5% MICA 5pf	1	
18	C9,10,12	ERIE	8131-050-650-105M	CAPACITOR 50V 1.0μf	3	
19	C13	ERIE	8121-050-650-474M	CAPACITOR 50V .47μf	1	
20	U1	NATIONAL	LH0032CG	IC	1	
21	U2	NATIONAL	LH0033CG	IC	1	
22	L1	MILLER	9230-44	CHOKE 10μh	1	
23	L2	MILLER	9230-84	CHOKE 470μh	1	
24	CR1	AERTECH	A2S800	DIODE	1	
25		ROBINSON/NUGENT	MP-12100	IC SOCKET 12 PIN	2	
26		NRAO	B1323053	SCHEMATIC	REF	
27		NRAO	B13230AB9	ARTWORK	REF	
28		BELDEN	8020	BUS BAR WIRE 20 AWG	1"	
29						
30						
31						
32						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[x] ELECTRICAL [ ] MECHANICAL BOM # A13230Z18 REV A DATE 3/3/75 PAGE 2 OF 2

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16	C9,C10 C11	Spectrum Control	F3B102W	.001μF Feed Through Cap	3	
17	E1	NRAO	B13230M98	Turret Terminal	1	
18	J1,J2,J3, J4,J5,J6	OMNI-SPECTRA	OSM 211	SMA Connector	6	
19		NRAO	A13230Z19	Board Assy.	1	
20						
21		NRAO	C13230S4	Schematic	Ref	
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

☒ ELECTRICAL ☐ MECHANICAL BOM # A13230Z19 REV A DATE 3 SEPT 75 PAGE 1 OF 2

MODULE # L4 L9 NAME L4 L O RECEIVER L9 CENTRAL LO RECEIVER DWG # _____ SUB ASMB 5 MHz PHASE DETECTOR BOARD ASSY DWG # B13230P31

SCHEMATIC DWG # C13230S4 LOCATION _____ QUA/SYSTEM _____ PREPARED BY Harold Ward APPROVED [illegible]

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	A13230Z19	5 MHz PHASE DETECTOR BOARD ASSY (B13230P31)	—	
2		NRAO	C13230M55	5 MHz PHASE DETECTOR DRILL DIAGRAM	1	
3	R1,2,3,4,12, 13,20,27		RCR07-102-5S	RESISTOR 1/4W 1K	8	
4	R5,6, 7,10		RCR07-472-5S	4.7K	4	
5	R8,29		RCR07-511-5S	510 OHMS	2	
6	R9		RCR07-241-5S	240 OHMS	1	
7	R11,23		RCR07-510-5S	51 OHMS	2	
8	R14,21		RCR07-303-5S	30 K	2	
9	R15,19		RCR07-101-5S	RESISTOR 1/4W 100 OHMS	2	
10	R16	BOURNS	3339P-1-104	POTENTIOMETER 100 K	1	
11	R17	BOURNS	3339P-1-102	POTENTIOMETER 1 K	1	
12	R18,26		RCR07-470-5S	RESISTOR 1/4W 47 OHMS	2	
13	R22	BOURNS	3339P-1-202	POTENTIOMETER 2 K	1	
14	R24		RCR07-105-5S	RESISTOR 1/4W 1 MEG	1	
15	R25		RCR07-121-5S	RESISTOR 1/4W 120 OHMS	1	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

☒ ELECTRICAL ☐ MECHANICAL BOM # A13230719 REV A DATE 3 SEPT 75 PAGE 2 OF 2

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16	R28		RCR07-560-5S	RESISTOR 1/4 W 56 OHMS	1	
17	C1,4,5,6,14	ERIE	8131-050-651-105M	CAPACITOR 50 V 1.0 μf	5	
18	C2	ERIE	8121-050-651-103M	CAPACITOR 50V .01 μf	1	
19	C3,7	ERIE	8121-050-651-104M	CAPACITOR 50V .1 μf	2	
20	C8	ERIE	8121-050-651-222M	CAPACITOR 50V 2200 pf	1	
21	C12,13	ERIE	8121-050-651-474M	CAPACITOR 50V .47 μf	2	
22	CR1	AERTECH (HP 2800)	A2S800	DIODE	1	
23	U1	SIGNETICS	AD741KN	IC	1	
24	U2	FAIRCHILD (N5733)	μA733CN	IC	1	
25	U3	MCL	SRA-1	MIXER	1	
26	Q1,2	MOTOROLA	2N3904	TRANSISTOR	2	
27	L1	MILLER	9230-80	CHOKE 330 μh	1	
28		ROBINSON NUGENT	ICN-143-S3	IC SOCKET 14 PIN	1	
29		ROBINSON NUGENT	ICN-083-S3	IC SOCKET 8 PIN	1	
30		CINCH	3-LPS-B	TRANSISTOR SOCKET	2	
31		NRAO	C13230S4	SCHEMATIC	REF	
32		NRAO	B13230AB4	ARTWORK	REF	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A13230Z24 REV _____ DATE 3/3/75 PAGE 1 OF 2

MODULE # L4 NAME LO Receiver DWG # _____ SUB ASMB Buffer Amplifier DWG # B13230P24

SCHEMATIC DWG # B13230S8 LOCATION _____ QUA/SYSTEM _____ PREPARED BY H. Ward APPROVED _____

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	A13230Z24	Assembly (B13230P24)	--	
2		NRAO	A13230Z25	P. C. Board Assy. (B13230P35)	1	
3	J1, J2	OMNI SPECTRA	OSM 211	SMA Connector	2	
4	C2, C3	Spectrum Control	FA-5C	.001μF Feed Through	2	
5	E1	Keystone	1587-1	Turret Terminal	1	
6		NRAO	B13230S8	Schematic	Ref	
7						
8						
9						
10						
11						
12						
13						
14						
15						

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A13230Z25 REV A DATE 2/28/75 PAGE 1 OF 2

MODULE # L4 NAME LO Receiver DWG # D13230P4 SUB ASMB Buffer Amplifier DWG # B13230P35

SCHEMATIC DWG # B13230S8 LOCATION QUA/SYSTEM PREPARED BY Harold Wand APPROVED

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
1		NRAO	A13230Z25	Assembly (B13230P35)	-	
2	R1, R10		RCR07 303-5S	Resistor 1/4W 30 K	2	
3	R2, R9		RCR07 101-5S	Resistor 1/4W 100 OHMS	2	
4	R3, R7, R4, R12		RCR07 102-5S	Resistor 1/4W 1K	4	
5	R8		RCR07 470-5S	Resistor 1/4W 47 OHMS	1	
6	R5	Bourns	3339H-1-102	1 K ohm potentiometer	1	
7	R6	Bourns	339H-1-104	100 K ohm potentiometer	1	
8	C1	Erie	831-050-651-105M	1.0 MF 50 v Ceramic Capacitor	1	
9	U1	National Circuits	LM318H	I.C.	1	
10		NRAO	B13230M58	Board P.C.	1	
11		Robinson Nugent	DP5178	I.C. Socket 8 Pin	1	
12	C4	Erie	8101-050-651-102M	.001mF. Cap 50V ceramic	1	
13	R11		RCR05 510-5S	Resistor 1/8W 51 OHMS	1	
14		Keystone	1589-2	Swage Type Threaded Standoff	2	
15		NRAO	B13230S8	Schematic	Ref	

BILL OF MATERIAL

NATIONAL RADIO ASTRONOMY OBSERVATORY

[X] ELECTRICAL [ ] MECHANICAL BOM # A13230Z25 REV A DATE 2/28/75 PAGE 2 OF 2

ITEM #	REF DESIG	MANUFACTURER	MFG PART #	DESCRIPTION	TOTAL QUA	
16		NRAO	B13230AB6	Artwork Master	Ref	
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						

7.0 MANUFACTURERS' DATA SHEETS

7.0.1 Aertech D0102B

7.0.2 LM733

7.0.3 Anzac DCG-10-4

TABLE B
ELECTRICAL SPECIFICATIONS

	Frequency (GHz)	Type	Cap. (Max.) pF (Cv)	K (Min.) mV/mW	M (Min.)	Flatness Typical (dB)	TSS[7] Typ. (dBm)	VSWR (Max.)	VSWR Typ.	Price
Standard Octaves	0.1-0.5	105D	500	1000	100	±0.2	−51	2.0	1.5	$130
	0.5-1.0	510D	100	1000	100	±0.2	−51	2.0	1.5	125
	1.0-2.0	102B	50	1000	100	±0.2	−51	2.0	1.5	125
	2.0-4.0	204B	25	1000	100	±0.2	−51	2.0	1.5	125
	4.0-8.0	408B	15	700	70	±0.4	−50	2.5	1.7	140
	8.0-12.0	812B	15	700	70	±0.4	−50	2.5	1.7	140
	8.0-16.0	816B	15	450	45	±0.6	−48	3.0	2.2	150
	12.0-18.0	208F*	7	400	40	±0.5	−48	2.5	2.0	150
	18.0-26.0	806F**†	5	250	25	±1.5	−47	4.0	2.5	200
Broad Bands	0.1-1.0	110D	500	700	70	±0.5	−50	3.0	1,8	140
	0.5-2.0	520D	100	800	80	±0.5	−50	3.0	1,8	135
	0.7-1.4	714D	50	1000	100	±0.3	−51	2.0	1.5	130
	1.0-4.0	104B	50	800	80	±0.5	−50	3.0	2.0	130
	1.0-12.0	112B	25	500	50	±1.5	−50	4.0	2.5	160
	2.0-8.0	208B	25	600	60	±0.7	−50	3.5	2.0	150
	2.0-12.0	212B	15	500	50	±1.0	−50	4.0	3.0	155
	2.0-18.0	218B*	15	400	40	±1.0	−48	4.0	3.0	170
	4.0-12.0	412B	15	600	60	±0.7	−48	3.5	2.0	150
	7.0-11.0	711B	15	700	70	±0.4	−50	2.5	1.8	140
	7.0-12.0	712B	15	600	60	±0.5	−50	3.0	2.0	145
Waveguide Mounted	8.2-12.4	W812B	15	700	70	±0.4	−50	2.0	1.7	155
	8.5-9.6	W8596B	15	1000	100	±0.2	−51	1.7	1.4	165
	12.0-18.0	W208F	7	500	50	±0.5	−48	2.5	2.0	180
	18.0-26.0	W806F†	5	250	25	±1.5	−47	4.0	2.5	225

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

TECHNICAL NOTES ON SPECIFICATIONS:

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

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. It's 120 MHz bandwidth and selectable gains of 10, 100, and 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.

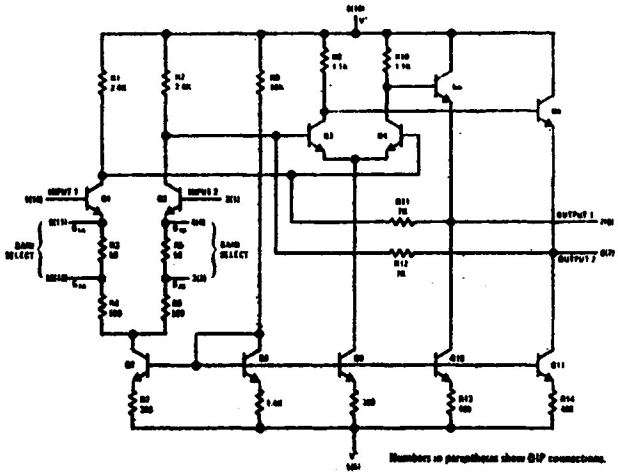
features

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

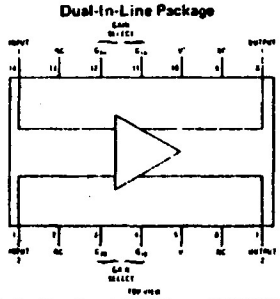
applications

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

schematic and connection diagrams



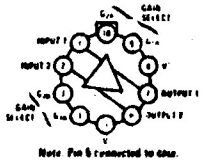
Dual-In-Line Package



Order Number LM733D or LM733CD
See Package 1

Order Number LM733CN
See Package 22

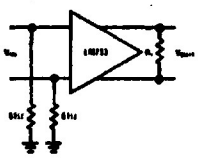
Metal Can Package



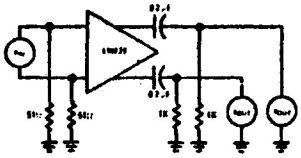
Order Number LM733H or LM733CH
See Package 14

test circuits

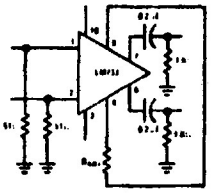
Test Circuit 1



Test Circuit 2



Voltage Gain Adjust Circuit



absolute maximum ratings

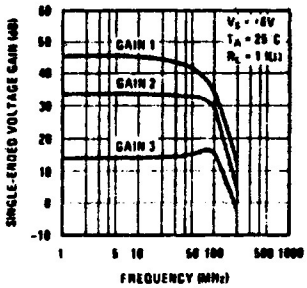
Differential Input Voltage	±5V
Common Mode Input Voltage	±6V
V_{CC}	±8V
Output Current	10 mA
Power Dissipation (Note 1)	500 mW
Junction Temperature	+150°C
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range LM733	−55°C to +125°C
LM733C	0°C to +70°C
Lead Temperature (Soldering, 10 sec)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

electrical characteristics (T_A = 25°C, unless otherwise specified, see test circuits, V_S = ±6.0V)

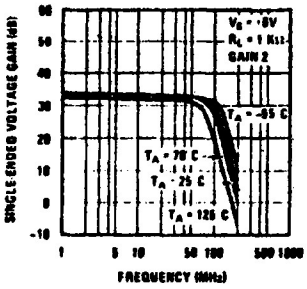
CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1 (Note 2)			300	400	500	250	400	600	
Gain 2 (Note 3)	1	R_L = 2 kΩ V_{OUT} = 3 V_{pp}	90	100	110	80	100	120	
Gain 3 (Note 4)			9.0	10	11	8.0	10	12	
Bandwidth									
Gain 1				40			40		MHz
Gain 2	2			90			90		MHz
Gain 3				120			120		MHz
Rise Time									
Gain 1		V_{OUT} = 1 V_{pp}		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} = 1 V_{pp}							
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				4.0			4.0		kΩ
Gain 2			20	30		10	30		kΩ
Gain 3				250			250		kΩ
Input Capacitance		Gain 2		2.0			2.0		pF
Input Offset Current				0.4	3.0		0.4	5.0	μA
Input Bias Current				9.0	20		9.0	30	μA
Input Noise Voltage		BW 1 kHz to 10 MHz		17			17		μVrms
Input Voltage Range	1		±1.0			±1.0			V
Common Mode Rejection Ratio									
Gain 2	1	V_{CM} = ±1V f ≤ 100 kHz	60	86		60	86		dB
Gain 2		V_{CM} = ±1V f = 5 MHz		60			60		dB
Supply Voltage Rejection Ratio									
Gain 2	1	ΔV_S ±0.5V	50	70		50	70		dB
Output Offset Voltage									
Gain 1	1	R_L = ∞		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 = ∞	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		Ω
Power Supply Current	1	R_L = ∞		18	24		18	24	mA

typical performance characteristics (con't)

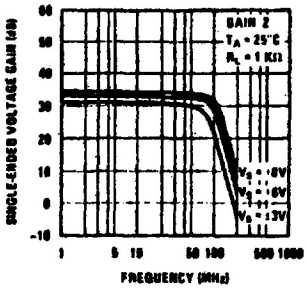
Voltage Gain vs Frequency



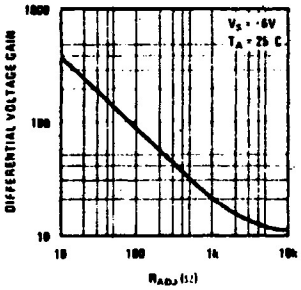
Gain vs Frequency Temperature



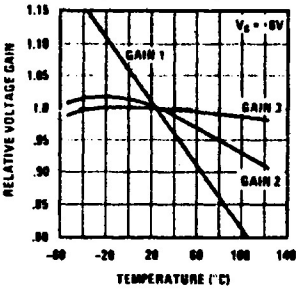
Gain vs Frequency vs Supply Voltage



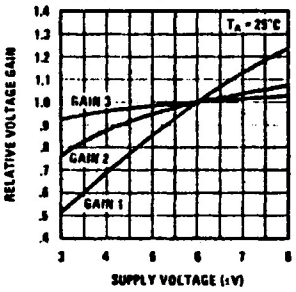
Voltage Gain vs R_{ADJ}



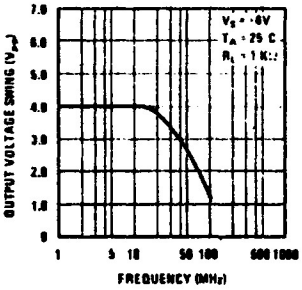
Voltage Gain vs Temperature



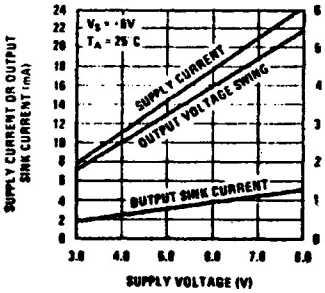
Voltage Gain vs Supply Voltage



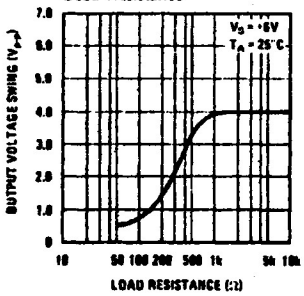
Output Voltage Swing vs Frequency



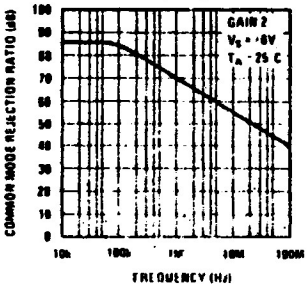
Supply Current, Output Voltage and Current Swing vs Supply Voltage



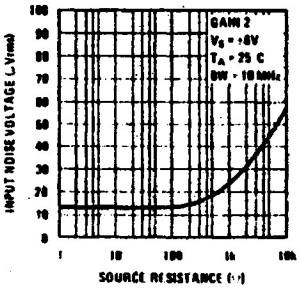
Output Voltage Swing vs Load Resistance



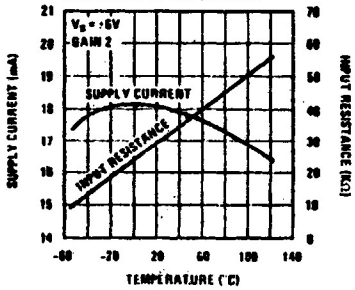
Common Mode Rejection Ratio vs Frequency



Input Noise Voltage vs Source Resistance



Supply Current and Input Resistance vs Temperature



electrical characteristics

(The following specifications apply for $-55°C < T_A < 125°C$ for the LM733 and $0°C < T_A < 70°C$ for the LM733C, $V_S = \pm 6.0V$)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733 MIN	LM733 TYP	LM733 MAX	LM733C MIN	LM733C TYP	LM733C MAX	UNITS
Differential Voltage Gain									
Gain 1			200		600	250		600	
Gain 2	1	$R_L = 2 kΩ$, $V_{OUT} = 3 V_{p-p}$	80		120	80		120	
Gain 3			8.0		12.0	8.0		12.0	
Input Resistance Gain 2			5			8			kΩ
Input Offset Current					5			6	μA
Input Bias Current					40			40	μA
Input Voltage Range	1		±1			±1			V
Common Mode Rejection Ratio									
Gain 2	1	$V_{CM} = \pm 1V$, $f < 100 kHz$	50			50			dB
Supply Voltage Rejection Ratio									
Gain 2	1	$\Delta V_S = \pm 0.5V$	50			50			dB
Output Offset Voltage									
Gain 1	1	$R_L = \infty$			1.5			1.5	V
Gain 2 and 3					1.2			1.5	V
Output Voltage Swing	1	$R_L = 2k$	2.5			2.8			V_{p-p}
Output Sink Current			2.2			2.5			mA
Power Supply Current	1	$R_L = \infty$			27			27	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.

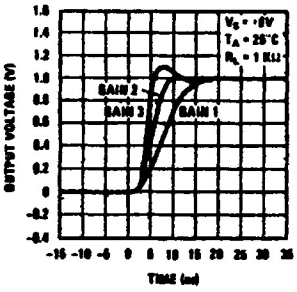
Note 2: Pins G1A and G1B connected together.

Note 3: Pins G2A and G2B connected together.

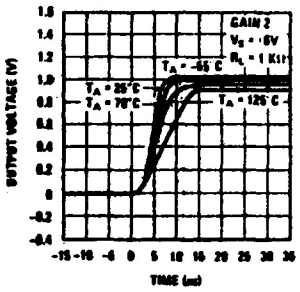
Note 4: Gain select pins open.

typical performance characteristics

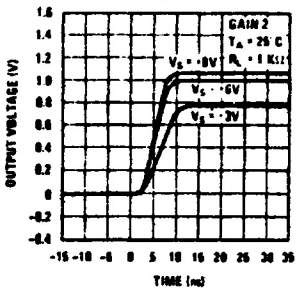
Pulse Response



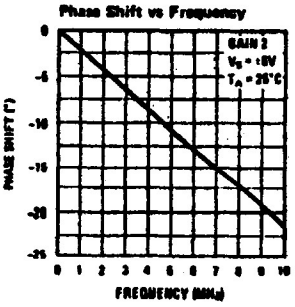
Pulse Response vs Temperature



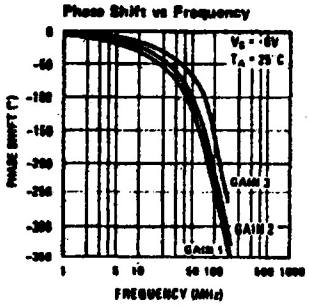
Pulse Response vs Supply Voltage



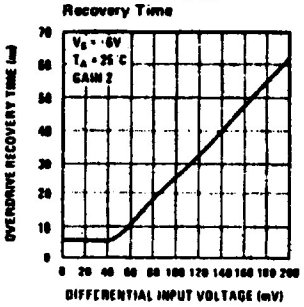
Phase Shift vs Frequency



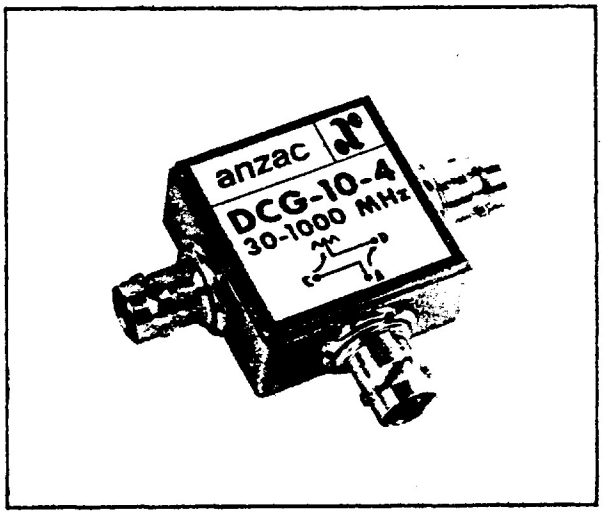
Phase Shift vs Frequency



Differential Overdrive Recovery Time



10db BI-DIRECTIONAL COUPLER



30 MHz — 1 GHz

FEATURES

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

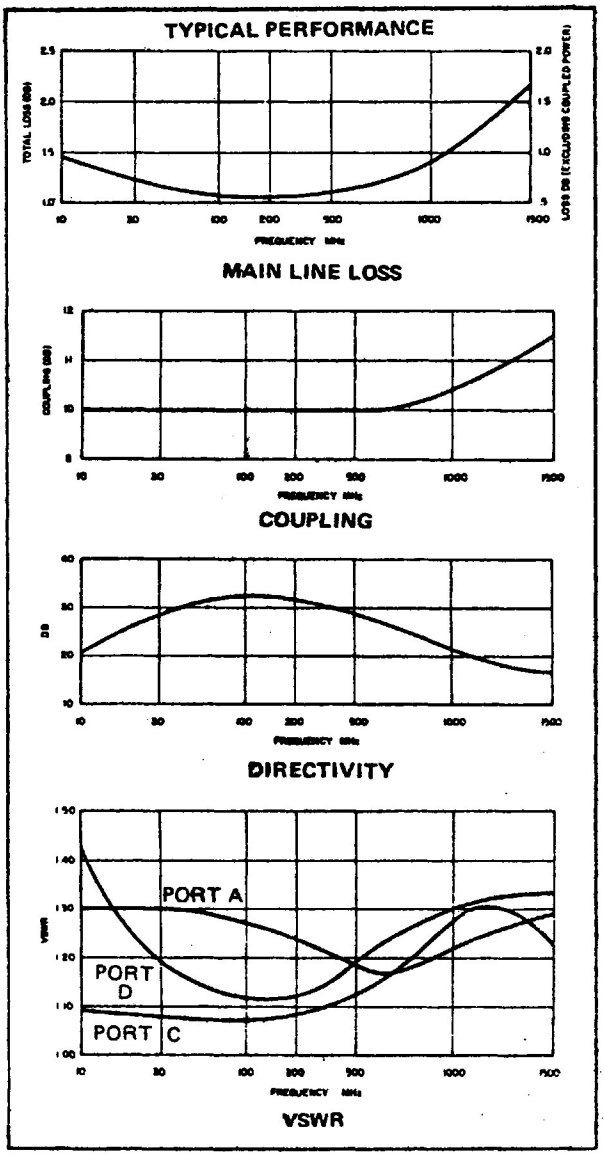
GUARANTEED SPECIFICATIONS

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 ± 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



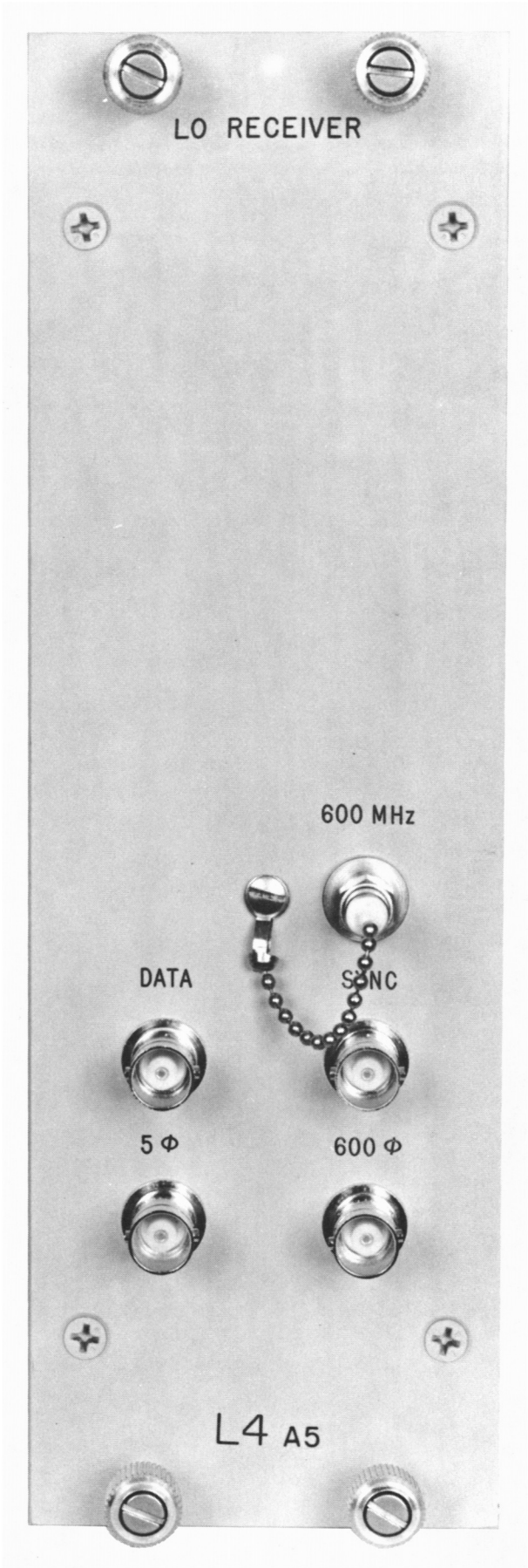


FIGURE 1 L4 FRONT VIEW

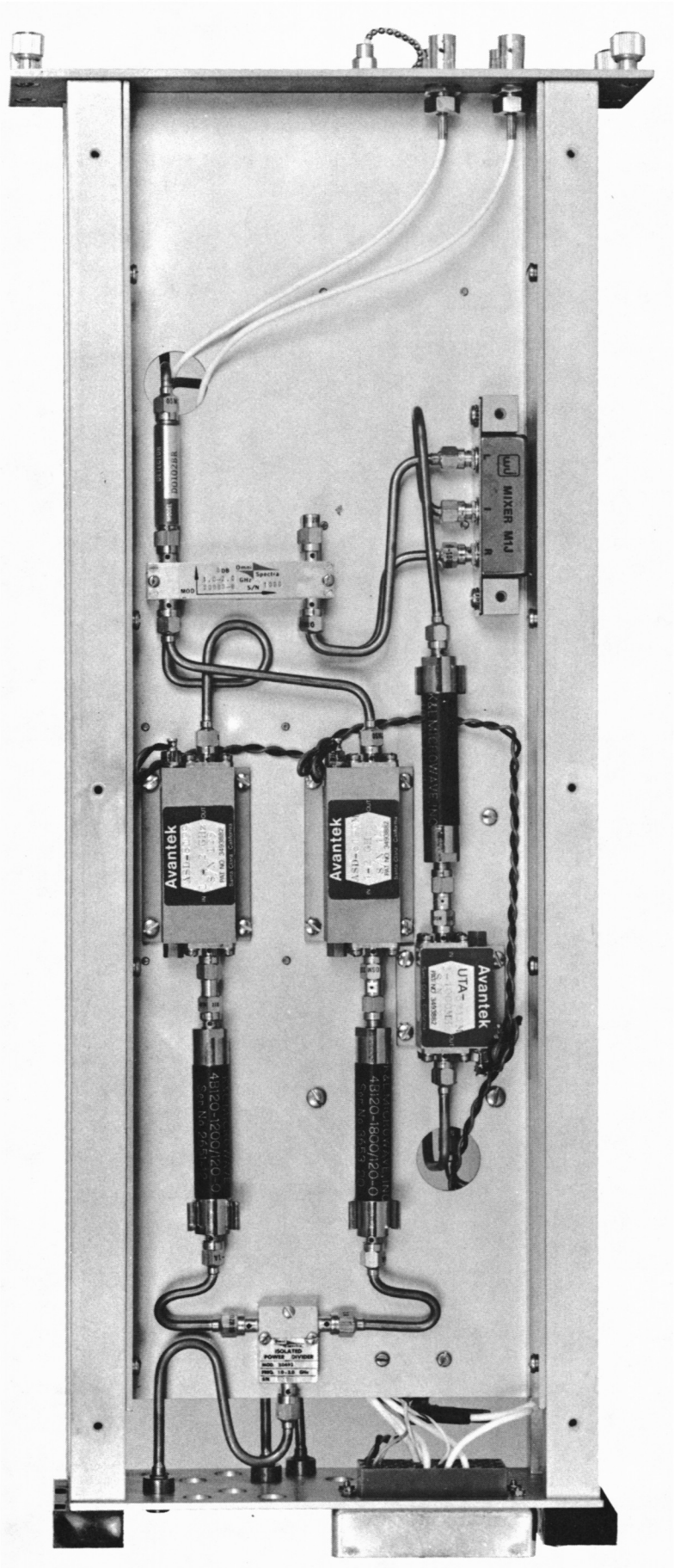


FIGURE 2 L4 RIGHT SIDE VIEW

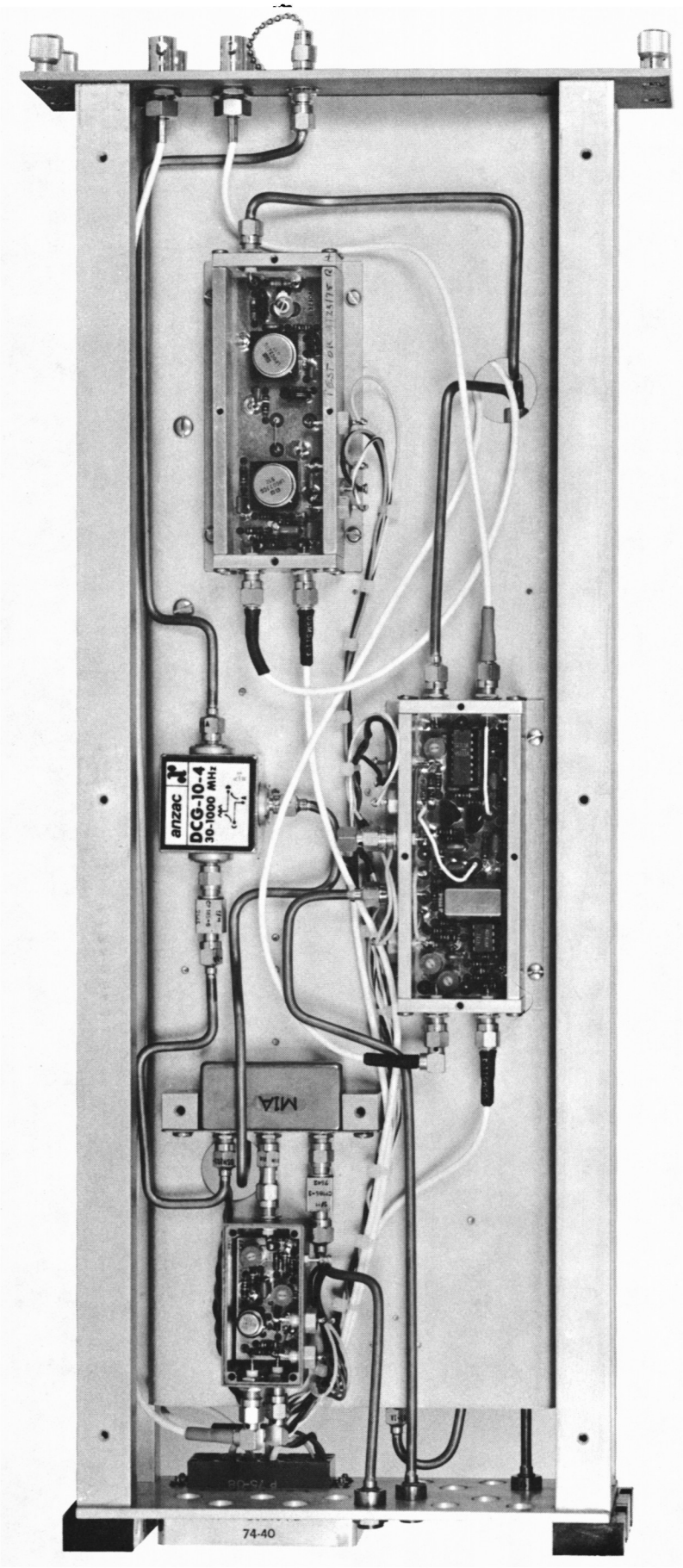
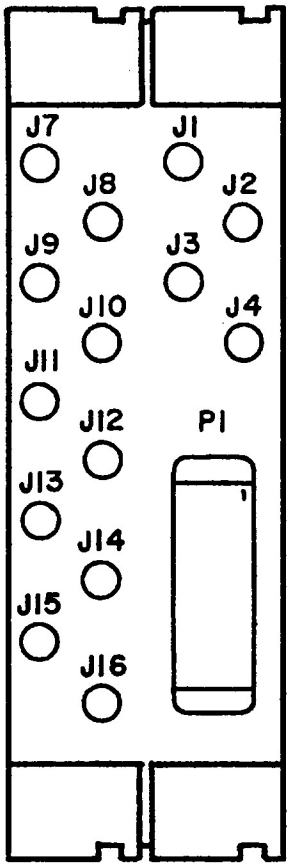
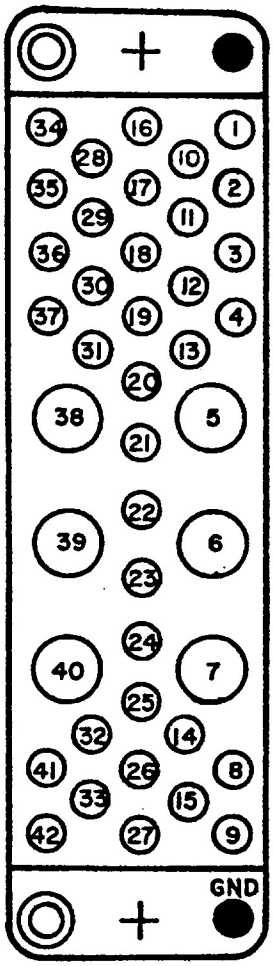


FIGURE 3 L4 LEFT SIDE VIEW



DOUBLE WIDE MODULE
(REAR VIEW)

CONN	FUNCTION
J1	1.2 & 1.8 GHZ INPUT
J2	
J3	
J4	
J7	
J8	
J9	
J10	5 MHZ INPUT
J11	600 MHZ REF. INPUT
J12	
J13	
J14	
J15	
J16	



P1 (REAR VIEW)

P1

PIN	FUNCTION	WIRE COLOR	PIN	FUNCTION	WIRE COLOR
1			22	1.8 GHZ MON.	
2			23		
3			24		
4			25		
5	DIG. DATA OUT		26		
6	600 MHZ PHASE DET.		27		
7	5 MHZ PHASE DET.		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	1200 MHZ MON.		42	HIGH QUAL. GROUND	

FIGURE 4 L.O. RECEIVER L 4