VLA Technical Report No. 33

50 MHz HARMONIC GENERATOR (L2C)

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March 1978

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2.0 FUNCTION

As the name suggests the "50 MHz Harmonic Generator" L2C produces harmonics of 50 MHz required in the system. The 50 MHz signal from 5 to 50 MHz VCXO (L1) is spectral limited using a 50 MHz VCXO in a phase-lock loop. The 50 MHz signal from the VCXO goes to a broadband power amplifier. Output of the amplifier drives a Step Recovery Diode comb generator to produce harmonics of the 50 MHz up to about 2 GHz. The 50 MHz VCXO is phase-locked to the 50 MHz reference signal derived from the L1 module. To overcome the poor phase stability of the comb generator with operating conditions, it is included in the phase-lock loop. To phase-lock the VCXO 100 to 200 MHz spectrum is used instead of the 50 MHz. It minimizes the effect on the phase stability of the output harmonics due to direct transmission of the input (50 MHz) signal through the comb generator.

Two comb outputs at harmonics of the 50 MHz are provided for 2 to 4 GHz Synthesizers (L6's) and front-end IF offset (F8) modules. Also amplified outputs of 1200 and 1800 and 50, 100 and 200 MHz are provided. The outputs at 1200 and 1800 MHz are filtered in L.O. Transmitter (L3) module and returned to the Central Electronics Room. The 50 MHz output is given to Fringe Generator (L7) modules and 100 and 200 MHz outputs provide reference signals required by Upconverter Pump (F2) and 17 to 20 GHz L.O. (F3) modules.

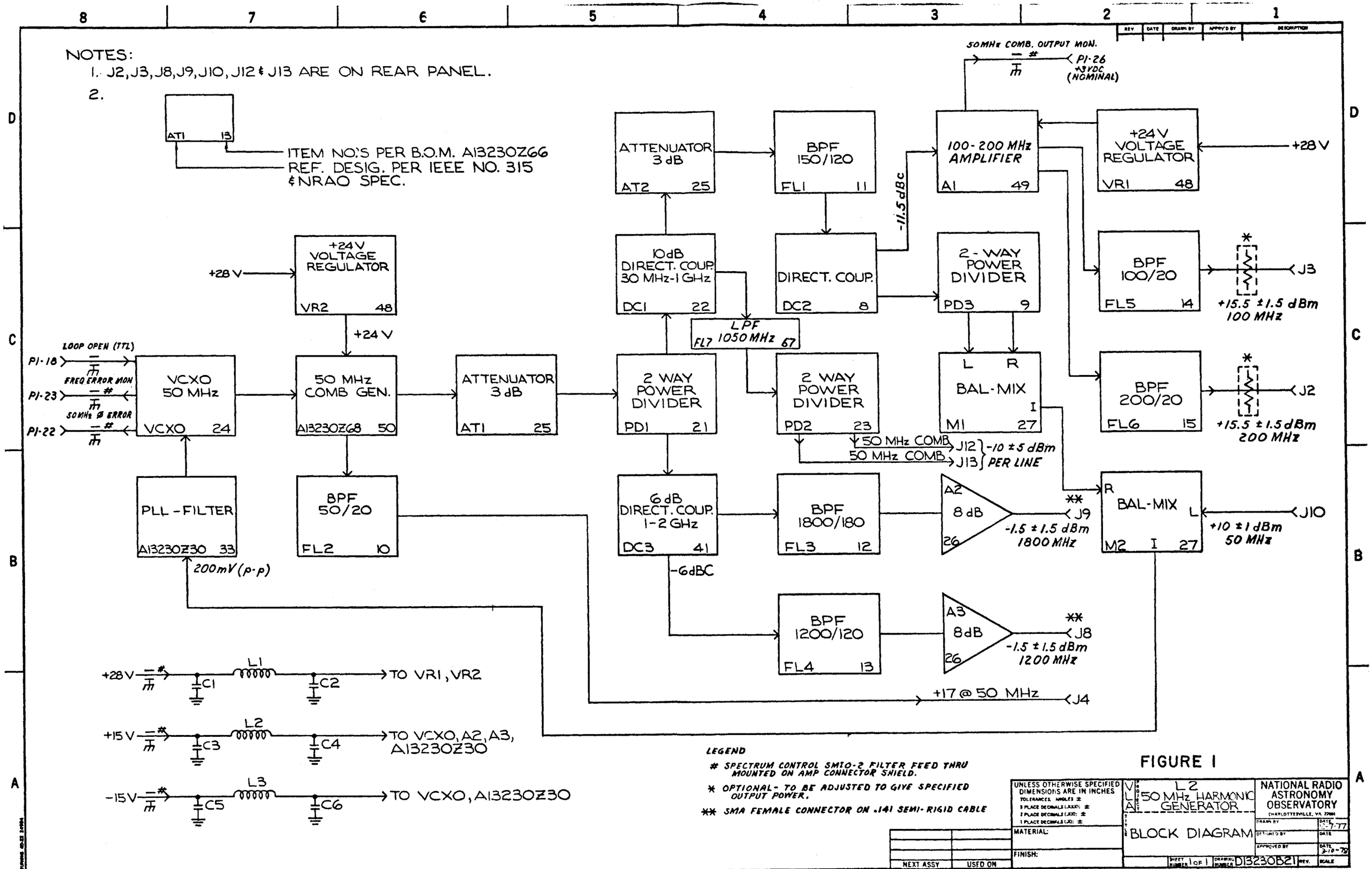
3.0 THEORY OF OPERATION

A block diagram of the 50 MHz Harmonic Generator (L2C) module with input and output connections and power levels is shown in Figure 1.

The 50 MHz VCXO (Model VCXO-10 made by Isotemp) has an output power level of at least 10 mW and drives a 1 W output broadband power amplifier (type CA2810 by TRW). Output of the 50 MHz amplifier is passed through a 11·5 dB directional coupler (type PDC-10-1 by Mini Circuits Lab). The direct output of the directional coupler drives a comb generator employing a Hewlett-Packard 5082-0820 Step Recovery Diode. Output of the comb generator built for the prototype unit is shown in Figure 2. The coupled output of the 11·5 dB directional coupler provides 50 MHz signal which is passed through a 50/20 MHz BPF to provide 50 MHz output at Jack J4.

The output of the comb generator is connected through a 3 dB attenuator to a broadband (30 to 2000 MHz) power divider (PD-1). The 3 dB attenuator is put to improve the load VSWR as seen by the comb generator output circuit. One output of the power divider is given to a 6 dB directional coupler (DC-3). The direct and coupled outputs of the 6 dB directional coupler are spectrum limited using 10% bandwidth BPFs and are amplified using 8 dB gain amplifiers to provide 1800 and 1200 MHz outputs at Jacks J9 and J8 respectively. The other output of the broadband power divider (PD-1) is given to a 30 to 1000 MHz 10 dB directional coupler (DC-1). The -10 dBc coupled output of the directional coupler is passed through a 1050 MHz LPF and is then divided by a 2-way power divider (PD-2) to provide two 50 MHz comb outputs at Jacks J12 and J13. The outputs at J12 and J13 provide the 50 MHz harmonics required for 2 to 4 GHz Synthesizers (L6's) and Front-end IF Offset (F8) modules respectively. The 1050 MHz LPF is used to limit the output spectrum of the comb so that any leakage of this signal does not interfere in the L-Band observations (see below for L-Band interference problem). The

NOTES:
1. J2, J3, J8, J9, J10, J12 & J13 ARE ON REAR PANEL.
2.



LEGEND
SPECTRUM CONTROL SMIO-2 FILTER FEED THRU MOUNTED ON AMP CONNECTOR SHIELD.
* OPTIONAL- TO BE ADJUSTED TO GIVE SPECIFIED OUTPUT POWER.
** SMA FEMALE CONNECTOR ON .141 SEMI-RIGID CABLE

FIGURE I

REV	DATE	DRAWN BY	APPR'D BY	DESCRIPTION

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

NEXT ASSY	USED ON

VLA — L2 50 MHz HARMONIC GENERATOR

TITLE: BLOCK DIAGRAM

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA 22901

DRAWN BY — DATE 12-7-77
DETAILED BY — DATE
APPROVED BY — DATE 3-10-79

SHEET NUMBER 1 OF 1 — DRAWING NUMBER D13230B21 — REV. — SCALE

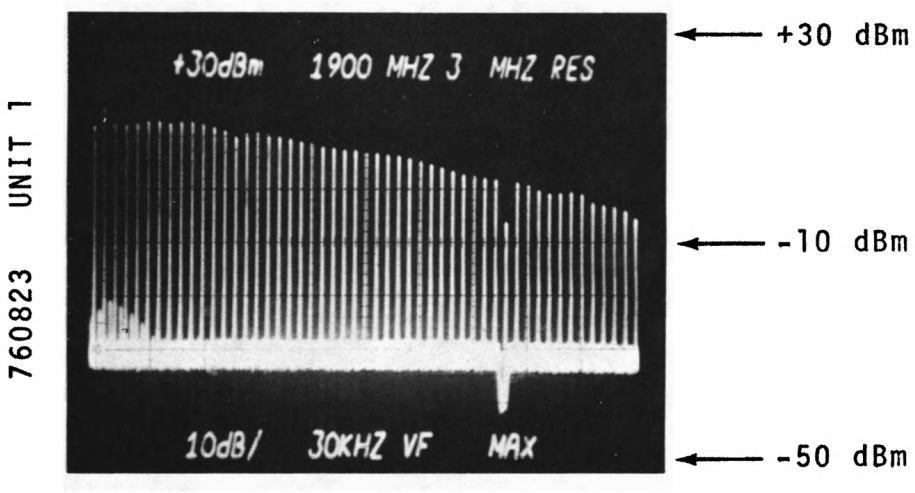
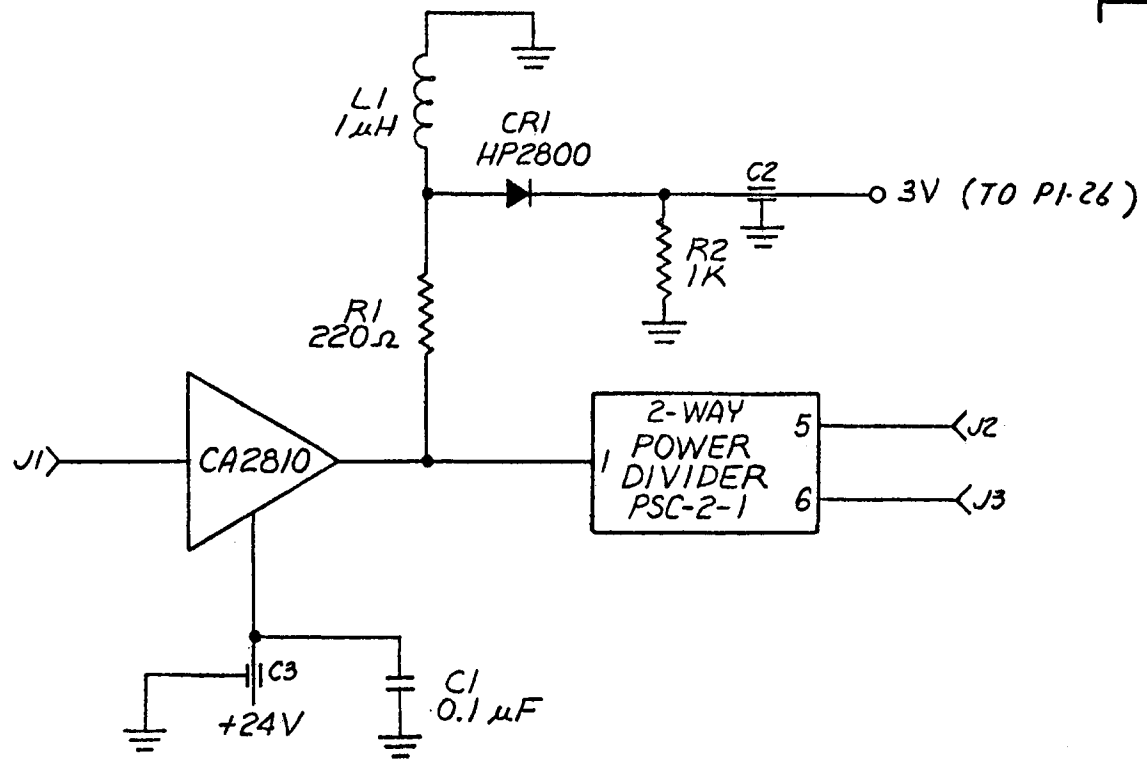


FIGURE 2 - OUTPUT OF 50 MHz COMB GENERATOR

direct output of DC1 is passed through a 3 dB attenuator (to improve matching) and a 150/120 MHz BPF. This provides a 100 to 200 MHz spectrum of the comb. This output is used to provide desired signals at 100 and 200 MHz at Jacks J3 and J2 respectively, after amplification and filtering by 10% bandwidth BPFs (see Fig. 5). The module output power at 50, 100 and 200 MHz is adjusted to the specified values (see block diagram for levels) by putting suitable attenuators between the output band-pass filter and the appropriate OMQ connector. Nominal values of the pads used is 3 dB.

Also the 100 to 200 MHz spectrum is used to get 50 MHz by mixing the signal with itself. This 50 MHz is phase compared with the 50 MHz reference from L1 to phase-lock the 50 MHz voltage controlled crystal oscillator.



NOTE:
1. MOUNTED IN MODIFIED AVANTEK UC-2M CASE WITH AVANTEK FEED THRU CAPACITORS AND CONNECTORS.

FIGURE 5

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

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

MATERIAL:

FINISH:

NEXT ASSY	USED ON
	A13230E69

PROJECT: L2 50 MHz HARMONIC GENERATOR

TITLE: 100-200MHz AMPLIFIER SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY	DATE 12-12-77
DESIGN'D BY	DATE 12-14-76
APPROVED BY	DATE 1-10-78

SHEET NUMBER 1 OF 1 | DRAWING NUMBER B13230S28 | REV. | SCALE

BRUNING 40-22 24984-1

4.0 RFI SHIELDING

During testing of the two prototype units of the module on antennas it was found that at all harmonics of 50 MHz very large signals are radiated in the antenna Vertex Room. This makes the L-Band observations virtually impossible. To keep the radiated signals low enough it was found necessary to completely RFI shield the module. Serious radiation problems due to the 42 pin AMP Connector hole in the back plate of the module was found. Therefore all the pins connected to the AMP Connector had to be filtered and the connector hole had to be shielded. Also high RF leakage which varied with time was found from the OMQ connectors connecting signals at 1200 and 1800 MHz to L3 (J8 and J9 outputs). To solve this problem it was decided that these two outputs will be SMA connectors on a 0·141" semi-rigid cable extending out about 2" from the back of the module. This makes it necessary that before pulling out a module from the rack two SMA connectors on the back should be disconnected. To protect from accidental pulling the module back panel should be screwed to the rack bin plate using a fastener.

5.0 CIRCUIT DETAILS

5.1.1 50 MHz comb generator

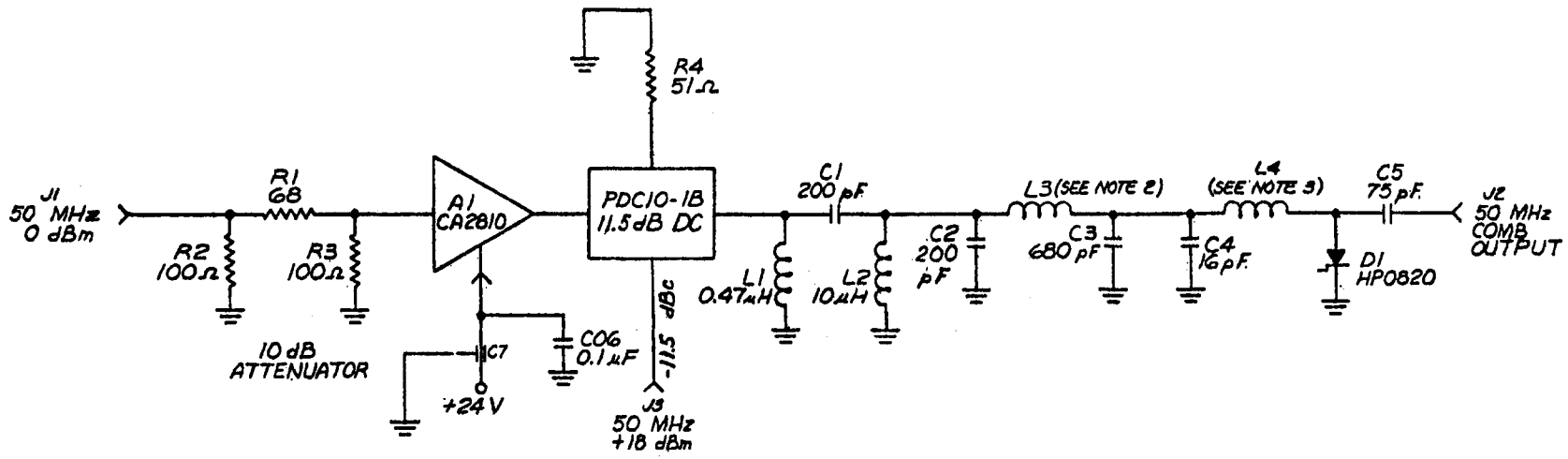
The comb generator unit consists of a 10 dB attenuator, a 32 dB gain 1 Watt output broadband amplifier (type CA2810 made by TRW), a 11·5 dB directional coupler and a 50 MHz comb generator. The comb generator design employs a Step Recovery Diode in shunt mode. For a discussion of the theory and design of comb generators using Step Recovery Diodes see Hewlett-Packard Application Notes 913 and 920.

5.1.2 Diode selection

Consider the selection of a suitable Step Recovery Diode for impulse generator based on the requirements for (i) transit time $\tau_t \leq 1/f_o$ (where f_o = maximum output frequency), (ii) the carrier life time $\tau >> 1/2\pi f_{in}$ (where f_{in} = input frequency), (iii) diode impedance level $10 < X_o < 20\ \Omega$ (where $X_o = 1/2\pi f_o C_{VR}$, C_{VR} = reverse bias capacitance of the diode) assuming a 50 Ω system, (iv) diode package inductance $L_p < X_o/2\pi f_o$, (v) power handling capacity considering maximum dissipation power ($P_{diss\ max}$), and (vi) the reverse breakdown voltage (V_{BR}) for the height of the impulse. For f_{in} = 50 MHz, f_o = 2 GHz and 1 Watt input power with minimum efficiency of 50% power in the impulse the diode hp 5082-0820 with τ = 30 ns, τ_t = 80 ps, $C_{VR(6V)} \geq 1$ pF, $V_{BR} \geq 45$ Volts and package inductance L_p = 1 nH and package capacitance C_p = 0·2 pF is adequate.

5.1.3 Impulse generator - See Figure 3

For the comb generator application the pulse width, t_p, determines the power variation between the various harmonics



NOTES:

1. MOUNTED IN MODIFIED AVANTEK UC-2M CASE WITH AVANTEK FEED THRU CAPACITOR AND CONNECTORS.
2. L3 - FOUR TURNS NO. 20 AWG SILVER PLATED COPPER WIRE; 5mm I.D.
3. L4 - ONE TURN NO. 20 AWG SILVER PLATED COPPER WIRE; 5mm I.D.
4. CAPACITORS C1-C8 ARE PORCELIN CHIP CAPACITORS.
5. ALL RESISTORS ARE 1/8 W.

REV.	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION

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

MATERIAL:

FINISH:

NEXT ASSY	USED ON
A13230270	
C13230P60	C13230P59

VLA

L2
50 MHz HARMONIC GENERATOR

COMB GENERATOR SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA. 22901

DRAWN BY — DATE 12-12-77
DESIGNED BY — DATE 12-14-76
APPROVED BY — DATE

SHEET NUMBER 1 OF 1 — DRAWING NUMBER C13230329 — REV. — SCALE

FIGURE 3

of f_{in}. For the output spectrum of the comb generator to be good to about 2 GHz, the pulse width $t_p \sim 300$ ps. The driving circuit inductance $L_d = (t_p/\pi)^2 C_{VR}^{-1}$ and the tuning capacitance $C_T \simeq C_{VR}(2f_{in}t_p)^{-2}$; which implies that for $C_{VR} = 1$ pF, $L_d = L4 = 10$ nH and $C_T \sim 10^3$ pF. The capacitor C_T carries the RF current at all frequencies and therefore should be good RF capacitor to maximum f_o. For this purpose we have chosen C_T consisting of C3 = 680 pF in parallel with a C4 = 16 pF, the 16 pF being good up to 2 GHz.

5.1.4 Matching, stability and bias circuits

The matching network consists of L3 and C2. The impedance across C_T is essentially resistive and is given by $R_{in} \sim 2\pi f_{in} L_d$. Thus values of $L3 = X_m/\omega_i = 40$ nH and C2 = 250 pF. Values used in actual circuit are shown in Figure 3. The stability of a Step Recovery Diode multiplier is related to the impedance seen by the diode below frequency f_{in} and no high Q series resonance should be allowed at low frequencies. Therefore the RF choke L2 should not be bypassed to ground. Values of C1 and L1 are chosen to form a high pass filter at about 0·8 f_{in} and should be located close to diode closer than $\lambda_{in}/4$ (where λ_{in} = wavelength at input frequency). The values of L2 = 10 μH, L1 = 0·47 μH and C1 = 200 pF are used. The bias resistor $R_b = 2\tau/\pi C_T N^2$ where $N = 1/2\ f_{in} t_p$. In our case $R_b = 2{\cdot}39\ \Omega$. The DC resistance of the 10 μH choke is about this value and therefore it is directly put to ground.

The comb generator output coupling capacitance is 75 pF and is selected to pass the lower harmonics of 50 MHz without attenuating them.

5.2.1 Phase-lock loop - Reference Block Diagram D13230B21 and Schematic C13230S11 (Figure 4)

The 50 MHz signal, derived by dividing 100 to 200 MHz spectrum of the 50 MHz comb and mixing it in mixer M1, is phase compared in mixer M2 with the 50 MHz +10 dBm reference signal from 5 to 50 MHz VCXO (L1) module. The phase error output at the I-port of the balanced mixer M2 is terminated at E7 by 51 Ω (R29) and a 0·001 μF (C7). This provides about 50 Ω at the sum term (100 MHz) and 50 MHz and a high impedance at the difference term (DC) for maximum sensitivity. The phase detector output is amplified by adjustable gain amplifier U1. It employs operational amplifier LM118 with feed back resistor R21 and DC offset pot R12. Output of the amplifier U1 is adjusted to ±10 V peak-to-peak. With resistive divider R18 and R19 a ±5 V p-p can be monitored at E6 on the PC board and pin P1-22 of the AMP connector. A remote open/close loop control is provided by control switch AD7513 (U2). A + TTL "1" to pin P1-21 and E4 opens the loop switch. A 3-position manual switch S1 provides on board open/close position for testing and remote position for remote operation. The control switch (U2) output is connected to the loop integrator U3 through R24. R23 provides a bias return for U3 when the switch U2 is open. DC offset adjustment for U3 is provided by R7. C1, R1 and R24 form the integration time constants. Output of the integrator is applied to the 50 MHz VCXO through an isolating resistor R2. Monitoring of this voltage is provided through an isolating resistor R3 at E3 and pin P1-23. A front panel indicator LED is connected anode to E11 and cathode to E12. When the integrator output has a value of +2·5 V, Q1 will begin to conduct and current

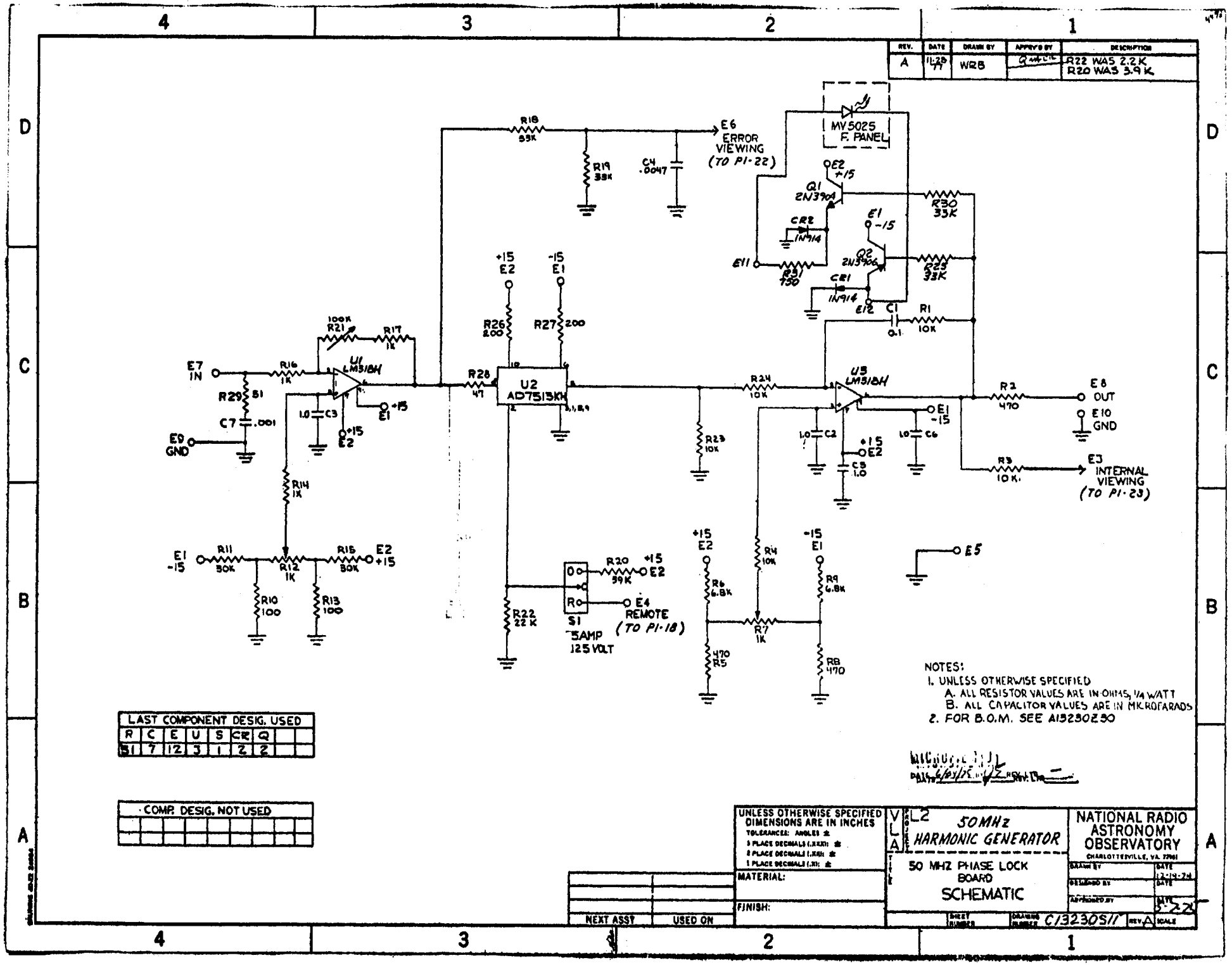

REV. A | DATE 11-20-77 | DRAWN BY WRB | DESCRIPTION R22 WAS 2.2K R20 WAS 3.9K
R18 33K
R19 33K
C4 .0047
E6 ERROR VIEWING (TO P1-22)
MV5025 F. PANEL
Q1 2N3904
Q2 2N3906
CR2 1N914
CR1 1N914
R30 33K
R29 33K
R31 750
E11
E12
C1 0.1
R1 10K
R2 470
E8 OUT
E10 GND
R3 10K
E3 INTERNAL VIEWING (TO P1-23)
E7 IN
E9 GND
R16 1K
R29 51
C7 .001
R21 100K
R17 1K
U1 LM318H
C3 1.0
R14 1K
R11 30K
R12 1K
R15 30K
R10 100
R13 100
R28 47
R26 200
R27 200
U2 AD7513KN
R22 22K
R20 39K
S1 .5AMP 125 VOLT
E4 REMOTE (TO P1-18)
R24 10K
R23 10K
U3 LM318H
C2 1.0
C5 1.0
C6 1.0
R4 10K
R6 6.8K
R5 470
R7 1K
R9 6.8K
R8 470
E5
NOTES:
1. UNLESS OTHERWISE SPECIFIED
A. ALL RESISTOR VALUES ARE IN OHMS, 1/4 WATT
B. ALL CAPACITOR VALUES ARE IN MICROFARADS
2. FOR B.O.M. SEE A13230230
LAST COMPONENT DESIG. USED
R C E U S CR Q
51 7 12 3 1 2 2
COMP. DESIG. NOT USED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
MATERIAL:
FINISH:
NEXT ASSY
USED ON
VLA
VLL2 50MHz HARMONIC GENERATOR
50 MHz PHASE LOCK BOARD SCHEMATIC
NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA 22901
DRAWN BY
DATE 12-14-78
DESIGNED BY
APPROVED BY
DATE 3-22
DRAWING NUMBER C13230511
REV A
SCALE

FIGURE 4

will flow through Q1 emitter resistor R31, the LED and CR1 to ground. At +5 V and up Q1 is saturated and the LED is full ON. Operation in the negative direction is through Q2, the LED, R31 and CR2.

5.2.2 Loop characteristics

The basic purpose of the VCXO is to provide filtering to eliminate harmonics of 5 MHz and to restrict the AM and FM noise sidebands prior to further multiplication. For the theory of operation of phase-lock loops and terminology used here see Phase-Lock Techniques by F.M. Gardner (John Wiley and Sons, Inc., New York 1966).

The detector gain K_D is determined by the output of the phase detector and the gain setting of U1. The phase detector output is sinusoidal. For R21 set to give ±10 V p-p at the output of U1 we have K_D = 10 V/rad. From the VCXO characteristics the oscillator control sensitivity is 50 Hz/Volt. Therefore the VCO gain constant $K_o = 2\pi \times 50$ radian/Volt. We assume a loop bandwidth that will provide pull in and lock with a maximum open loop error of ±650 Hz (due to limits of the loop integrator output at ±13 V and the VCO sensitivity of 50 Hz/V). Using the values for R24, C1 and R1 as used in the circuit we calculate values of the loop natural frequency ω_n, the loop damping factor ζ and pull in range $\Delta\omega_p$.

$$T_1 = R24.C1 = 10^4 \times 0{\cdot}1 = 0{\cdot}001 \text{ S}$$

$$T_2 = R1\ C1 = 10^4 \times 0{\cdot}1 = 0{\cdot}001 \text{ S}$$

$$\omega_n = (K_o K_D)^{\frac{1}{2}}/T_1$$

$$\doteq 1775 \text{ rad/S} = 282 \text{ Hz}$$

$$\zeta = \frac{T_2}{Z} \cdot \omega_n$$

$$= \frac{0 \cdot 001}{2} \times 1775 = 0 \cdot 89$$

$$\Delta\omega_p = 2(\zeta\omega_n K_o K_D)^{\frac{1}{2}}$$

$$= 709 \text{ Hz}$$

The loop tracks dynamically with an error of -40 dB/decade below the loop corner frequency. This would give an error of about -90 dB at 1 Hz (1 Hz being over all 600 MHz loop bandwidth at antenna) and provides excellent tracking of 5 MHz (x 10) oscillator signal. Outside the loop natural frequency ω_n the frequency response falls off 20 dB/decade and the signal spectrum rapidly becomes that of the 50 MHz VCXO.

Spectrum Analyser dynamic range limits a direct measurement of signal to FM noise ratio at 5 or 50 MHz. We estimate it using the following procedure:

a) The 50 MHz VCXO specifications require that output carrier to noise ratio in 1 MHz bandwidth should be at least 100 dB. Without detail data of the noise spectrum it is hard to predict the behavior exactly. However it is reasonable to assume that noise outside 100 Hz will be at least 20 dB lower than around the carrier, i.e. oscillator noise 100 Hz away from the carrier will be ≈ -180 dBc/Hz. Within the loop natural frequency of 282 Hz most of the noise will be that due to the 5 MHz (x 10) VCXO.

b) 50 MHz VCXO power to the amplifier in comb generator = 0 dBm and the noise figure of

the amplifier = 8 dB.

c) The noise power in 1 Hz bandwidth at room temperature = -174 dBm/Hz.

d) Therefore the signal-to-noise ratio at 600 MHz in a 300 kHz bandwidth should be = -174 + (NF = 8 dB) + 10 log (BW = 3×10^5) + 20 log (600/50) ≈ -89 dB.

Measured signal-to-noise ratio 3 MHz on either side of the carrier using HP spectrum analyzer 141 T on the comb output with a 600/50 MHz BPF is better than 86 dB. This is in good agreement with the estimated value. Measurement closer to the carrier is not possible due to the limits of the spectrum analyzer.

6.0 PROCEDURE TO SET UP PHASE-LOCK LOOP - Reference Block Diagram D13230B21 and Schematic C13230S11

a) Adjustment of the 50 MHz VCXO frequency - (i) with a frequency counter on external reference (from L1 module) and the VCXO frequency control port connected to ground adjust the VCXO "Frequency" pot to measure 50,000,000 ± 50 Hz on the counter, (ii) with the VCXO frequency control port connected to +10 V DC set the VCXO "MOD.SENS." pot to give 50,000,500 ± 50 Hz and with -10 V DC read 49,999,500 ± 50 Hz.

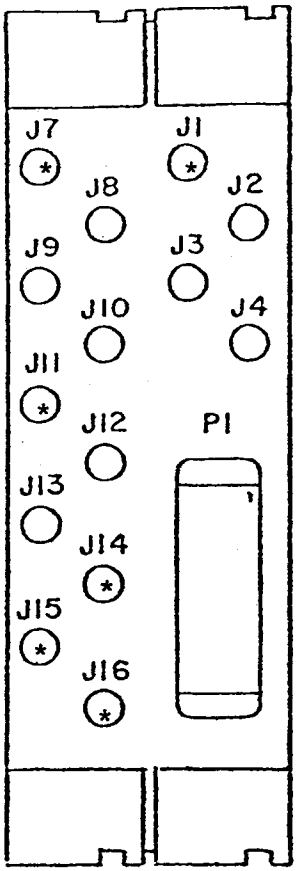
b) With all the module internal connections normal and (i) a +10 dBm 50 MHz signal from L1J1 to L2J10 and (ii) the toggle switch S1 on the phase-lock PC board in open position adjust gain pot R21 to give a +10 V p-p at P1-22 (or E6) at about 500 Hz and pot R12 to set DC offset to about zero (±100 mV).

c) Close the toggle switch S1. The loop should lock to 50,000,000 Hz on the counter and the frequency control voltage as measured at P1-23 (or E8) should be about zero (±1 V).

d) Check the phase error voltage at P1-22 (or E6). It should be within -100 to +200 mV when the loop is locked. Otherwise adjust the DC offset pot R7.

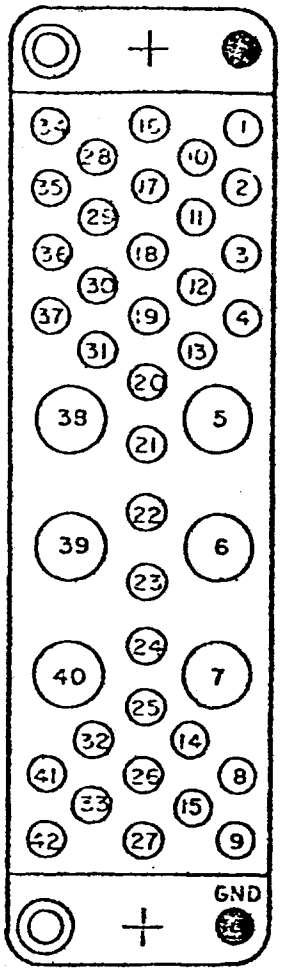
e) Set the toggle switch S1 to remote position. Apply a +5 V DC to pin P1-21. The loop should open.

7.0 INPUT-OUTPUT CONNECTIONS AND POWER LEVELS



DOUBLE WIDE MODULE
(REAR VIEW)

CONN	FUNCTION
J1	
J2	
J3	+15·5 ± 1·5 dBm @ 200 MHz Output
J4	+15·5 ± 1·5 dBm @ 100 MHz Output
J7	+17 ± 2 dBm @ 50 MHz Output
J8	-1·5 ± 1·5 dBm @ 1200 MHz Output
J9	-1·5 ± 1·5 dBm @ 1800 MHz Output
J10	+10 ± 1 dBm @ 50 MHz Input
J11	
J12	50 MHz Comb -10 ± 5 dBm/line Output
J13	50 MHz Comb -10 ± 5 dBm/line Output
J14	
J15	
J16	



P1 (REAR VIEW)

P1					
PIN	FUNCTION	WIRE COLOR	PIN	FUNCTION	WIRE COLOR
1			22	50 MHz PLL Phase-Error	
2			23	50 MHz VCXO Control Voltage	
3			24		
4			25		
5			26	50 MHz Comb Output Power	
6			27		
7			28		
8			29		
9			30		
10	+5VDC		31		
11			32		
12			33		
13			34	PWR. GROUND	BLACK
14			35		
15			36		
16	+15VDC		37		
17	-15VDC		38		
18	Open 50 MHz Loop (Control, CMOS)		39		
19			40		
20			41		
21			42	HIGH QUAL. GROUND	

* INDICATES A FUNCTION NOT FOUND IN THIS MODULE.

8.0 BILLS OF MATERIALS

50 MHz HARMONIC GENERATOR

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

MODULE: L02 PROJECT NO. 13230 DRAWING NO.: A13230Z30
DATA SET: 50/600 MHZ MULTIPLIER BOM: 50 MHZ PHASE LOCK BOARD 0

MOD-Q/S-Q/M		DESCR	VALUE		MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L02		DSA			A13230Z30	NRAO	1	A13230Z30	50 MHZ PHASE LOCK BOARD 0	0.00
L02	1	EPCD			C13230M67	NRAO	2	A13230Z30	50 MHZ PHASE LOCK BRD DRL6	0.00
L02		R 04	10.0	K	RCR07 103-5S		3	A13230Z30	RESISTOR 1/4W	0.06
L02		R 03	10.0	K	RCR07 103-5S		3	A13230Z30	RESISTOR 1/4W	0.06
L02	5	R 01	10.0	K	RCR07 103-5S		3	A13230Z30	RESISTOR 1/4W	0.06
L02		R 24	10.0	K	RCR07 103-5S		3	A13230Z30	RESISTOR 1/4W	0.06
L02		R 23	10.0	K	RCR07 103-5S		3	A13230Z30	RESISTOR 1/4W	0.06
L02	3	R 02	470.0		RCR07 471-5S		4	A13230Z30	RESISTOR 1/4W	0.06
L02		R 05	470.0		RCR07 471-5S		4	A13230Z30	RESISTOR 1/4W	0.06
L02		R 08	470.0		RCR07 471-5S		4	A13230Z30	RESISTOR 1/4W	0.06
L02	2	R 06	6.8	K	RCR07 682-5S		5	A13230Z30	RESISTOR 1/4W	0.06
L02		R 09	6.8	K	RCR07 682-5S		5	A13230Z30	RESISTOR 1/4W	0.06
L02		R 12	1.0	K	3339H-1-102	BOURNS	6	A13230Z30	POTENTIOMETER 4 TURN	1.53
L02	2	R 07	1.0	K	3339H-1-102	BOURNS	6	A13230Z30	POTENTIOMETER 4 TURN	1.53
L02	2	R 10	100.0		RCR07 101-5S		7	A13230Z30	RESISTOR 1/4W	0.06
L02		R 13	100.0		RCR07 101-5S		7	A13230Z30	RESISTOR 1/4W	0.06
L02	2	R 15	30.0	K	RCR07 303-5S		8	A13230Z30	RESISTOR 1/4W	0.06
L02		R 11	30.0	K	RCR07 303-5S		8	A13230Z30	RESISTOR 1/4W	0.06
L02		R 16	1.0	K	RCR07 102-5S		9	A13230Z30	RESISTOR 1/4W	0.06
L02	3	R 14	1.0	K	RCR07 102-5S		9	A13230Z30	RESISTOR 1/4W	0.06
L02		R 17	1.0	K	RCR07 102-5S		9	A13230Z30	RESISTOR 1/4W	0.06
L02	4	R 25	33.0	K	RCR07 333-5S		10	A13230Z30	RESISTOR 1/4W	0.06
L02		R 30	33.0	K	RCR07 333-5S		10	A13230Z30	RESISTOR 1/4W	0.06
L02		R 19	33.0	K	RCR07 333-5S		10	A13230Z30	RESISTOR 1/4W	0.06
L02		R 18	33.0	K	RCR07 333-5S		10	A13230Z30	RESISTOR 1/4W	0.06
L02	1	R 20	39.0	K	RCR07 393-5S		11	A13230Z30	RESISTOR 1/4W	0.06
L02		R 27	200.0		RCR07 201-5S		12	A13230Z30	RESISTOR 1/4W	0.06
L02	2	R 26	200.0		RCR07 201-5S		12	A13230Z30	RESISTOR 1/4W	0.06
L02	1	R 28	47.0		RCR07 470-5S		13	A13230Z30	RESISTOR 1/4W	0.06
L02	1	R 29	51.0		RCR07 510-5S		14	A13230Z30	RESISTOR 1/4W	0.06
L02	1	R 22	2.2	K	RCR07 222-5S		15	A13230Z30	RESISTOR 1/4W	0.06
L02	1	R 21	100.0	K	3339H-1-104	BOURNS	16	A13230Z30	POTENTIOMETER 4 TURN	1.53
L02		C 03	1.0	UF	8131-050-651-105M	ERIE	17	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02		C 05	1.0	UF	8131-050-651-105M	ERIE	17	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02		C 06	1.0	UF	8131-050-651-105M	ERIE	17	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02	4	C 02	1.0	UF	8131-050-651-105M	ERIE	17	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02	1	C 04	4700.0	PF	8121-050-651-472M	ERIE	18	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	0.11
L02	1	C 01	0.1	UF	192P1049R8	SPRAGUE	19	A13230Z30	CAPACITOR, MYLAR	0.29
L02		E 09			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 05			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 08			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 03			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 07			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 04			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 11			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 06			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 10			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 02			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02		E 12			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02	12	E 01			1587-1	KEYSTONE	20	A13230Z30	TERMINAL,TURRET .125 4-40THD	0.09
L02	2	U 01			LM318H	NAT SEMICOND	21	A13230Z30	OP AMP	1.88
L02		U 03			LM318H	NAT SEMICOND	21	A13230Z30	OP AMP	1.88

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L02	2	J		DP-5178	ROB NUGENT	22	A13230Z30	SOCKET,8 PIN TO-5	1.98
L02	1	U 02		AD7513KH	ANALOG DEV	23	A13230Z30	SWITCH,ANALOG	3.50
L02	1	J		DP-5171C-T-23	ROB NUGENT	24	A13230Z30	SOCKET, 10 PIN TC-5	3.18
L02	4	MPP		1596-2	KEYSTONE	25	A13230Z30	STANDOFF,SWAGE 2-56 3/8H	0.08
L02	1	C 07	0.001UF	8101-050-651-102M	ERIE	26	A13230Z30	CAPACITOR,MONOLYTHIC 50VDC	0.10
L02	1	S 01		MTM106E-PC	ALCO	27	A13230Z30	SWITCH, TOGGLE PC	1.61
L02		DSH		C13230S11	NRAO	28	A13230Z30	50 MHZ PHASE LCK BRD SCH 2	0.00
L02	1	EPCA		B13230A801	NRAO	29	A13230Z30	50/600 MHZ MULT PHASE LOK4	4.75
L02	1	Q 01		2N3904	MOTOROLA	30	A13230Z30	TRANSISTOR,AMPLIFIER NPN	0.12
L02		CR 02		1N914B	GE	31	A13230Z30	DIODE,GENL PUR	0.07
L02	2	CR 01		1N914B	GE	31	A13230Z30	DIODE,GENL PUR	0.07
L02	1	R 31	750.0	RCR07 751-5S		32	A13230Z30	RESISTOR 1/4W	0.06
L02	1	Q 02		2N3906	MOTOROLA	33	A13230Z30	TRANSISTOR,AMPLIFIER PNP	0.12
L02	2	X		3-LPS-B	CINCH	34	A13230Z30	SOCKET,TRANSISTOR TO-5,TO-18	0.12
L02	01	EPCP		C13230P40	NRAO	35	A13230Z30	50 MHZ PHASE LCK BRD ASSY1	0.00

*** TOTAL COST= 34.47 ***

50 MHz HARMONIC GENERATOR

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

MODULE: L02 PROJECT NO. 13230 DRAWING NO.: A13230Z66
DATA SET: 50/600 MHZ MULTIPLIER BOM: 50 MHZ HARM GEN TOP ASSY 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L02		NST		A13230Z66	NRAO	01	A13230Z66	50 MHZ HARM GEN TOP ASSY 0	0.00
L02	01	MPM		C13210M04	NRAO	02	A13230Z66	PANEL, REAR E	15.93
L02	01	MPM		D13231M09-1	NRAO	03	A13230Z66	BAR, SUPPORT, TOP G	32.00
L02	01	MPM		D13231M09-2	NRAO	05	A13230Z66	BAR, SUPPORT, BOTTOM G	32.00
L02	01	MPM		D13231M14	NRAO	06	A13230Z66	PARTITION PLATE H	32.00
L02	01	MPM		B13230M20	NRAO	07	A13230Z66	PANEL, FRONT A	27.44
L02	01	DC 02		ZMDC-10-1	MINI CKT LABS	08	A13230Z66	11-5DB DIR CPLR 300MHZ-1GHZ	40.00
L02	01	PD 03		ZMSC-2-1	MINI CKT LABS	09	A13230Z66	2 WAY POWER DIVIDER	50.00
L02	01	FL 02		4B120-50/20-0	K&L MICROWAVE	10	A13230Z66	FILTER,TUBULAR BP	45.00
L02	01	FL 01		4B120-150/120-0	K&L MICROWAVE	11	A13230Z66	FILTER,TUBULAR BP	45.00
L02	01	FL 03		4B120-1800/180-0	K&L MICROWAVE	12	A13230Z66	FILTER,TUBULAR BP	45.00
L02	01	FL 04		4B120-1200/120-0	K&L MICROWAVE	13	A13230Z66	FILTER,TUBULAR BP	45.00
L02	01	FL 05		4B120-100/20-0	K&L MICROWAVE	14	A13230Z66	FILTER,TUBULAR BP	45.00
L02	01	FL 06		4B120-200/20-0	K&L MICROWAVE	15	A13230Z66	FILTER,TUBULAR BP	45.00
L02	33	P		OSM-201-1A	OMNI-SPECTRA	16	A13230Z66	CONNECTOR,PLUG 141SR	0.85
L02	07	P		OSM-201-1	OMNI-SPECTRA	17	A13230Z66	CONNECTOR,PLUG 141SR	0.94
L02	03	P		OSM-218	OMNI-SPECTRA	18	A13230Z66	ADAPTER,STRGHT PLUG/PLUG	4.56
L02	08	P		OMQ-3043-75	OMNI-SPECTRA	19	A13230Z66	JACK,BLKHD RP MOUNT 141SR	1.50
L02	02	P		OSM-531-3	OMNI-SPECTRA	20	A13230Z66	PLUG RT ANGL RG188	3.57
L02	01	PD 01		H-8-4	ANZAC	21	A13230Z66	2 WAY POWER DIVIDER	200.00
L02	01	DC 01		DCG-10-4	ANZAC	22	A13230Z66	COUPLER,10DB 30MHZ-1GHZ	64.00
L02	01	PD 02		T-1000	ANZAC	23	A13230Z66	2 WAY POWER DIVIDER	80.00
L02	01	VCXO		VCXO-10	ISOTEMP	24	A13230Z66	OSCILLATOR,VOLT CONTR 50MHZ	178.00
L02	02	AT 01		FP87-03	TEXSCAN	25	A13230Z66	3DB ATTENUATOR	35.00
L02		AT 02		FP87-03	TEXSCAN	25	A13230Z66	3DB ATTENUATOR	35.00
L02	02	A 02		UTA-8713M	AVANTEK	26	A13230Z66	AMPLIFIER, 1-2GHZ	218.00
L02		A 03		UTA-8713M	AVANTEK	26	A13230Z66	AMPLIFIER, 1-2GHZ	218.00
L02	02	M 01		M1A	WATKINS JOHN	27	A13230Z66	MIX,DBL BAL DC-1GHZ SMA CON	72.00
L02		M 02		M1A	WATKINS JOHN	27	A13230Z66	MIX,DBL BAL DC-1GHZ SMA CON	72.00
L02	01	P		204186-5	AMP SPEC IND	28	A13230Z66	BLOCK,PIN 42 MIXER	1.68
L02	01	P		202394-2	AMP SPEC IND	29	A13230Z66	HOOD,PIN(42 AND 50 BLOCK)	0.87
L02	01	P		202514-1	AMP SPEC IND	30	A13230Z66	GROUND GUIDE PIN	0.42
L02	01	P		200833-4	AMP SPEC IND	31	A13230Z66	GUIDE PIN	0.23
L02	02	P		203964-6	AMP SPEC IND	32	A13230Z66	GUIDE SOCKET	0.21
L02	01	NSA		A13230Z30	NRAO	33	A13230Z66	50 MHZ PHASE LOCK BOARD 0	0.00
L02		L 02		42605	FREED TRANS	34	A13230Z66	TOROIDAL INDUCTOR 0.1MH	8.90
L02		L 03		42605	FREED TRANS	34	A13230Z66	TOROIDAL INDUCTOR 0.1MH	8.90
L02	03	L 01		42605	FREED TRANS	34	A13230Z66	TOROIDAL INDUCTOR 0.1MH	8.90
L02	01	C 01		8141-050-651-225M	ERIE	35	A13230Z66	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02	01	C 02		CS13BE156K	SPRAGUE	36	A13230Z66	CAPACITOR,TANTALUM 20VDC	0.24
L02	01	C 03		8141-050-651-225M	ERIE	37	A13230Z66	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02	01	C 04		CS13BE156K	SPRAGUE	38	A13230Z66	CAPACITOR,TANTALUM 20VDC	0.24
L02	01	C 05		8141-050-651-225M	ERIE	39	A13230Z66	CAPACITOR,MONOLYTHIC 50VDC	1.23
L02	01	C 06		CS13BE685K	SPRAGUE	40	A13230Z66	CAPACITOR,TANTALUM 35VDC	0.24
L02	01	DC 03		2023-6121-06	OMNI-SPECTRA	41	A13230Z66	DIRECTIONAL COUPLER 1-2 GHZ	110.00
L02	04	H		47-10-204-10	SOUTHCO	42	A13230Z66	FASTNER,CAPTIVE	0.67
L02	38	H		PHSS 4-40 X 0.250	HW	43	A13230Z66	PAN HEAD SLOTTED SS	0.02
L02	16	H		PHSS 6-32 X 1900	HW	44	A13230Z66	PAN HEAD SLOTTED SS	0.02
L02	20	H		FHSS 6-32 X 0.375	HW	45	A13230Z66	FLAT HEAD SLOTTED SS SCREW	0.02
L02	06	H		PHSS 2-56 X 0.250	HW	46	A13230Z66	PAN HEAD SLOTTED SS	0.02
L02	02	H		PHSS 2-56 X 0.500	HW	47	A13230Z66	PAN HEAD SLOTTED SS	0.02
L02	02	VR 01		UA78M24UC	FAIRCHILD	48	A13230Z66	+24V VOLTAGE REGULATOR	1.00

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L02		VR 02		UA78M24UC	FAIRCHILD	48	A13230Z66	+24V VOLTAGE REGULATOR		1.00
L02	01	A 01		A13230Z67	NRAO	49	A13230Z66	BROAD BAND AMPL ASSY	O	0.00
L02	01	CG1		A13230Z68	NRAO	50	A13230Z66	50 MHZ COMB GEN ASSY	O	0.00
L02	15			51-723-301	SPEC CONTROL	51	A13230Z66	RFI SUPP FILTER SOLDER		2.00
L02	01			B13230AA19	NRAO	52	A13230Z66	FRONT PANEL SILKSCREEN	S	0.00
L02	01	CR		MV5025	MONSANTO	53	A13230Z66	LED,RED		0.30
L02	10	H		M12-A	K&L MICROWAVE	54	A13230Z66	MOUNTING CLIP		0.05
L02	08	MPM		B13231M27	NRAO	55	A13230Z66	PARTITION PLATE SPACER	M	5.00
L02	08	H		HSHS 6-32 X 1.250	HW	56	A13230Z66	HEX-SOCKET HD SLOTTED SS		0.02
L02	44	H		SST1M-MP	PANDUIT	57	A13230Z66	TIE WRAP,CABLE		0.02
L02	01	MPM		GASKETAMPCONN	TECKNIT	58	A13230Z66	PER B13231M36		2.25
L02	01	MPM		B13231M32	NRAO	58	A13230Z66	POWER CONN SHIELD BOX	L	5.00
L02	01	MPM		B13231M34	NRAO	59	A13230Z66	GASKET, SHIELD BOX	U	2.00
L02	05	FT		20-11101	TECKNIT	60	A13230Z66	1/8 ROUND RFI BRAID		1.80
L02	09	MPM		B13231M31	NRAO	61	A13230Z66	PWR CONN PIN CNTR FERRULE	M	0.50
L02	04	MPM		B13231M30	NRAO	62	A13230Z66	PWR CONN SHIELD SPACER	M	1.50
L02	01	BD		D13230B21	NRAO	63	A13230Z66	BLOCK DIAGRAM	7	0.00
L02	09	P.		204188-1	AMP SPEC IND	64	A13230Z66	CONTACT, PIN		0.23
L02	01	H		1411-4	H H SMITH	65	A13230Z66	LUG,TERMINAL LOCK		0.15
L02	01	MPM		B13231M26	NRAO	66	A13230Z66	REAR SPACER	M	2.00
L02	01	FL 07		6L120-1050-0	K&L MICROWAVE	67	A13230Z66	FILTER,TUBULAR LP		110.00

*** TOTAL COST= 2111.88 ***

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

MODULE: L02
DATA SET: 50/600 MHZ MULTIPLIER

PROJECT NO. 13230

DRAWING NO.: A13230Z67
BOM: BROAD BAND AMPL ASSY 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L02		NSA		A13230Z67	NRAO	01	A13230Z67	BROAD BAND AMPL ASSY	0	0.00
L02	01	DSA		C13230P58	NRAO	02	A13230Z67	BROAD BAND AMPL ASSY	1	0.00
L02	01	MPN		B13231M17	NRAO	03	A13230Z67	COMB GEN/AMPL SPACER	M	5.00
L02	02	H		PHSS 6-32 X 0.562	HW	04	A13230Z67	PAN HEAD SLOTTED SS		0.02
L02	01	P		2052-5516	OMNI-SPECTRA	05	A13230Z67	JACK/TERM 4 HOLE FLANGE		5.00
L02	01	P		330-001767-001	AVANTEK	06	A13230Z67	UC VOLTAGE ACCESSORY PACK		5.00
L02	01	P		38-000593	AVANTEK	07	A13230Z67	UC ACCESSORY PACK		2.50
L02	01	MPZ		UC2-M	AVANTEK	08	A13230Z67	ENCLOSURE		25.00
L02	01	NSB		A13230Z69	NRAO	09	A13230Z67	BROAD BAND AMP PCB ASSY	0	0.00
L02	04	H		PHSS 4-40 X 0.250	HW	10	A13230Z67	PAN HEAD SLOTTED SS		0.02
L02	01	MPZ		B13231M11	NRAO	11	A13230Z67	STEP REC DIODE BBAND AMPLU		30.00
L02	05	H		PHSS 0-80 X 0.188	HW	12	A13230Z67	PAN HEAD SLOTTED SS		0.02
L02	05	H		SLWS #0	HW	13	A13230Z67	SPLIT-LOCK WASHER SS		0.02
L02	02	H		B13231M36	NRAO	14	A13230Z67	GASKET	U	2.00

*** TOTAL COST= 76.82 ***

50 MHz HARMONIC GENERATOR

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

MODULE: L02 PROJECT NO. 13230 DRAWING NO.: A13230Z68
DATA SET: 50/6C0 MHZ MULTIPLIER BOM: 50 MHZ COMB GEN ASSY 0

MOD-C/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION		COST
L02		NSA		A13230Z68	NRAO	01	A13230Z68	50 MHZ CCMB GEN ASSY	0	0.00
L02	01	DSA		C13230P59	NRAO	02	A13230Z68	50 MHZ CCMB GEN ASSY	1	0.00
L02	01	MPN		B13231M17	NRAO	03	A13230Z68	COMB GEN/AMPL SPACER	M	5.00
L02	02	H		PHSS 6-32 X 0.562	HW	04	A13230Z68	PAN HEAD SLCTTED SS		0.02
L02	01	P		2052-5516	OMNI-SPECTRA	05	A13230Z68	JACK/TERM 4 HCLE FLANGE		5.00
L02	01	P		330-001767-001	AVANTEK	06	A13230Z68	UC VOLTAGE ACCESSORY PACK		5.00
L02	01	MPZ		UC2-M	AVANTEK	08	A13230Z68	ENCLOSURE		25.00
L02	01	NSB		A13230Z70	NRAO	09	A13230Z68	COMB GEN PCB ASSY	0	0.00
L02	04	H		PHSS 4-40 X 0.250	HW	10	A13230Z68	PAN HEAD SLCTTED SS		0.02
L02	01	MPZ		B13231M11	NRAO	11	A13230Z68	STEP REC DICDE BBAND AMPLU		30.00
L02	05	H		PHSS 0-80 X 0.188	HW	12	A13230Z68	PAN HEAD SLOTTED SS		0.02
L02	05	H		SLWS #0	HW	13	A13230Z68	SPLIT-LCCK WASHER SS		0.02
L02	01	H		622-000401-001	AVANTEK	14	A13230Z68	PLUG		2.00
L02	02	H		B13231M36	NRAO	15	A13230Z68	GASKET	U	2.00
L02	01	MPM		GASKETSR	TECKNIT	15	A13230Z68	PER B13231M34		2.25

*** TOTAL COST= 78.57 ***

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

MODULE: L02 PROJECT NO. 13230 DRAWING NO.: A13230Z69
DATA SET: 50/600 MHZ MULTIPLIER BOM: BROAD BAND AMP PCB ASSY 0

MOD-C/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L02		NSB		A13230Z69	NRAO		A13230Z69	BROAD BAND AMP PCB ASSY 0	0.00
L02	01	EPCB		C13230P57	NRAO	01	A13230Z69	BROAD BAND AMP PCB ASSY 1	0.00
L02	01	EPCA		B13230AB32	NRAO	02	A13230Z69	AMP & 2-WAY PWR DIV PCBAW4	0.00
L02	01	EPCD		B13231M10	NRAO	03	A13230Z69	AMPL & 2-WAY PWR DIV DR D6	0.00
L02	01	P		PSC-2:1	MINI CKT LABS	04	A13230Z69	POWER,SPLTR 3DB .1-400MHZ	9.45
L02	01	A1		CA2810	TRW	05	A13230Z69	WIDE BAND AMPLIFIER	50.00
L02	01	CR 01		5082-2800	HEWLETT PACK	06	A13230Z69	DIODE,HOT CARRIER	1.20
L02	01	C 01	0.1 UF	8131-050-651-104M	ERIE	07	A13230Z69	CAPACITOR,MONOLYTHIC 50V	0.19
L02	01	L 01	1.0 UF	9230-20	MILLER	08	A13230Z69	CHOKE,RF MICRO MINATURE	0.30
L02	01	R 01	220.0	RCR05 221-5S		09	A13230Z69	RESISTOR 1/8W	0.22
L02	01	R 02	1.0 K	RCR05 102-5S		10	A13230Z69	RESISTOR 1/8W	0.22
L02	01	DSH		B13230S28	NRAO	11	A13230Z69	AMPL & 2-WAY PWR DIV SCH 2	0.00

*** TOTAL COST= 61.58 ***

50 MHz HARMONIC GENERATOR

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

MODULE: L02 PROJECT NO. 13230 DRAWING NO.: A13230Z70
DATA SET: 50/600 MHZ MULTIPLIER BOM: COMB GEN PCB ASSY 0

MOD-Q/S-Q/M		DESCR	VALUE	MFG. PART NO.	MANUFACTURER	ITEM#	BOM#	DESCRIPTION	COST
L02		NSB		A13230Z70	NRAO		A13230Z70	COMB GEN PCB ASSY 0	0.00
L02	01	EPCP		C13230P60	NRAO	01	A13230Z70	50 MHZ COMB GEN PCB ASSY 1	0.00
L02	01	EPCA		B13230AB31	NRAO	02	A13230Z70	STEP RECOVERY DIODE PCB 4	0.00
L02	01	EPCD		B13231M08	NRAO	03	A13230Z70	STEP RECOV DIODE DR DIAG 6	0.00
L02	01	DSH		C13230S29	NRAO	04	A13230Z70	COMB GEN SCHEMATIC 2	0.00
L02	01	A 01		CA2810	TRW	08	A13230Z70	WIDE BAND AMPLIFIER	50.00
L02	01	P		PCD10-1B	MINI CKT LABS	09	A13230Z70	COUPLER,10DB	100.00
L02	01	CR 01		HP0820	HEWLETT PACK	10	A13230Z70	STEP RECOVERY DIODE	25.00
L02	02	C 01	200.0 PF	ATC-B-201-K-P-300	AMER TECH CER	11	A13230Z70	PORCELAIN CHIP CAPACITORS	6.00
L02		C 02	200.0 PF	ATC-B-201-K-P-300	AMER TECH CER	11	A13230Z70	PORCELAIN CHIP CAPACITORS	6.00
L02	01	C 03	680.0 PF	ATC-B-691-K-P-100	AMER TECH CER	12	A13230Z70	PORCELAIN CHIP CAPACITORS	6.00
L02	01	C 04	16.0 PF	ATC-B-160-K-P-500	AMER TECH CER	13	A13230Z70	PORCELAIN CHIP CAPACITORS	6.00
L02	01	C 05	75.0 PF	ATC-B-750-K-P-500	AMER TECH CER	14	A13230Z70	PORCELAIN CHIP CAPACITORS	6.00
L02	01	C 06	0.1 MF	8131-050-651-104M	ERIE	15	A13230Z70	CAPACITOR,MONOLYTHIC 50V	0.19
L02	01	L 01	0.47 MH	9230-12	MILLER	16	A13230Z70	CHOKE,.47MH 10%	0.65
L02	01	L 02	10.0 MH	9230-44	MILLER	17	A13230Z70	CHOKE,10MH 10%	0.60
L02	01	L 03		C13230P60	NRAO	18	A13230Z70	50 MHZ COMB GEN PCB ASSY 1	0.00
L02	01	L 04		C13230P60	NRAO	19	A13230Z70	50 MHZ COMB GEN PCB ASSY 1	0.00
L02	01	R 01	68.0	RCR05 680-5S		20	A13230Z70	RESISTOR 1/8W	0.22
L02	02	R 02	100.0	RCR05 101-5S		21	A13230Z70	RESISTOR 1/8W	0.22
L02		R 03	100.0	RCR05 101-5S		21	A13230Z70	RESISTOR 1/8W	0.22
L02	01	R 04	51.0	RCR05 510-5S		22	A13230Z70	RESISTOR 1/8W	0.22

*** TOTAL COST= 207.32 ***

*** TOTAL COST FOR MODULE L02 IS 2570.64 ***

9.0 SPECIFICATIONS AND MANUFACTURER'S DATA SHEETS

NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VIRGINIA
VERY LARGE ARRAY PROJECT

SPECIFICATION NO.: 13220N1

NAME: Voltage Controlled XTAL Oscillator

DATE: February 13, 1974

PREPARED BY: _____ APPROVED BY: _____

1. TYPE: Overtone resonator, fundamental oscillator and buffer amplifier output

2. OUTPUT FREQUENCY: = 50 MHz

3. OUTPUT POWER: = 10.0 mW min.

4. OUTPUT IMPEDANCE: = 50 Ω

5.
   a. Setability = 1×10^{-7} = 5 Hz over temp. range in 9.a
   b. Setability Range = a combination of mech. trim for 5 years aging and electrical trim for 30 day aging.

6.
   a. Voltage/Freq. Control = ± .5 kHz, ± 10 V 3 point average
   b. Linearity $\Delta f/\Delta V$ = .9 to 1.1
   c. Tuning Rate = 0 to 10 kHz full deviation
   d. Input Impedance = 2000 Ω or greater DC to 10 kHz

7. FREQUENCY STABILITY $\Delta f/f_o$ = 1×10^{-8} in .01 seconds
   1×10^{-8} in .1 seconds
   1×10^{-8} in 1.0 seconds
   2×10^{-8} in 10 seconds
   1×10^{-7} in 8 hours

8. OUTPUT CNR = 100 dB in 1 MHz BW

30 day drift must not limit 6 (a) (b)

9. ENVIRONMENTAL

a. Design to operate at a stable ambient or mounted on a controlled heat sink of 0.1° rms in the range of 20° to 55°C.

b. Warm up 30 min. to 1×10^{-7} of last setting.

c. Maintain $\Delta f/f = 1 \times 10^{-7}$ for any position (static 1g any direction)

10. POWER SOURCE

Supplies Available = ± 15V, (± 15V reg. .01%)

11. DESIGN (WITH OVEN IF NECESSARY): Smallest possible size and power consumption. Height not over 1.0".

12. INPUT POWER LEADS: Solder connections feed-thru filter A-B type SF or equivalent. No leads on top or bottom.

13. INPUT MODULATION: Solder F. T. internal RF decoupling of 100 dB or greater.

14. OUTPUT: Solder F. T.

Maximum Ratings

Operating Temperature Range ..... -65°C to +200°C

Storage Temperature Range ..... -65°C to +200°C

DC Power Dissipation ..... $\frac{200°C - T_{CASE}}{\Theta_{JC}}$

Electrical Specifications and Typical Parameters at $T_A = 25°C$ Ceramic Packaged Devices

Device Type 5082-	Package Outline (1)	Typical Output Frequency Range [GHz]	Typical Output Power (2) [W]	Junction Capacitance at -6V* (3) [pF]		Minimum Breakdown Voltage* [V]	Minimum Cutoff Frequency (4) [GHz]	Typical Lifetime* [ns]	Typical Transition Time*		Typical Thermal Resistance [°C/W]
				Min.	Max.	@I_R=10μA		τ	t_t [ps]	Charge Level [pC]	
0800 0801 0802	40 31 41	1-3	10	3.5	5.0	75	100	250	300	1500	12
0805 0806 0807	31 40 41	3-5	6	2.5	3.5	60	140	60	250	1500	16
0810 0811 0812	31 40 41	5-8	4	1.5	2.5	60	140	60	200	1000	22
0820 0821 0822	31 41 40	7-10	2.5	1.0	1.7	45	160	30	80	200	25
0830 0831	31 41	8-12	1.0	0.35	1.2	25	200	30	80	100	45
0835 0836 0885	31 41 56	10-20	0.3	0.1	0.5	15	350	15	50	100	60

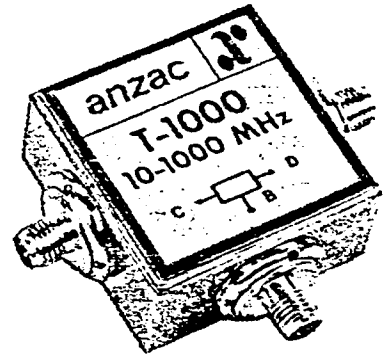
*Data supplied with each diode includes measured V_{BR} and $C_{T(-6)}$, and lot-typical τ and t_t.

Electrical Specifications and Typical Parameters at $T_A = 25°C$ Glass Packaged Devices(5)

Device Type 5082-	Maximum Junction Capacitance at -6V [pF]	Minimum Breakdown Voltage [V] @I_R=10μA	Minimum Cutoff Frequency (4) [GHz]	Typical Lifetime [ns] τ	Typical Transition Time	
					t_t [ps]	Charge Level [pC]
0803	6.0	70	100	250	350	1500
0815	4.0	50	140	60	225	1000
0825	2.0	40	160	30	150	200
0833	1.6	25	175	30	90	100
0840	0.9	15	200	15	70	100

BROADBAND IN-PHASE (ISO-T) 2-WAY POWER DIVIDER

10 MHz - 1 GHz



FEATURES

- High Isolation
- Low Insertion Loss
- Phase Balance 2° Max.
- Broadband Frequency Range — 10 MHz - 1 GHz
- Standard Connector Types: BNC, TNC, SMA, N

GUARANTEED SPECIFICATIONS

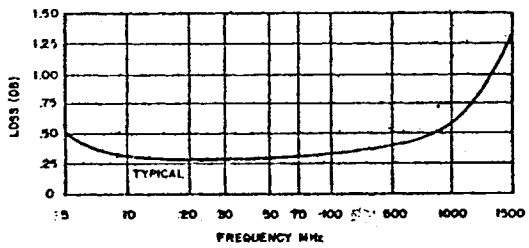
Frequency Range:	10 MHz - 1 GHz
Isolation — Ports C to D:	
10-20 MHz	25 db Min.
20-500 MHz	30 db Min.
500 MHz - 1 GHz	25 db Min.
Insertion Loss:	
10 MHz - 500 MHz	0.5 db Max.
500 MHz - 1 GHz	0.8 db Max.
VSWR:	
10-20 MHz	1.5 : 1 Max.
20 MHz - 1 GHz	1.3 : 1 Max.
Impedance:	50 ohms (all ports)
Amplitude Balance:	0.2 db Max.
Phase Balance:	2° Max.
Input Power:	2.5 Watts Max. (see Note)
Temperature Range:	-54° to +95°C

NOTE: Dissipation in the internal resistor of the T-1000 should not exceed 0.5 watt. If the VSWR of the two loads is K_1 and K_2, the applied power P should not exceed:

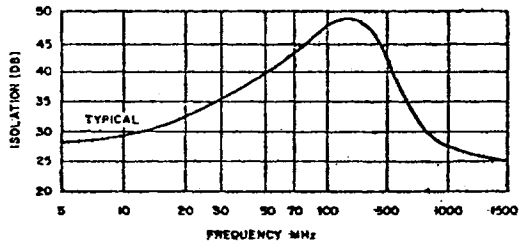
$$P \leqslant \frac{0.5}{\left[\frac{K_1 - 1}{K_1 + 1}\right]^2 + \left[\frac{K_2 - 1}{K_2 + 1}\right]^2} \text{ watts}$$

Thus, with a VSWR of 2 on both loads $P \leqslant 2.25$ watts.
This is a worst case formula, which assumes that the two load reflections are out of phase at the output ports. If they are identical, P may be several times larger.

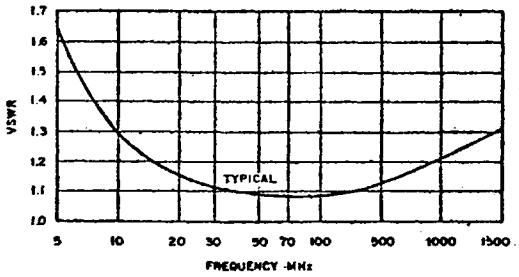
TYPICAL PERFORMANCE



LOSS



ISOLATION



VSWR

DESCRIPTION

The Model T-1000 in-phase (ISO-T) 2-way power divider/combiner provides broad frequency coverage (10 MHz - 1 GHz) with high isolation and low insertion loss in a rugged, compact (only 1-11/32" sq.) package. The device is intended as a broadband power divider and signal combiner.

Power fed into the sum port is divided equally between the two side ports, whose outputs are in phase. Conversely, two signals fed into the side ports are vectorially added at the sum port.

ENVIRONMENTAL

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

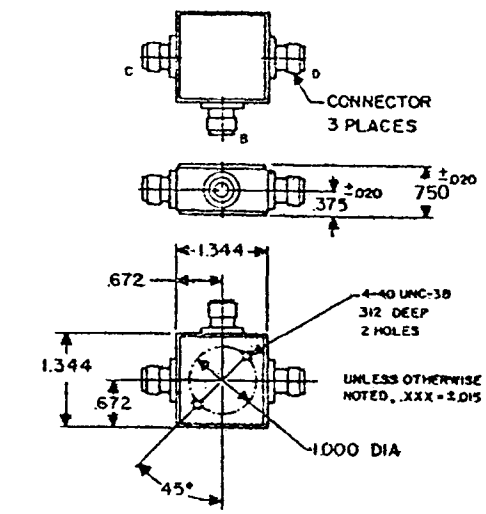
Thermal Shock:	Method 107, Test Condition A -55°C to 85°C, 30 minutes at temperature extremes, 5 cycles
Humidity:	Method 103, Test Condition B (96 hours)
Barometric Pressure:	Method 105, Test Condition D 100,000 feet
Moisture Resistance:	Method 106
Life Test:	Method 108, Test Condition B (250 hours)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

ORDERING INFORMATION

Please specify Model No. and Connector Type when ordering.

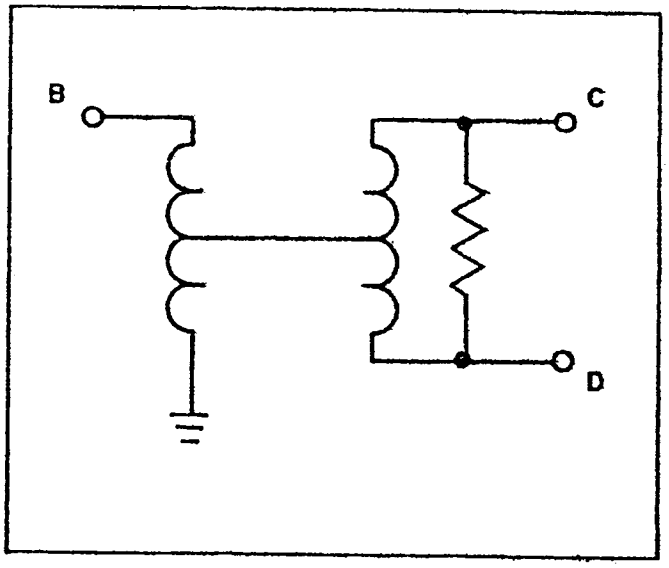
Model T-1000:	$90.00 (1-5 Qty.)
Connector Types:	BNC, TNC, SMA, N
Availability:	Stock
Terms:	Net 30, f.o.b. factory

MECHANICAL DATA



Mounting Area:	1.9 sq. in.	12.3 sq. cm.
Volume:	1.4 cu. in.	23 cu. cm.
Weight (approx.)	2.5 ounces	71 grams

SCHEMATIC



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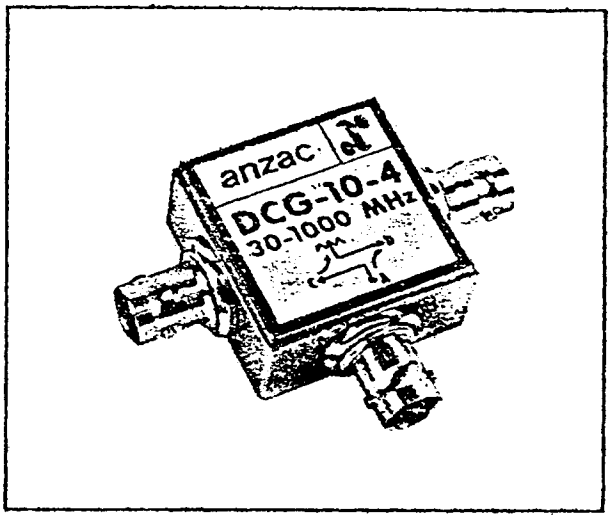
10db BI-DIRECTIONAL COUPLER

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

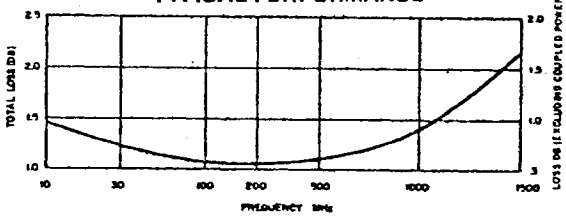
Frequency Range:	30 MHz - 1 GHz
VSWR:	1.35 : 1 Max.
Impedance:	50 ohms
Main Line Loss (above theoretical 0.46 db power split):	1.0 db Max.
Coupling (Output to Output):	10.0 ± 0.5 db Max.
Directivity:	20 db Min.
Input Power:	5 Watts Max.
Operating Temperature Range:	-55°C to +85°C

ENVIRONMENTAL

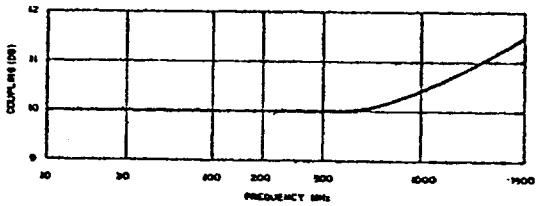
This Device Has Been Designed to Meet the Following Environmental and Physical Conditions of MIL-STD-202.

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

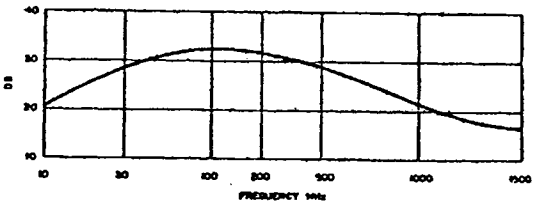
TYPICAL PERFORMANCE



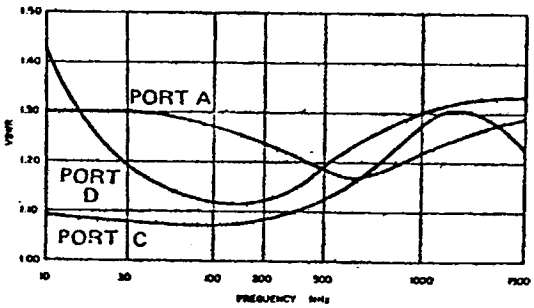
MAIN LINE LOSS



COUPLING



DIRECTIVITY

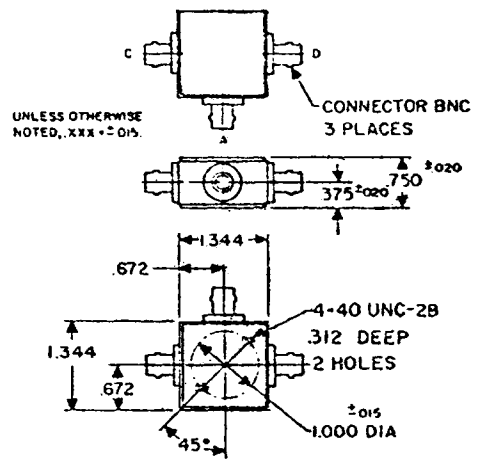


VSWR

DESCRIPTION

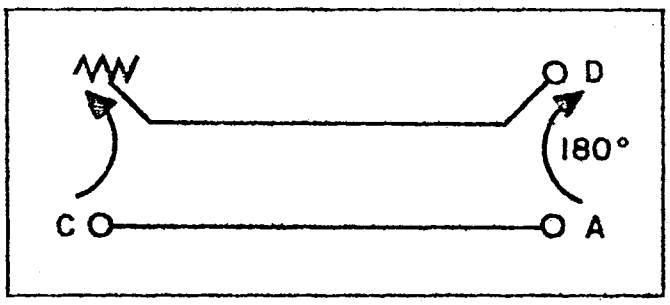
The Model DCG-10-4 directional coupler operates over a frequency range of 30 MHz - 1 GHz. Its main line loss of only 1.0 db Max. (above the theoretical 0.46 db power split) makes this device superior to a 3 db hybrid when used as a reference for levelling radio frequency sources.

MECHANICAL DATA



Mounting Area:	1.9 sq. in.	12.3 sq. cm.
Volume:	1.4 cu. in.	23 cu. cm.
Weight (approx.)	1.76 ounces	50 grams

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

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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).

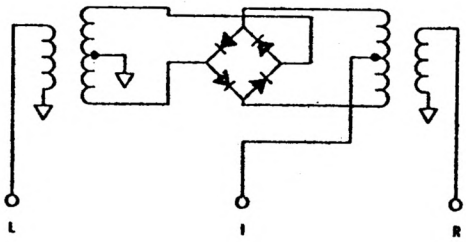
Weight 45 grams (1.6 oz.) maximum

Connectors BNC, TNC, SMA

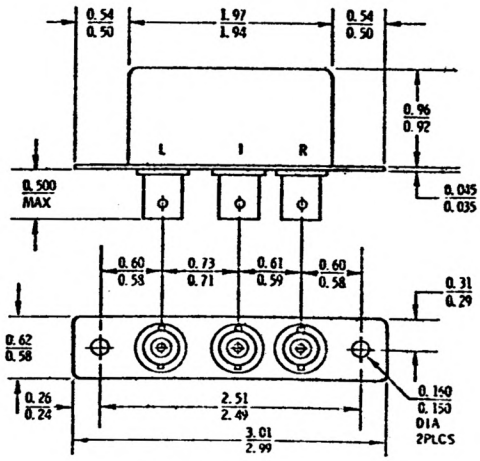
Absolute Maximum Ratings

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



NOTE: DIMENSIONS ARE IN INCHES.

absolute maximum ratings

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

electrical characteristics (Note 4)

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

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

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

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

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

Operational Amplifiers

LM318 operational amplifier general description

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

features

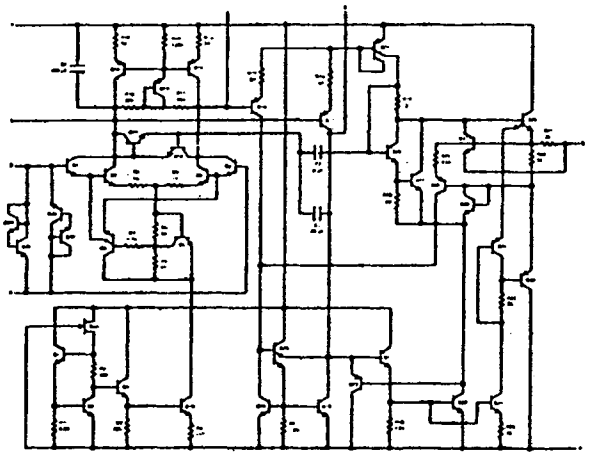
- 15 MHz small signal bandwidth
- Guaranteed 50V/μs slew rate
- Maximum bias current of 500 nA
- Operates from supplies of ±5V to ±20V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

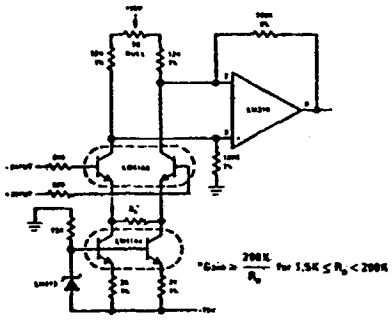
The LM318 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting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

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

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

schematic diagram and typical application

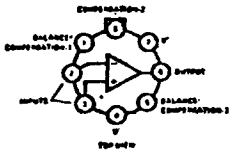




Instrumentation Amplifier.

connection diagrams

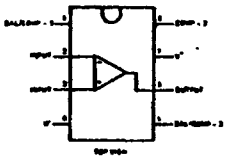
Metal Can Package*



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

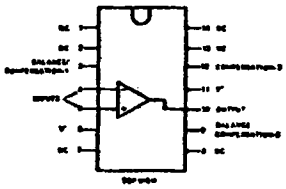
Order Number LM318H
See Package 11

Dual-In-Line Package



Order Number LM318N
See Package 20

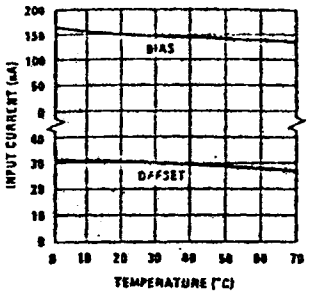
Dual-In-Line Package



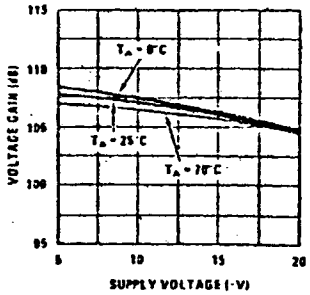
Order Number LM318D
See Package 1

typical performance characteristics

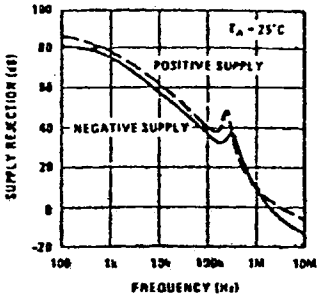
Input Current



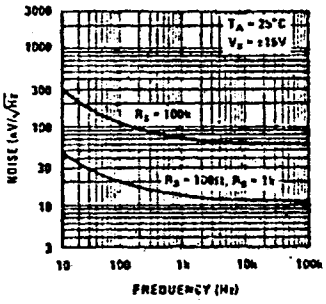
Voltage Gain



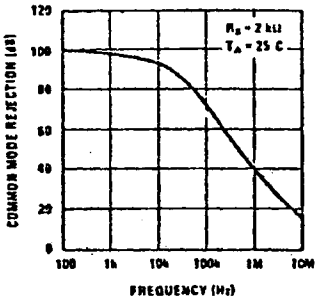
Power Supply Rejection



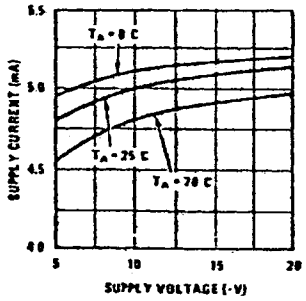
Input Noise Voltage



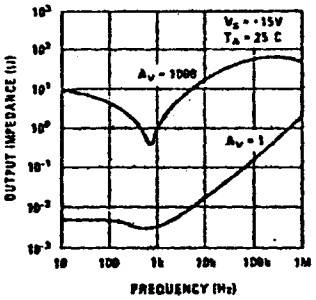
Common Mode Rejection



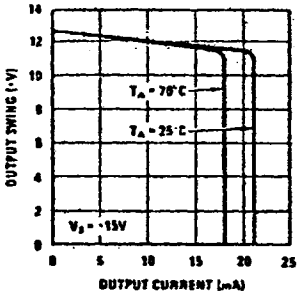
Supply Current



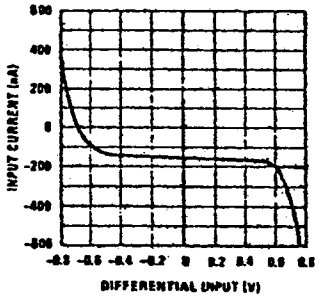
Closed Loop Output Impedance



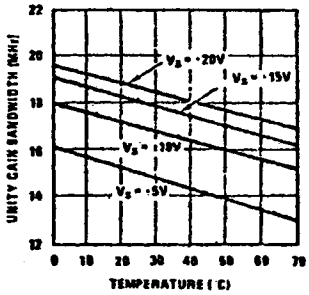
Current Limiting



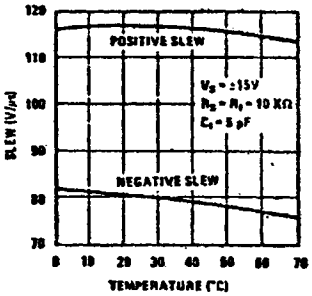
Input Current



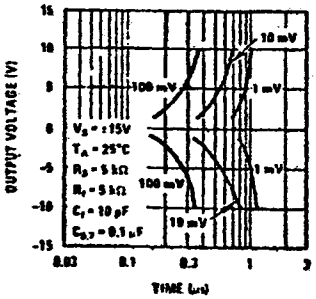
Unit Gain Bandwidth



Voltage Follower Slew Rate

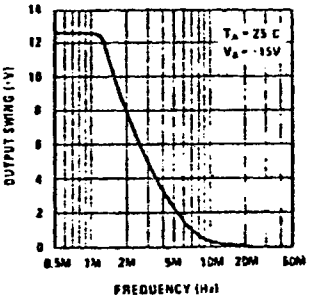


Inverter Settling Time

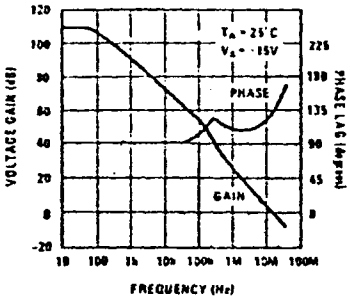


typical performance characteristics (con't)

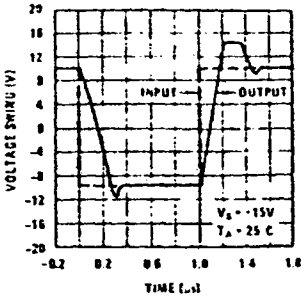
Large Signal Frequency Response



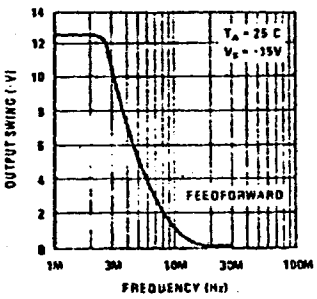
Open Loop Frequency Response



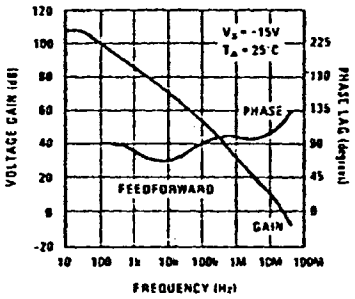
Voltage Follower Pulse Response



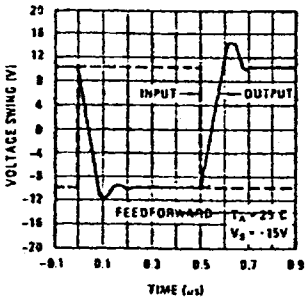
Large Signal Frequency Response



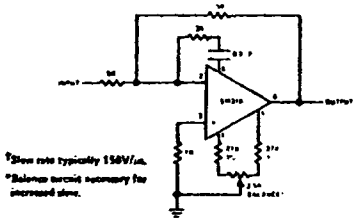
Open Loop Frequency Response



Inverter Pulse Response

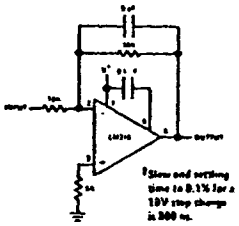


auxiliary circuits



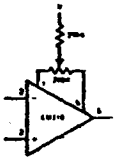
†Slew rate typically 150V/μs.
*Balance circuit necessary for increased slew.

Feedforward Compensation for Greater Inverting Slew Rate†

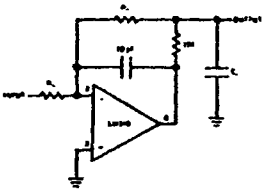


†Slew and settling time to 0.1% for a 10V step change is 300 ns.

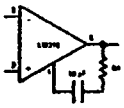
Compensation for Minimum Settling† Time



Offset Balancing

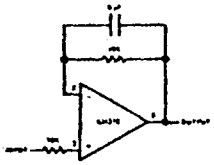


Isolating Large Capacitive Loads

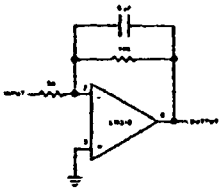


Overcompensation

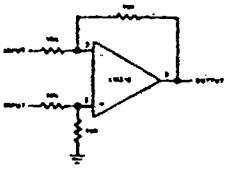
typical applications (con't)



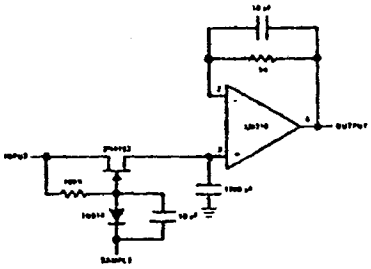
Fast Voltage Follower



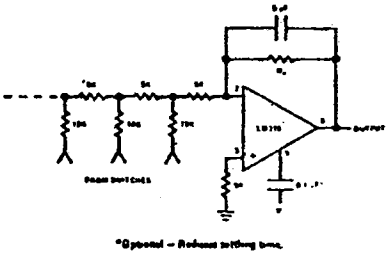
Fast Summing Amplifier



Differential Amplifier

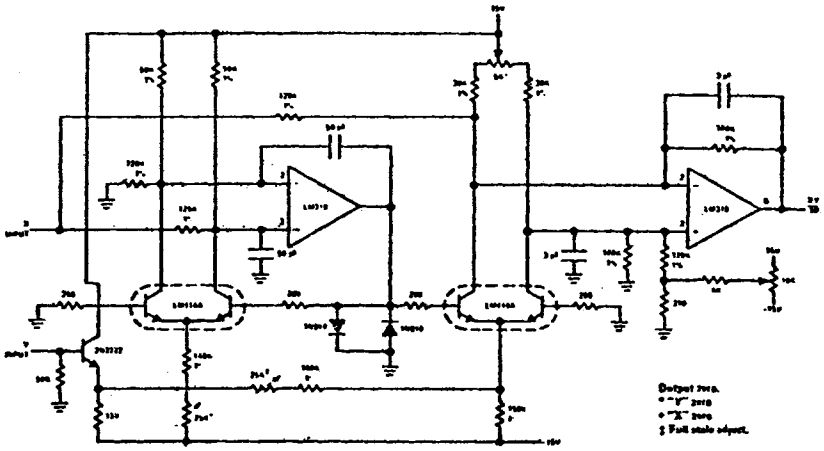


Fast Sample and Hold

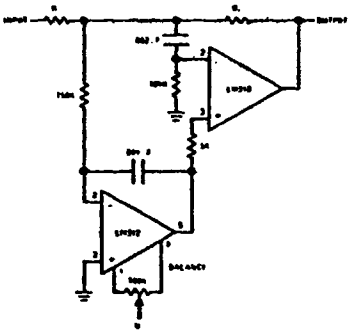


*Optional – Reduces settling time.

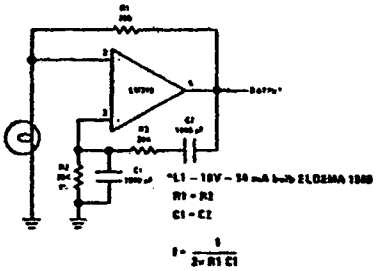
D/A Converter Using Ladder Network



Four Quadrant Multiplier



Fast Summing Amplifier with Low Input Current



*L1 – 18V – 50 mA bulb ELDEMA 1380

R1 = R2

C1 = C2

$f = \frac{1}{2\pi R1 C1}$

Wein Bridge Sine Wave Oscillator

Mini-Circuits Laboratory

DIRECTIONAL COUPLERS

11.5 dB

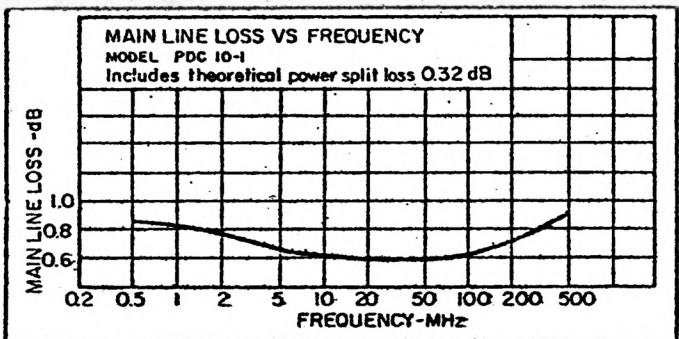
	MODEL PDC 10-1	
Frequency Range, MHz	0.5-500	
Coupling, dB (Input To Coupled Port)	11.5±0.5	
Coupling Flatness, dB	±0.6	
VSWR	1.2:1 Typ.	
Impedance	50 ohms	
Directivity, dB	Typical	Minimum
Lower Band Edge To One Decade Higher	32	25
Mid Range	32	25
Upper Band Edge To One Octave Lower	22	15
Main Line Loss, dB (Includes Theoretical 0.32 dB Power Split Loss)	Typical	Maximum
One Octave From Band Edge	.65	1.0
Total Range	.85	1.2
Input Power		
Total Range (1)	3 Watts	
(1) Lower Band Edge To One Decade Higher	1.5 Watts	

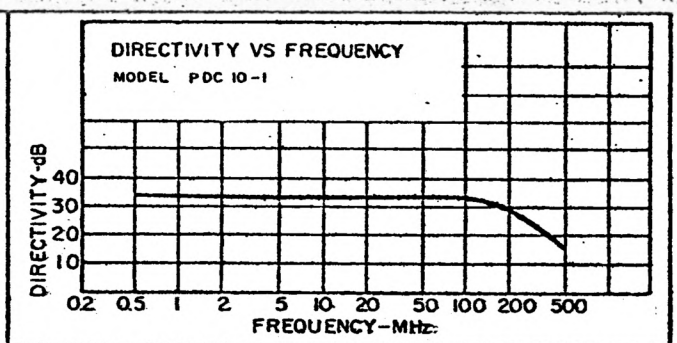
PDC 10-1 Series

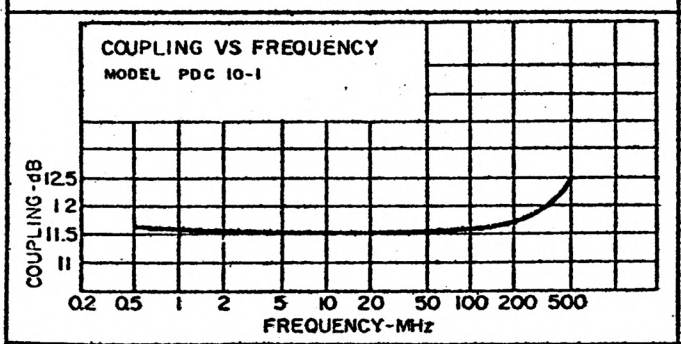
PDC 10-1 0.5-500 MHz $11.95 (5-49)

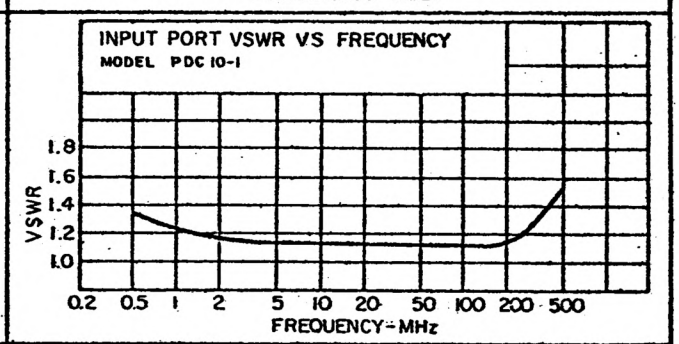
FAST DELIVERY
From stock, one week max

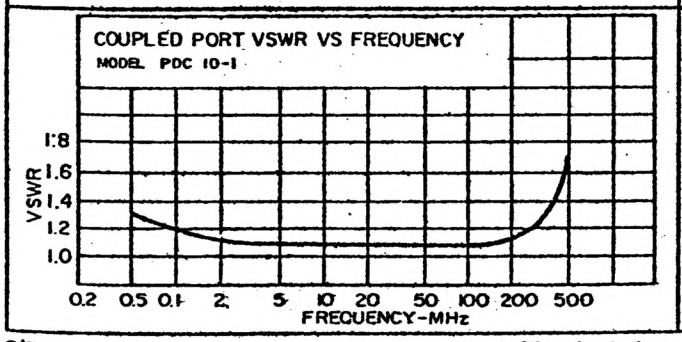
For connector version see ZDC10-1 series

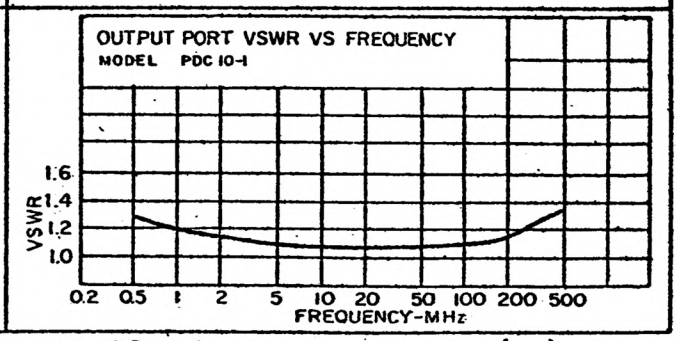












INTRODUCTION TO PDC SERIES
DIRECTIONAL COUPLERS

PDC Series

PDC 10-1	0.5-500 MHz	$11.95	(5-49)
PDC 10-2	250-1000 MHz	$15.95	(5-49)
PDC 15-6	0.01-35 MHz	$19.95	(5-49)
PDC 20-3	0.2-250 MHz	$11.95	(5-49)
PDC 20-1	25-400 MHz	$19.95	(5-49)
PDC 10-1B	1-400 MHz	$ 9.95	(6-49)
PDC 20-1B	0.5-200 MHz	$14.95	(5-49)

FAST DELIVERY
From stock; one week max.

For connector version see ZDC series

FEATURES

BROAD FREQUENCY RANGE, 10 KHz-1000 MHz

WIDE SELECTION OF COUPLING

LOW MAIN LINE LOSS FROM 0.1 dB

HIGH DIRECTIVITY TO 35 dB

HERMETICALLY SEALED METAL CASE

PC BOARD MOUNTING

LOW COST FROM $9.95 IN SMALL QUANTITIES

APPLICATIONS

MEASURE INCIDENT AND REFLECTED POWER TO DETERMINE VSWR

SIGNAL SAMPLING

S PARAMETER MEASUREMENT

SIGNAL INJECTION

SIGNAL GENERATOR/OSCILLATOR LEVELING

POWER FLOW MONITORING

DESCRIPTION

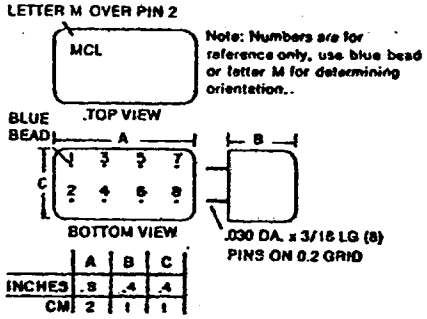
The PDC series directional couplers are economically priced while covering the frequency range from 10 kHz to 1000 MHz. They offer main-line loss as low as 0.1 dB and high directivity of up to 35 dB. A wide selection of coupling ratios are available and exceptional unit to unit matched performance is standard.

Having a volume of only 0.128 cu. inches, the PDC series is offered at the lowest prices available in the industry.

Packaged within an rfi shielded metal enclosure and hermetically-sealed header, these high performance units have their pins oriented on a 0.2 inch grid. Ruggedness and durability are built into the PDC series. Only well matched and ruggedly constructed transmission line transformers are used. Internally every component is bonded to the header and case with silicone rubber to provide super reliable protection against shock vibration and acceleration.

The PDC series uses the same construction technology as our SRA double-balanced mixer. This unit has become an industry standard throughout the world and is believed to be the number one volume leader. Used by all branches of the Department of Defense, NASA, FAA and every major communications company, the SRA has proven to be an industry work horse. Used in over 250 different military contracts, and over a period of years, enable sufficient history to establish SRA as one of the most reliable mixers obtainable, even when considering high priced models. The PDC series is expected to provide the same kind of results.

High reliability is associated with every PDC series directional coupler. Every production run is 100% tested and every unit must pass our rigid inspection and high quality standards. Naturally, our one year guarantee applies to these units.



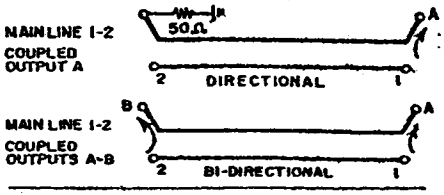
	A	B	C
INCHES	.8	.4	.4
CM	2	1	1

WEIGHT 5.2 grams .18 ounces

PIN CONNECTIONS

	PDC 10-1 10-2, 15-6 20-1, 20-3	PDC 10-1B 20-1B
MAIN LINE 2	4	4
MAIN LINE 1	1	1
COUPLE A	3	3
COUPLE B		6
GROUND	2,5,7,8	2,5,7,8

Model with Suffix B denotes external 50 ohm load required



ABSOLUTE MAXIMUM RATINGS

Operating & Storage Temperature −55° C to +100° C

Pin Temperature (10 seconds) 510° F

Mini-Circuits Laboratory

DIRECTIONAL COUPLERS

11.5 dB

	MODEL ZDC 10-1	
Frequency Range, MHz	0.5-500	
Coupling, dB (Input To Coupled Port)	11.5±0.5	
Coupling Flatness, dB	±0.6	
VSWR	1.2:1 Typ.	
Impedance	50 ohms	
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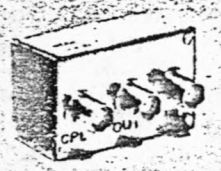
Main Line Loss, dB (Includes Theoretical 0.32 dB Power Split Loss)	Typical	Maximum
One Octave From Band Edge	.65	1.0
Total Range	.85	1.2
Input Power		
Total Range (1)	3 Watts	
(1) Lower Band Edge To One Decade Higher	1.5 Watts	

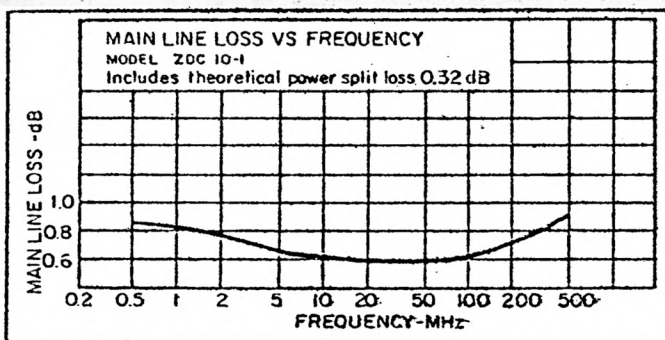
ZDC 10-1 Series

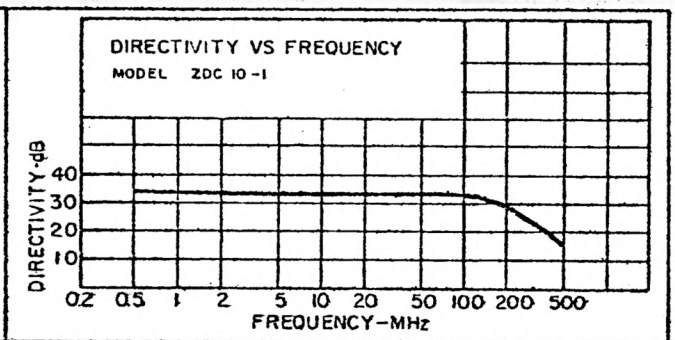
ZDC 10-1 0.5-500 MHz $26.95 (4-24)

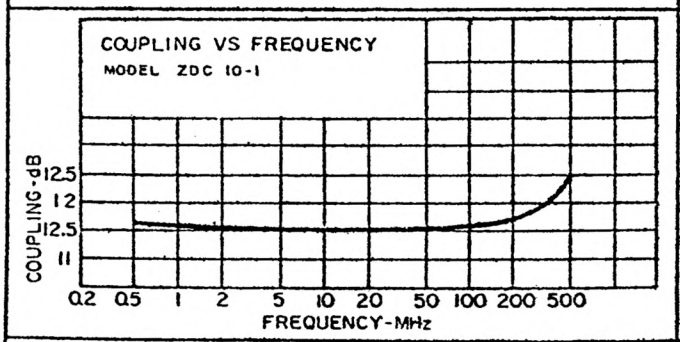
FAST DELIVERY
From stock, one week max

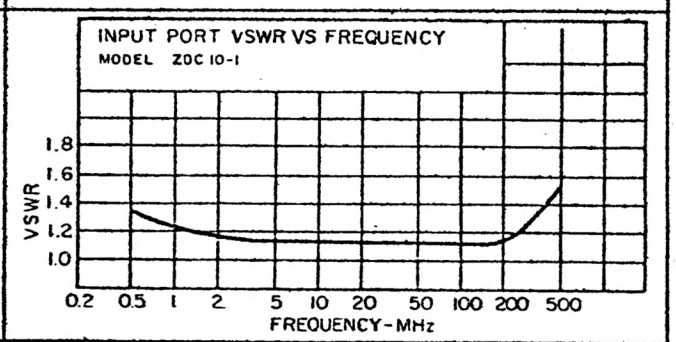


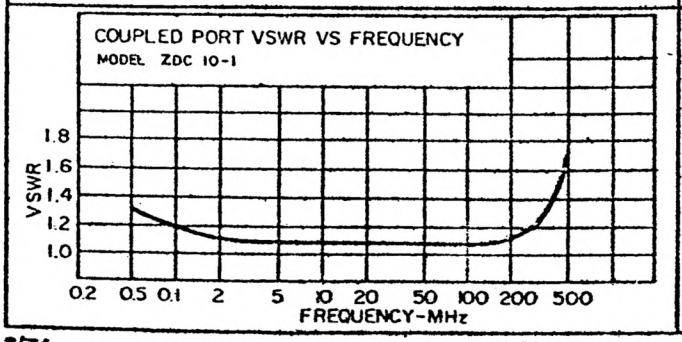
For pin version see PDC 10-1 series

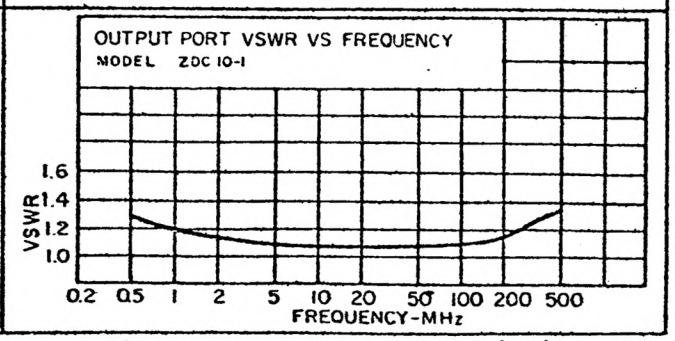












8/74

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Mini-Circuits Laboratory

DIRECTIONAL COUPLERS

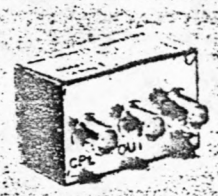
10 dB

	MODEL ZDC 10-2	
Frequency Range, MHz	250-1000	
Coupling, dB (Input To Coupled Port)	10±0.5	
Coupling Flatness, dB	±0.5	
VSWR	1.5:1 Typ.	
Impedance	50 ohms	
Directivity, dB	Typical	Minimum
250-400 MHz	40	30
400-800 MHz	30	20
800-1000 MHz	20	15
Main Line Loss, dB (Includes Theoretical 46dB Power Split Loss)	Typical	Minimum
250-600 MHz	1.1	1.4
600-1000 MHz	1.6	1.9
Input Power	5 Watts	

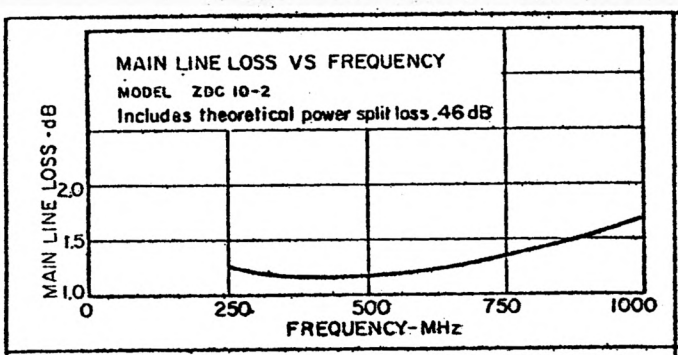
ZDC 10-2 Series

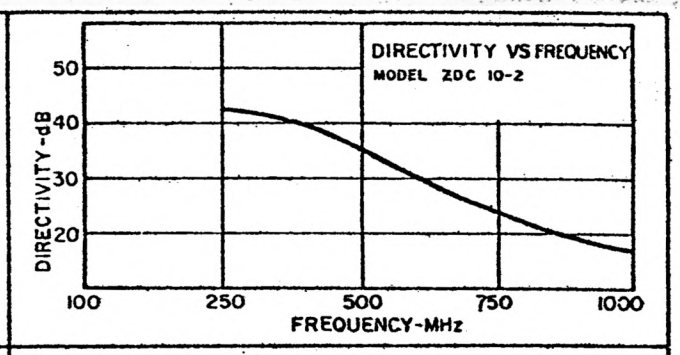
ZDC 10-2 250-1000 MHz $30.95 (4-24)

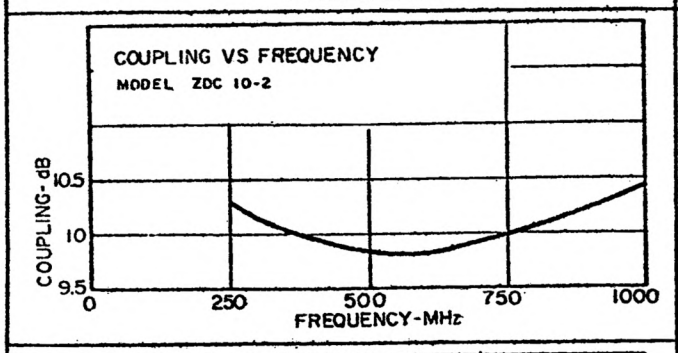
FAST DELIVERY
From stock, one week max

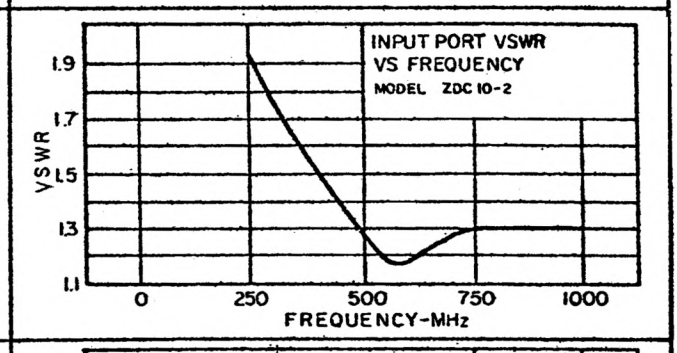


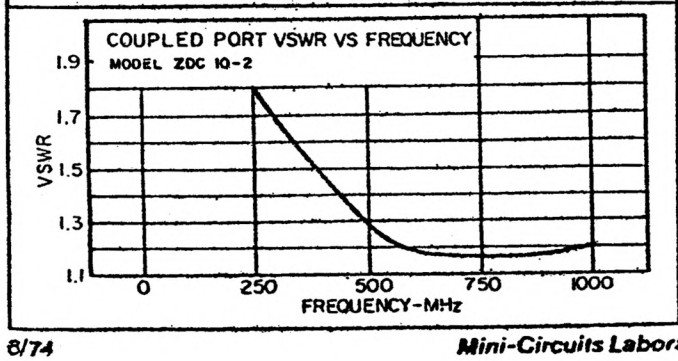
For pin version see PDC10-1 series

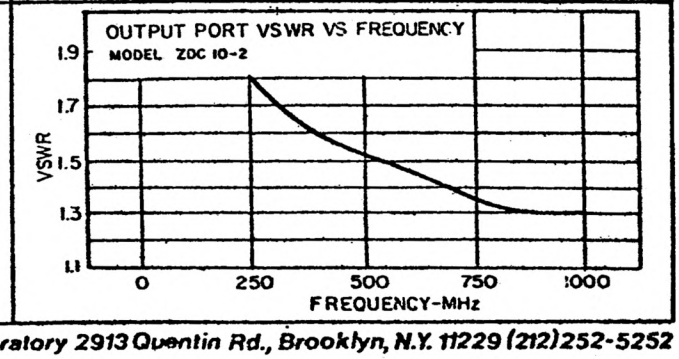












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INTRODUCTION TO ZMSC-2 SERIES
MINIATURE POWER SPLITTER-COMBINERS

Two-Way
(In Phase 0°)

ZMSC-2 Series

ZMSC-2-1	100KHz-400MHz
ZMSC-2-2	2KHz-60MHz

FAST DELIVERY
From stock; one week max.

For pin version see PSC-2 series

FEATURES

BROAD FREQUENCY RANGE
2KHz - 400MHz

EXCEPTIONALLY GOOD BALANCE

LOW INSERTION LOSS

HIGH ISOLATION

DIE CAST ALUMINUM CASE

LOW COST FROM $34.95
IN SMALL QUANTITIES

APPLICATIONS

ADD OR SUBTRACT SIGNALS VECTORIALLY

OBTAIN MULTI IN-PHASE OUTPUT SIGNALS PROPORTIONAL TO THE LEVEL OF A COMMON INPUT SIGNAL

SPLIT AN INPUT SIGNAL INTO MULTI-OUTPUTS

COMBINE SIGNALS FROM DIFFERENT SOURCES TO OBTAIN A SINGLE PORT OUTPUT

PROVIDE CAPABILITY TO OBTAIN OF LOGIC ARRANGEMENTS

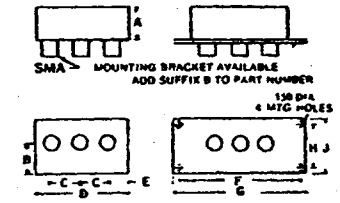
DESCRIPTION

The model ZMSC-2 2-way power splitter/combiner is a high performance broad band hybrid junction. Internally, terminations and transformers are provided to ensure a well matched 50 ohm impedance at all ports. Signals fed into the input S port are equally divided, in phase, to the two output (1 and 2) ports. Similarly, signals fed into ports 1 and 2 are vectorially summed at the output S port.

The ZMSC-2 features exceptionally good amplitude and phase balance between the signals at the 2 output ports. Typically, over most of the frequency range, the phase balance is within 1 degree and the amplitude balance is within .05 dB.

Housed in a die cast aluminum case, these rugged units are double shielded to meet your tough EMI requirements. The case is finished with a blue baked enamel per Federal Standard 595*25109 over phosphoric etch per MIL-C-15328A.

Every unit is 100% tested and inspected under strict MCL quality control standards to ensure superior electrical performance and reliability. The exceptionally low cost of the ZMSC-2 is attributable to the breakthrough in production techniques achieved by MCL during the manufacture of its high performance low price double balanced mixers. Utilizing this technology, the high performance ZMSC-2 is offered at a remarkable price of ½ to ⅓ of competitive units.



	A	B	C	D	E	F	G	H	J
INCHES	0.88	0.66	0.38	1.50	.312	1.22	2.50	0.84	1.15
CM	2.2	1.7	1.1	3.8	7.9	3.09	6.35	2.1	2.9

WEIGHT 34.0 grams 1.02 ounces

CONNECTORS
SMA (3mm) standard

MOUNTING BRACKET
On request, add $1.50 to unit cost. See dimensions above.

ABSOLUTE MAXIMUM RATINGS
Operating and Storage Temperature —55° C to +100° C

Mini-Circuits Laboratory

MINIATURE POWER SPLITTER·COMBINERS

Two·Way
(In Phase 0°)

ZMSC·2 Series

ZMSC-2-1	100KHz-400MHz	$34.95 (4-24)
ZMSC-2-2	2KHz-60MHz	$44.95 (4-24)

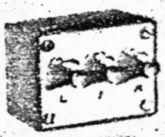
MODEL ZMSC-2-1

Frequency Range (MHz)	.1-400MHz	
Nominal Phase Difference Between Output Ports	0°	
Impedance, All Ports	50 ohms	
Isolation Between Output 1 and 2, dB	Typical	Minimum
2-40MHz	40	30
.4-400MHz	25	20
.1-.4MHz	20	15
Insertion Loss, dB (above 3dB split)	Typical	Maximum
.1-100MHz	.2	.5
100-200MHz	.4	.75
200-400MHz	.6	1.0
Phase Unbalance, degrees	Typical	Maximum
0.1-100MHz	.5	2
100-200MHz	1	3
200-400MHz	2	4
Amplitude Unbalance, dB	Typical	Maximum
.1-100MHz	.05	.15
100-200MHz	.05	.2
200-400MHz	.1	.3
VSWR	1.2 typical	
Matched Power Rating	1 watt maximum	
Internal Load Dissipation	⅛ watt	

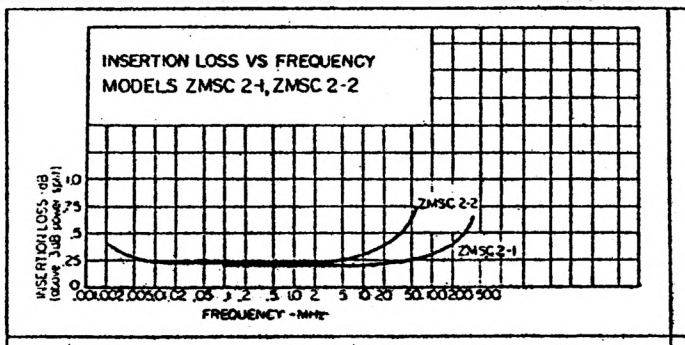
MODEL ZMSC-2-2

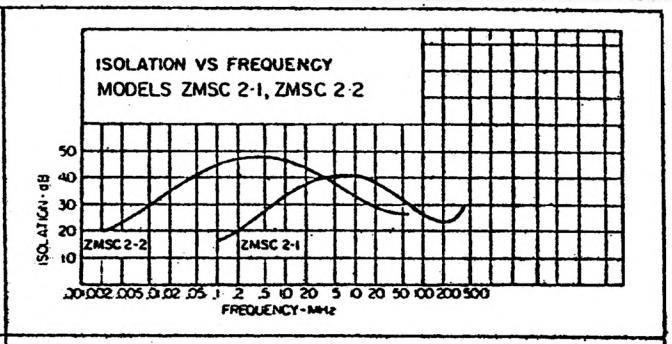
Frequency Range (MHz)	2KHz-60MHz	
Nominal Phase Difference Between Output Ports	0°	
Impedance, All Ports	50 ohms	
Isolation Between Output 1 & 2, dB	Typical	Minimum
15KHz-6MHz	40	30
2KHz-60MHz	27	20
Insertion Loss, dB (above 3dB split)	Typical	Maximum
10KHz-3MHz	.2	.4
2KHz-20MHz	.3	.6
20MHz-60MHz	.6	1.0
Phase Unbalance, degrees	Typical	Maximum
10KHz-3MHz	.5	2
2KHz-20MHz	1	3
20MHz-60MHz	2	4
Amplitude Unbalance, dB	Typical	Maximum
2KHz-20MHz	.05	.15
20MHz-60MHz	.1	.3
VSWR	1.2 typical	
Matched Power Rating	1 watt maximum	
Internal Load Dissipation	⅛ watt	

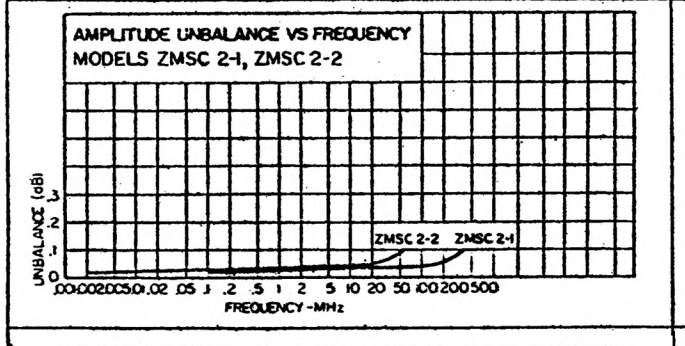
FAST DELIVERY
From stock, one week max.

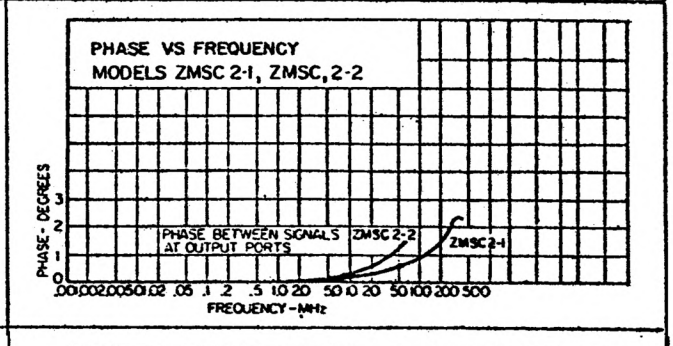


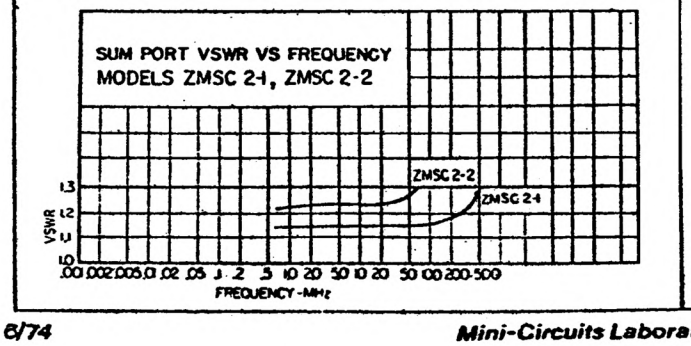
For pin version see PSC-2 series

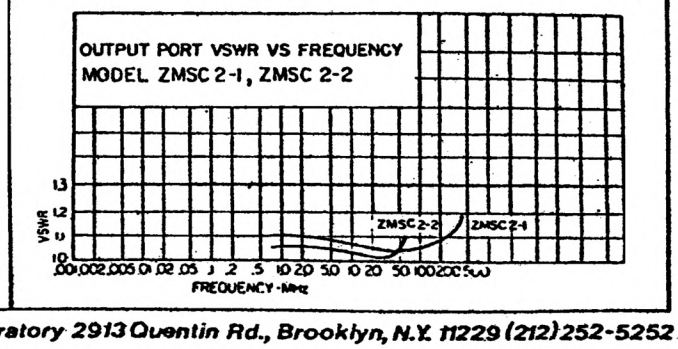










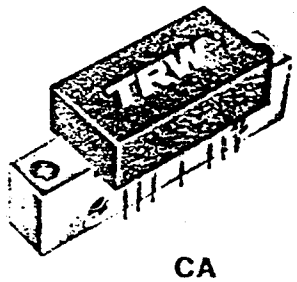


TRW RF SEMICONDUCTORS

CA2810

Wide Bandwidth Linear Hybrid Amplifier

- Power Output, 800mW
- 33dB Gain
- 400mW PEP @ -32dB IMD
- Instantaneous Bandwidth, 10-350MHz
- Low Noise Figure, 4.5dB



CA

The CA2810 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for wide bandwidth linear operation in 50 to 100 ohm systems. This hybrid provides excellent gain stability with temperature and very low distortion due to push-pull amplifier circuitry. This module is recommended for wide bandwidth, low noise and linear applications.

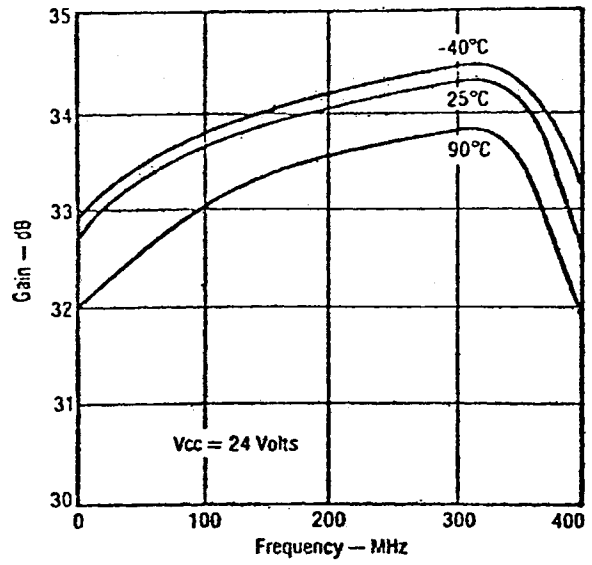
Absolute Maximum Ratings

V_{CC}	RF Power Input	Storage Temperature	Operating Temperature
28 Volts	+5dBm	-40°C to +100°C	-20°C to +90°C

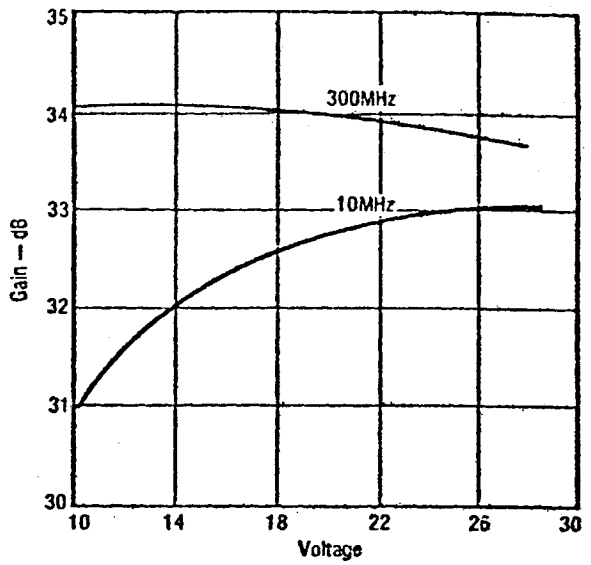
Electrical Characteristics for 50Ω Systems (T_{CASE} = 25°C and 24V)

Symbol	Characteristic	Conditions	Value
P_G	Power Gain	f = 50MHz	33 ±1dB
NF	Noise Figure, Broadband	f = 60MHz f = 300MHz	4.5dB Typ 8.0dB Max
I_{TO}	Third Order Intercept, See Figure 1	f_1 = 300MHz	+43dBm Typ
VSWR	Input/Output VSWR for 50Ω Systems	f = 10-350MHz	2:1 Typ
I_{CC}	Supply Current	24V	330mA Max
P_o	Power Output — 1dB Compression	f = 200MHz	800mW
P_{RI}	Reverse Isolation	f = 10-350MHz	40dB Typ
F_R	Frequency Response	f = 30-300MHz f = 10-350MHz	±1.0dB Max ±1.5dB Max
dso	Second Harmonic Distortion	Tone at 10mW f_{2H} = 10-300MHz	-66dB Typ
PEP	Peak Envelope Power for Two Tone Distortion Test See Figure 1	f = 10-300MHz at -32dB	400mW Typ

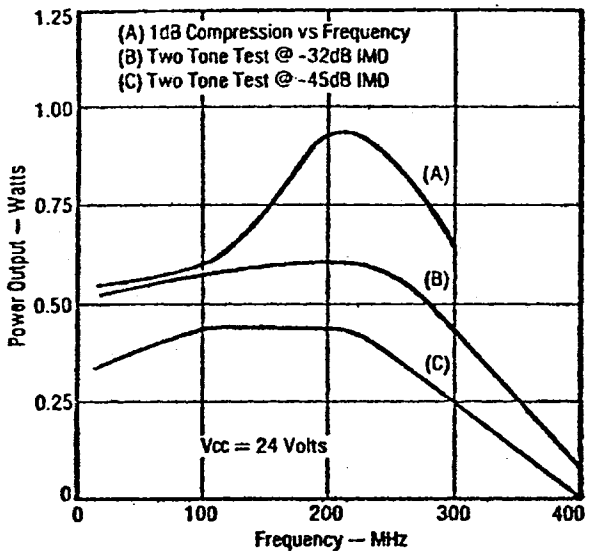
Gain vs Frequency



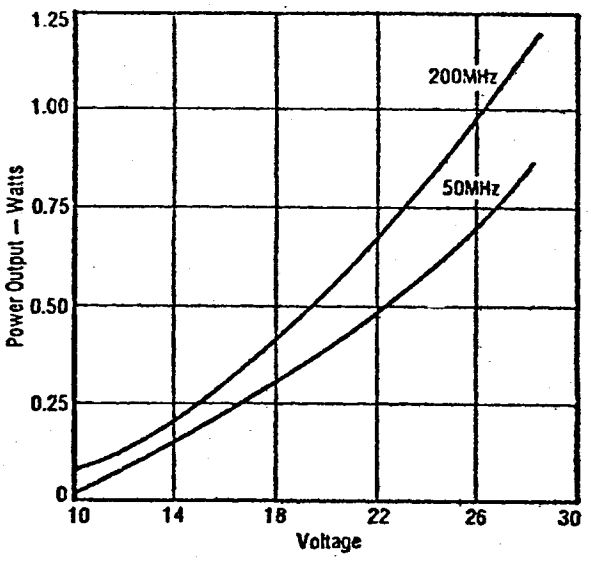
Gain vs Voltage



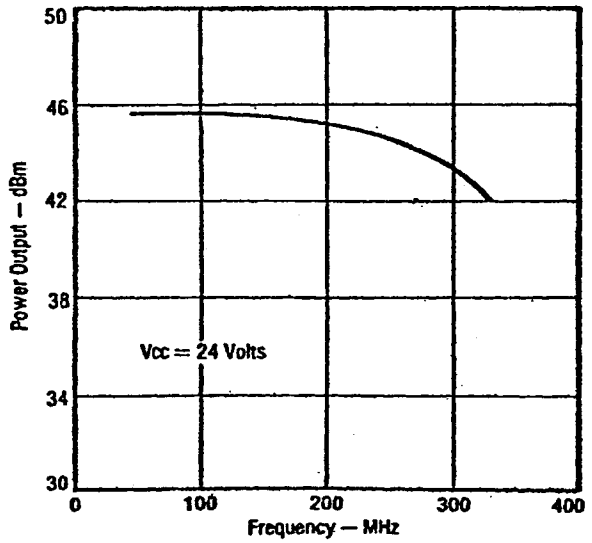
Power Output vs Frequency



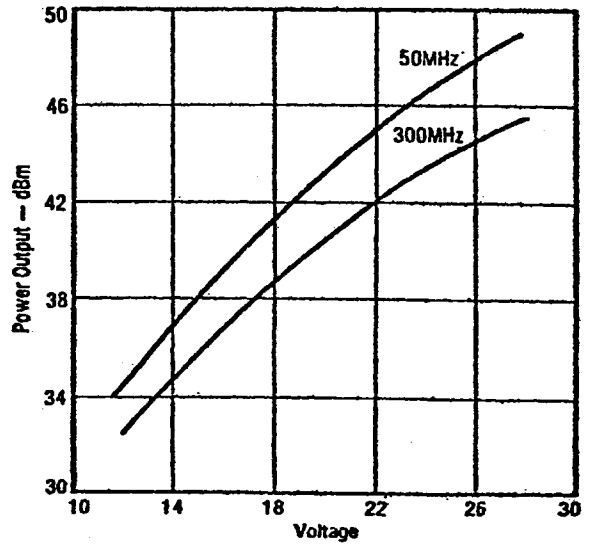
1dB Compression vs Voltage



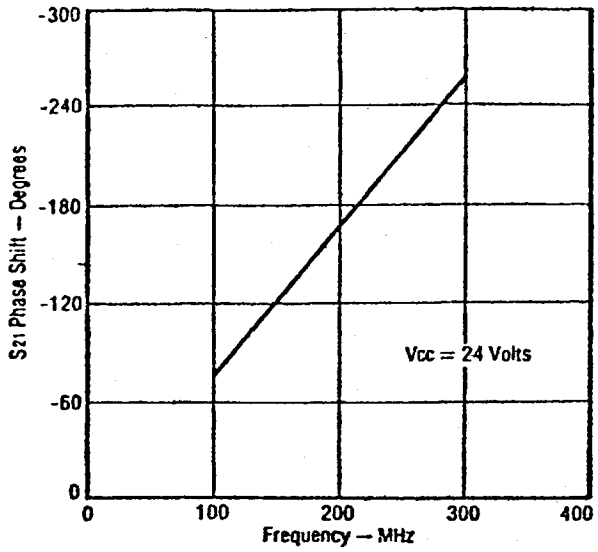
Third Order Intercept vs Frequency



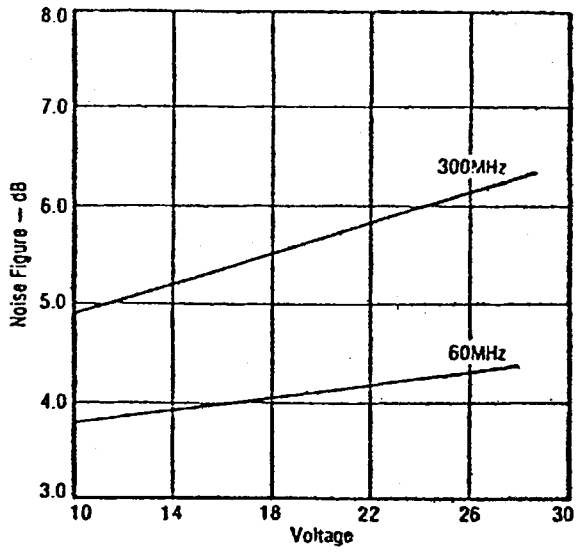
Third Order Intercept vs Voltage



Phase Shift vs Frequency



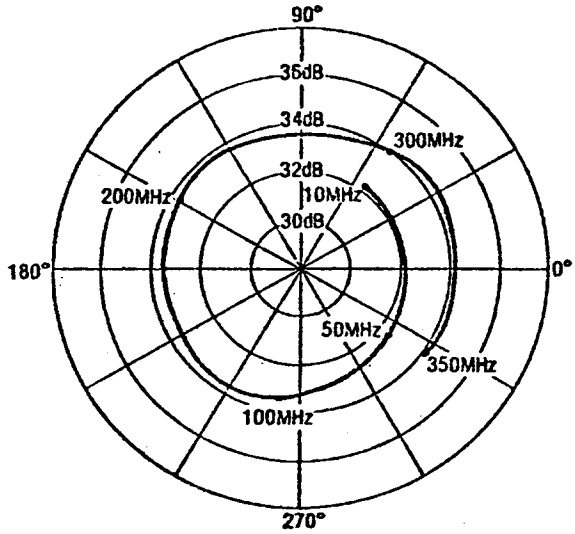
Noise Figure vs Voltage



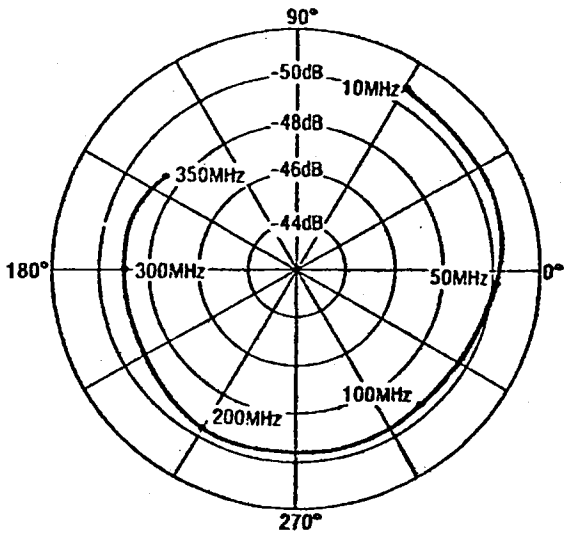
S-Parameters

Vcc = 24V, Z_o = 50Ω

S21



S12



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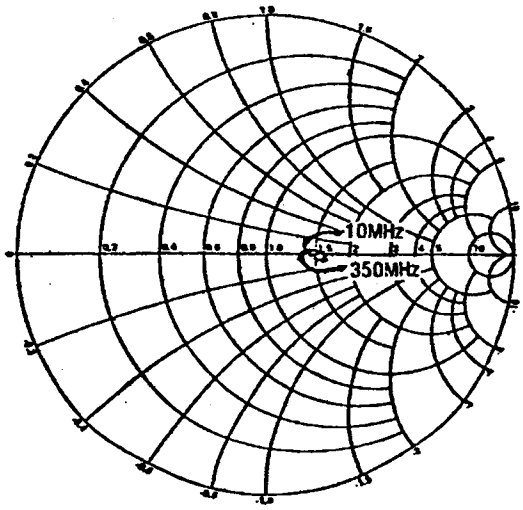

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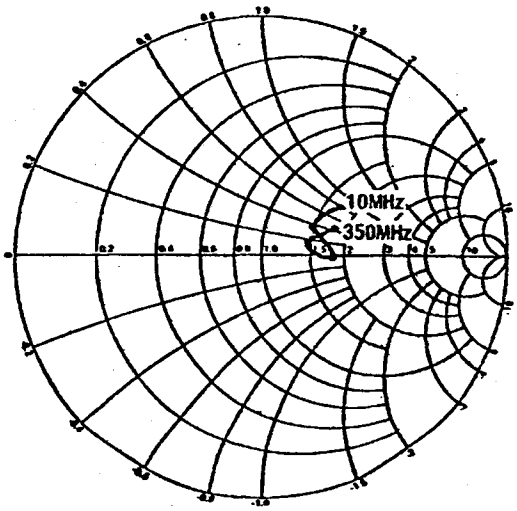


CA Package Outline

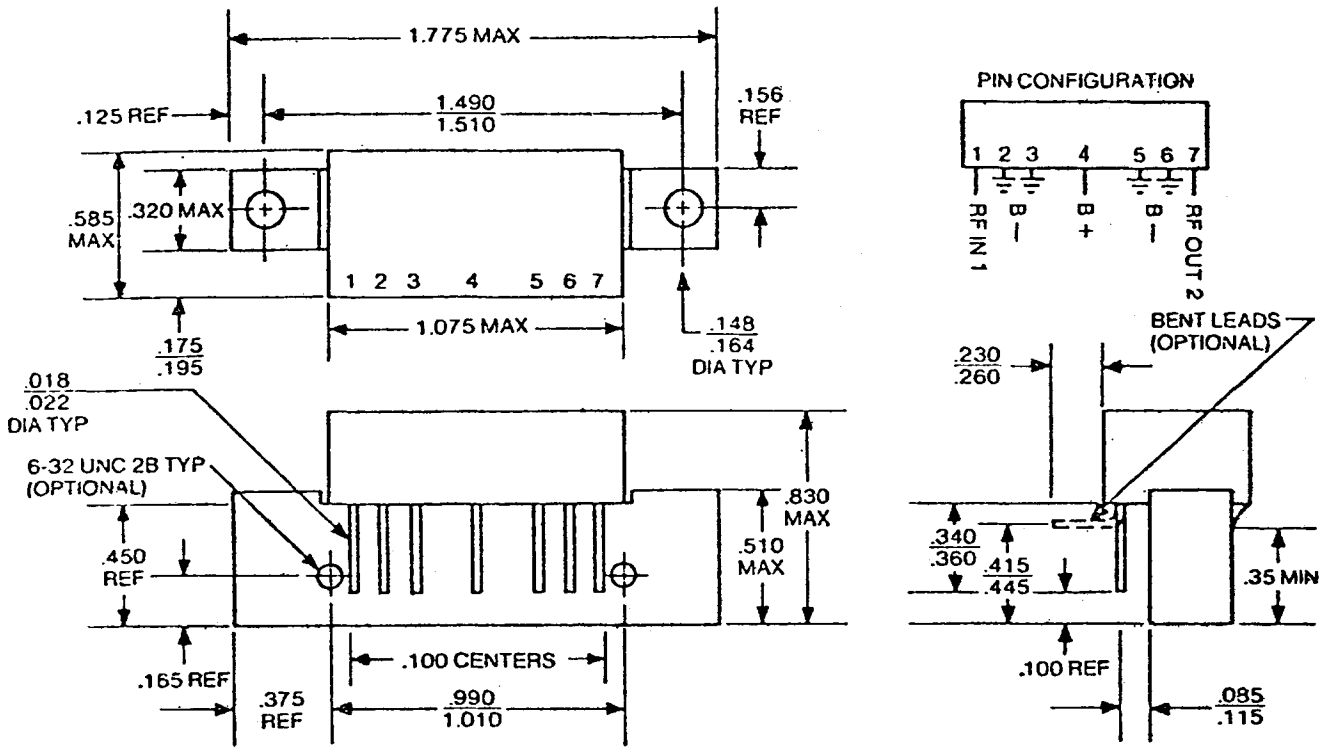
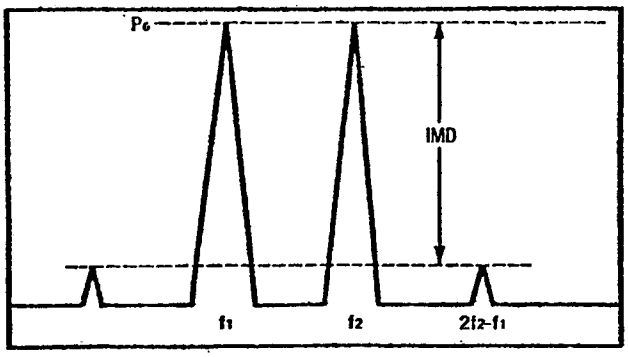


Figure 1. Intermodulation Test



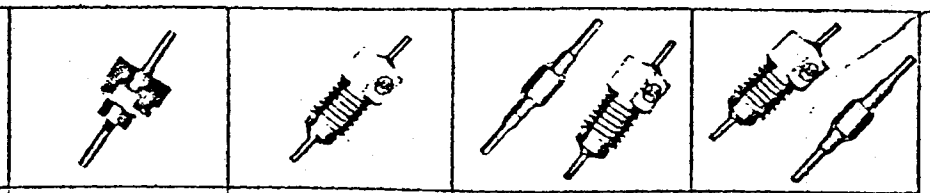
$$ITO = P_o + \frac{IMD}{2} \quad @ \ IMD > 60dB$$

$$PEP = P_o \ @ \ IMD = -32dB$$

EMI/RFI SUPPRESSION FILTERS

THREAD BUSHING

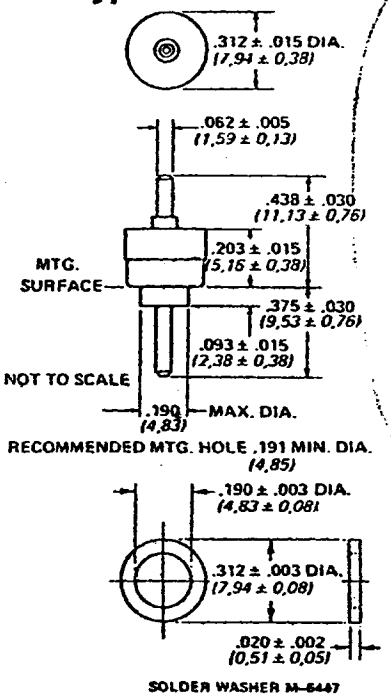
SPECTRUM CONTROL



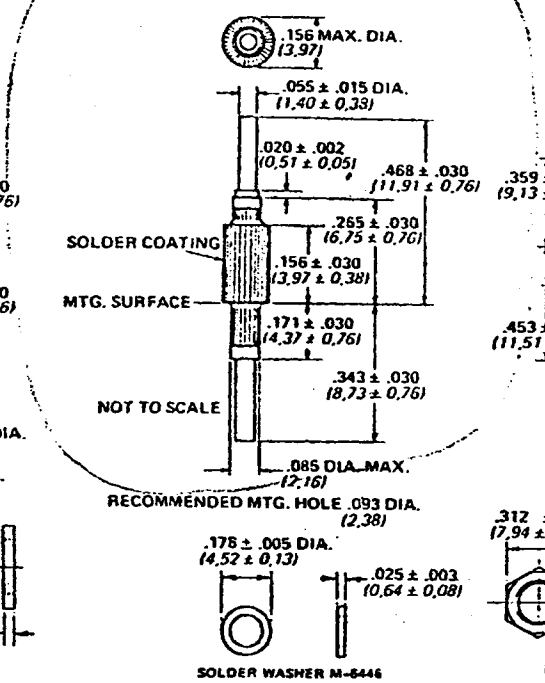
Specifications	Type FCS-C	Type SMFB-A4	Type SMFO-1 / Type SMFB-A1	Type SMFB-A2 / Type SMFO-2
Attenuation See explanation below table.	25 dB @ 25°C 20 dB @ 85°C	50 dB @ 25°C 45 dB @ 125°C	35 dB @ 25°C 35 dB @ 125°C	60 dB @ 25°C 50 dB @ 85°C
Operating Temperature Range	−55°C to +85°C	−55°C to +125°C	−55°C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

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

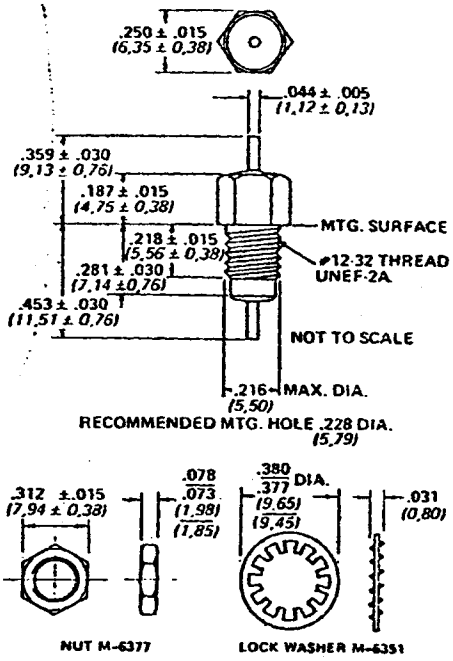
Type FCS-C



Types SMFO-1, SMFO-2



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



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

SPECTRUM ACQUIRES ALLEN BRADLEY LINE

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

SPECTRUM CONTROL INC.

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

10.0 MODULE PHOTOGRAPHS

Note that 1050 MHz LPF is not yet connected in this unit.

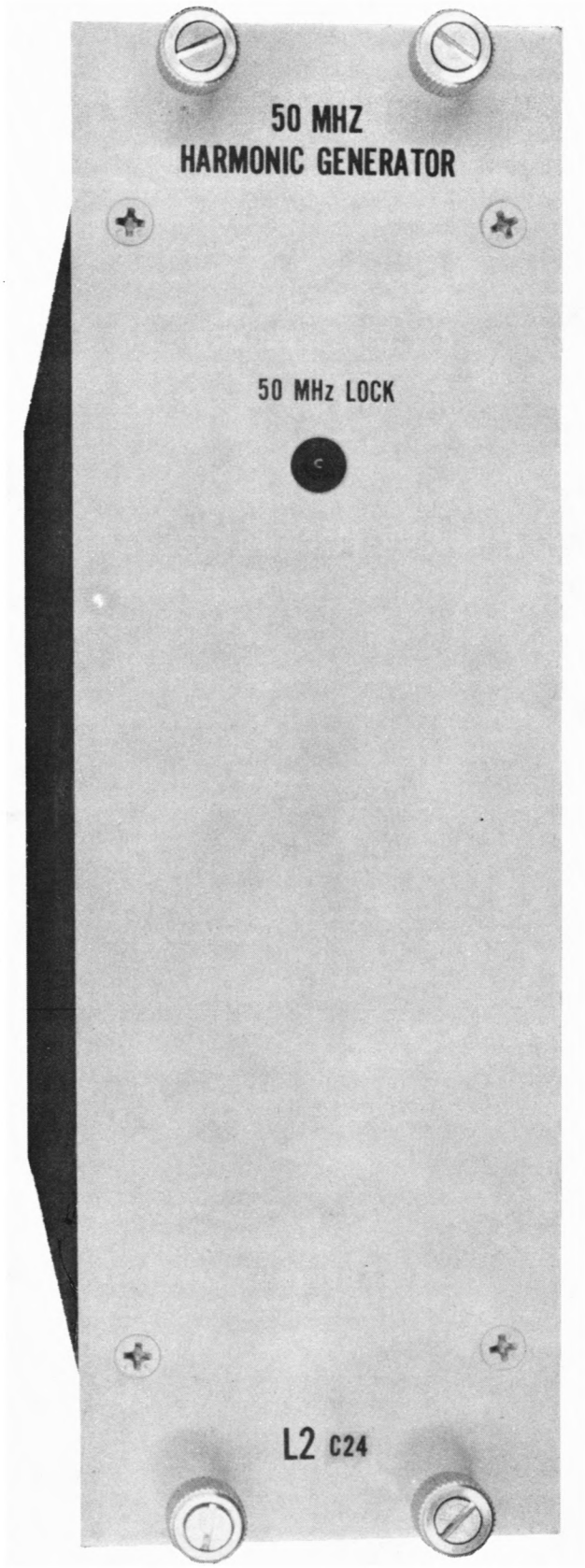


FIGURE 6: FRONT PANEL, FRONT VIEW

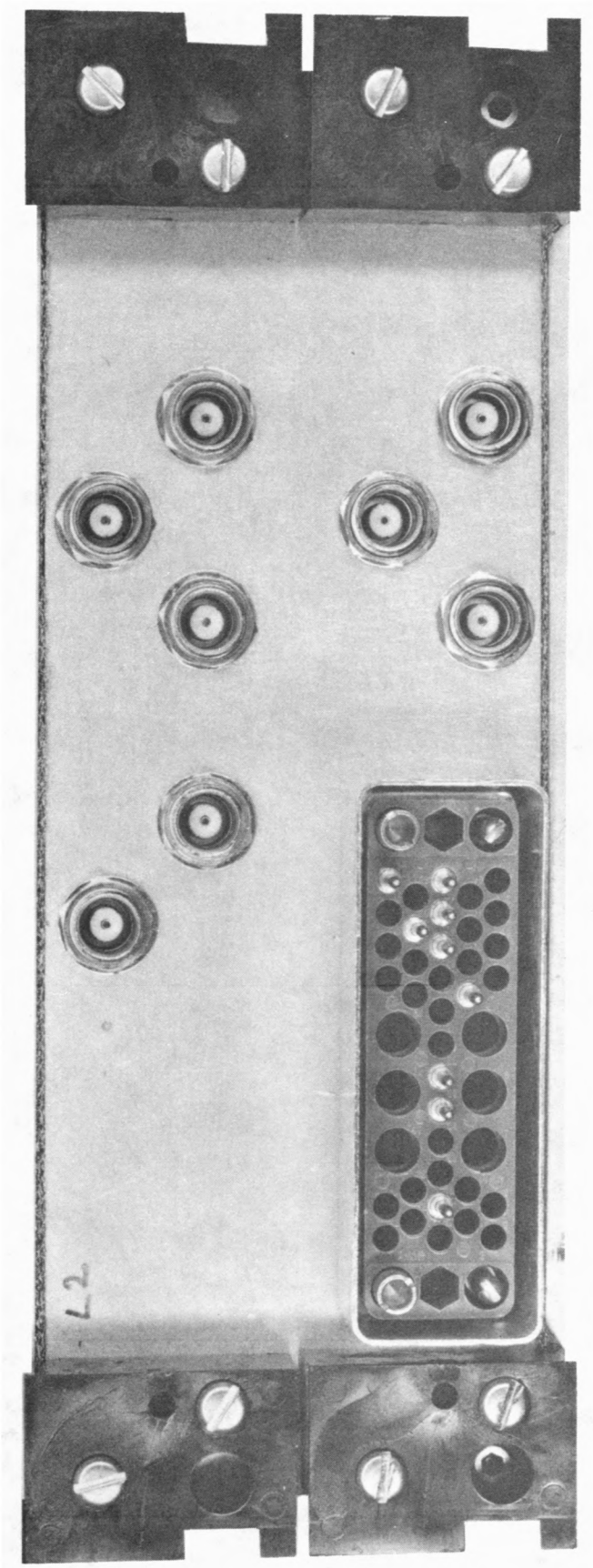


FIGURE 7: REAR PANEL

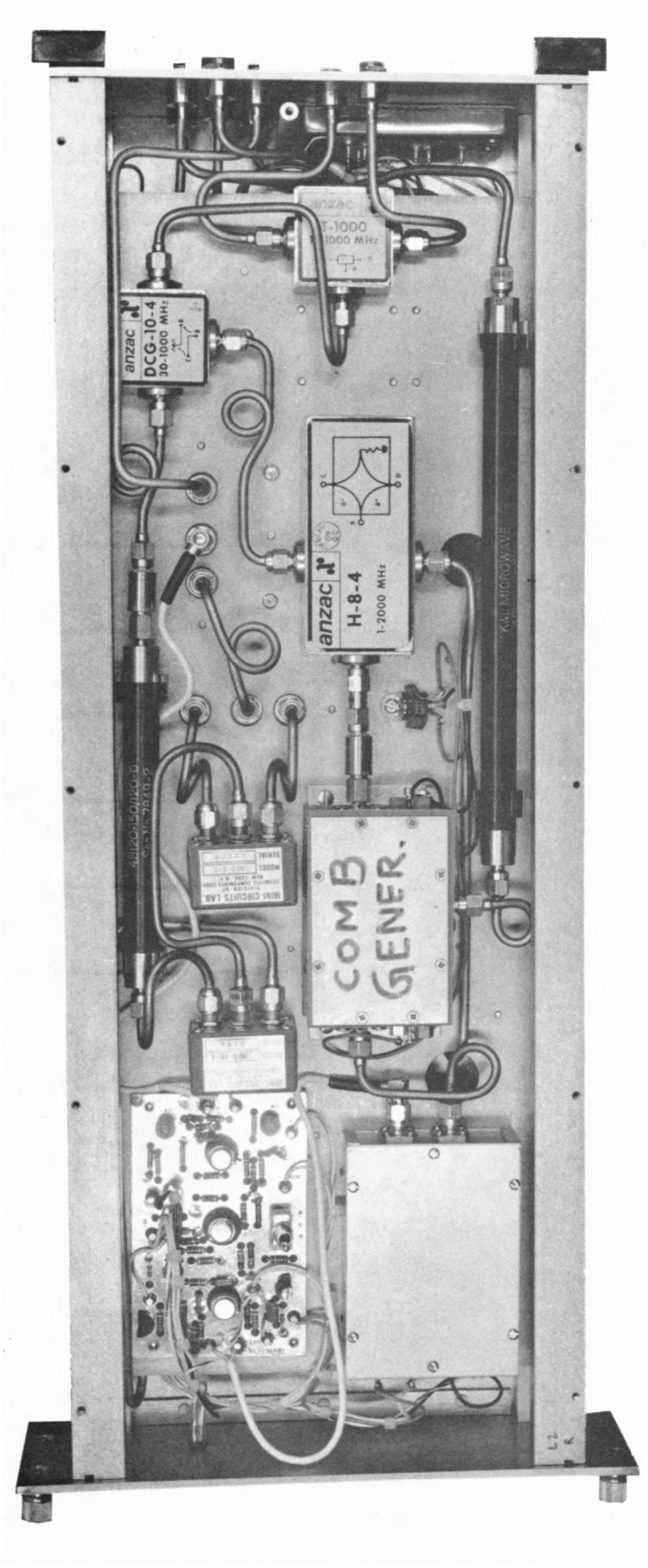


FIGURE 8: RIGHT-HAND SIDE VIEW
(Note that 1050 MHz LPF is not yet connected in this unit)

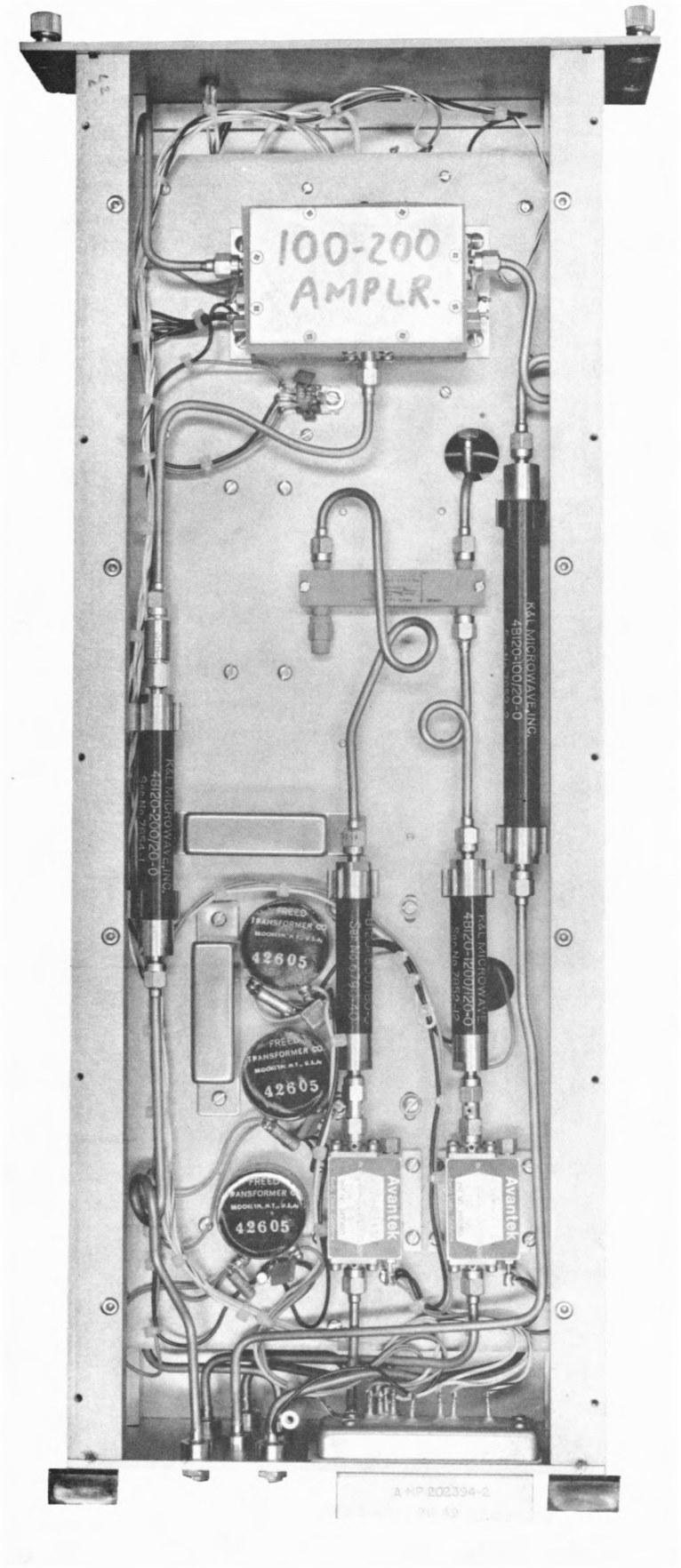


FIGURE 9: LEFT-HAND SIDE VIEW