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

VLA ELECTRONICS MEMORANDUM NO. 168

PHASE STABILITY OF SOME COMPONENTS AND SUB-SYSTEMS IN VLA ELECTRONICS

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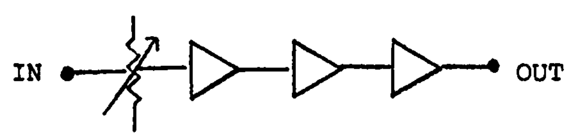
1.0 INTRODUCTION

Phase stability of many components and sub-systems was measured during 1976-1977 while trying to understand phase stability of the VLA system. In most cases stress was to determine phase-stability with temperature variation ($\Delta\phi/\Delta T$) around room temperature. For many components phase variations with other parameters like power level, gain, etc. were also determined. The results are given in this report.

COMPONENT/SIGNAL DESCRIPTION	PHASE VARIATION WITH	CONDITION OF MEASUREMENT AND/OR TEST SET-UP	RESULTS - NOTES
1. Band-Pass Filters			
a) ½" tubular coaxial BPF by K&L Microwave, Inc. Filters in frequency range of 100 to 2000 MHz	Temperature	Figure 1	$k = 30$ to 70×10^{-6} (see Note 1)
b) IF band-pass filters in 1 to 2GHz range for Front End IF filters (F7) and IF off-set (F8) modules. Designed by RLC Electronics.	Temperature	Figure 1	A 4-section 1325/60 MHz BPF has $\Delta\phi/\Delta T \sim 0.05^{\circ}/^{\circ}C$. This gives $k \sim 6 \times 10^{-6}$ (see Note 1)
c) 10.1 MHz crystal BPF in Fringe Generator (L7) module having 3 dB bandwidth = 30 kHz.	Temperature	Figure 1	$\Delta\phi/\Delta T$ at 10.1 MHz = $0.2^{\circ}/^{\circ}C$
2. 1 to 2 GHz Amplifiers			
a) Avantek ASD8199M Gain ~ 27 dB, P_{out} at 1 dB Compression = +7dBm	Temperature	Figure 2A, @ 1800 MHz and P_{out} = +10 dBm	$\Delta\phi/\Delta T \sim 0.2^{\circ}/^{\circ}C$
	Power Supply Voltage	Variation by ± 500 mV @ + 15 V and P_{out} = 0 to 10 dBm at 1200 MHz.	$\Delta\phi \leq 0.3^{\circ}$ for ± 500 mV
	Output Power	At P_{out} = +7 dBm for both 1200 and 1800 MHz	$\Delta\phi/\Delta P_{in} \lesssim 0.15^{\circ}/dB$
		At P_{out} = 0 dBm for both 1200 and 1800 MHz	$\Delta\phi/\Delta P_{in} \lesssim 0.05^{\circ}/dB$
b) Variable gain amplifier consisting of following stages:	Temperature at different P_{out}, and gain values for input at both 1200 and 1800 MHz simultaneously	Test set up Figure 2B	For results see Figure 2C



Type:	G1	UTO-2002	UTO-2003	A37
Mfr:	WJ	AVANTEK		WJ

COMPONENT/SIGNAL DESCRIPTION	PHASE VARIATION WITH	CONDITION OF MEASUREMENT AND/OR TEST SET-UP	RESULTS - NOTES
2. b) (Cont'd) Maximum Gain - 25 dB P_{out} @ 1 dB Compression = +15 dBm at 1200 and 1800 MHz			
c) LOCUS Amplifier RF668 used in Transmit side of MODEM (T1) modules. Gain = 28 ± 1 dB P_{out} at 1 dB compression = +17 dBm (Min)	Temperature	Figure 2B; P_{out} (Total) = +17 dBm (+14 at each 1200 and 1800 MHz)	$\Delta\phi/\Delta T \sim 0.35^\circ/^\circ C$ @ 1800 MHz
3. <u>Balanced Mixers</u>			
a) Watkins-Johnson Mixer M1A used as phase detector at 50 MHz	Temperature at different L.O. Power	Figure 3A, RF port power ~ -3 dBm	$\Delta\phi/\Delta T$ (@ P_{LO}=+17dBm)=$0.13^\circ/^\circ C$ (@ P_{LO}=+10dBm)=$0.2^\circ/^\circ C$ (@ P_{LO}=0dBm)=$0.8^\circ/^\circ C$
b) Watkins-Johnson Mixer M1J used as Modulator	Temperature, L.O. Power, Modulation	Figure 4A	Figure 4B
4. PIN Diode Attenuator, Vectronics Microwave Corporation type DA 0125-40	Attenuation	Figure 5	ATT.(dB) 0 5 10 15 20 25 30 PHASE(°) 0 5 7 8 7.5 5.5 4 ATT 35 40 PHASE 2 0
5. 50 MHz COMB GENERATOR using step recovery diode HP 5082-0112	Temperature	Figure 6, @ 1800 MHz	$\Delta\phi/\Delta T=0.6^\circ/^\circ C$; $\Delta\phi/\Delta P_{in} \simeq 2^\circ/dB$ Phase stability using SRD type HP 5082-0820 is similar. For 50 MHz Harmonic Generator (L2C) module comb generator employing HP 0820 diode is used

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6. L1: 5 to 50 MHz VCXO	Temperature	Figure 7	
a) 5 MHz			$\Delta\phi_5/\Delta T \leq 0.1^\circ/^\circ C$
b) 50 MHz			$\Delta\phi_{50}/\Delta T \approx 2^\circ/^\circ C$ The phase variation of the phase shifter in 5 MHz (5ϕ) is $\leq 0.05^\circ/^\circ C$
7. L2A: 50 to 600 MHz Multiplier	Temperature	Similar to Figure 8	
a) 100 MHz			$\Delta\phi_{100}/\Delta T \sim 0.38^\circ/^\circ C$
b) 600 MHz			$\Delta\phi_{600}/\Delta T \sim 1.7^\circ/^\circ C$
8. L2C: 50 MHz Harmonic Generator	Temperature	Figure 8	
a) 600 MHz line in 50 MHz Comb			$\Delta\phi_{600}/\Delta T = 0.2^\circ/^\circ C$
b) 1200 MHz Output			$\Delta\phi_{1200}/\Delta T = 0.3^\circ/^\circ C$
c) 1800 MHz Output			$\Delta\phi_{1800}/\Delta T = 0.5^\circ/^\circ C$
9. L2C (50 MHz Harmonic Generator) and L3C (Antenna L.O. Transmitter) Together	Temperature	Figure 9	
a) 600 MHz @ L3J10			$\Delta\phi_{600}/\Delta T \sim 0.2^\circ/^\circ C$
b) 1200 MHz @ L3J8			$\Delta\phi_{1200}/\Delta T \sim 0.4^\circ/^\circ C$
c) 1800 MHz @ L3J8			$\Delta\phi_{1800}/\Delta T \sim 0.6^\circ/^\circ C$
10. L2C, L3C and L6 (2-4 GHz Synthesizer)	Temperature	Figure 10	
a) 600 MHz from 50 MHz comb @ L2J12			$\Delta\phi_{600}/\Delta T \sim 0.2^\circ/^\circ C$
b) 1200 MHz @ L3J8			$\Delta\phi_{1200}/\Delta T \sim 0.35^\circ/^\circ C$
c) 2990 MHz @ L6J12			$\Delta\phi_{2990}/\Delta T \sim 1^\circ/^\circ C$

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11. L7: Fringe Generator 10.1 MHz	Temperature	Figure 11, fringe rate set to zero.	$\Delta\phi_{10.1}/\Delta T \sim 0.65^\circ/^\circ C$
12. T2: IF Combiner XMIT 1200 MHz XMIT 1800 MHz RCV 1200 MHz RCV 1800 MHz	Temperature and Power Level	Figure 12	XMIT @ 1200 $\Delta\phi/\Delta T = .05^\circ/^\circ C$ XMIT @ 1800 $\Delta\phi/\Delta T = 0.1^\circ/^\circ C$ RCV @ 1200 $\Delta\phi/\Delta T = 0.1^\circ/^\circ C$ RCV @ 1800 $\Delta\phi/\Delta T = 0.15^\circ/^\circ C$
13. F4: Frequency Converter (Proposed Design)	Temperature, Power Level	Figure 13A, B	$\Delta\phi/\Delta T$ @ 1010 MHz = $0.1^\circ/^\circ C$ $\Delta\phi/\Delta P_{in} \leq 0.2^\circ/dB$ for fixed output around nominal value of VCA attenuation
14. Vertex Room Front End Electronics at L-Band (Antenna 3)	Temperature	Figure 14	
a) From upconverter up to F4 output			$\frac{\Delta\phi}{\Delta T}$ (up to F4) ~ 3 to $4^\circ/^\circ C$
b) From upconverter up to T2 XMIT IF monitor on front panel	A-Rack Power Supply	Figure 14 Each power supply voltage varied separately by 100 mV	$\frac{\Delta\phi}{\Delta T}$ (up to T2) ~ $3^\circ/^\circ C$ 100 mV @ +15 V gives $\Delta\phi \leq 1^\circ$ 100 mV @ -15 V gives $\Delta\phi \leq 1^\circ$ 100 mV @ +5 V gives $\Delta\phi \leq 1^\circ$

Note 1 - Phase variation at center frequency of pass-band is expressed: $\frac{\Delta\phi}{\Delta T}$ (in degrees) $= m \times 90^\circ \times \frac{f_o}{BW} \cdot k$

where, m = number of sections
f_o = center frequency
BW = 3 dB bandwidth
k = A constant, whose value is determined

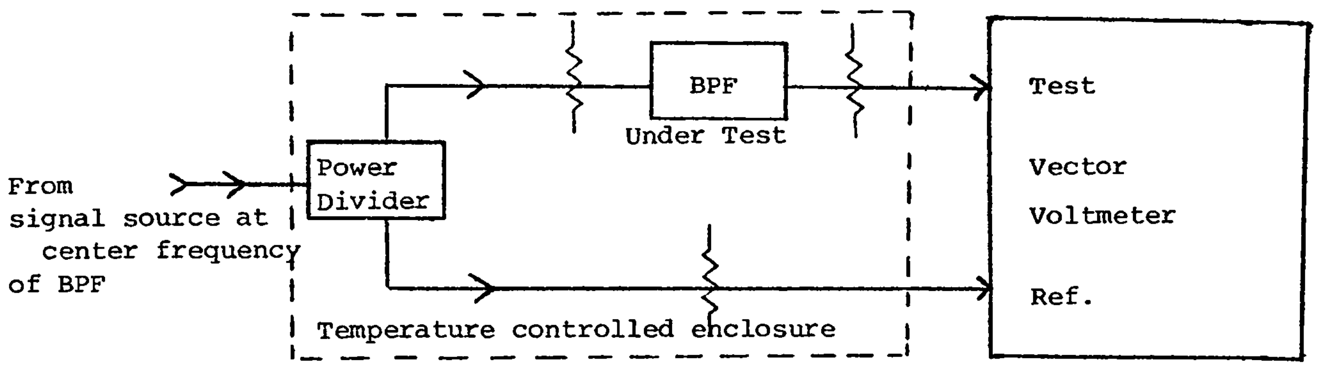


FIGURE 1: SET UP FOR MEASURING BPF PHASE VARIATIONS WITH TEMPERATURE

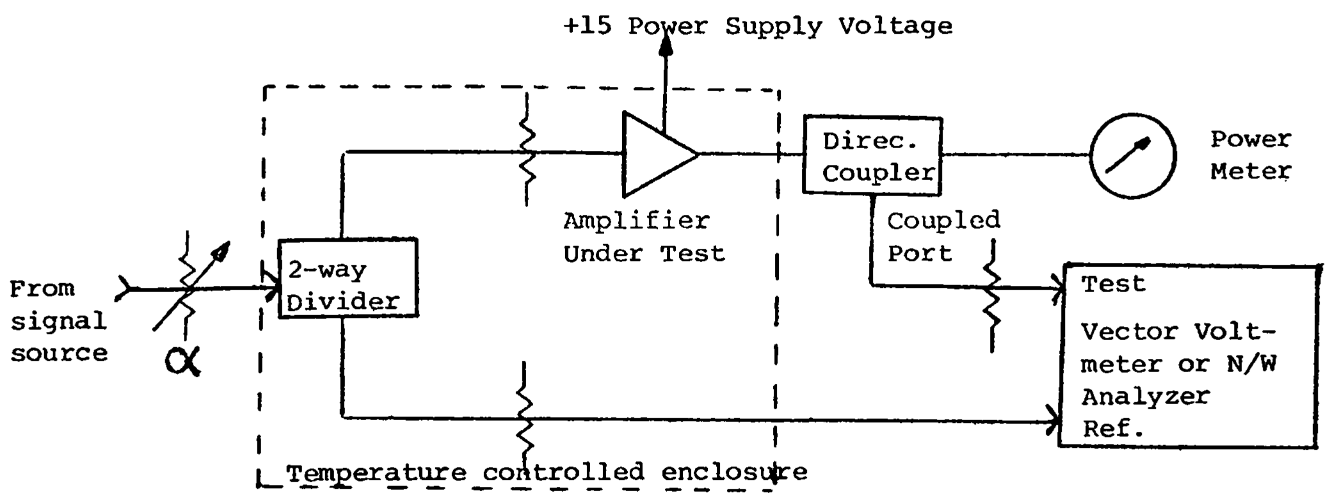


FIGURE 2A: SET UP FOR MEASURING 1-2 GHz AMPLIFIER PHASE STABILITY

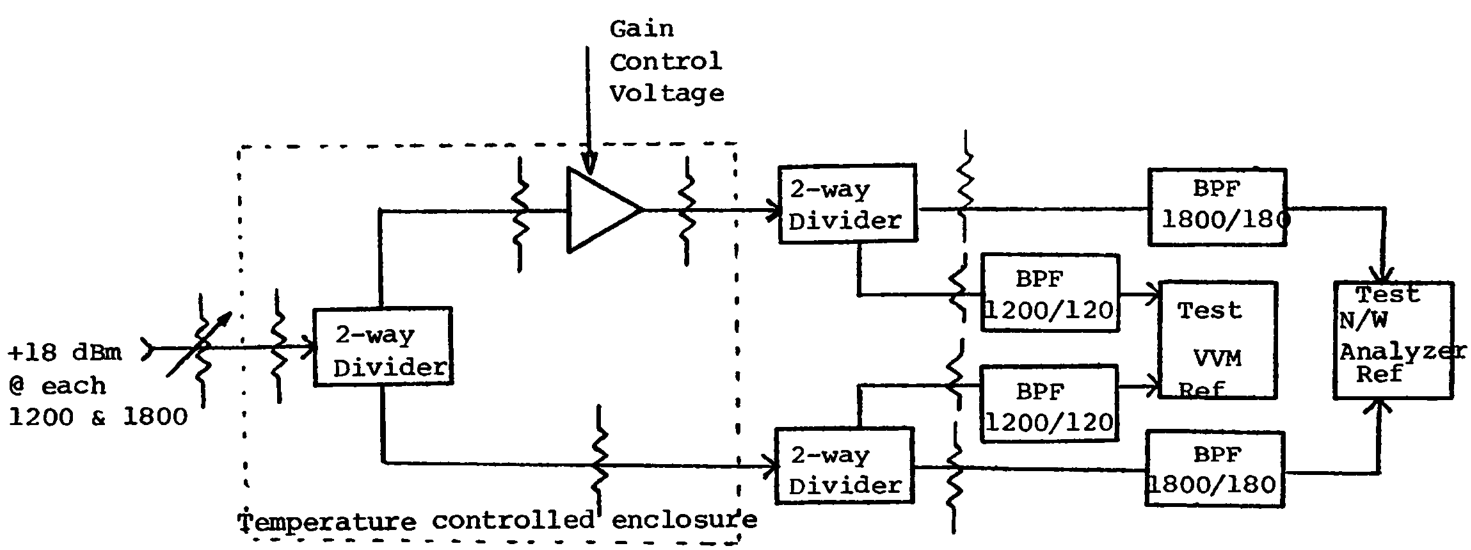
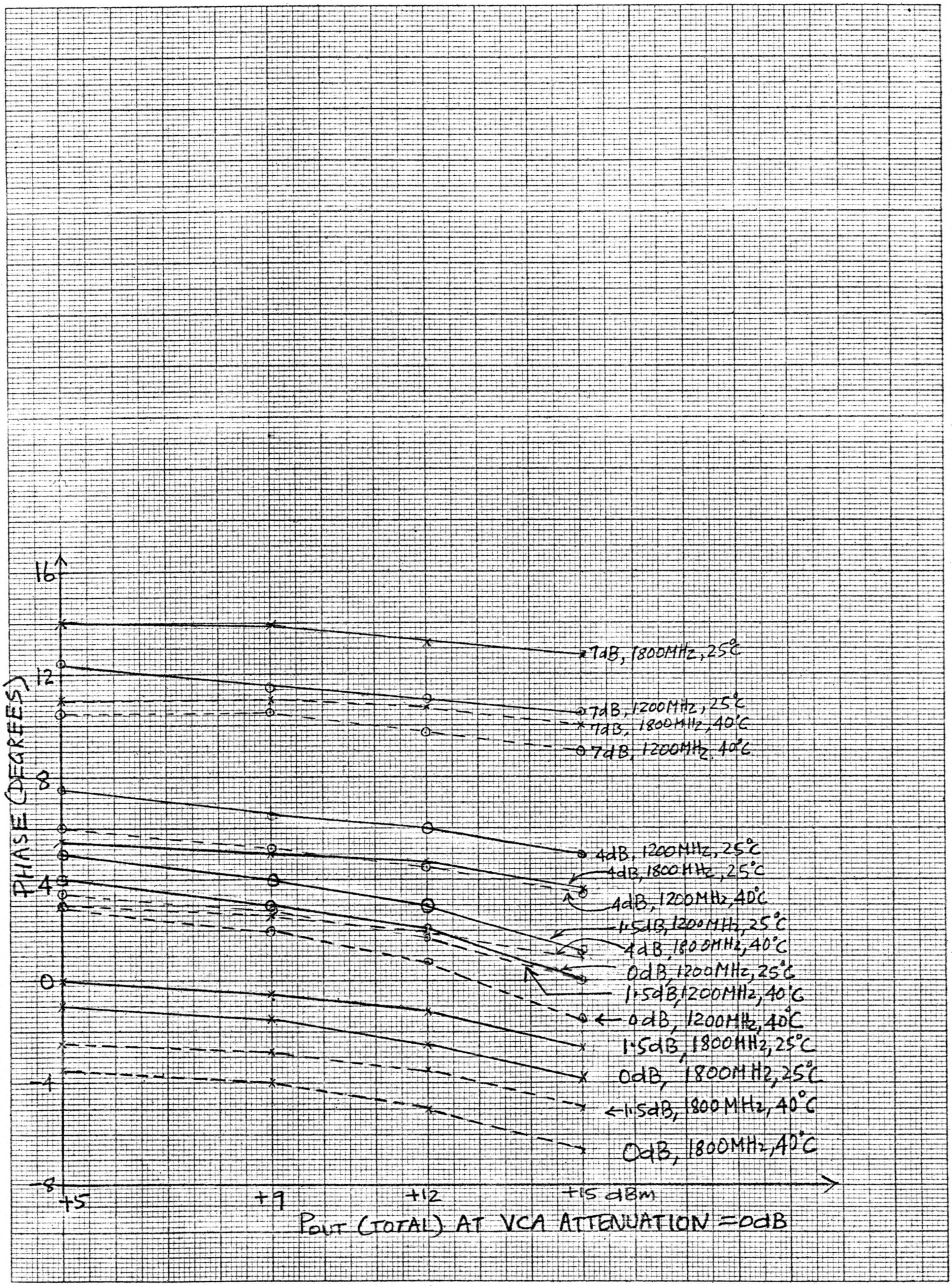


FIGURE 2B: SET UP TO MEASURE PHASE STABILITY OF VARIABLE GAIN 1-2 GHz AMPLIFIER

461510
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.



+5 FIGURE 2C: PHASE VARIATIONS WITH P_{out}, GAIN, TEMPERATURE AT 1200 AND 1800 MHz (see Figure 2B for set up)

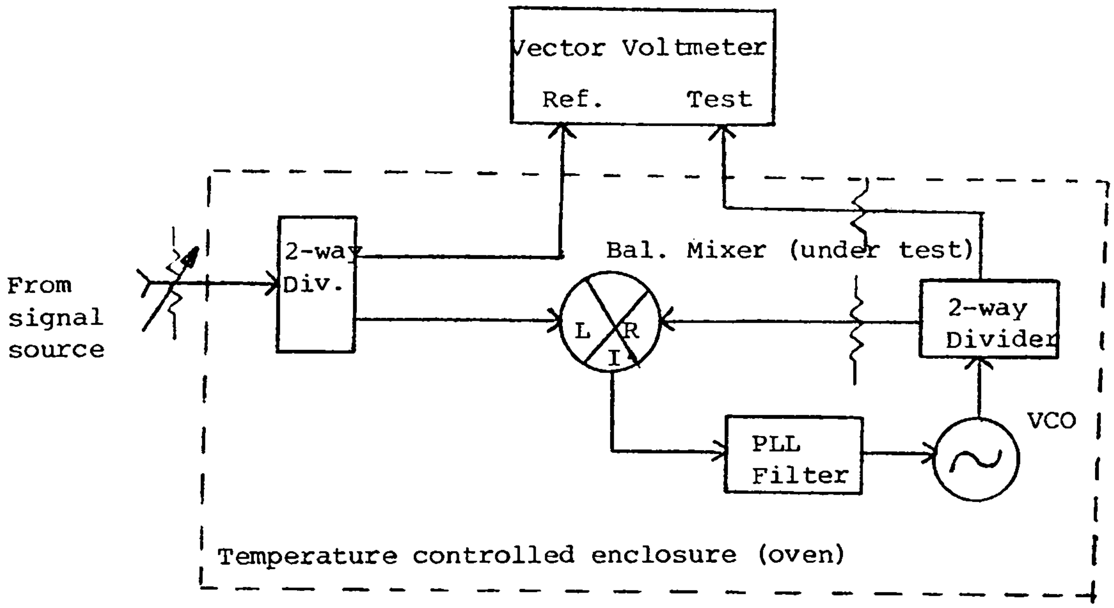
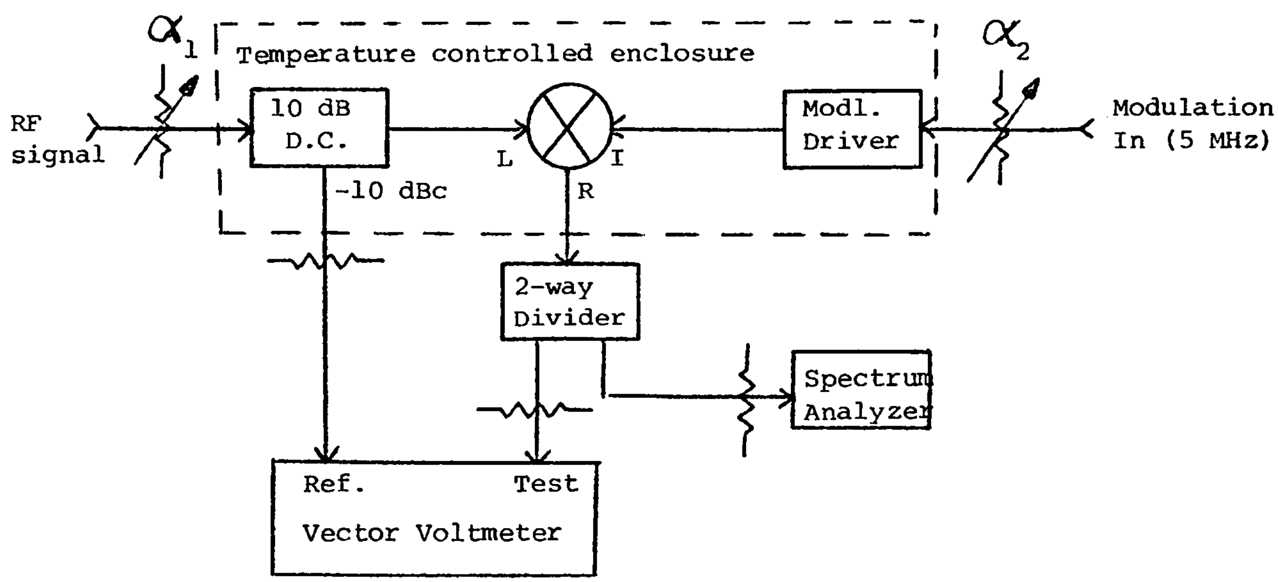


FIGURE 3: SET UP FOR MEASURING PHASE STABILITY OF BALANCED MIXER MIA USED AS PHASE DETECTOR AT 50 MHz



1) Modulation is adjusted to give ±5 MHz sidebands to carrier ratio = -10 dBc
2) Modulator driver bias adjusted to give modulator carrier output = -18 dBm

FIGURE 4A: SET UP FOR MEASURING PHASE STABILITY OF A MODULATOR

$P_{L.O.}$	dBm	+2	+5	+9	+13
$\Delta\phi/\Delta P_{in(L.O.)}$	(^{o}/dB)	2^{o}	3^{o}	$1{\cdot}5^{o}$	1^{o}
$\Delta\phi/\Delta P_{mod}$	(*)	$<0.1^{o}$	$<0.1^{o}$	$<0.1^{o}$	$<0.1^{o}$
$\Delta\phi/\Delta T$	(^{o}/^{o}C)	0·23	0·22	0·20	0·20

*when 5 MHz modulation/carrier ratio reduced from -10 to -20 dBc

FIGURE 4B: RESULTS OF MODULATOR PHASE STABILITY

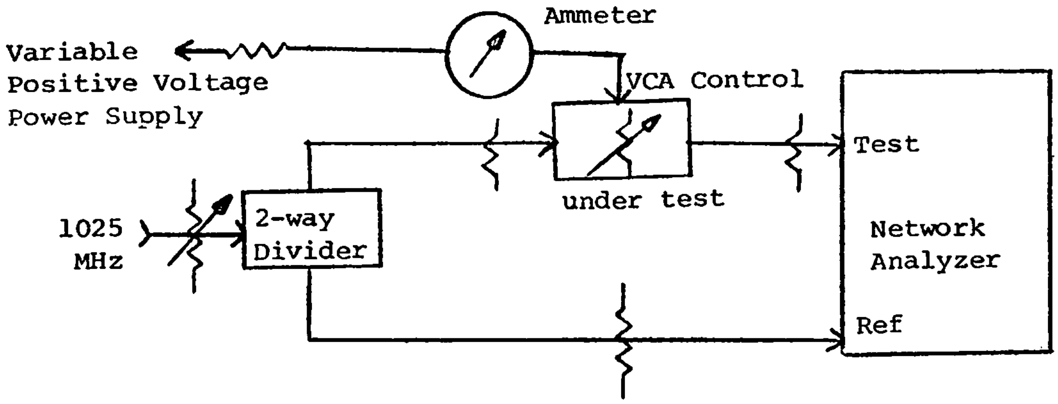


FIGURE 5: SET UP FOR MEASURING PHASE VARIATION WITH ATTENUATION FOR PIN DIODE ATTENUATOR

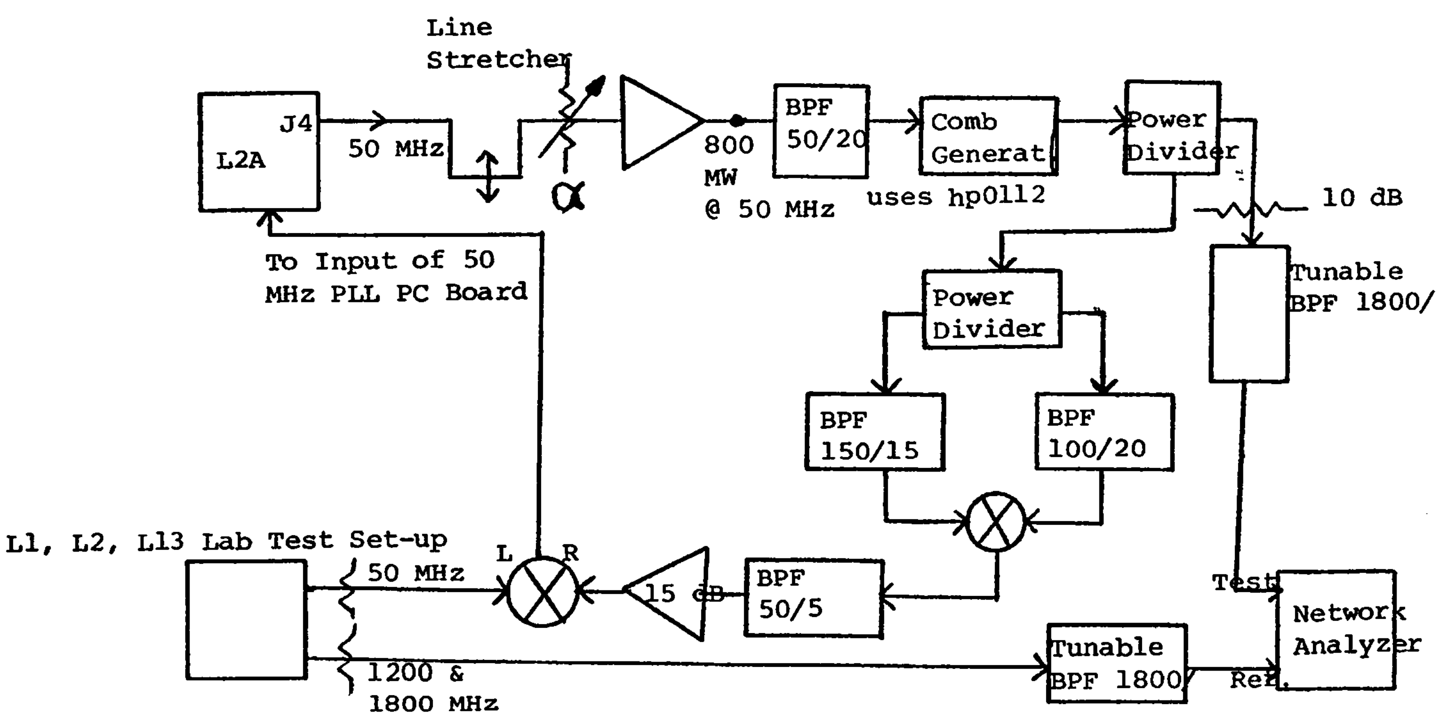


FIGURE 6: SET UP FOR MEASURING PHASE STABILITY OF 50 MHz COMB-GENERATOR

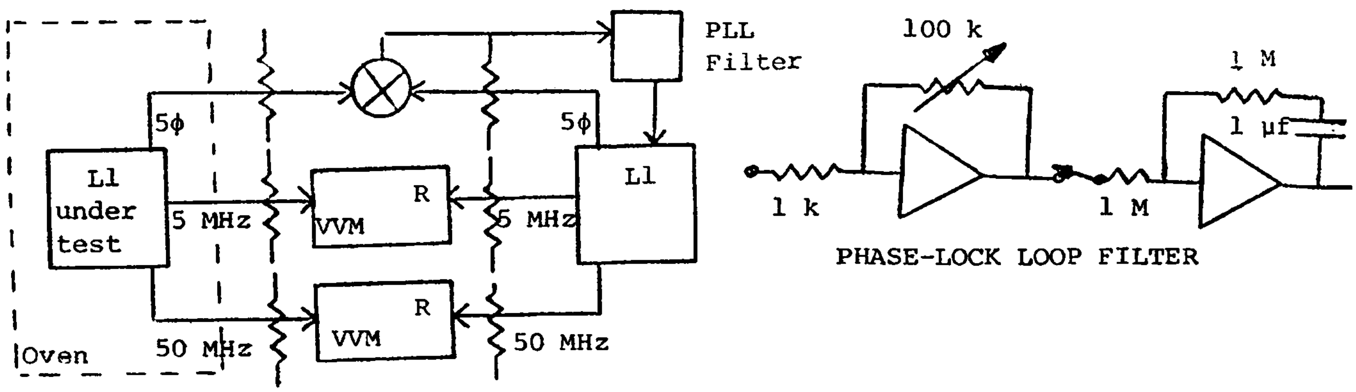


FIGURE 7: SET UP FOR MEASURING PHASE VARIATION WITH TEMPERATURE OF L1 MODULE SIGNALS

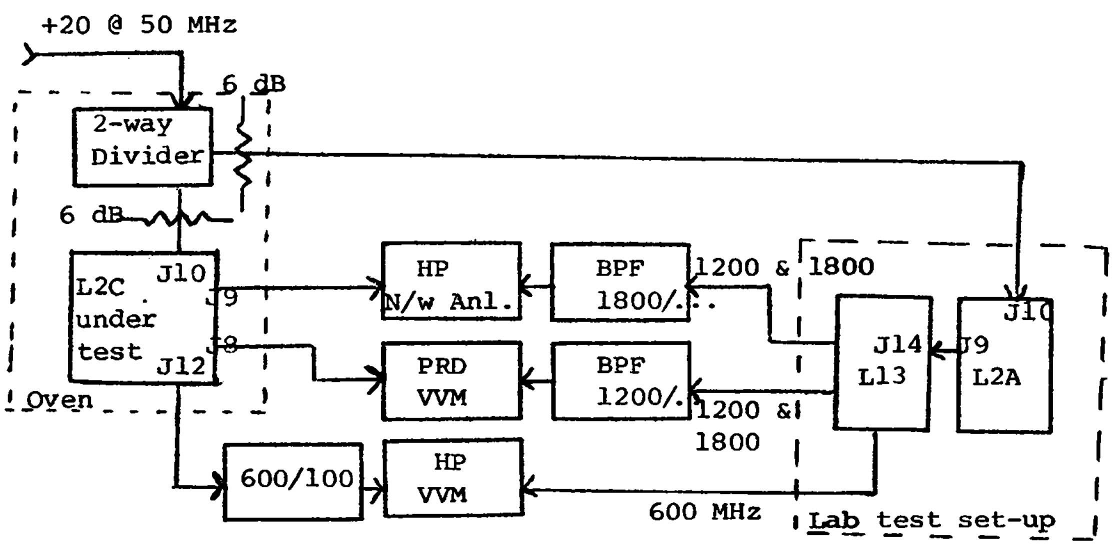


FIGURE 8: SET UP FOR MEASURING PHASE VARIATION WITH TEMPERATURE OF L2C MODULE

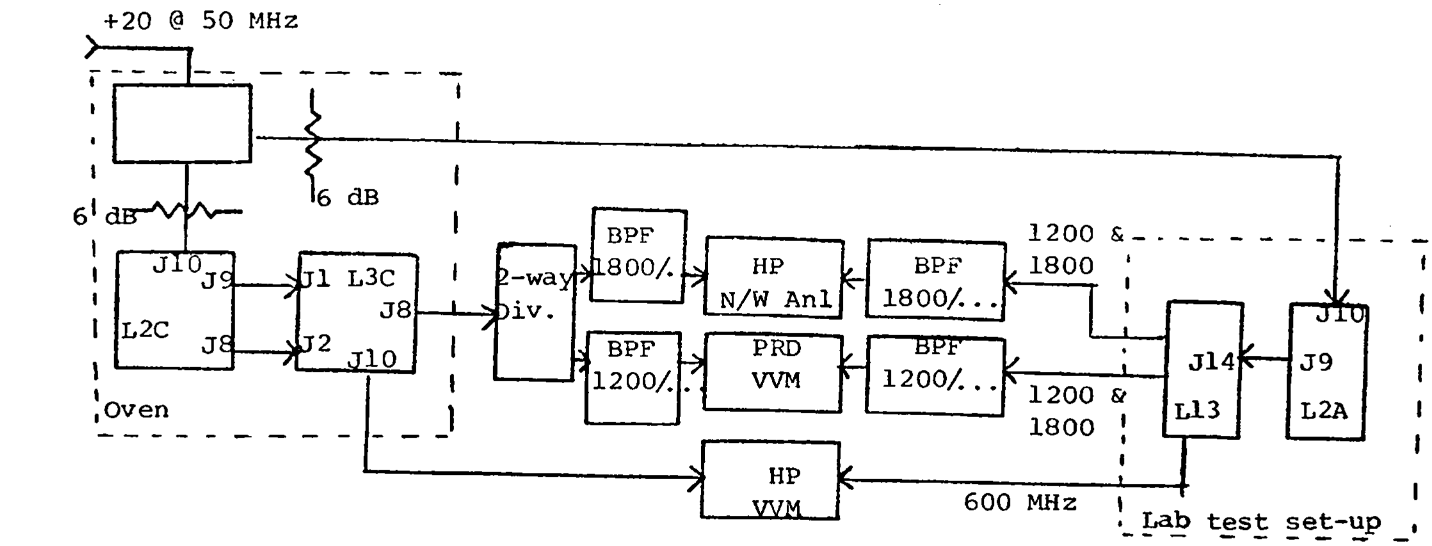
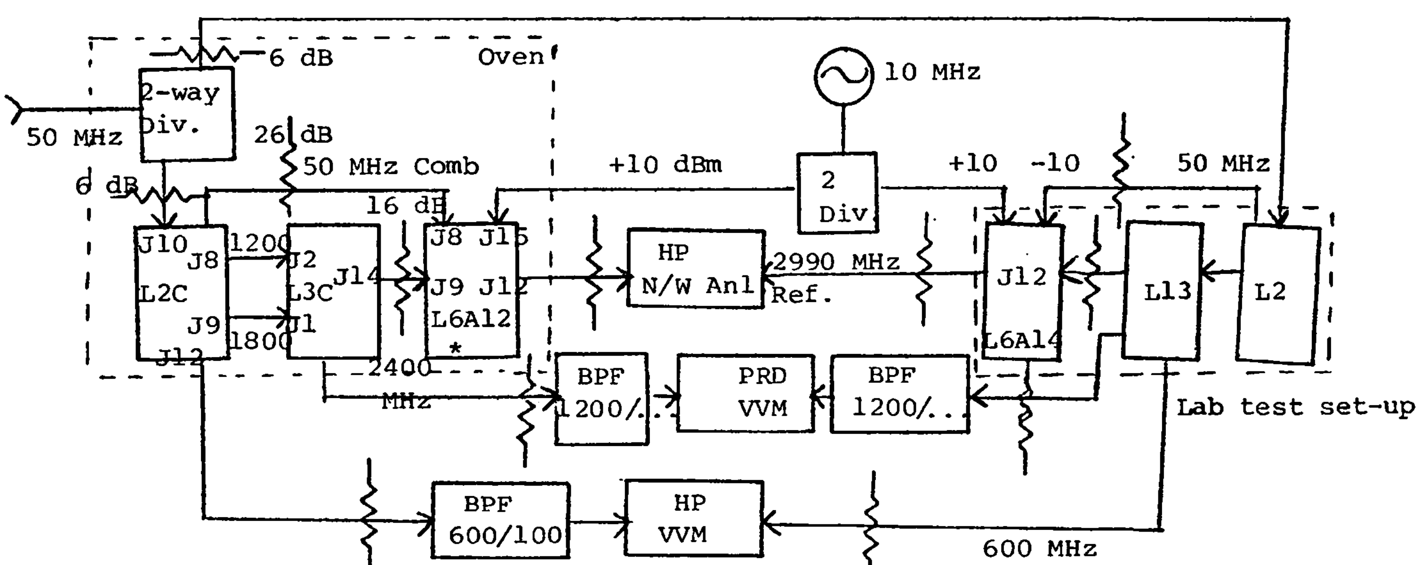


FIGURE 9: SET UP FOR MEASURING PHASE VARIATIONS WITH TEMPERATURE OF L2C AND L3C TOGETHER



*50 MHz Comb Generator inside L6A12 bypassed, temperature probe on L6A12 center plate.

FIGURE 10: SET UP TO MEASURE PHASE VARIATION WITH TEMPERATURE FOR MODULES L2C, L3C and L6

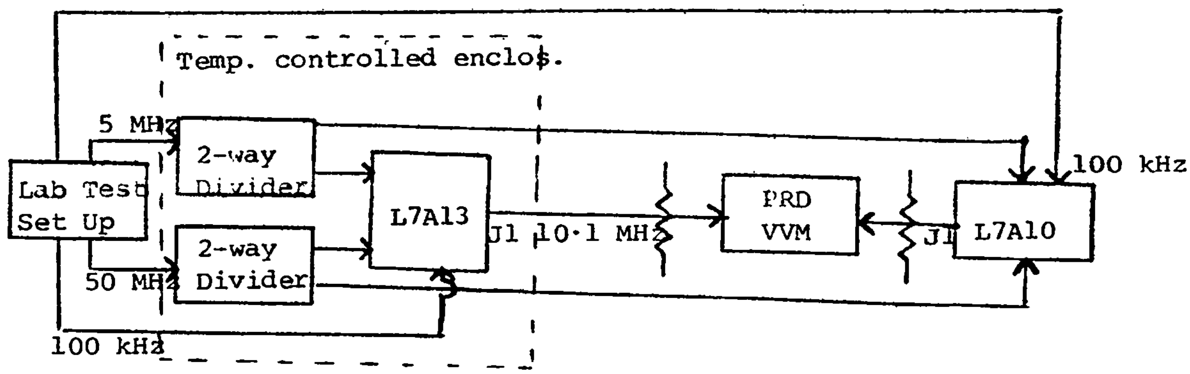


FIGURE 11: SET UP TO MEASURE PHASE VARIATION WITH TEMPERATURE FOR L7 MODULE

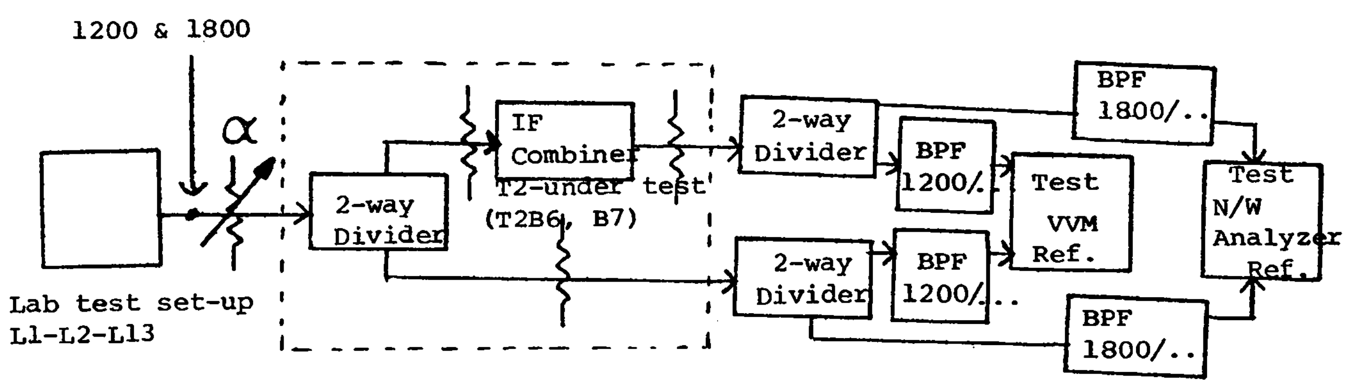
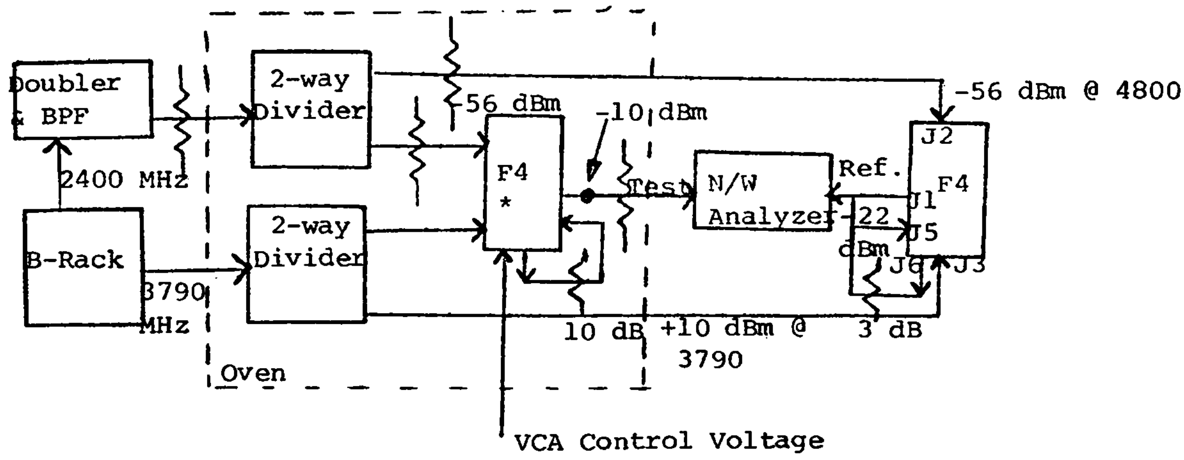


FIGURE 12: SET UP TO MEASURE PHASE STABILITY OF T2 MODULE



*Unit under test, has ALC loop open - VCA control voltage adjusted to provide 15 dB attenuation (nominal value). Block diagram of proposed freq. converter (F4) is shown below.

FIGURE 13A: SET UP TO MEASURE PHASE STABILITY OF F4 MODULE

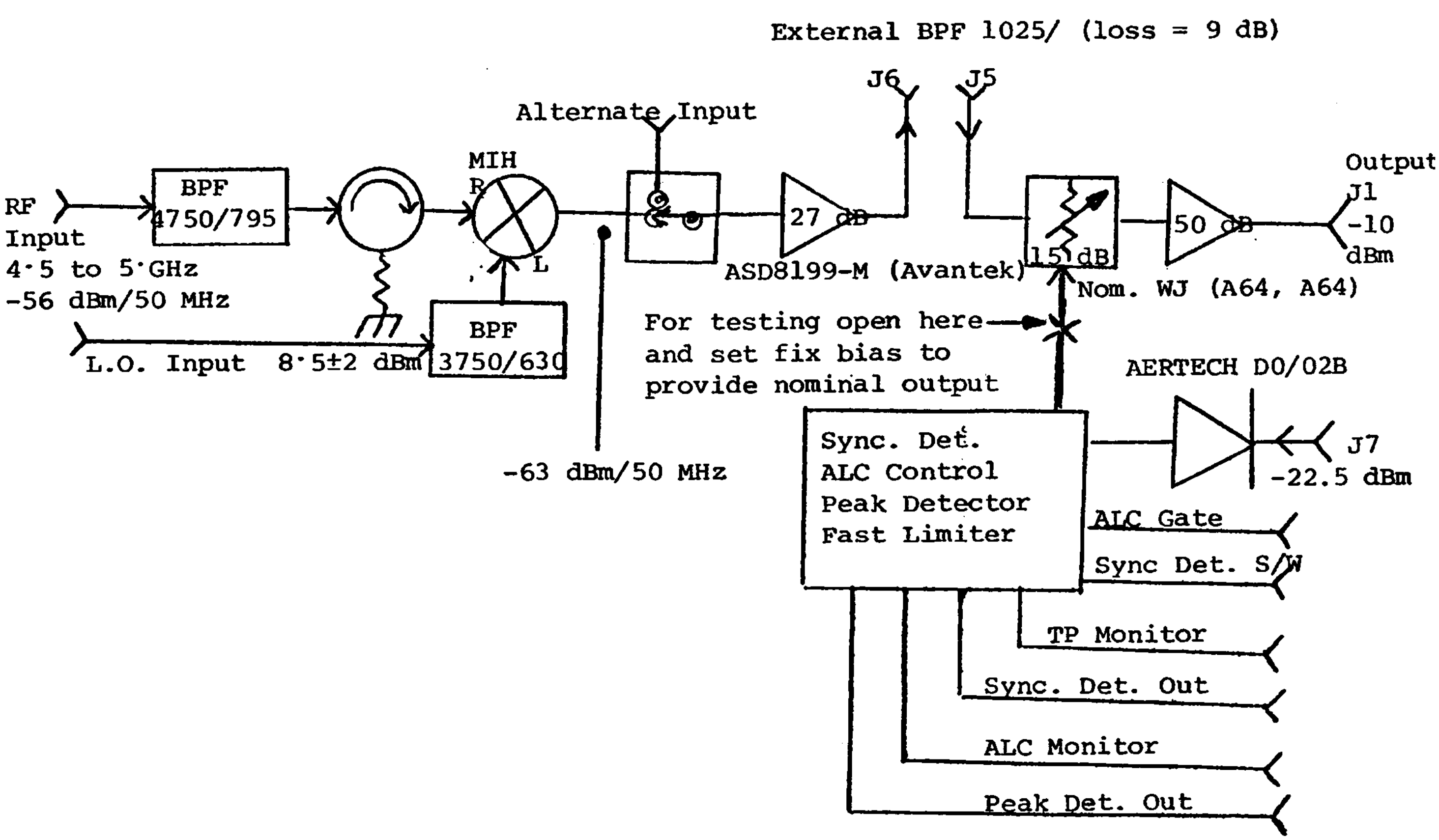


FIGURE 13B: BLOCK DIAGRAM OF PROPOSED F4, USED FOR TESTING PHASE STABILITY

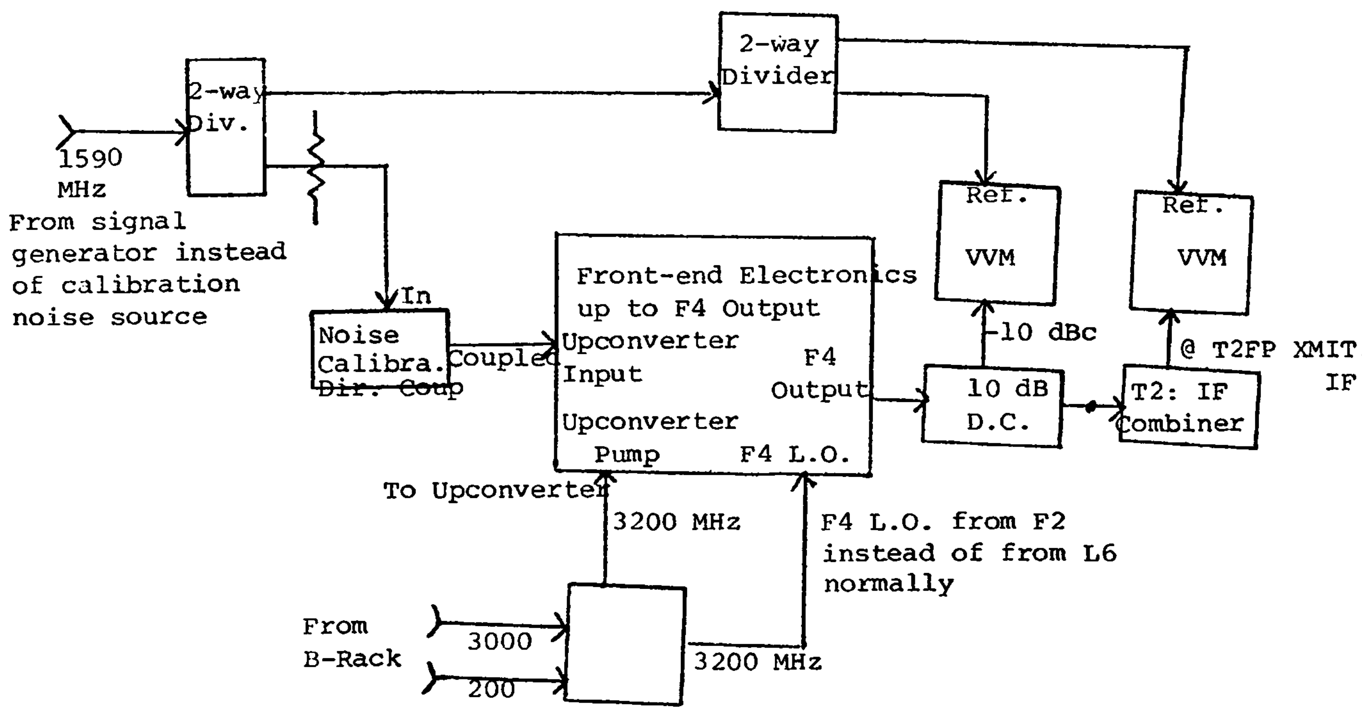


FIGURE 14: SET UP TO MEASURE FRONT-END ELECTRONICS PHASE STABILITY