VLA Technical Report No. 37

SYSTEM PERFORMANCE IN DECEMBER 1977

D. S. Bagri

March 1978

ACKNOWLEDGMENTS

Success of this work largely depends on many helpful discussions with Larry R. D'Addario during modifications and testing of the L.O. System and cooperation of Larry R. D'Addario and Peter J. Napier during system testing. Help of Bob Cohee, Jim Oty and Fred Dunn during assembly and testing of the L.O. System was essential for completing the work. Wonderful job of typing has been done by Doris R. Gill and Kathy McConnell and drafting by Robert S. Runyon and Thomas Cote. Finally I would like to thank Dr. A. R. Thompson for his continuous guidance during the entire work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

This report describes status of modified electronics for antennas 3 and 5 as in December, 1977. Optimum signal levels for system as well as individual modules are given. Results of measurements on the L.O., IF and waveguide communication channel for electronics of antenna 3 are described. Interferometer consisting of antennas 3 and 5 was used to measure phase stability of fringe-visibility on calibration radio sources. A summary of results of various tests is given below:

1) Optimum power levels within the system have been determined. The signal levels are given on the block diagrams describing the electronics. Power levels with tolerances of the inputs and outputs of L.O. and IF modules are given in TABLES 2.1 and 2.2.
2) A set of photographs of spectra and waveforms showing performance of the system was taken and are reproduced here.
3) Considerably large passband ripples, of the order of 5 to 6 dB, have been observed in the IF passband of 50 MHz at the base band frequency.
4) Coefficients of 600 MHz round-trip phase (ϕ_{600RT}) and 5 MHz phase at antenna (ϕ_{5ANT}) with the vertex room temperature (T_{VR}) have been determined. $\Delta\phi_{600RT}/\Delta T_{VR} = 0^{\circ}.5/^{\circ}C$ and $\Delta\phi_{5ANT}/\Delta T_{VR} \lesssim 0^{\circ}.1/^{\circ}C$.
5) L.O. phase jumps due to slipping of 600 MHz cycle are caused by 5 MHz phase jumps. Fine scale ripple with about 5 to 10 MHz ripple period in the waveguide transfer function appear to be source of the 5 MHz phase jumps.
6) For observations of calibration radio sources at C-Band (4900 MHz) the phase stability of the fringe visibility is about 15° peak-to-peak for a 30 hour continuous observing time. This appears to be marginally acceptable. However

a similar phase stability is observed at L-Band and is clearly not acceptable.

7) Coefficient of the fringe visibility phase with the vertex room temperature is about $2^{\circ}.8/^{\circ}C$ at both C-Band and L-Band. At C-Band it is acceptable but clearly not at L-Band.

2.0 SYSTEM CONFIGURATION

Block diagram in Figure 2.1 shows electronics of Master Local Oscillator system located at Central Electronics Room (CR), and electronics for one antenna located at both CR and antenna Vertex Room (VR) and connected by waveguide communication channel. Block diagrams with signal levels are shown in Figures 2.2 through 2.4 for the Master Local Oscillator System, CR electronics for each antenna, Rack D, and VR electronics consisting of front-end and antenna L.O. Racks A and B respectively. Optimum signal levels and their tolerances have been determined. Nominal signal levels are indicated on the block diagrams. Input and output signal levels for L.O. and IF modules at antenna and VR are shown in TABLES 2.1 and 2.2 respectively. The system signal levels are shown in Figure 2.5. For all tests system signal levels are adjusted to within 0·5 dB using controls provided. A procedure to adjust the signal levels is given in TABLE 2.3. The module serial numbers installed as of December 25, 1977 are given in TABLES 2.4 to 2.6.

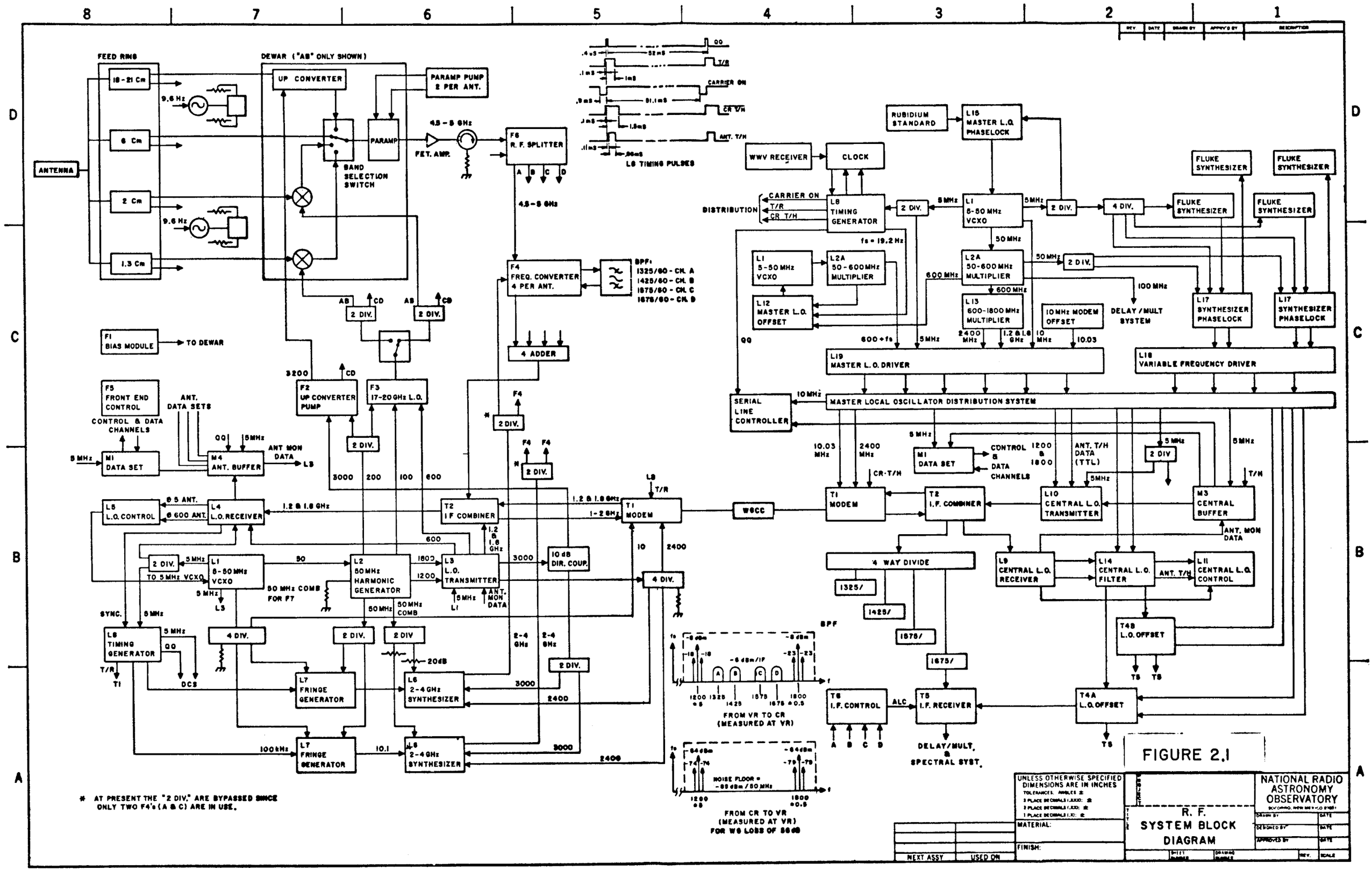

FEED RING
18-21 Cm
6 Cm
2 Cm
1.3 Cm
9.6 Hz
ANTENNA
DEWAR ("AB" ONLY SHOWN)
UP CONVERTER
PARAMP PUMP 2 PER ANT.
PARAMP
BAND SELECTION SWITCH
FET. AMP.
4.5 - 5 GHz
F6 R.F. SPLITTER
A B C D
4.5 - 5 GHz
F4 FREQ. CONVERTER 4 PER ANT.
BPF: 1325/60 - CH. A
1425/60 - CH. B
1575/60 - CH. C
1675/60 - CH. D
4 ADDER
2 DIV.
AB
CD
F1 BIAS MODULE
TO DEWAR
3200
F2 UP CONVERTER PUMP
F3 17-20 GHz L.O.
F5 FRONT END CONTROL
CONTROL & DATA CHANNELS
ANT. DATA SETS
M1 DATA SET
M4 ANT. BUFFER
ANT MON DATA
L5 L.O. CONTROL
L4 L.O. RECEIVER
1.2 & 1.8 GHz
T2 I F COMBINER
T1 MODEM
W6CC
L1 5-50 MHz VCXO
TO 5 MHz VCXO
L2 50 MHz HARMONIC GENERATOR
L3 L.O. TRANSMITTER
10 dB DIR. COUP.
4 DIV.
50 MHz COMB FOR F7
50 MHz COMB
ANT. MON DATA
SYNC.
L8 TIMING GENERATOR
T/R
DCS
L7 FRINGE GENERATOR
L6 2-4 GHz SYNTHESIZER
100 kHz
10.1
2-4 GHz
20dB
L8 TIMING PULSES
CARRIER ON
CR T/H
ANT. T/H
RUBIDIUM STANDARD
L15 MASTER L.O. PHASELOCK
WWV RECEIVER
CLOCK
DISTRIBUTION
fs = 19.2 Hz
L12 MASTER L.O. OFFSET
L2A 50-600 MHz MULTIPLIER
L13 600-1800 MHz MULTIPLIER
10 MHz MODEM OFFSET
DELAY/MULT SYSTEM
FLUKE SYNTHESIZER
L17 SYNTHESIZER PHASELOCK
L19 MASTER L.O. DRIVER
L18 VARIABLE FREQUENCY DRIVER
SERIAL LINE CONTROLLER
MASTER LOCAL OSCILLATOR DISTRIBUTION SYSTEM
CR-T/H
CONTROL & DATA CHANNELS
ANT. T/H DATA (TTL)
L10 CENTRAL L.O. TRANSMITTER
M3 CENTRAL BUFFER
4 WAY DIVIDE
1325/
1425/
1575/
1675/
L9 CENTRAL L.O. RECEIVER
L14 CENTRAL L.O. FILTER
L11 CENTRAL L.O. CONTROL
T4B L.O. OFFSET
T4A L.O. OFFSET
T6 I.F. CONTROL
T5 I.F. RECEIVER
ALC
DELAY/MULT. & SPECTRAL SYST.
BPF
FROM VR TO CR (MEASURED AT VR)
FROM CR TO VR (MEASURED AT VR) FOR W6 LOSS OF 56dB
NOISE FLOOR = -89 dBm/50 MHz
* AT PRESENT THE "2 DIV." ARE BYPASSED SINCE ONLY TWO F4's (A & C) ARE IN USE.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
MATERIAL:
FINISH:
NEXT ASSY
USED ON
NATIONAL RADIO ASTRONOMY OBSERVATORY
R.F. SYSTEM BLOCK DIAGRAM

FIGURE 2.1

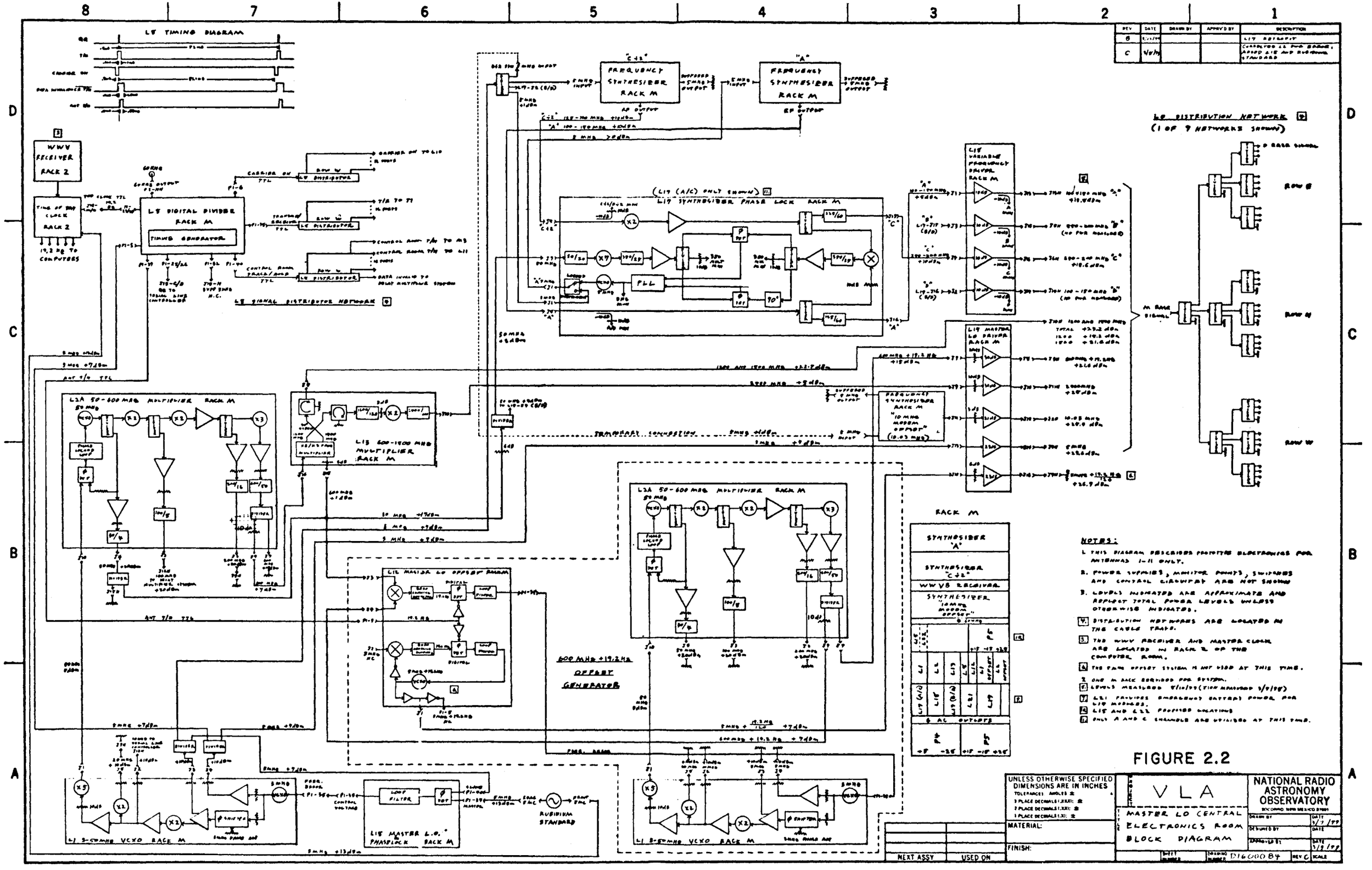
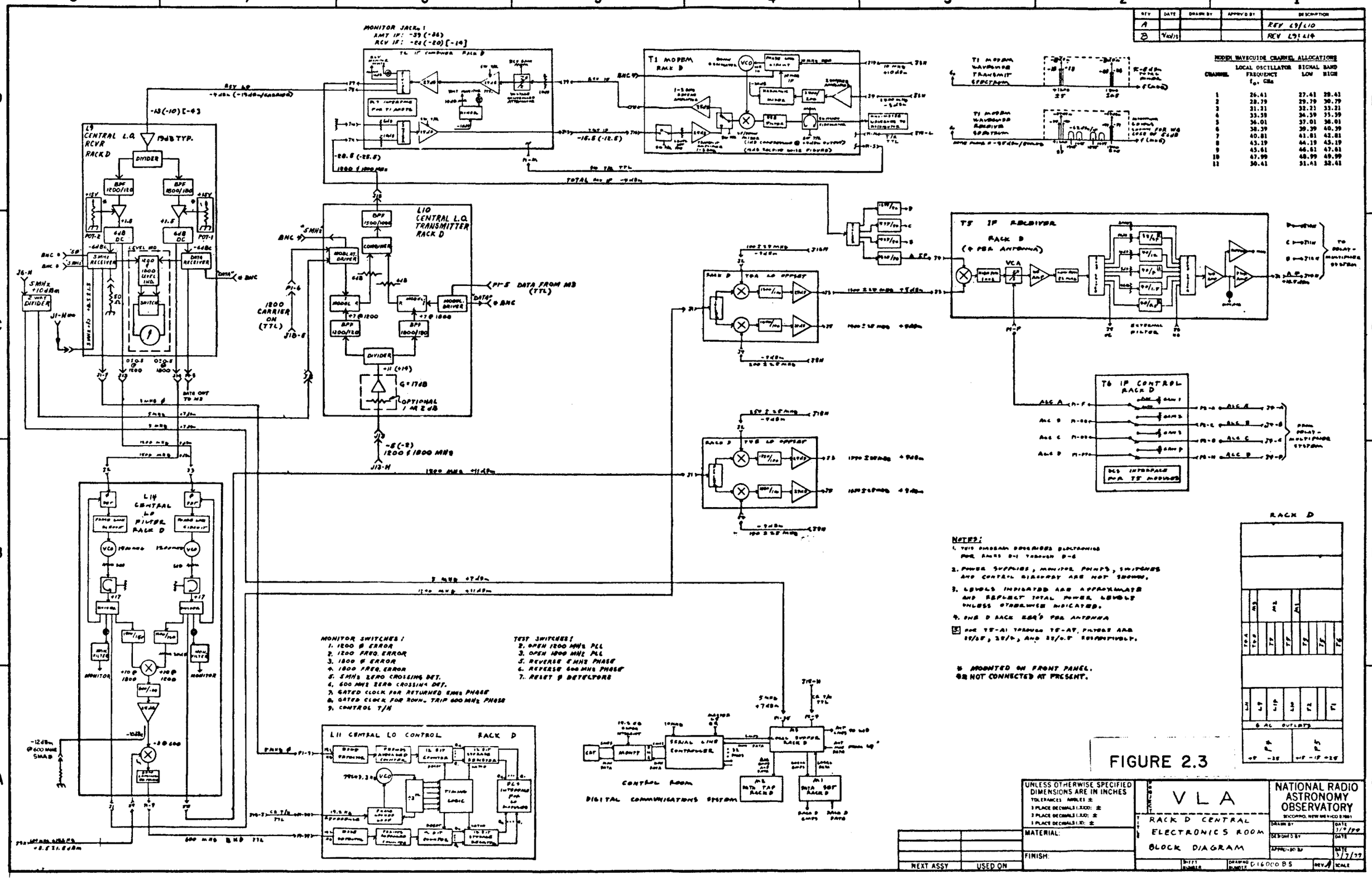

LO TIMING DIAGRAM
WWV RECEIVER RACK 2
TIME OF DAY CLOCK RACK 2
19.2 PPS TO COMPUTERS
LO DIGITAL DIVIDER RACK M
TIMING GENERATOR
LO SIGNAL DISTRIBUTION NETWORK
LO DISTRIBUTION NETWORK
(1 OF 9 NETWORKS SHOWN)
FREQUENCY SYNTHESIZER RACK M
"C+2"
"A"
(L17 (A/C) ONLY SHOWN)
L17 SYNTHESIZER PHASE LOCK RACK M
PLL
L17 VARIABLE FREQUENCY DRIVER RACK M
L17 MASTER LO DRIVER RACK M
L2A 50-600 MHZ MULTIPLIER RACK M
L13 600-1500 MHZ MULTIPLIER RACK M
L17 MASTER LO OFFSET DRIVER
600 MHz +19.2 Hz OFFSET GENERATOR
L17 MASTER L.O. PHASELOCK RACK M
LOOP FILTER
RUBIDIUM STANDARD
L1 5-GHz VCXO RACK M
RACK M
SYNTHESIZER "A"
SYNTHESIZER "C+2"
WWVB RECEIVER
SYNTHESIZER "10 MHz MODEM OFFSET"
AC OUTLETS
M RACK SIGNAL
ROW B
ROW N
ROW W
NOTES:
1. THIS DIAGRAM DESCRIBES PROTOTYPE ELECTRONICS FOR ANTENNAS 1-11 ONLY.
2. POWER SUPPLIES, MONITOR POINTS, SWITCHES AND CONTROL CIRCUITRY ARE NOT SHOWN.
3. LEVELS INDICATED ARE APPROXIMATE AND REFLECT TOTAL POWER LEVELS UNLESS OTHERWISE INDICATED.
4. DISTRIBUTION NETWORKS ARE LOCATED IN THE CABLE TRAYS.
5. THE WWV RECEIVER AND MASTER CLOCK ARE LOCATED IN RACK 2 OF THE COMPUTER ROOM.
6. THE 10 MHz OFFSET SYSTEM IS NOT USED AT THIS TIME.
7. ONE IN RACK REQUIRED FOR SYSTEM.
8. LEVELS MEASURED 8/10/79 (TIM MEASURED 3/9/79)
9. L21 PROVIDES EMERGENCY BATTERY POWER FOR L17 MODULES.
10. L17 AND L22 PROPOSED LOCATIONS
11. ONLY A AND C CHANNELS ARE UTILIZED AT THIS TIME.
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
MASTER LO CENTRAL ELECTRONICS ROOM BLOCK DIAGRAM
NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801
DRAWN BY
DESIGNED BY
APPROVED BY
DATE 3/7/79
SHEET NUMBER
DRAWING NUMBER D16000B4
REV C
SCALE

FIGURE 2.2

REV	DATE	DRAWN BY	APPRV'D BY	DESCRIPTION
A				REV L9/L10
B	4/20/77			REV L9/L14



CHANNEL	LOCAL OSCILLATOR FREQUENCY f_{LO}, GHz	SIGNAL BAND LOW	SIGNAL BAND HIGH
1	26.41	27.41	28.41
2	28.79	29.79	30.79
3	31.21	32.21	33.21
4	33.59	34.59	35.59
5	36.01	37.01	38.01
6	38.39	39.39	40.39
7	40.81	41.81	42.81
8	43.19	44.19	45.19
9	45.61	46.61	47.61
10	47.99	48.99	49.99
11	50.41	51.41	52.41

MODEM WAVEGUIDE CHANNEL ALLOCATIONS

FIGURE 2.3

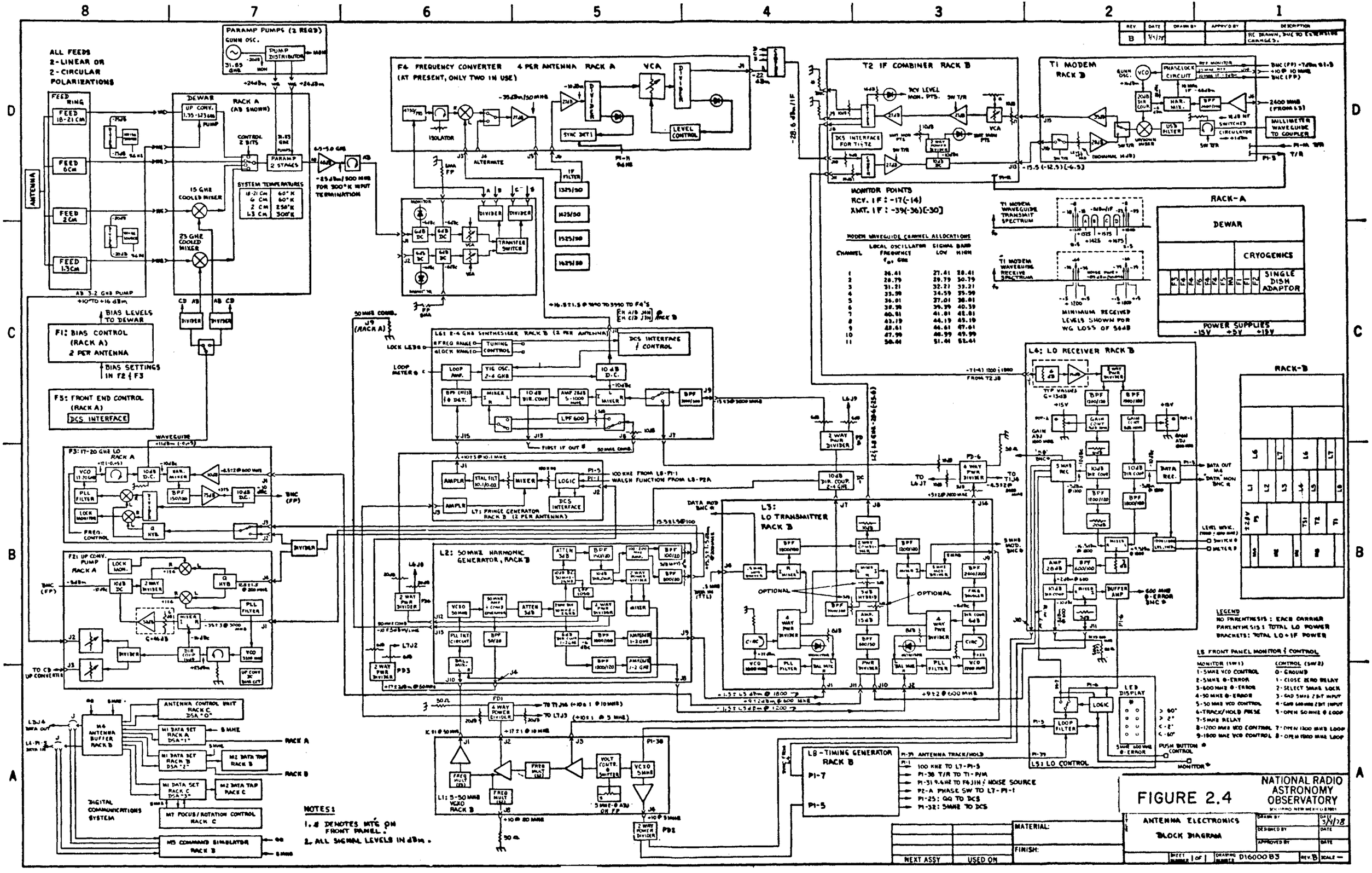

ALL FEEDS
2-LINEAR OR
2-CIRCULAR
POLARIZATIONS
PARAMP PUMPS (2 REQD)
GUNN OSC.
PUMP DISTRIBUTOR
FEED RING
FEED 18-21 CM
FEED 6CM
FEED 2CM
FEED 1.3CM
ANTENNA
DEWAR
RACK A (AS SHOWN)
UP CONV. 1.35-1.75 GHz
PUMP
CONTROL 2 BITS
PARAMP 2 STAGES
SYSTEM TEMPERATURES
18-21 CM 60°K
6 CM 60°K
2 CM 250°K
1.3 CM 300°K
15 GHz COOLED MIXER
23 GHz COOLED MIXER
AB 5.2 GHz PUMP
BIAS LEVELS TO DEWAR
F1: BIAS CONTROL (RACK A) 2 PER ANTENNA
BIAS SETTINGS IN F2 & F3
F5: FRONT END CONTROL (RACK A)
DCS INTERFACE
F4 FREQUENCY CONVERTER 4 PER ANTENNA RACK A
(AT PRESENT, ONLY TWO IN USE)
ISOLATOR
ALTERNATE
SYNC DET.
LEVEL CONTROL
IF FILTER
1325/50
1425/50
1525/50
1625/50
MONITOR
TRANSFER SWITCH
T2 IF COMBINER RACK B
RCV LEVEL MON. PTS.
DCS INTERFACE FOR T1/T2
MONITOR POINTS
RCV. IF: -17(-14)
XMT. IF: -39(-36)[-30]
T1 MODEM RACK B
PHASELOCK CIRCUIT
HAR. MIX.
BPF
USB FILTER
CIRCULATOR
MILLIMETER WAVEGUIDE TO COUPLER
2400 MHz (FROM L5)
MODEM WAVEGUIDE CHANNEL ALLOCATIONS
CHANNEL
LOCAL OSCILLATOR FREQUENCY f_{LO} GHz
SIGNAL BAND LOW
HIGH
T1 MODEM WAVEGUIDE TRANSMIT SPECTRUM
T1 MODEM WAVEGUIDE RECEIVE SPECTRUM
MINIMUM RECEIVED LEVELS SHOWN FOR WG LOSS OF 56dB
RACK-A
DEWAR
CRYOGENICS
SINGLE DISH ADAPTOR
POWER SUPPLIES
-15V +5V +15V
RACK-B
L6: LO RECEIVER RACK B
L6: 2-4 GHz SYNTHESIZER RACK B (2 PER ANTENNA)
TUNING CONTROL
DCS INTERFACE & CONTROL
YIG OSC. 2-4 GHz
LOOP AMP.
MIXER
LPF 600
FIRST IF OUT
L7: PRINGE GENERATOR RACK B (2 PER ANTENNA)
100 KHz FROM L8-P1-1
WALSH FUNCTION FROM L8-P2A
L3: LO TRANSMITTER RACK B
OPTIONAL
L2: 50 MHz HARMONIC GENERATOR, RACK B
VCXO 50 MHz
PLL FILTER
L1: 5-50 MHz VCXO RACK B
VOLT CONTR. & SWITCH
VCXO 5 MHz
L5: LO CONTROL
LOGIC
LOOP FILTER
LED DISPLAY
PUSH BUTTON CONTROL
MONITOR
LEGEND
NO PARENTHESIS: EACH CARRIER
PARENTHESIS: TOTAL LO POWER
BRACKETS: TOTAL LO + IF POWER
L8 FRONT PANEL MONITOR & CONTROL
MONITOR (SW1)
1-5 MHz VCO CONTROL
2-5 MHz Φ-ERROR
3-600 MHz Φ-ERROR
4-50 MHz Φ-ERROR
5-50 MHz VCO CONTROL
6-TRACK/HOLD PHASE
7-5 MHz RELAY
8-1200 MHz VCO CONTROL
9-1800 MHz VCO CONTROL
CONTROL (SW2)
0-GROUND
1-CLOSE ZERO RELAY
2-SELECT 5 MHz LOCK
3-GND 5 MHz 2 BIT INPUT
4-GND 600 MHz 2 BIT INPUT
5-OPEN 50 MHz Φ LOOP
6-OPEN 1200 MHz LOOP
7-OPEN 1800 MHz LOOP
F3: 17-20 GHz LO RACK A
VCO 17.7 GHz
PLL FILTER
LOCK MONITOR
FREQ. CONTROL
F2: UP CONV. PUMP RACK A
TO CD UP CONVERTER
M4 ANTENNA BUFFER RACK B
ANTENNA CONTROL UNIT RACK C DSA "0"
M1 DATA SET RACK A DSA "1"
M1 DATA SET RACK B DSA "2"
M1 DATA SET RACK C DSA "3"
M2 DATA TAP RACK B
M2 DATA TAP RACK C
M7 FOCUS/ROTATION CONTROL RACK C
M5 COMMAND SIMULATOR RACK B
DIGITAL COMMUNICATIONS SYSTEM
L8-TIMING GENERATOR RACK B
P1-39 ANTENNA TRACK/HOLD
100 KHz TO L7-P1-5
P1-38 T/R TO T1-P/M
P1-31 9.6 KHz TO F4-J1H; NOISE SOURCE
P2-A PHASE SW TO L7-P1-1
P1-25: GQ TO DCS
P1-32: 5 MHz TO DCS
NOTES:
1. * DENOTES MTG ON FRONT PANEL.
2. ALL SIGNAL LEVELS IN dBm.
NATIONAL RADIO ASTRONOMY OBSERVATORY
ANTENNA ELECTRONICS BLOCK DIAGRAM
DRAWING NUMBER D16000B3
REV. B
SCALE —
MATERIAL:
FINISH:
NEXT ASSY
USED ON

FIGURE 2.4

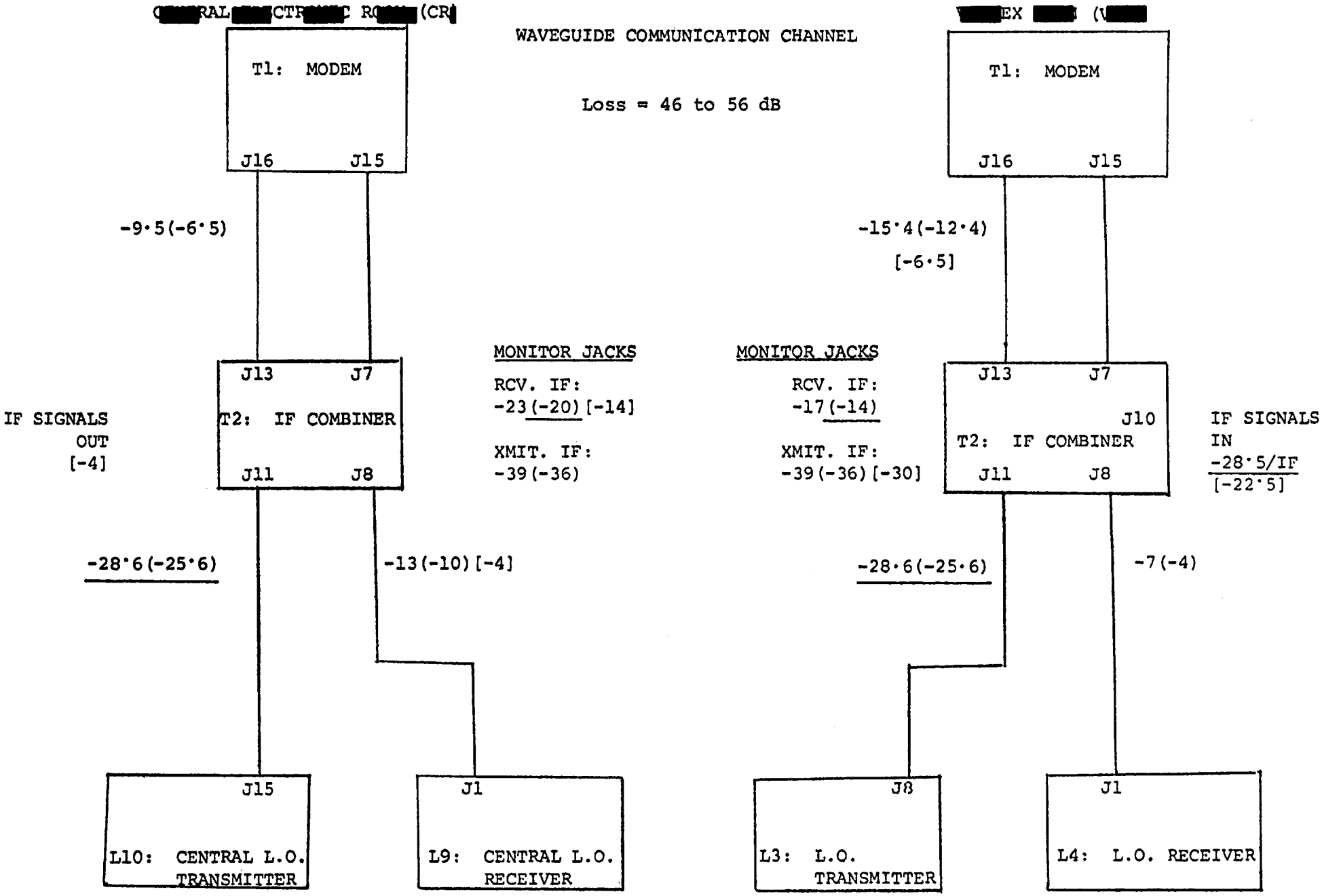


FIGURE 2.5 - SYSTEM SIGNAL LEVELS. All power levels in dBm and apply to carrier if no parenthesis, total L.O. carriers if in parenthesis, and total L.O. and IF in in brackets. All levels when the signal is ON, they are not average levels. Levels underlined are adjusted, other levels are nominal - see TABLE 1 and Block diagrams for tolerances.

TABLE 2.1: L.O./IF SIGNAL LEVELS IN VERTEX ROOM

All power levels in dBm and when ON. No parenthesis - L.O. power each carrier, parenthesis - total L.O. power, bracket - total L.O. and IF power.

	L1: 5-50 MHz VCXO	L2: 50 MHz Har. Gen.	L3: L.O. Transmitter	L4: L.O. Receiver	L6: 2-4 GHz Synth. A/C	L7: Fringe Gen. A/C	F2: Upconv. Pump	F3: 17-20 GHz L.O.	F4: Freq. Conv. A/B/C/D	
J1	+10±1 @ 50 MHz to L2J10		-1·5±1·5 @ 1·8 GHz* from L2J9	1·2 & 1·8 GHz (total = -4) from T2J8		+10±1 @ 10·1 MHz to L6J15	-35±3 @ 3 GHz from J6N (Rack A)	+8·5±2 @ 600 MHz from J7N (Rack A)	-22 @ IF to 4-way Adder & J1N (Rack A)	J1
J2	+17±1 @ 10 MHz to 4-way Div. (PD1)	+15·5±1·5 @ 200 MHz to J7N (Rack B)	-1·5±1·5 @ 1·2 GHz* from L2J8			+7±3 @ 50 MHz from L2J4, 2 Div., 6 dB	Adjustable 3·2 GHz to Upconv. AB	+12±2 @ 200 MHz from J9N (Rack A) & 2 Div.	4·5 to 5 GHz -56 dB/50 MHz from F6J6/4/3/5	J2
J3	+10±1 @ 5 MHz to L3J9	+15·5±1·5 @ 100 MHz to J8N (Rack B)				-10±1 @ 10 MHz from L1J2, 4 Div. & 20 dB	Adjustable 3·2 GHz to Upconv. CD	+15·5±1·5 @ 100 MHz from J8N (Rack A)	+16·5±1·5 @ fL6 from L6; J2N(AB) Rack A J4N(CD) Rack A	J3
J4	+10±1 @ 5 MHz to 2-way Div. (PD2)	+17±2 @ 50 MHz to 2-way Div. (PD3)	0·5 MHz Data (TTL) from M4 P1-3				+12±2 @ 200 MHz from J9N (Rack A) & 2 Div.		Alternate Input	J4
J5									-35 dBm/50 MHz IF to 50 MHz Ch. IF BPF	J5
J6									-36 dBm/50 MHz from CH. IF BPF	J6
J7			-4±2 @ 3 GHz to 10 dB DC (DC-1)		-15±2 @ 2400 MHz from L3J14, 3 dB, 4 Div. and 10 dB					J7
J8	+10 @ 20 MHz terminated	-1·5±1·5 @ 1·2 GHz* to L3J2	1·2 & 1·8 GHz -28·5(-25·5) to T2J11		50 MHz Comb -33±5/line from L2J12, 2 Div. & 20 dB					J8
J9		-1·5±1·5 @ 1·8 GHz* to L3J1	+10±1 @ 5 MHz from L1J3		-15±3 @ 3 GHz from L3J7, DC-1, 2 Div. & 6 dB					J9

TABLE 2.1: L.O./IF SIGNAL LEVELS IN VERTEX ROOM (CONT.)

All power levels in dBm and when ON. No parenthesis - L.O. power each carrier, parenthesis - total L.O. power, bracket - total L.O. and IF power.

	L1: 5-50 MHz VCXO	L2: 50 MHz Har. Gen.	L3: L.O. Transmitter	L4: L.O. Receiver	L6: 2-4 GHz Synth. A/C	L7: Fringe Gen. A/C	F2: Upconv. Pump	F3: 17-20 GHz L.O.	F4: Freq. Conv. A/B/C/D	
J10		+10±1 @ 50 MHz from L1J1	+9±2 @ 600 MHz to L4J11	+7±1 @ 5 MHz from L1J4 & 2 Div.						J10
J11			+9±2 @ 600 MHz to J6N (Rack B)	+9±2 @ 600 MHz from L3J10						J11
J12		50 MHz Comb. -10±5/line to 2-way Div. (PD4)			+16·5±1·5 @ 3·49 to 3·99 to J4N(A)/ J3N(C)-(Rack B)					J12
J13		50 MHz Comb. -10±5/line to J10N (Rack B)			First IF Out					J13
J14			+5±2 @ 2400 MHz to 3 dB & 4 Div. (PD6)							J14
J15					+10±1 @ 10·1 MHz from L7J1					J15
J16										J16
AMP	PIN P1-38 VCXO-Control Voltage from L5P1-5			P1-5: Data Out to M4-P1-38 P1-6: 600 ϕ Det. Out to L5P1-6 P1-7: ϕ Det. Out to L5P1-7 P1-38: Sync Out to L8-P1-7		P1-1: Walsh Switching from L8-P2A P1-5: 100 kHz from L3-P1-4/P1-36		+11 (+5,-0) dBm @ 17-20 GHz, Waveguide Out	P1-H 9·6 GHz Switching Waveform	
		*SMA Connector	*SMA Connector							

TABLE 2.2: L.O. AND IF SIGNAL LEVELS CENTRAL ELECTRONICS ROOM - RACK D

All power levels in dBm and when ON. No parenthesis - each L.O. carrier, parenthesis - total L.O. power, bracket - total L.O. and IF power.

	L9: Central L.O. Receiver	L10: Central L.O. Transmitter	L14: Central L.O. Filter	T4A: L.O. Offset	T4B: L.O. Offset	T5: IF Receiver A/B/C/D	
J1	1·2 & 1·8 GHz -13(-10)[-4] from T2J8		+10±2 @ 1200 MHz to T4AJ1	+10±2 @ 1200 MHz from L14J1	+10±2 @ 1800 MHz from L14J15	+16·5 dBm @ Base Band to J14/12/11/10 N (Rack D)	J1
J2			0±0·5 @ 1800 MHz from L9J14	-7±3 @ 100±25 from Master J16N	-7±3 @ 250∓25 from Master J15N		J2
J3			0±0·5 @ 1800 MHz from L9J13	+8±4 @ 1300±25 to T5AJ3	+8±4 @ 1550±25 to T5CJ3	from T4AJ3/--/ T4BJ3/--	J3
J4				-7±3 @ 200±25 from Master J8N	-7±3 @ 150∓25 from Master J7N	-13 to -20 in 50 MHz passband from T2J9, 4 Div., ch BPF	J4
J5				+8±4 @ 1400±25 to T5BJ3	+8±4 @ 1650±25 to T5DJ3		J5
J6							J6
J7			+8·5±1·5 @ 600 + f_s* from Master J5N				J7
J8		+7±1 @ 5 MHz from Master J6N and 2 Div.					J8
J9	+8·5±1·5 @ 5 MHz + f_s*from Master J1N**						J9
J10							J10
J11							J11

TABLE 2.2: L.O. AND IF SIGNAL LEVELS CENTRAL ELECTRONICS ROOM - RACK D (CONT.)

All power levels in dBm and when ON. No parenthesis - each L.O. carrier, parenthesis - total L.O. power, bracket - total L.O. and IF power.

	L9: Central L.O. Receiver	L10: Central L.O. Transmitter	L14: Central L.O. Filter	T4A: L.O. Offset	T4B: L.O. Offset	T5: IF Receiver A/B/C/D	
J12							J12
J13	0±0·5 @ 1200 MHz to L14J3	1·2 & 1·8 GHz -6(-3)±1·5 from Master J13N					J13
J14	0±0·5 @ 1800 MHz to L14J2						J14
J15		1·2 & 1·8 GHz -28·5(-25·5)± 1·5 to T2J11	+10±2 @ 1800 MHz to T4BJ1				J15
J16							J16
	P1-5: Data Out (TTL) to M3-P2-39 P1-7: 5 MHz ϕ-Err. to L11-P1-7		P1-5: Control T/H in from J18H (Rack D) P1-6: Control T/H out to L11-P1-40 P1-7: 600 MHz ϕ-Err. to L11-P1-39				

*f_s = 19·2 Hz

*f_s = 19·2 Hz

**Not connected at present

NOTE: In actual system the input power at 600 MHz + f_s to L14J7 is only -2±1 dBm instead of +8·5±1·5 dBm.

TABLE 2.3: PROCEDURE TO ADJUST SIGNAL LEVELS IN SYSTEM

	FUNCTION	ADJUSTMENT	MONITOR	CORRECT LEVEL
1.	1200 CR XMIT Level	R4 in 5 MHz Mod. Driver, L10	CR T2 XMIT IF FP Mon.*	-39 dBm @ 1200
2.	5 MHz Sidebands on 1200	R8 in 5 MHz Mod. Driver, L10	CR T2 XMIT IF FP Mon.*	-49 dBm @ 1195 and 1205
3.	1800 CR XMIT Level	R7 in Data Mod. Driver, L10	CR T2 XMIT IF FP Mon.*	-39 dBm @ 1800
4.	Data Sidebands on 1800	R4 in Data Mod. Driver, L10	CR T2 XMIT IF FP Mon.*	-54 dBm @ 1799·5 and 1800·5
5.	VR RCV Level	RCV Gain on VR T2 FP	VR T2 RCV IF FP Mon. #	-14 dBm with power meter
6.	1200 Level in L4	1200 FP Gain Pot with Switch on 1200 Side	L4 FP Meter Reading Zero for Switch on 1200 Side #	Internally adjusted
7.	1800 Level in L4	1800 FP Gain Pot with Switch on 1800 Side	L4 FP Meter Reading Zero for Switch on 1800 Side #	Internally adjusted
8.	1200 VR XMIT Level	R5 in 5 MHz Mod. Driver, L3	VR T2 XMIT IF FP Mon.	-39 dBm @ 1200
9.	5 MHz Sidebands on 1200	R4 in 5 MHz Mod. Driver, L3	VR T2 XMIT IF FP Mon.	-49 dBm @ 1195 and 1205
10.	1800 VR XMIT Level	R7 in Data Mod. Driver, L3	VR T2 XMIT IF FP Mon.	-39 dBm @ 1800
11.	Data Sidebands on 1800	R4 in Data Mod. Driver, L3	VR T2 XMIT IF FP Mon.	-54 dBm @ 1799·5 and 1800·5
12.	CR RCV Level	RCV Gain on CR T2 FP	CR T2 RCV IF FP Mon.	-10 dBm using Power Meter when IF signals are not present
13.	1200 Level in L9	1200 FP Gain Pot with Switch on 1200 Side	L9 FP Meter Reading Zero for Switch on 1200 Side	Internally adjusted
14.	1800 Level in L9	1800 FP Gain Pot with Switch on 1800 Side	L9 FP Meter Reading Zero for Switch on 1800 Side	Internally adjusted

* CR T1 in full XMIT.
\# CR T1 in full XMIT., VR T1 in full RCV.

TABLE 2.4: RACK D MODULE COMPLEMENT (RACK D2)

Module	Serial No.	Name - Remarks
M3	C12	Local Buffer
M1	D51	Data Set
T4A	A2	L.O. Offset
T4B	A2	L.O. Offset
T5	A23	IF Receiver, Ch. A: IF = 1325 MHz
T5	A24	IF Receiver, Ch. C: IF = 1575 MHz
T6	A2	IF Control
L11	C13	Central L.O. Control
L9	C13	Central L.O. Receiver
L14	C8	Central L.O. Filter
L10	C11	Central L.O. Transmitter
T2	C4	IF Combiner
T1	D22	Modem - Channel 4, Modem Offset = 30 kHz
P4	A1	+5 V @ 12 A, -28 V @ 0·2 A
P5	A2	+15 V @ 3·5 A, -15 V @ 1 A and +28 V @ 0·8 A

TABLE 2.5: RACK M MODULE COMPLEMENT (MASTER L.O.)

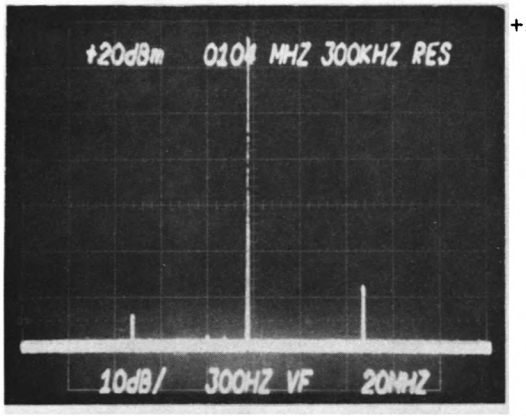
Module	Serial No.	Name - Remarks
L1	A3	5 to 50 MHz VCXO
L2	A3	50 to 600 MHz Multiplier
L13	A3	600 to 1800 MHz Multiplier
L8	A1	Timing Generator
L12	A1	Master L.O. Offset
L1	A6	5 to 50 MHz VCXO } for 600 MHz + f_s,
L2	A8	50 to 600 MHz Multiplier } f_s = 19·2 Hz Offset
L17	C4	Synthesizer Phase-lock
L18	A1	Variable Frequency Driver
L17	B3	Synthesizer Phase-lock
L21	A1	Synthesizer Phase-lock Emergency Power
L19	A1	Master L.O. Driver
P4	A3	+5 V @ 1 A, -28 V @ 1·7 A
P5	A4	+15 V @ 3 A, -15 V @ 1 A and +28 V @ 1·2 A

TABLE 2.6: ANTENNA 3 VERTEX ROOM ELECTRONICS

Module/ Rack	Serial No.	Name - Remarks
Rack A	A3	Front-end Rack
F3	C10/C17	17-20 GHz L.O., $f_{L.O.}$ = 17·6 GHz
F4	A5	Frequency Converter, Ch. A: IF = 1325 MHz
F6	A6	RF Splitter
F4	A6	Frequency Converter, Ch. C: IF = 1575 MHz
F5	B4	Front-end Control Module
M1	D23	Data Set
F1	A5	Front-end Bias Module, Ch. AB
F1	A2	Front-end Bias Module, Ch. CD
F2	B7/C13	Upconverter Pump
Rack B	B3	Vertex Room L.O. Rack - Modified
P1	A9	+5 V @ 17A, -5·2 V @ 2A
P2	A6	+15 V @ 4A, -15 V @ 0·9 A
L6	B14	2-4 GHz Synthesizer Ch. C, f_o = 3310 MHz
L7	B14	Fringe Generator Ch. C
L6	B18	2-4 GHz Synthesizer Ch. A, f_o = 3560 MHz
L7	B5	Fringe Generator Ch. A
L1	B10	5 to 50 MHz VCXO
L2	C16	50 MHz Harmonic Generator
L3	C17	L.O. Transmitter
L4	C4	L.O. Receiver
L5	B*	L.O. Control
L8	A12	Timing Generator
P3	A7	+28 V @ 1·4 A, -28 V @ 0·3 A
T2	B19	IF Combiner
T1	A2	Modem; Channel 4. Modem Oscillator frq = 33·59 GHz
M4	C9	Antenna Buffer
M2	-	Data Tap
M1	D62	Data Set

*Not assigned

3.0 SPECTRA AND OSCILLOGRAMS

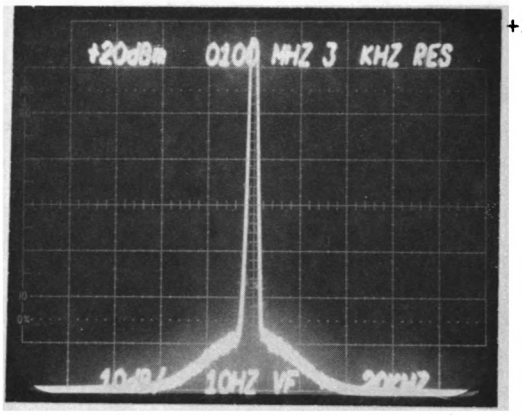


+20 dBm

100 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 1 - 100 @ Rack B J8N, Modems Normal

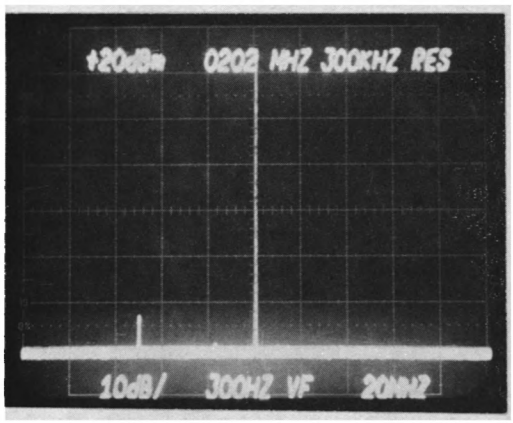


+20 dBm

100 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 2 - 100 @ Rack B J8N, Modems Normal

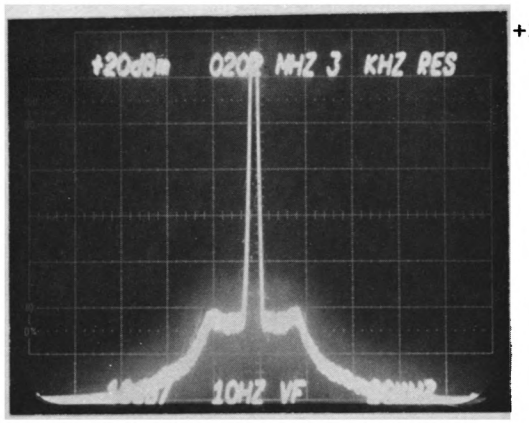


+20 dBm

200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 3 - 200 @ Rack B J7N, Modems Normal

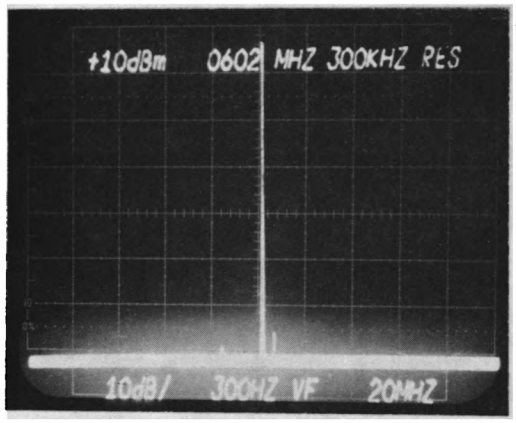


+20 dBm

200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 4 - 200 @ Rack B J7N, Modems Normal

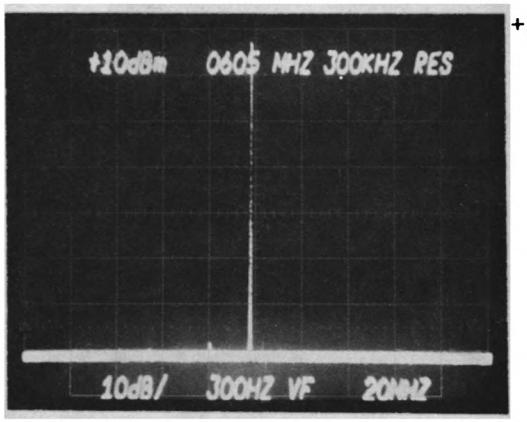


+10 dBm

600 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 5 - 600 @ Rack B J6N, Modems Normal

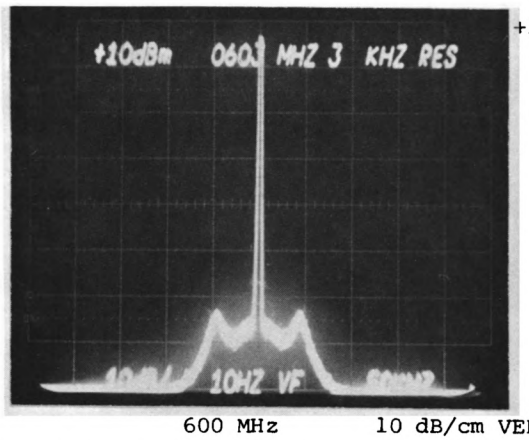


+10 dBm

600 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 6 - 600 @ Rack B J6N, VRTI Full XMIT

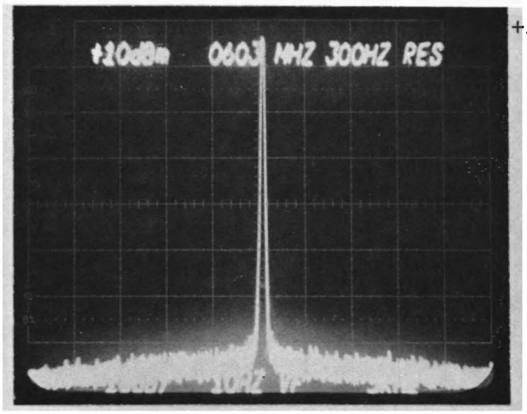


+10 dBm

600 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 7 - 600 @ Rack B J6N, Modems Normal

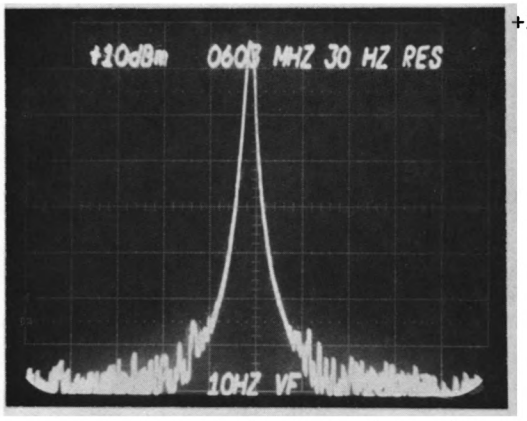


+10 dBm

600 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 8 - 600 @ Rack B J6N, Modems Normal

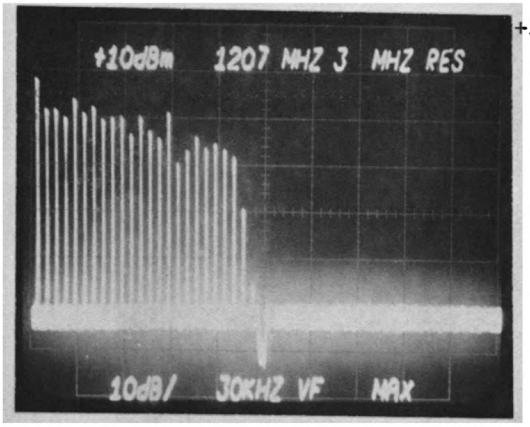


+10 dBm

600 Mhz 10 dB/cm VER

30 Hz BW 10 Hz VF 200 Hz/cm HOR

SP. 9 - 600 @ Rack B J6N, Modems Normal

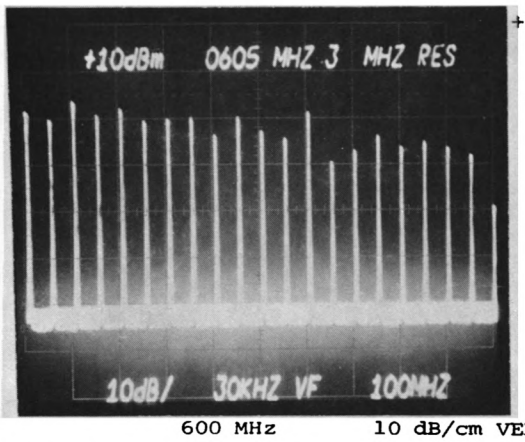


+10 dBm

- 10 dB/cm VER

3 MHz BW 30 kHz VF MAX. HOR

SP. 10 - 50 MHz Comb @ Rack B J10N, Modems Normal

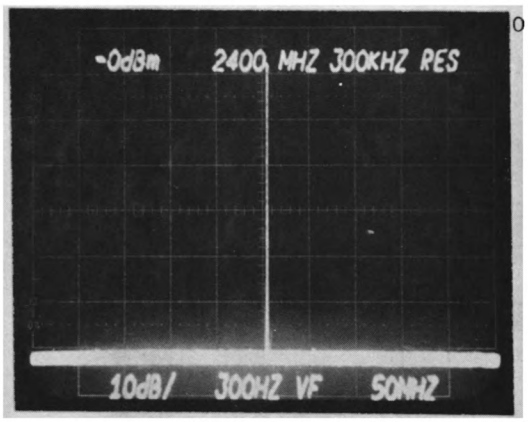


+10 dBm

600 MHz 10 dB/cm VER

3 MHz BW 30 kHz VF 100 MHz/cm HOR

SP. 11 - 50 MHz Comb @ Rack B J10N, Modems Normal

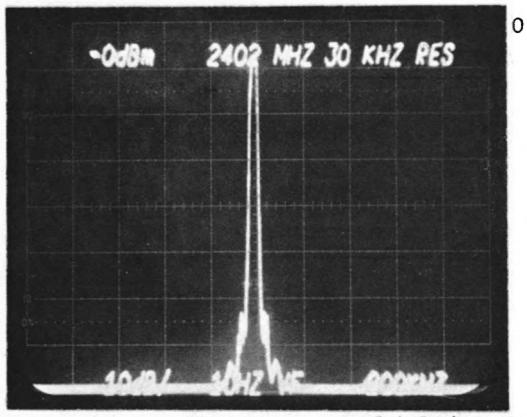


0 dBm

2400 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 50 MHz/cm HOR

SP. 12 - 2400 @ Normally Terminated Output 4 Div., Rack B

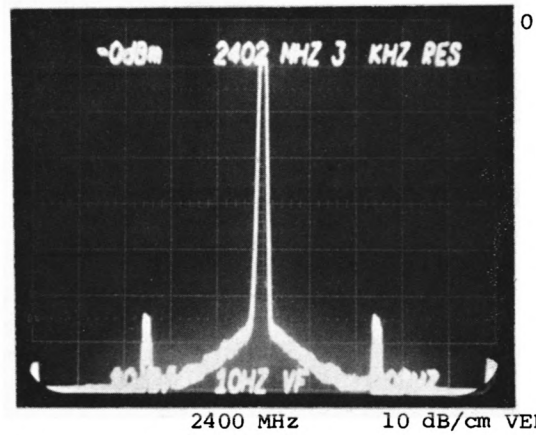


0 dBm

2400 MHz 10 dB/cm VER

30 kHz BW 10 Hz VF 200 kHz/cm HOR

SP. 13 - 2400 @ Normally Terminated Output 4 Div., Rack B

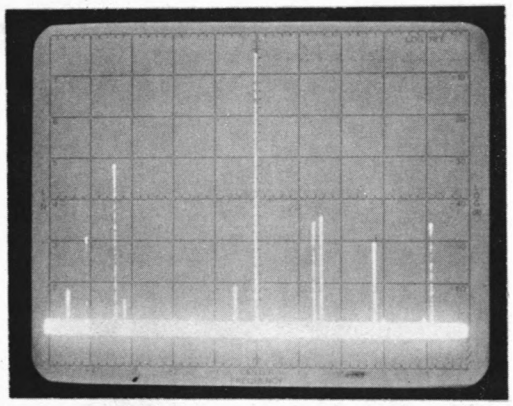


0 dBm

2400 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 14 - 2400 @ Normally Terminated Output 4 Div., Rack B

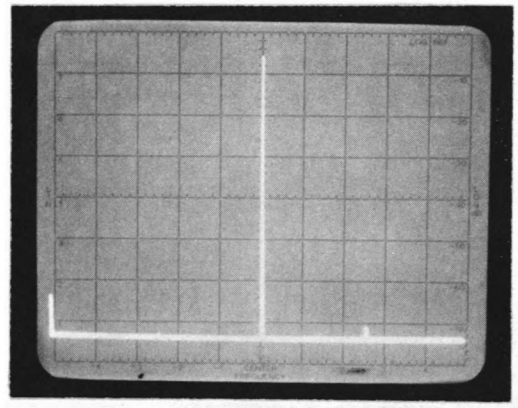


-10 dBm

3000 MHz 10 dB/cm VER

300 kHz BW 10 kHz VF 200 MHz/cm HOR

SP. 15 - 3000 @ -10 dBc of 10 dB Dir. Coup, Rack B

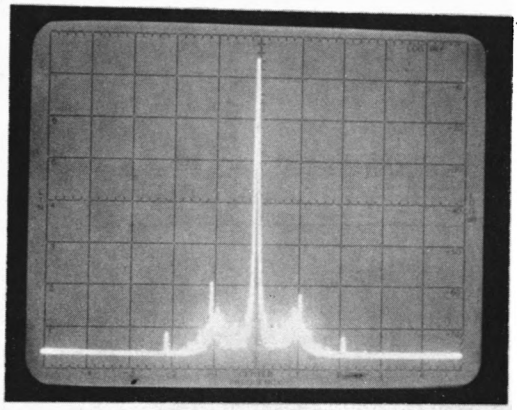


-10 dBm

3000 MHz 10 dB/cm VER

100 kHz BW 100 Hz VF 20 MHz/cm HOR

SP. 16 - 3000 @ -10 dBc of 10 dB Dir. Coup, Rack B

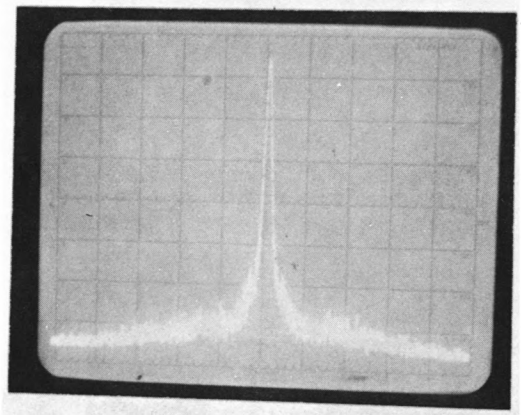


-10 dBm

3000 MHz 10 dB/cm VER

1 kHz BW 100 Hz VF 50 kHz/cm HOR

SP. 17 - 3000 @ -10 dBc of 10 dB Dir. Coup, Rack B

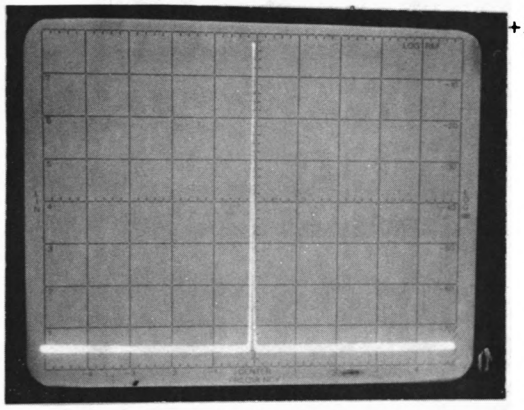


-10 dBm

3000 MHz 10 dB/cm VER

100 Hz BW 10 Hz VF 2 kHz/cm HOR

SP. 18 - 3000 @ -10 dBc of 10 dB Dir. Coup, Rack B

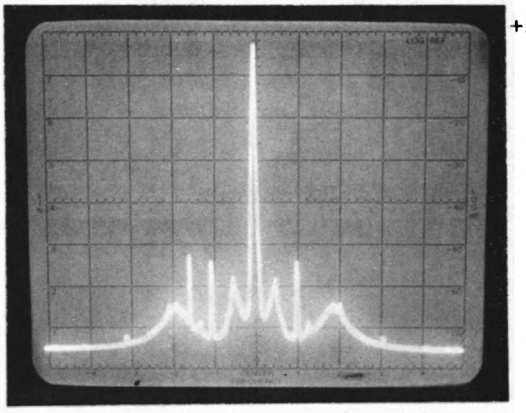


+20 dBm

3560 MHz 10 dB/cm VER

300 kHz BW 10 kHz VF 20 MHz/cm HOR

SP. 19 - L6A Rack B J4N, f_o = 3560 MHz, Manual Tuning

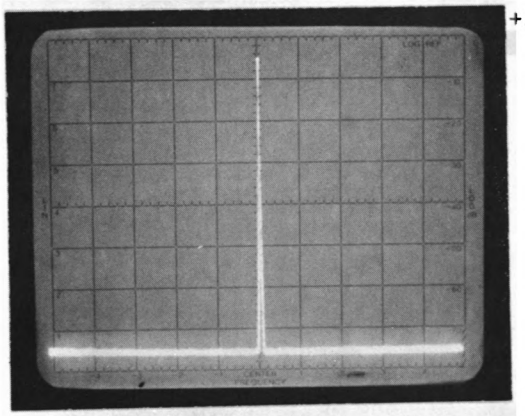


+20 dBm

3560 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 100 kHz/cm HOR

SP. 20 - L6A Rack B J4N, f_o = 3560 MHz, Manual Tuning

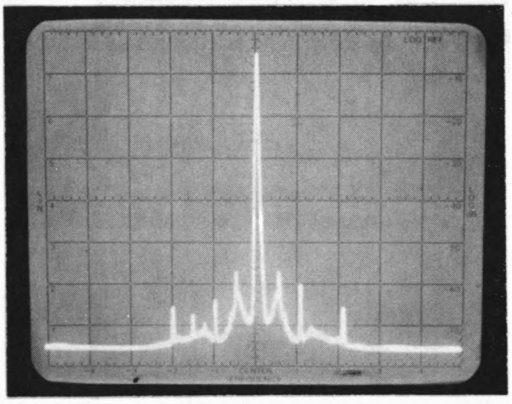


+20 dBm

3310 MHz 10 dB/cm VER

300 kHz BW 10 kHz VF 20 MHz/cm HOR

SP. 21 - L6C Rack B J3N, f_o = 3310 MHz, Manual Tuning

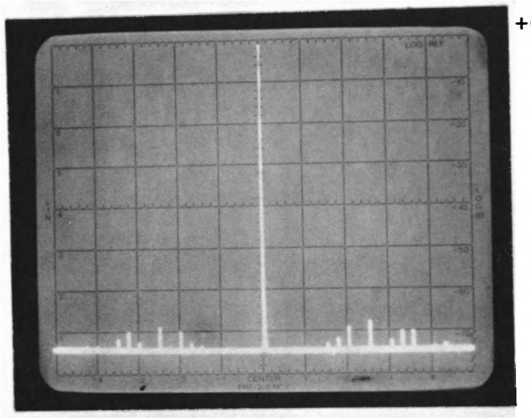


+20 dBm

3310 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 100 kHz/cm HOR

SP. 22 - L6C Rack B J3N, f_o = 3310 MHz, Manual Tuning

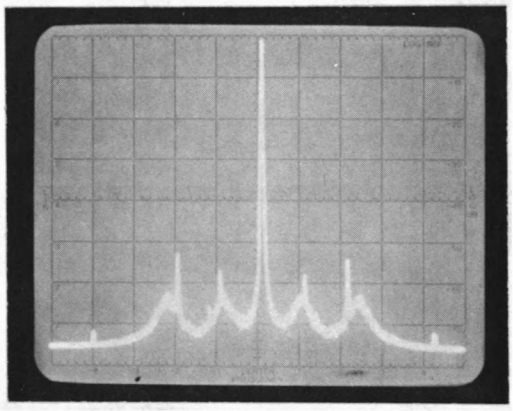


+0 dBm

3200 MHz 10 dB/cm VER

30 kHz BW 100 Hz VF 20 MHz/cm HOR

SP. 23 - 3200 F2 Output, To Upconverter

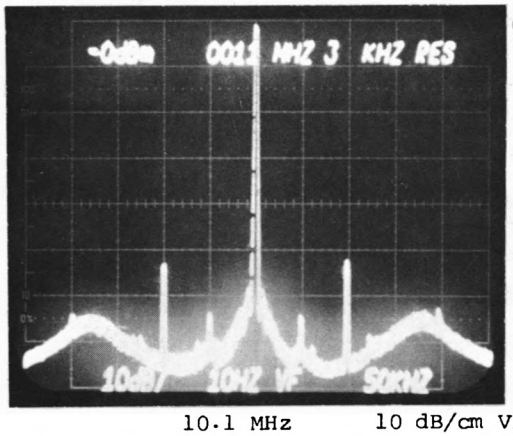


0 dBm

3200 MHz 10 dB/cm VER

1 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 24 - 3200 F2 Output, To Upconverter

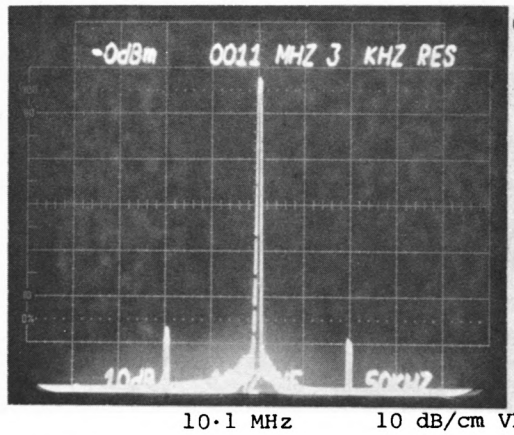


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 25 - L6A IF Monitor FP, Manual Tuning

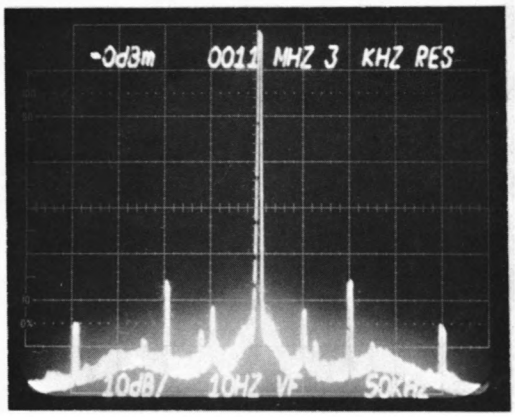


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 26 - L7A Monitor FP, No Computer Commands

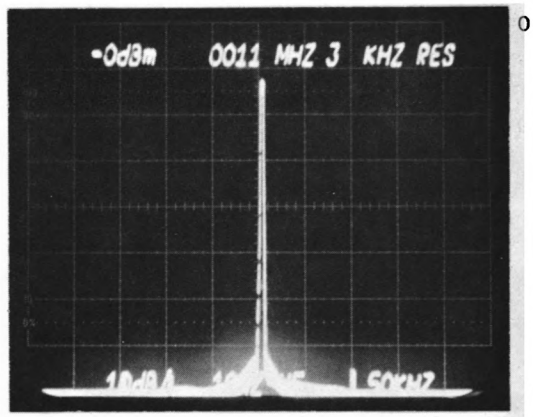


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 27 - L6C IF Monitor FP, Manual Tuning

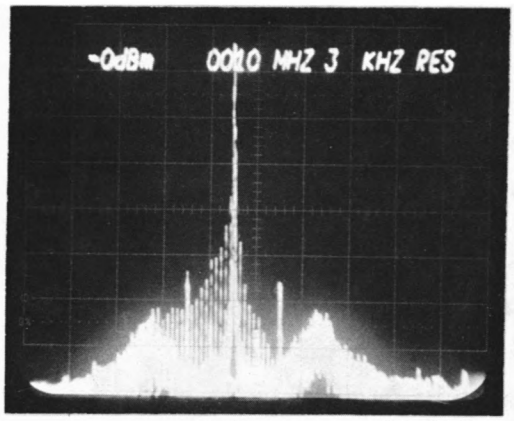


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 28 - L7C Monitor FP, No Computer Commands

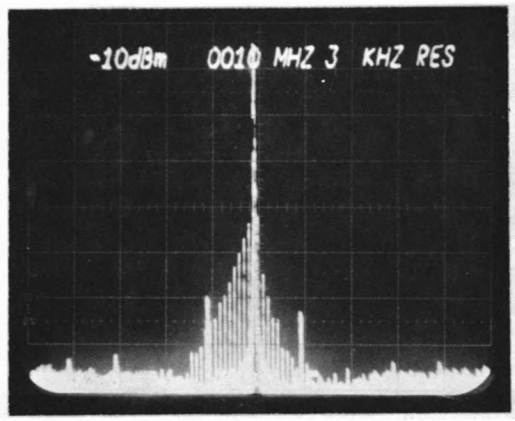


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 29 - L6A IF Monitor FP Computer Mode, System Normal, Tuning No. 3578

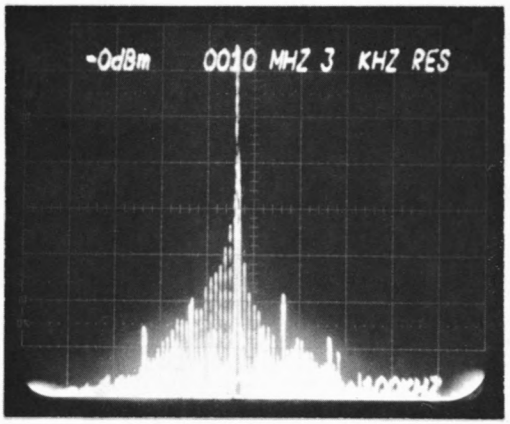


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 30 - L7A Monitor FP, System Normal

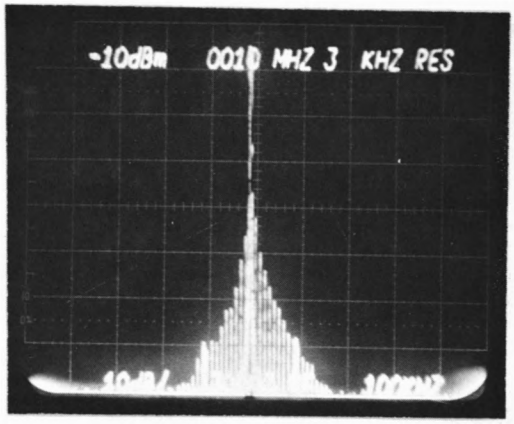


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 31 - L6C IF Monitor FP, Computer Mode, System Normal, Tuning No. 3328

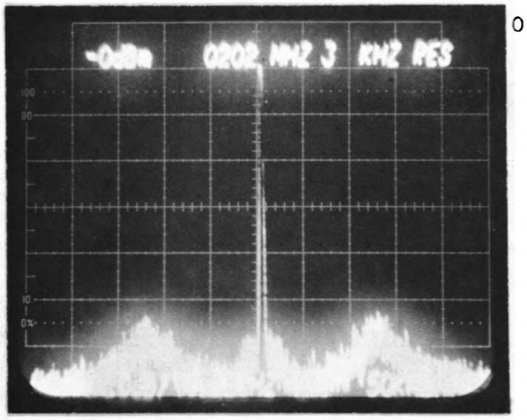


0 dBm

10·1 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 32 - L7C Monitor FP, System Normal

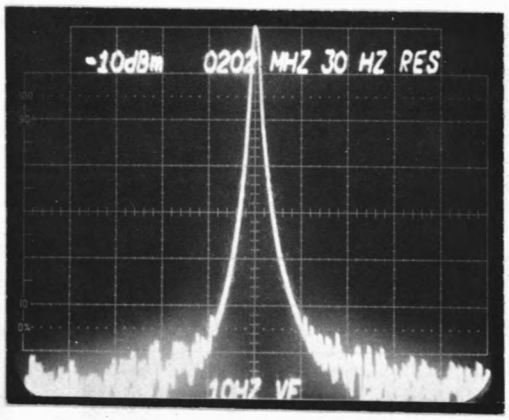


0 dBm

200 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 33 - F2 Front Panel IF Monitor (F2C13)

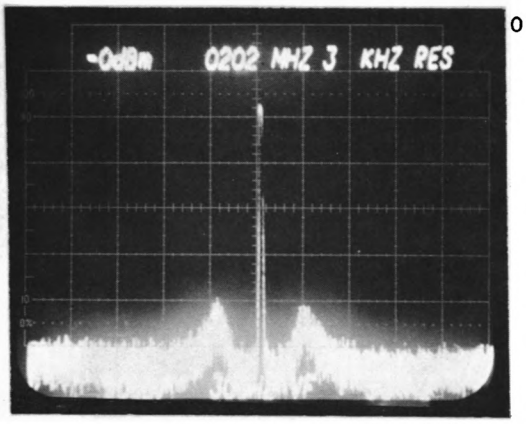


0 dBm

200 MHz 10 dB/cm VER

30 Hz BW 10 Hz VF 200 Hz/cm HOR

SP. 34 - F2 Front Panel IF Monitor (F2C13)

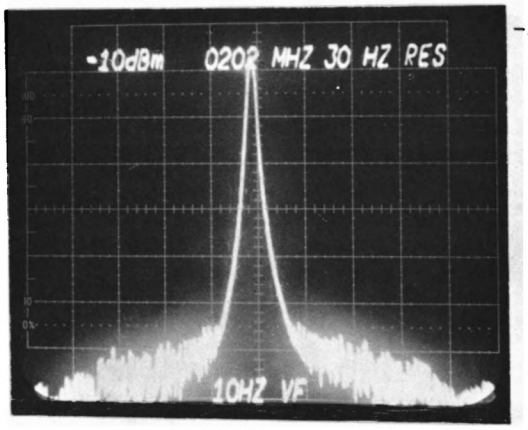


0 dBm

200 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 35 - F3 Front Panel IF Monitor, f_o = 17·6 GHz, (F3C10)

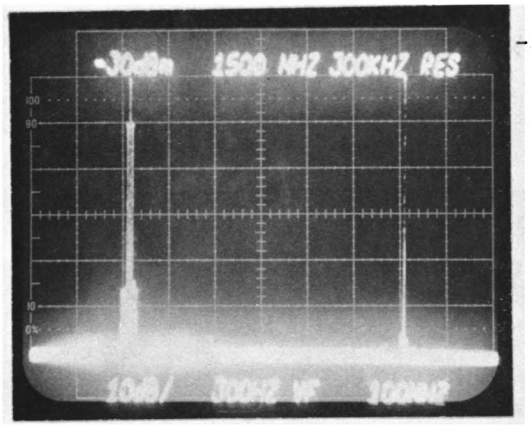


-10 dBm

200 MHz 10 dB/cm VER

30 Hz BW 10 Hz VF 200 Hz/cm HOR

SP. 36 - F3 Front Panel IF Monitor, f_o = 17·6 GHz, (F3C10)

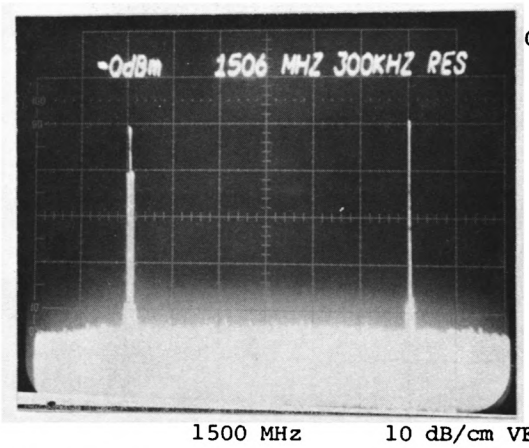


-30 dBm

1500 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 100 MHz/cm HOR

SP. 37 - CR T2 XMIT. IF, FP MON.,
CR Full XMIT.

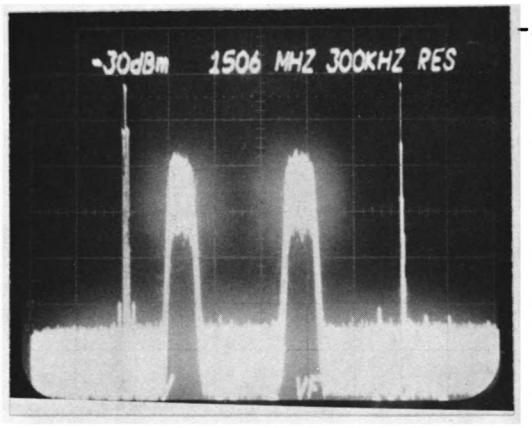


0 dBm

1500 MHz 10 dB/cm VER

300 kHz BW 30 kHz VF 100 MHz/cm HOR

SP. 38 - VR T2 RCV. IF, FP MON.,
CR Full XMIT, VR Full RCV.

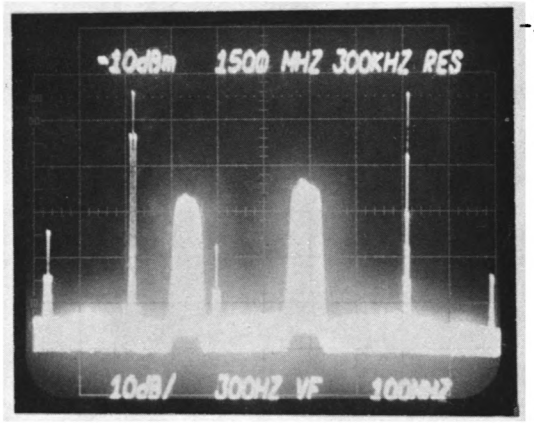


-30 dBm

1500 MHz 10 dB/cm VER

300 kHz BW 30 kHz VF 100 MHz/cm HOR

SP. 39 - VR T2 XMIT. IF, FP MON.,
VR Full XMIT.

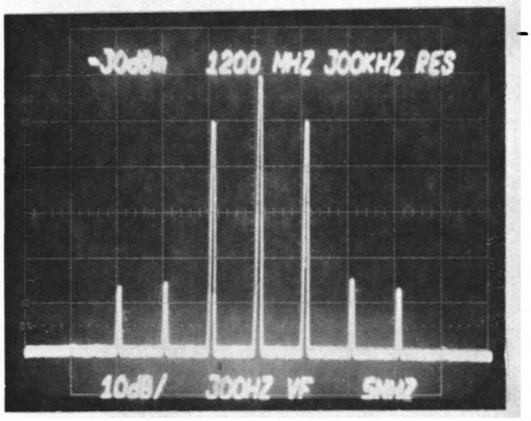


-10 dBm

1500 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 100 MHz/cm HOR

SP. 40 - CR T2 RCV. IF, FP MON.,
System Normal

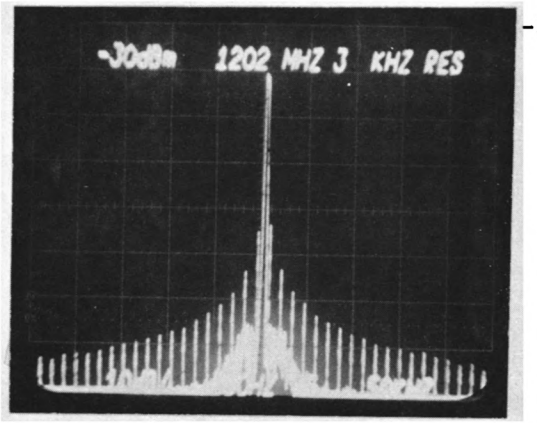


-30 dBm

1200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 5 MHz/cm HOR

SP. 41 - 1200 @ CR XMIT. IF FP MON.,
CR Full XMIT.

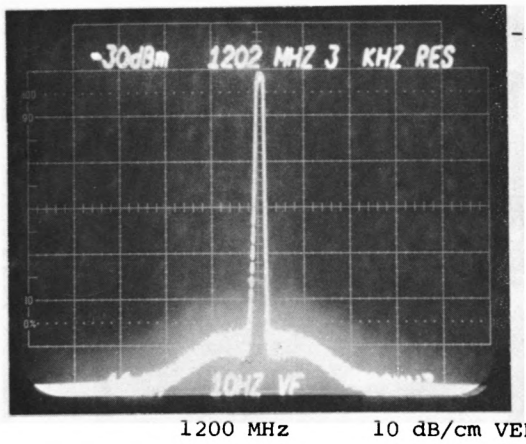


-30 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 42 - 1200 @ CR XMIT. IF FP MON.,
CR Full XMIT.

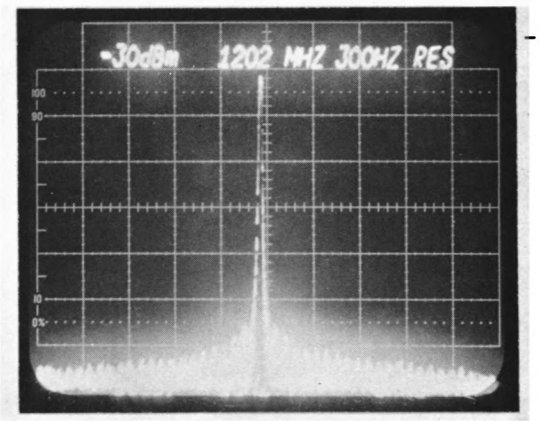


-30 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 43 - 1200 @ CR XMIT. IF FP MON., CR Full XMIT.

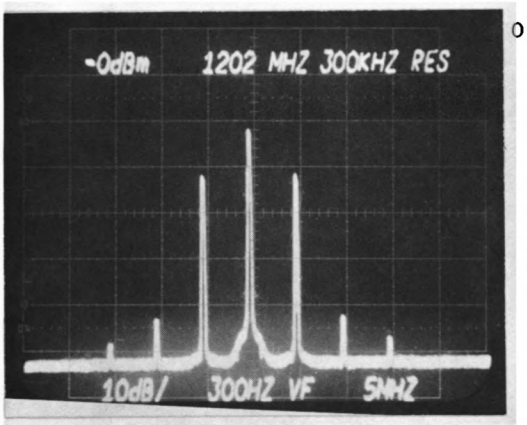


-30 dBm

1200 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 44 - 1200 @ CR XMIT. IF FP MON., CR Full XMIT.

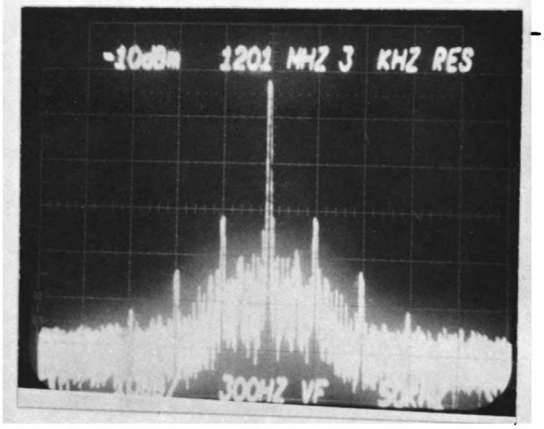


0 dBm

1200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 5 MHz/cm HOR

SP. 45 - 1200 @ VR RCV. IF FP MON., CR Full XMIT., VR Full RCV.

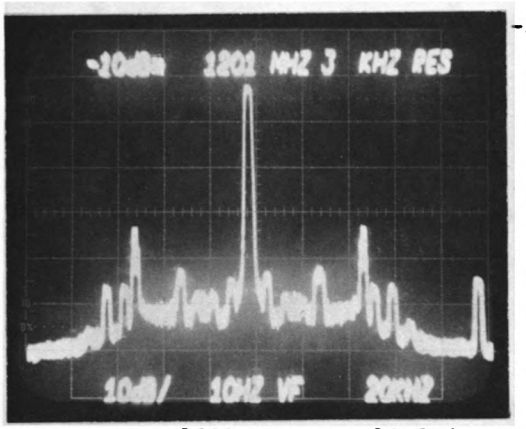


-10 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 46 - 1200 @ VR RCV. IF FP MON., CR Full XMIT., VR Full RCV.

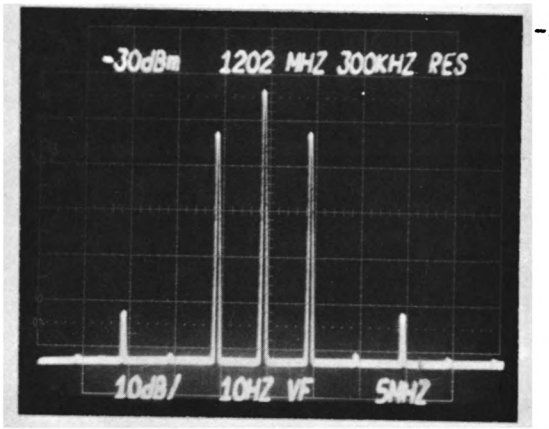


-10 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 47 - 1200 @ VR RCV. IF FP MON., CR Full XMIT., VR Full RCV.

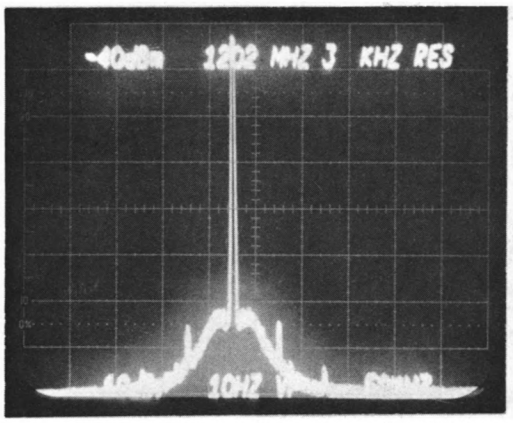


-30 dBm

1200 MHz 10 dB/cm VER

300 kHz 10 Hz VF 5 MHz/cm HOR

SP. 48 - 1200 @ VR T2 XMIT. IF FP MON., VR Full XMIT.

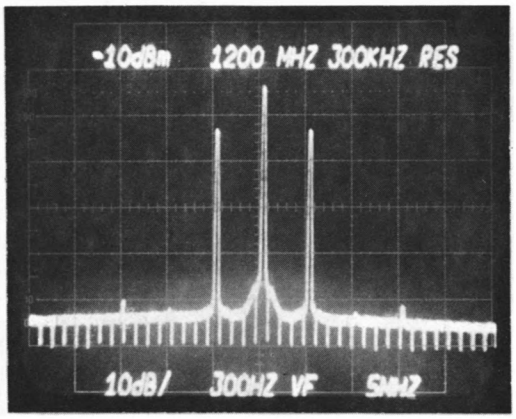


-40 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 49 - 1200 @ VR T2 XMIT. IF FP MON., VR Full XMIT.

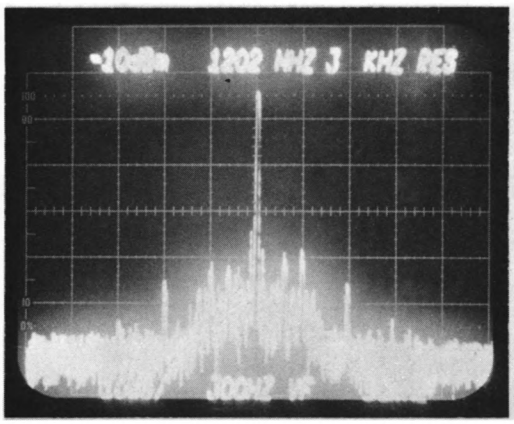


-10 dBm

1200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 5 MHz/cm HOR

SP. 50 - 1200 @ CR T2 RCV. IF FP MON., System Normal

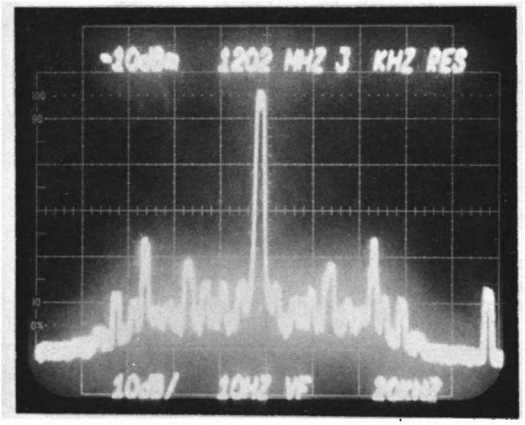


-10 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 51 - 1200 @ CR T2 RCV. IF FP MON., System Normal

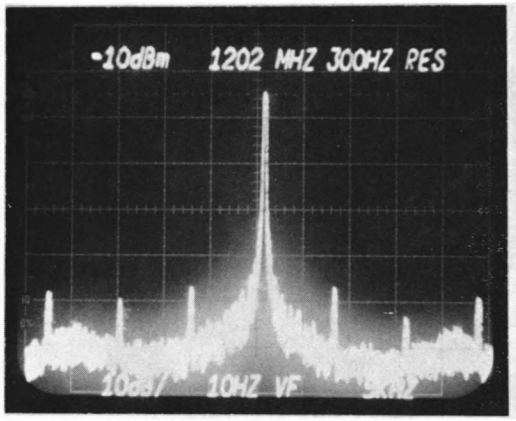


-10 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 52 - 1200 @ CR T2 RCV. IF FP MON., System Normal

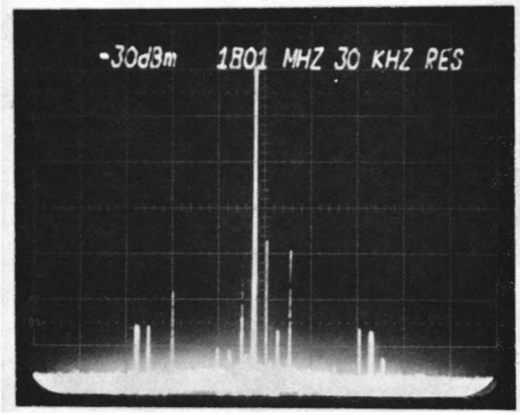


-10 dBm

1200 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 53 - 1200 @ CR T2 RCV. IF FP MON., System Normal

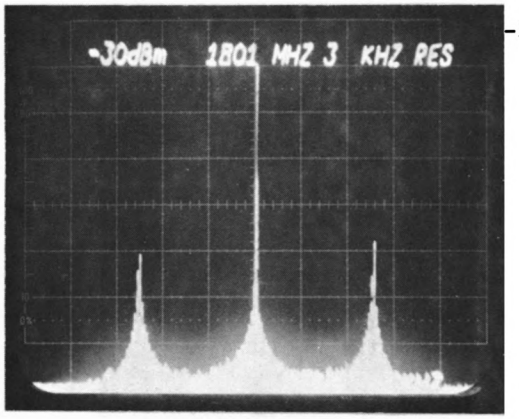


-30 dBm

1800 MHz 10 dB/cm VER

30 kHz BW 300 Hz VF 2 MHz/cm HOR

SP. 54 - 1800 @ CR T2 XMIT. IF FP MON., CR Full XMIT.

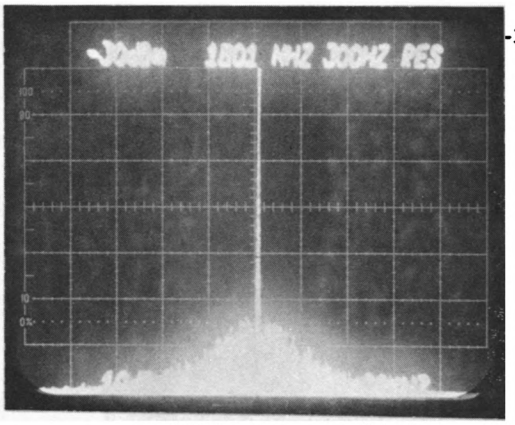


-30 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 200 kHz/cm HOR

SP. 55 - 1800 @ CR T2 XMIT. IF FP MON., CR Full XMIT.

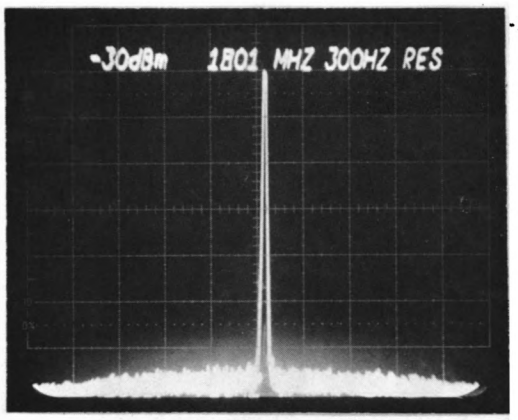


-30 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 300 Hz VF 20 kHz/cm HOR

SP. 56 - 1800 @ CR T2 XMIT. IF FP MON., CR Full XMIT.

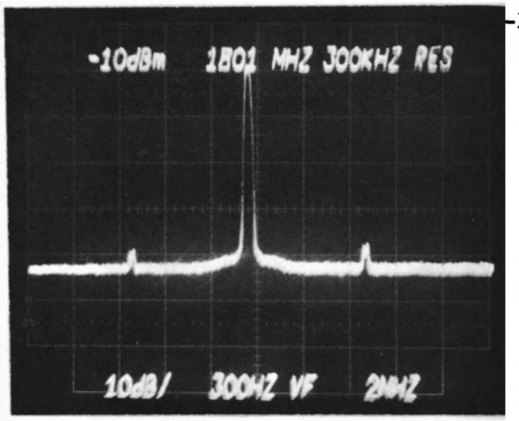


-30 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 57 - 1800 @ CR T2 XMIT. IF FP MON., CR Full XMIT.

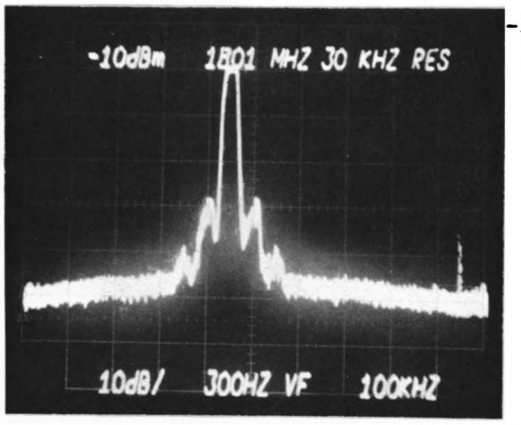


-10 dBm

1800 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 2 MHz/cm HOR

SP. 58 - 1800 @ VR T2 RCV. IF FP MON., CR Full XMIT., VR Full RCV.

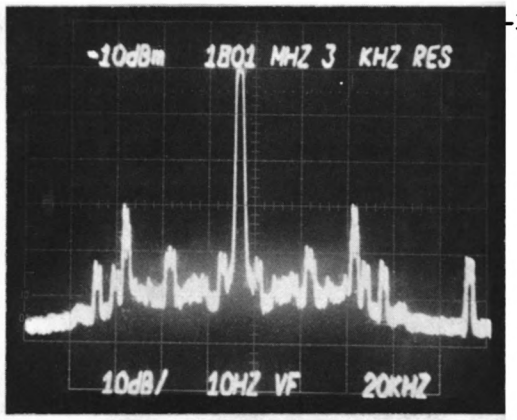


-10 dBm

1800 MHz 10 dB/cm VER

30 kHz BW 300 Hz VF 100 kHz/cm HOR

SP. 59 - 1800 @ VR T2 RCV. IF FP MON., CR Full XMIT., VR Full RCV.

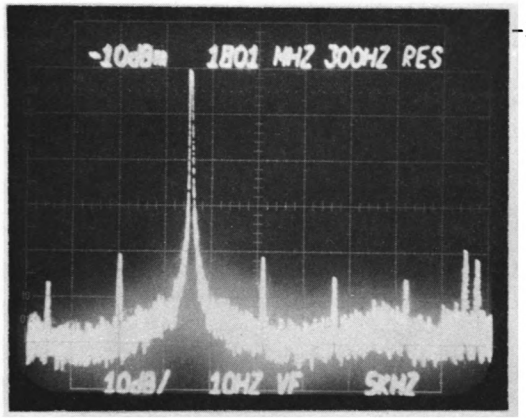


-10 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 60 - 1800 @ VR T2 RCV. IF FP MON., CR Full XMIT., VR Full RCV.

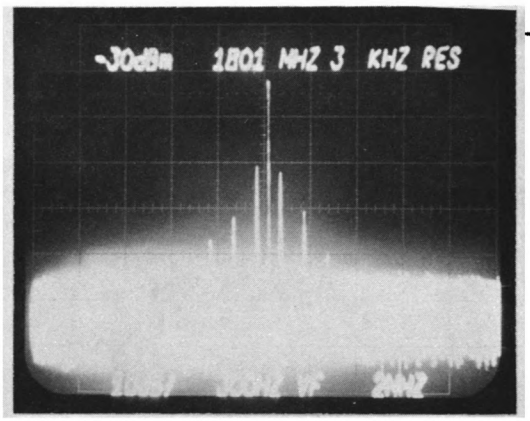


-10 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 61 - 1800 @ VR T2 RCV. IF FP MON., CR Full XMIT., VR Full RCV.

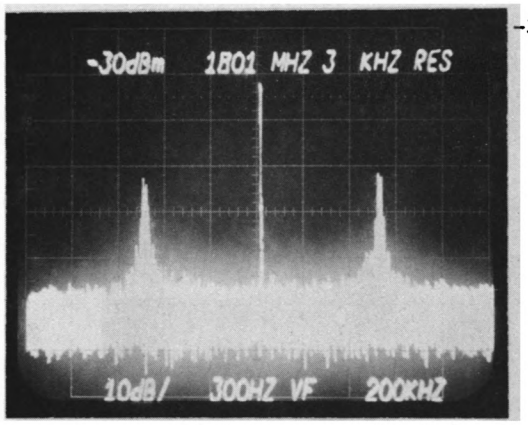


-30 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 300 Hz 2 MHz/cm HOR

SP. 62 - 1800 @ VR T2 XMIT. IF FP MON., VR Full XMIT.

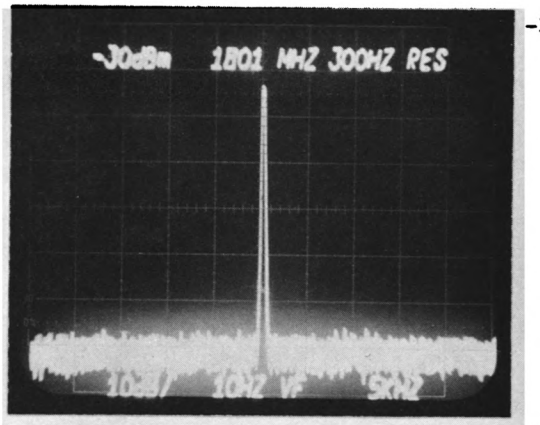


-30 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 200 kHz/cm HOR

SP. 63 - 1800 @ VR T2 XMIT. IF FP MON., VR Full XMIT.

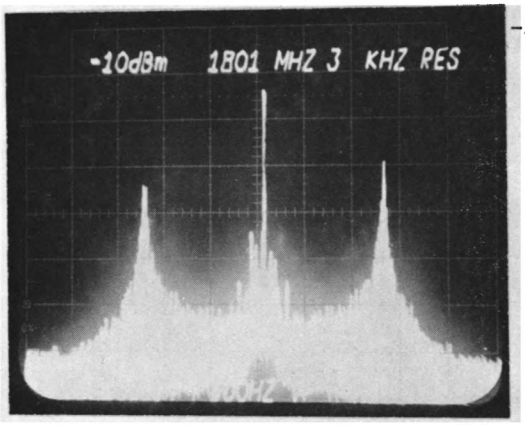


-30 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 64 - 1800 @ VR T2 XMIT. IF FP MON., VR Full XMIT.

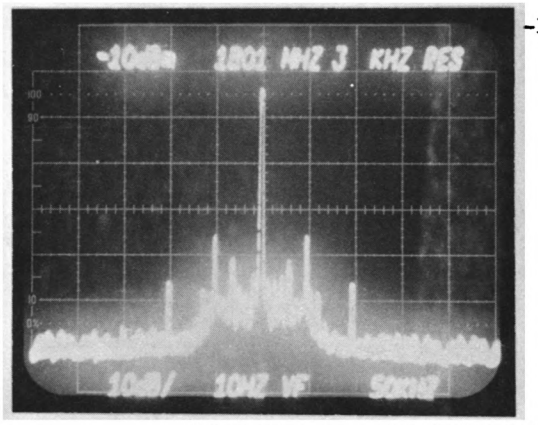


-10 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 200 kHz/cm HOR

SP. 65 - 1800 @ CR T2 RCV. IF FP MON., System Normal

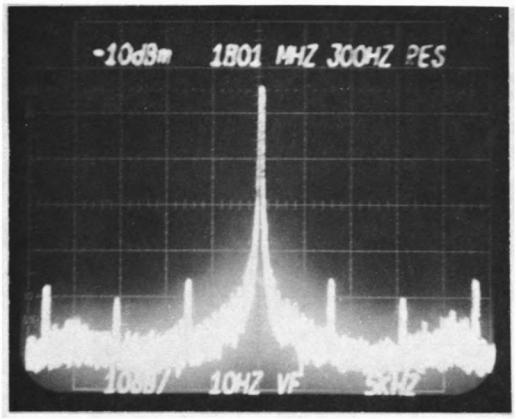


-10 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 66 - 1800 @ CR T2 RCV. IF FP MON., System Normal

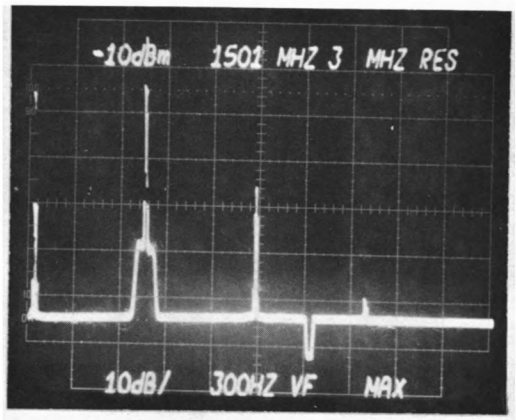


-10 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 5 kHz/cm HOR

SP. 67 - 1800 @ CR T2 RCV. IF FP MON., System Normal

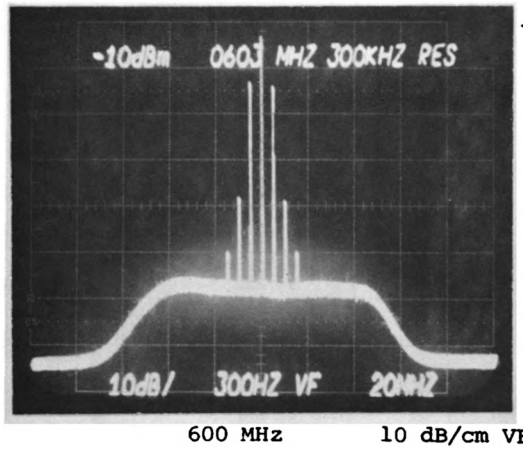


-10 dBm

- 10 dB/cm VER

3 MHz BW 300 Hz VF MAX. HOR

SP. 68 - 600 @ L4 FP MON., CR Full XMIT., VR Full RCV.

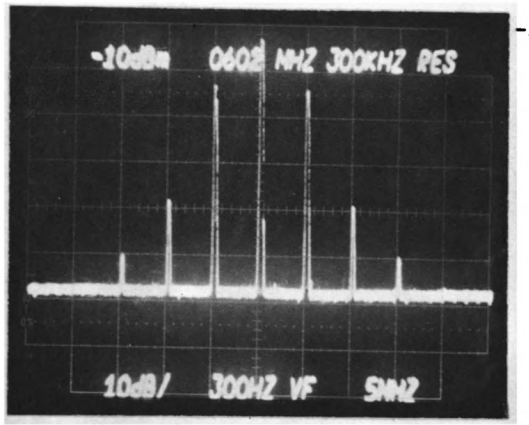


-10 dBm

600 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 69 - 600 @ L4 FP MON., CR Full XMIT., VR Full RCV.

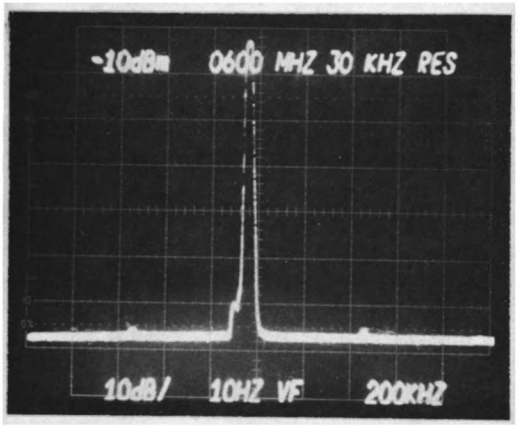


-10 dBm

600 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 5 MHz/cm HOR

SP. 70 - 600 @ L4 FP MON., CR Full XMIT., VR Full RCV.

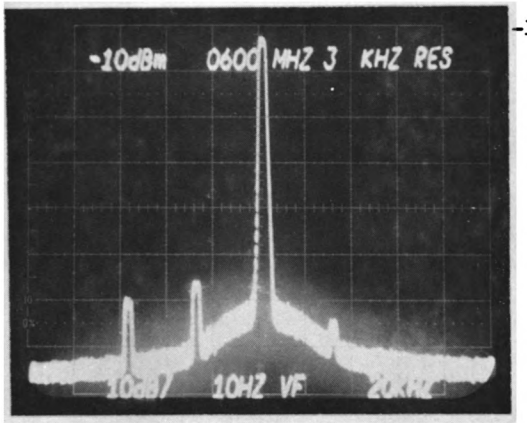


-10 dBm

600 MHz 10 dB/cm VER

30 kHz BW 10 Hz VF 200 kHz/cm HOR

SP. 71 - 600 @ L4 FP MON., CR Full XMIT., VR Full RCV.

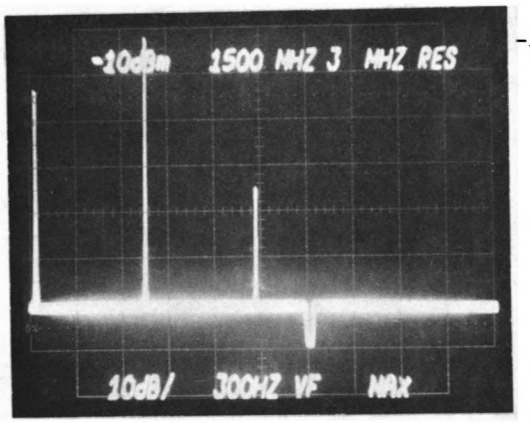


-10 dBm

600 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 72 - 600 @ L4 FP MON., CR Full XMIT., VR Full RCV.

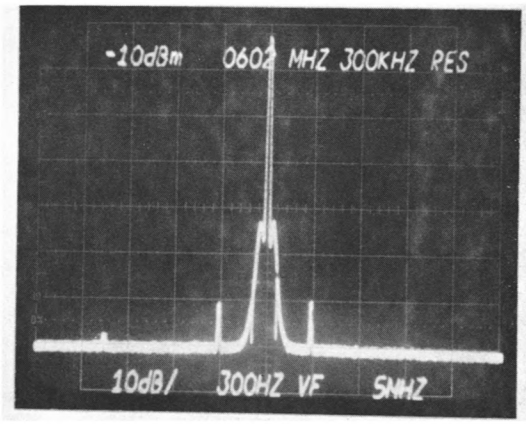


-10 dBm

10 dB/cm VER

3 MHz BW 300 Hz VF MAX. HOR

SP. 73 - 600 @ L14 FP MON., System Normal

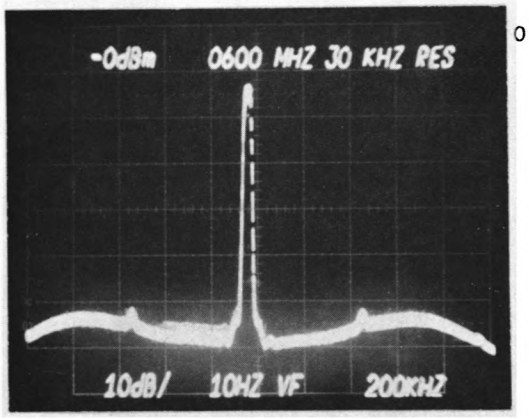


-10 dBm

600 MHz 10 dB/cm VER

300k Hz BW 300 Hz VF 5 MHz/cm HOR

SP. 74 - 600 @ L14 FP MON., System Normal

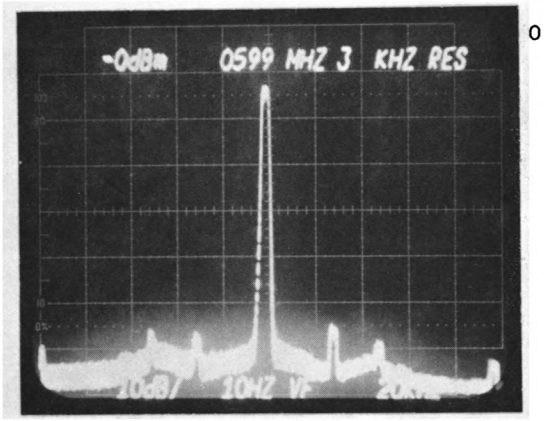


0 dBm

600 MHz 10 dB/cm VER

30 kHz BW 10 Hz VF 200 kHz/cm HOR

SP. 75 - 600 @ L14 FP MON., System Normal

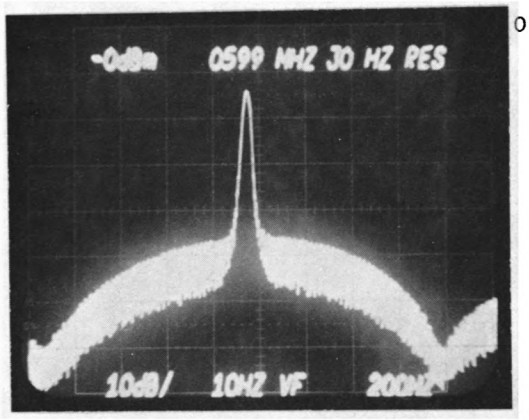


0 dBm

600 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 76 - 600 @ L14 FP MON., System Normal

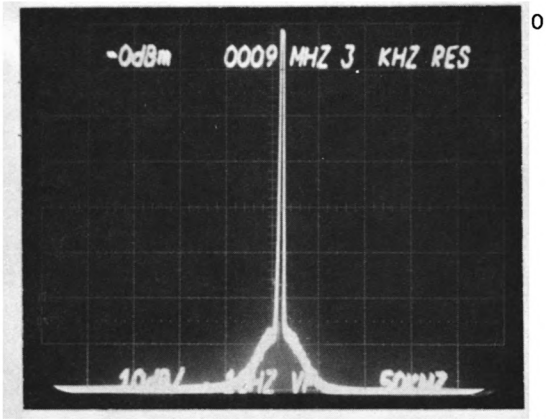


0 dBm

600 MHz 10 dB/cm VER

30 Hz BW 10 Hz VF 200 Hz/cm HOR

SP. 77 - 600 @ L14 FP MON., System Normal

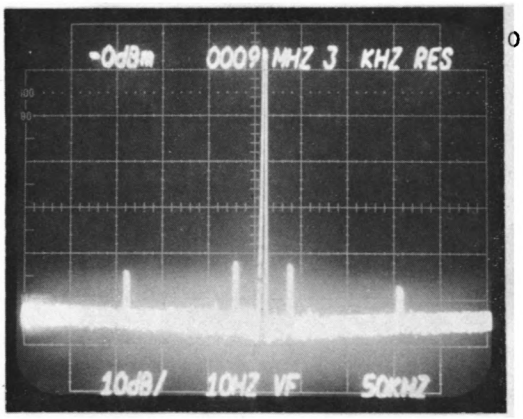


0 dBm

10 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 78 - 10 @ CR T1 REF. FP MON., System Normal

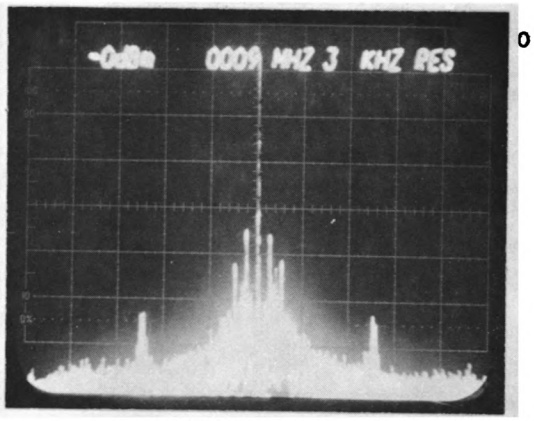


0 dBm

10 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 79 - 10 @ CR T1 IF FP MON., System Normal (Modem Offset = 30 kHz)

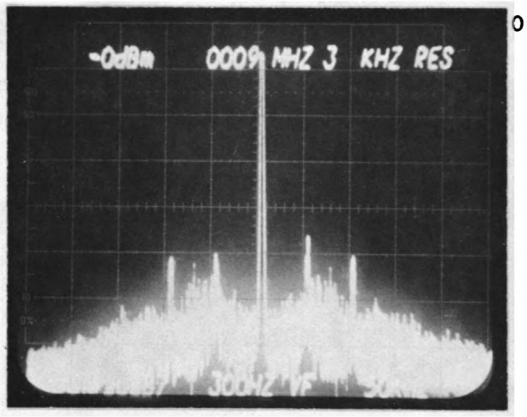


0 dBm

10 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 200 kHz/cm HOR

SP. 80 - 10 @ VR T1 IF FP MON., System Normal

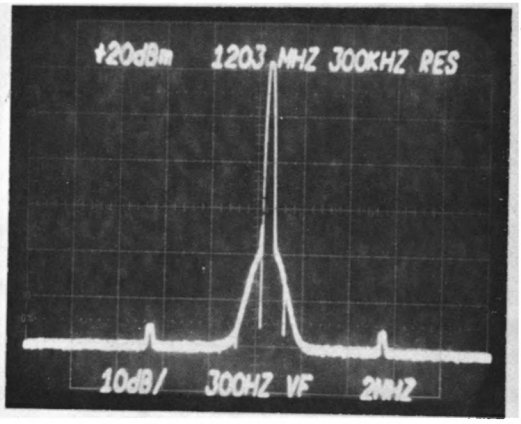


0 dBm

10 MHz 10 dB/cm VER

3 kHz BW 300 Hz VF 50 kHz/cm HOR

SP. 81 - 10 @ VR T1 IF FP MON., System Normal

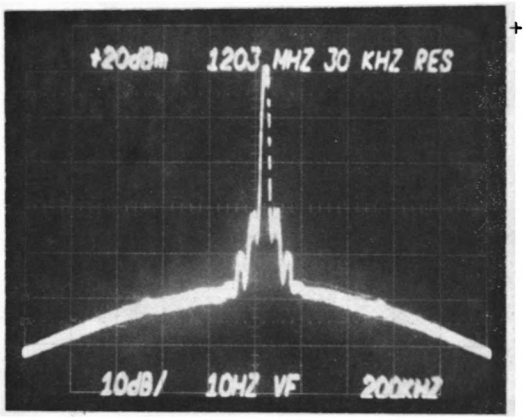


+20 dBm

1200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 2 MHz/cm HOR

SP. 82 - 1200 @ T4A Input

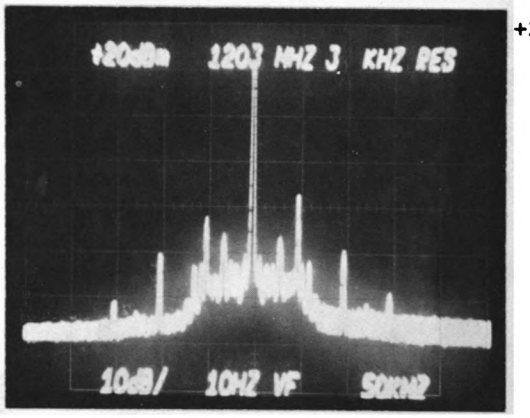


+20 dBm

1200 MHz 10 dB/cm VER

30 kHz BW 10 Hz VF 200 kHz/cm HOR

SP. 83 - 1200 @ T4A Input

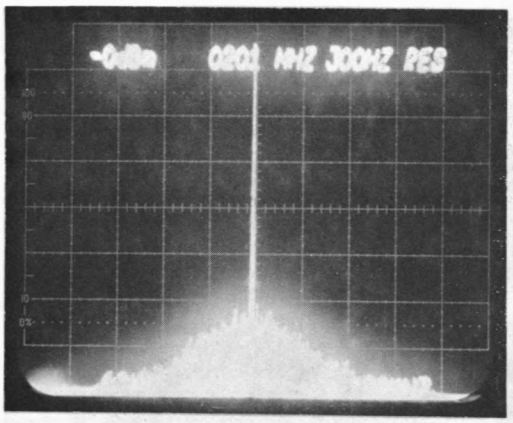


+20 dBm

1200 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP 84 - 1200 @ T4A Input

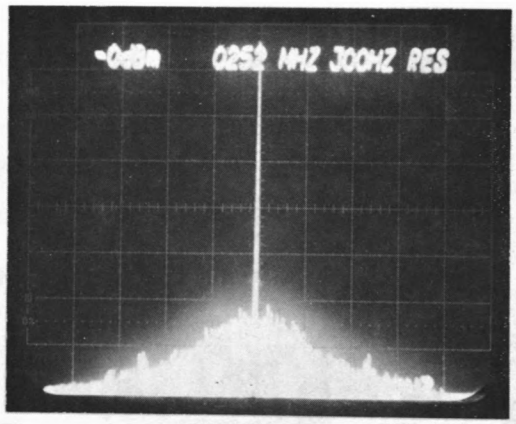


0 dBm

200 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 20 kHz/cm HOR

SP. 91 - 200 @ T4A Input, From Master L.O.

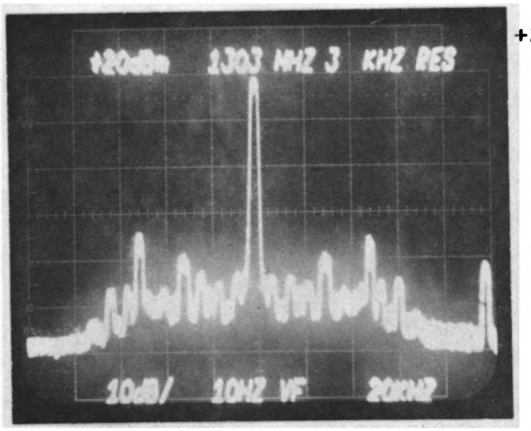


0 dBm

250 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 20 kHz/cm HOR

SP. 92 - 250 @ T4B Input, From Master L.O.

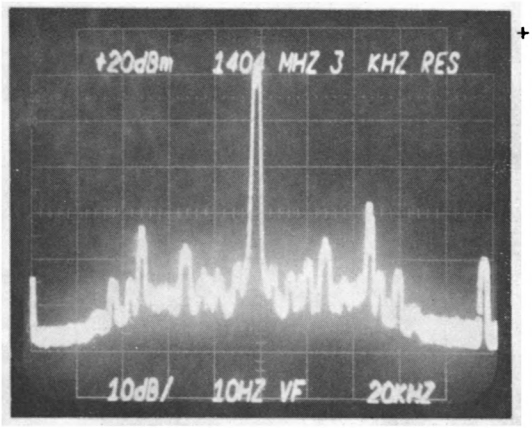


+20 dBm

1300 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 93 - 1300 @ T5A Input

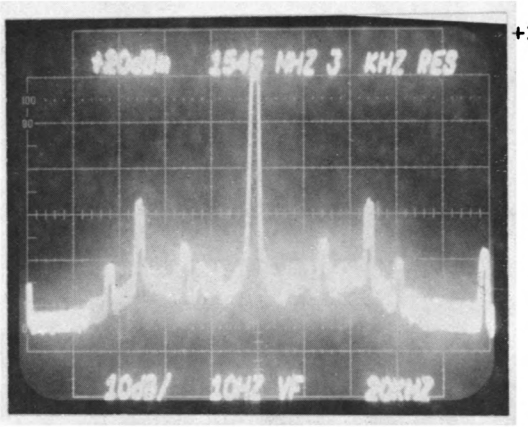


+20 dBm

1400 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 94 - 1400 @ T5B Input

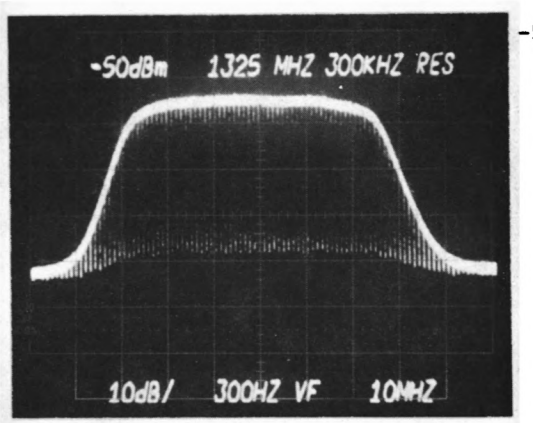


+20 dBm

1550 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 20 kHz/cm HOR

SP. 95 - 1550 @ T5C Input

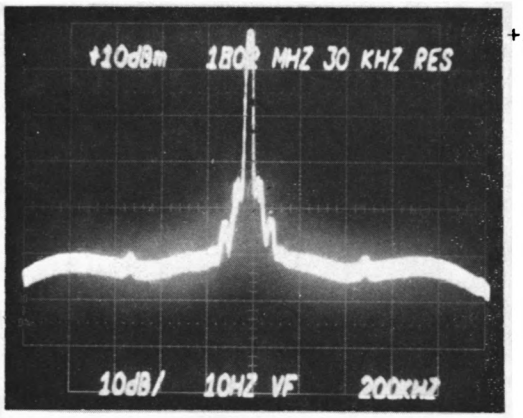


-50 dBm

1325 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 96 - 1325 IF @ VR T2 FP XMIT. MON., System Normal

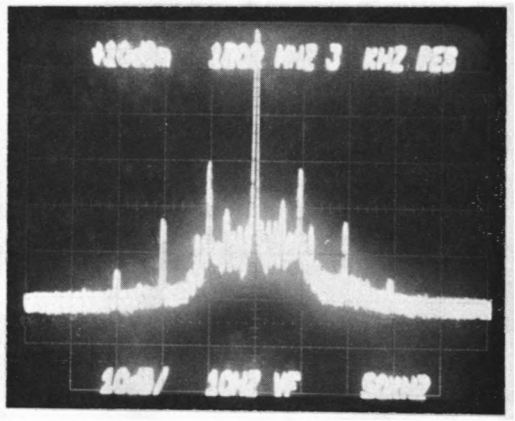


+10 dBm

1800 MHz 10 dB/cm VER

30 kHz BW 10 Hz VF 200 kHz/cm HOR

SP. 85 - 1800 @ T4B Input

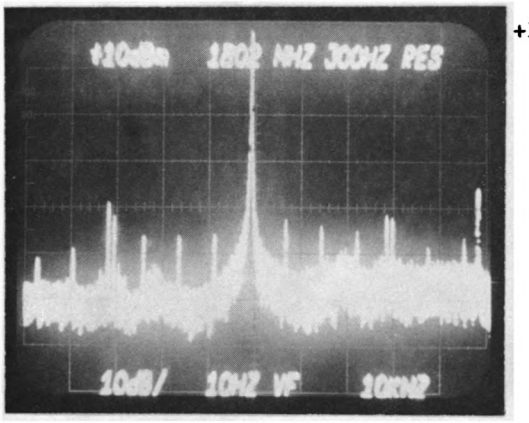


+10 dBm

1800 MHz 10 dB/cm VER

3 kHz BW 10 Hz VF 50 kHz/cm HOR

SP. 86 - 1800 @ T4B Input

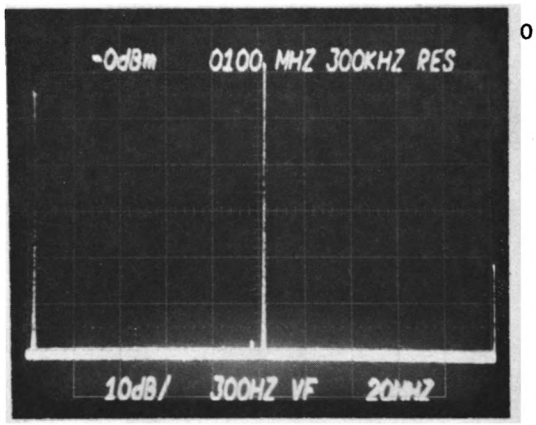


+10 dBm

1800 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 10 kHz/cm HOR

SP. 87 - 1800 @ T4B Input

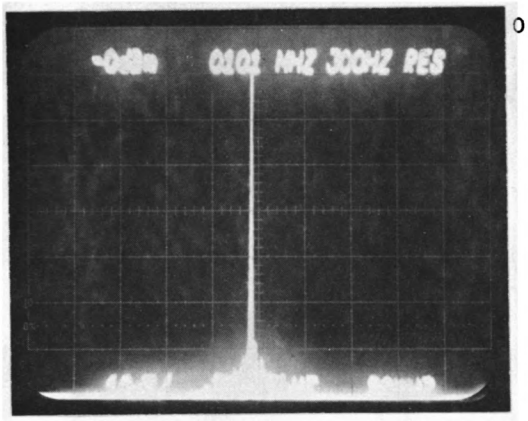


0 dBm

100 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 88 - 100 @ T4A Input, From Master L.O.

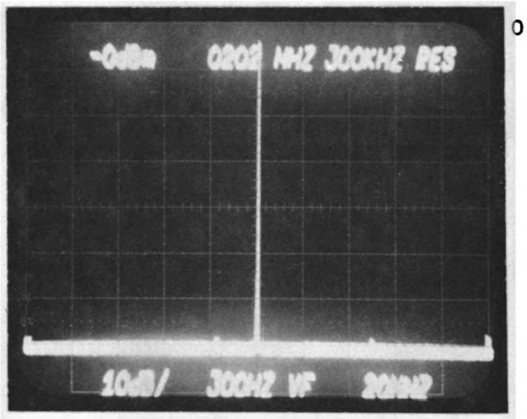


0 dBm

100 MHz 10 dB/cm VER

300 Hz BW 10 Hz VF 20 kHz/cm HOR

SP. 89 - 100 @ T4A Input, From Master L.O.

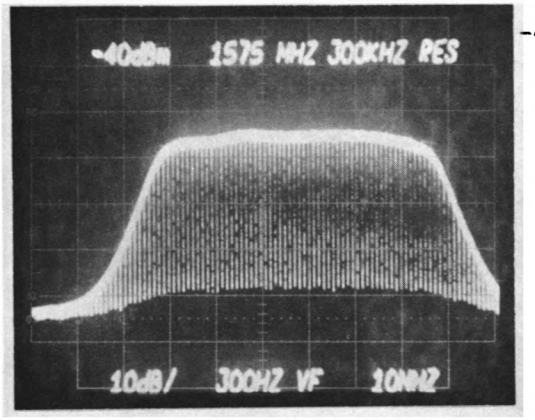


0 dBm

200 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 20 MHz/cm HOR

SP. 90 - 200 @ T4A Input, From Master L.O.

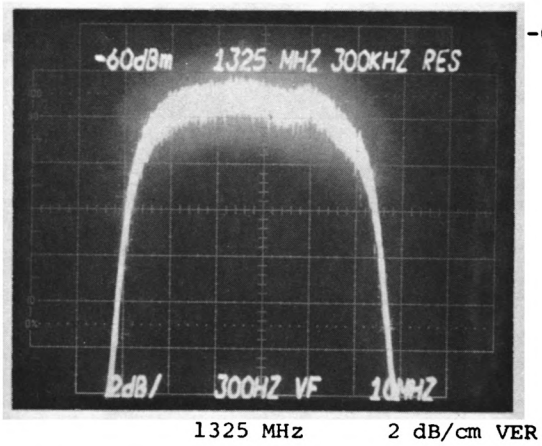


-40 dBm

1575 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 97 - 1575 IF @ VR T2 FP XMIT. MON., System Normal

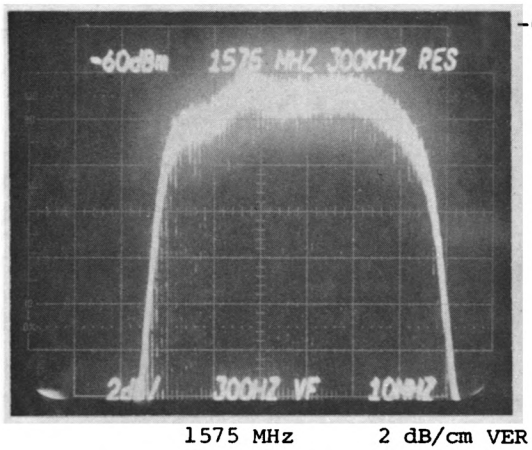


-60 dBm

1325 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 98 - 1325 IF @ VR T2 FP XMIT. MON., System Normal

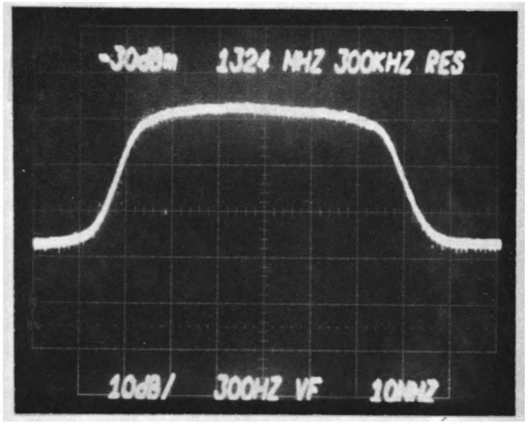


-60 dBm

1575 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 99 - 1575 IF @ VR T2 FP XMIT. MON., System Normal

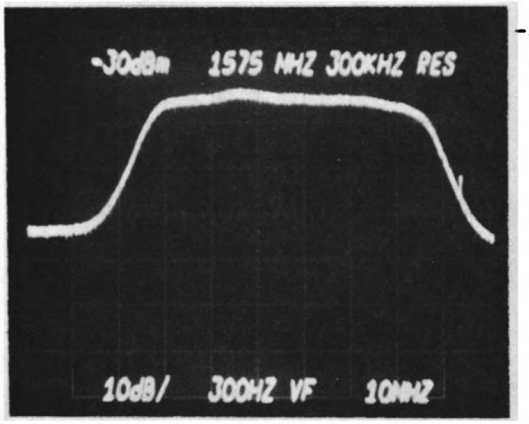


-30 dBm

1325 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 100 - 1325 IF @ CR T2 FP RCV. MON., System Normal

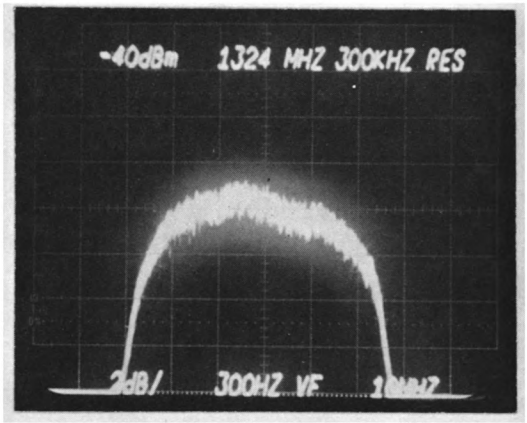


-30 dBm

1575 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 101 - 1575 IF @ CR T2 FP RCV. MON., System Normal

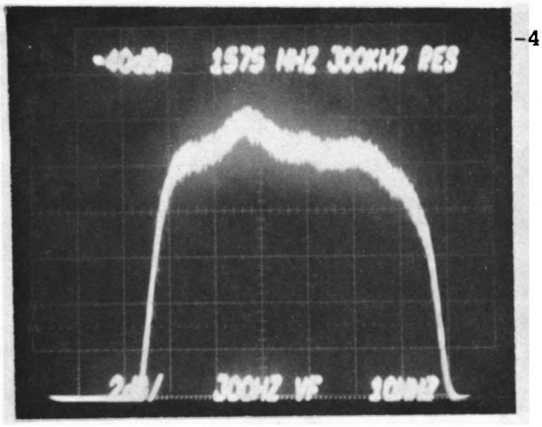


-40 dBm

1325 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 102 - 1325 IF @ CR T2 FP RCV. MON., System Normal

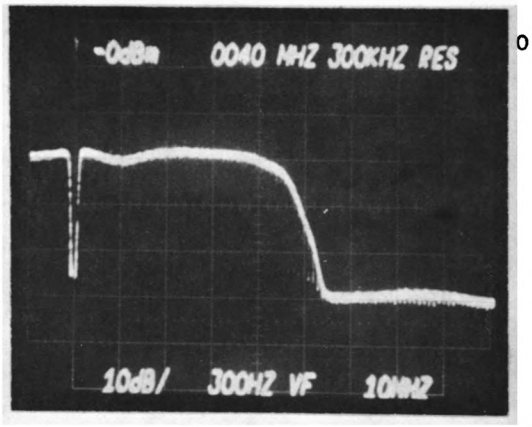


-40 dBm

1575 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 103 - 1575 IF @ CR T2 FP RCV. MON., System Normal

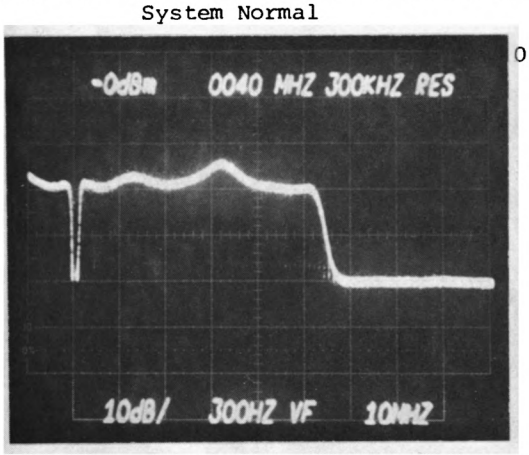


0 dBm

40 MHz 10 dB/cm VER

300 kHz 300 Hz VF 10 MHz/cm HOR

SP. 104 - Ch. A IF @ Baseband @ T5 FP MON., System Normal

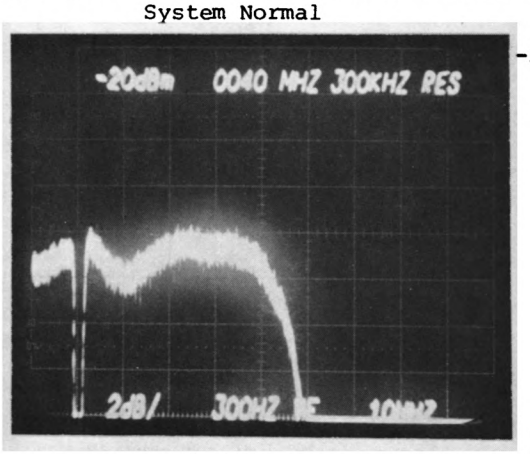


0 dBm

40 MHz 10 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 105 - Ch. C IF @ Baseband @ T5 FP MON., System Normal

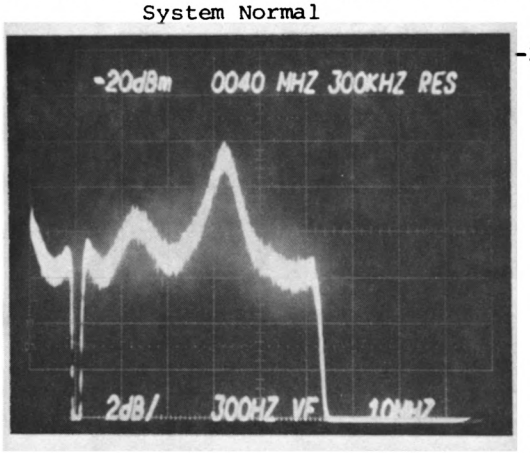


-20 dBm

40 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 106 - Ch. A IF @ Baseband @ T5 FP MON., System Normal

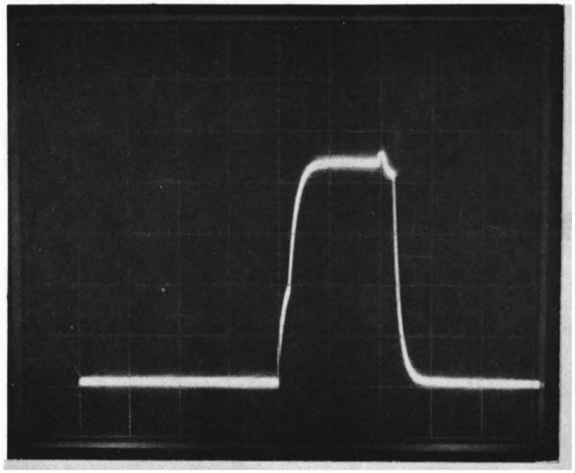


-20 dBm

40 MHz 2 dB/cm VER

300 kHz BW 300 Hz VF 10 MHz/cm HOR

SP. 107 - Ch. C IF @ Baseband @ T5 FP MON., System Normal



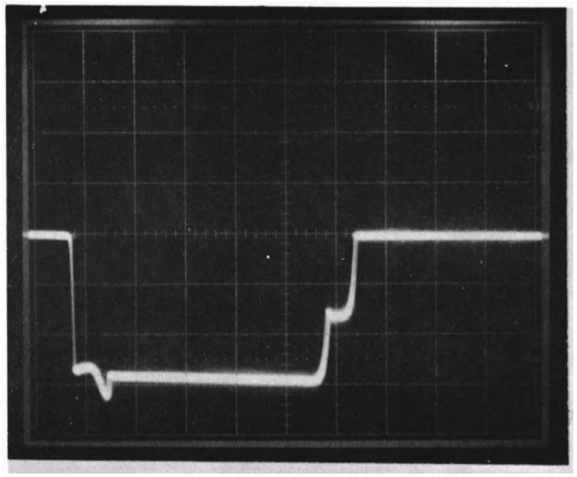
0·2 V/cm

-0

0·5 ms/cm

Trigger on L11 Control T/H

Oscillogram 1 - CR XMIT. Level @ T2 FP



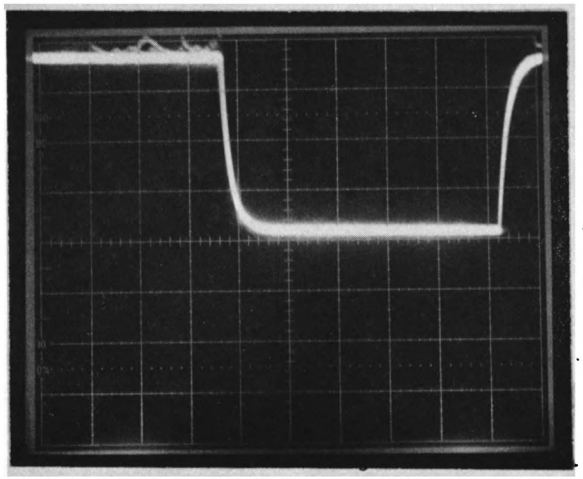
-0

2 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 2 - VR RCV. Level @ T2 FP



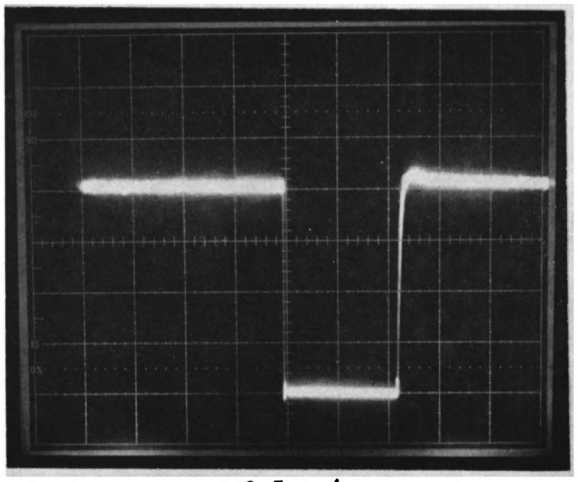
-0

0·5 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 3 - VR XMIT. Level @ T2 FP



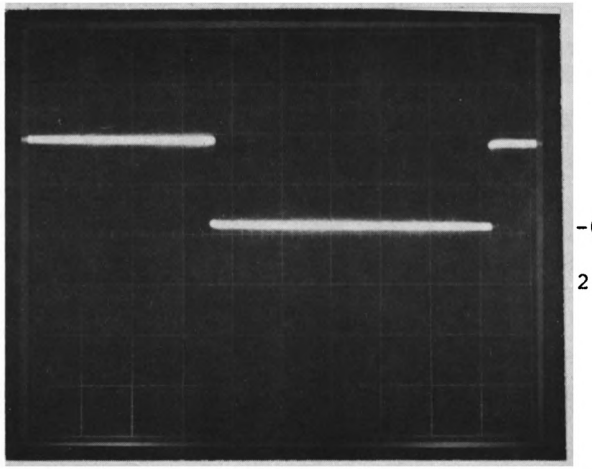
2 V/cm

-0

0·5 ms/cm

Trigger on L11 Control T/H

Oscillogram 4 - CR RCV. Level @ T2 FP



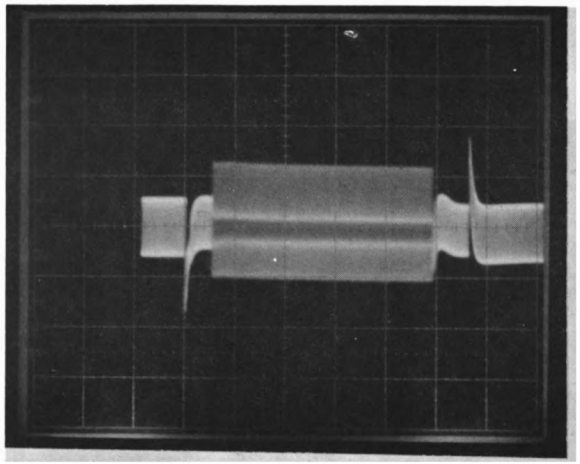
-0

2 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 5 - VR L8 T/R FP



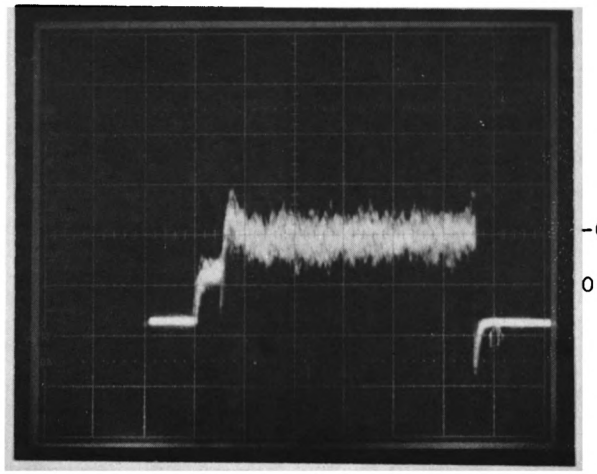
-0

0·1 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 6 - Data @ L4 FP MON.



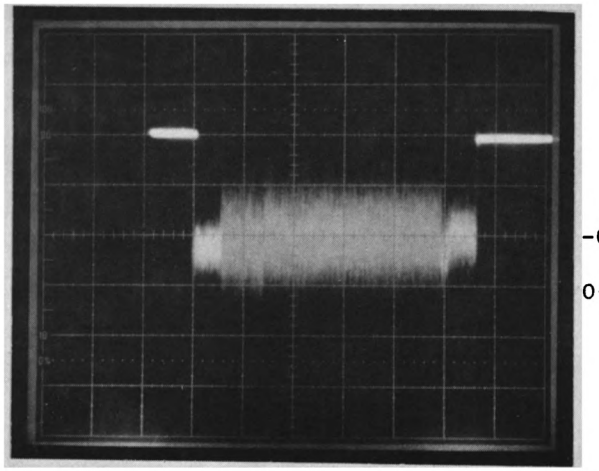
-0

0·1 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 7 - 5ϕ @ L4 FP MON.



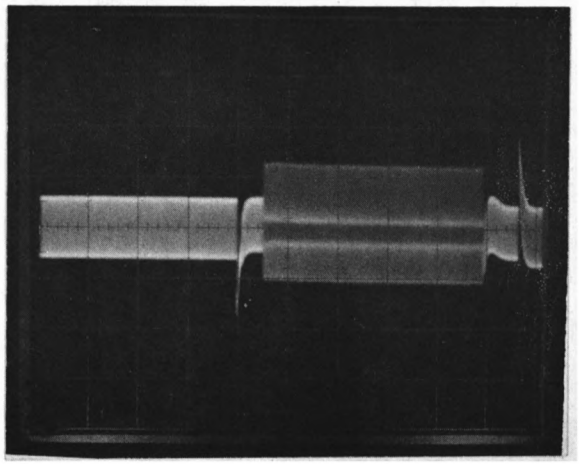
-0

0·2 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 8 - 600ϕ @ L4 FP MON.



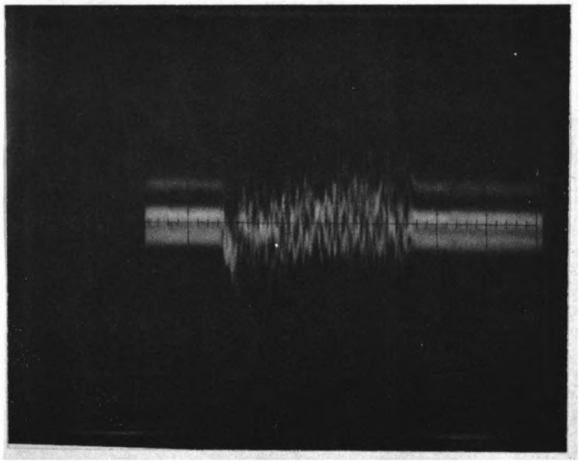
-0

0·1 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 9 - RCV. Data @ L4 FP MON.



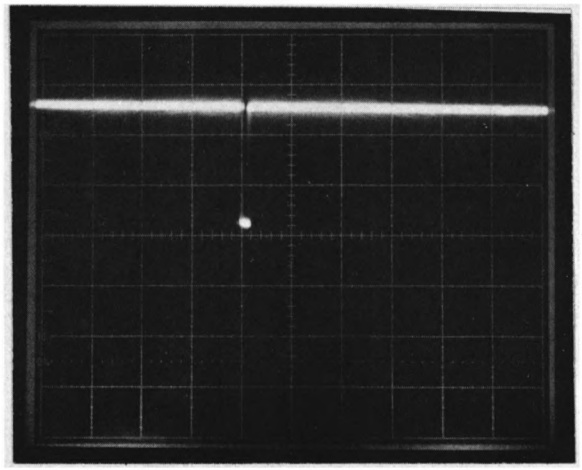
-0

50 mV/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 10 - 600ϕ @ L5 Monitor PT. 3



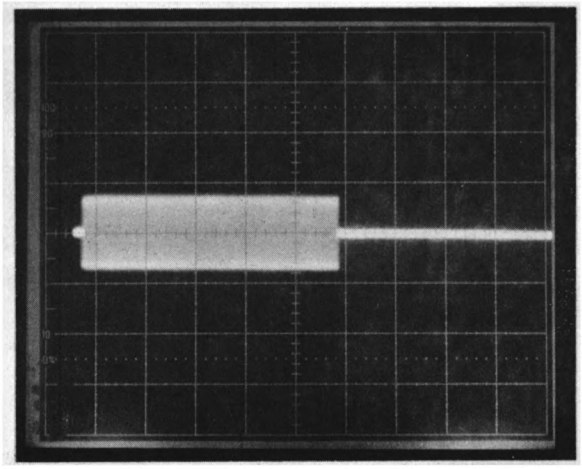
-0

2 V/cm

0·2 ms/cm

Trigger on Carrier ON L8 FP

Oscillogram 11 - L8 SYNC @ FP



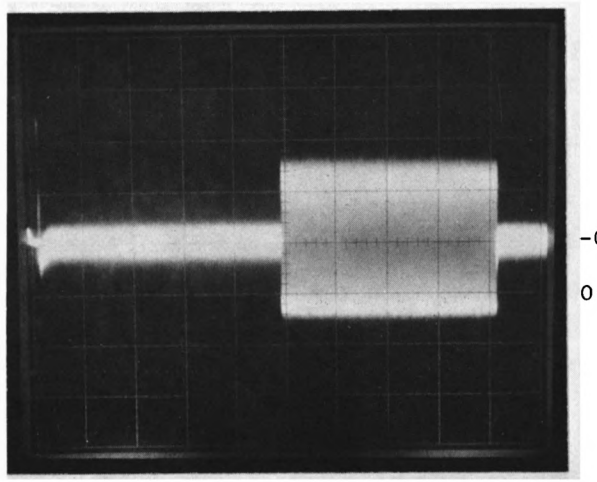
-0

0·1 V/cm

0·2 ms/cm

Trigger on VR SYNC.

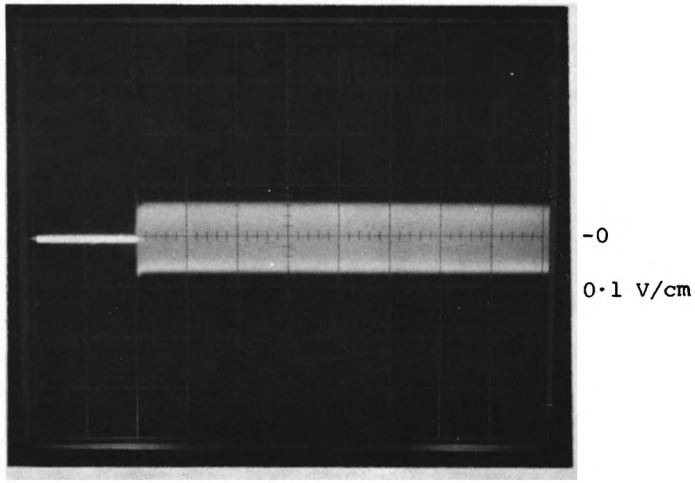
Oscillogram 12 - SYNC. RCV. @ L4 FP MON.



5 ms/cm

Trigger on L11 Control T/H

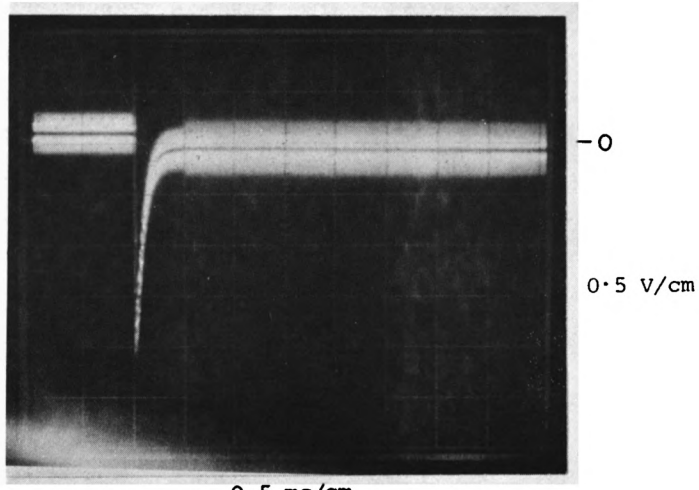
Oscillogram 13 - Data @ L9 FP MON.



0·5 ms/cm

Trigger on L11 Control T/H

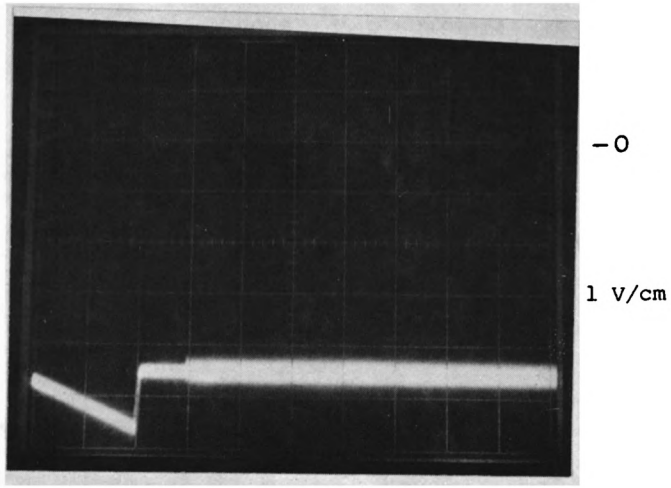
Oscillogram 14 - 5 MHz @ L9 FP MON.



0·5 ms/cm

Trigger on L11 Control T/H

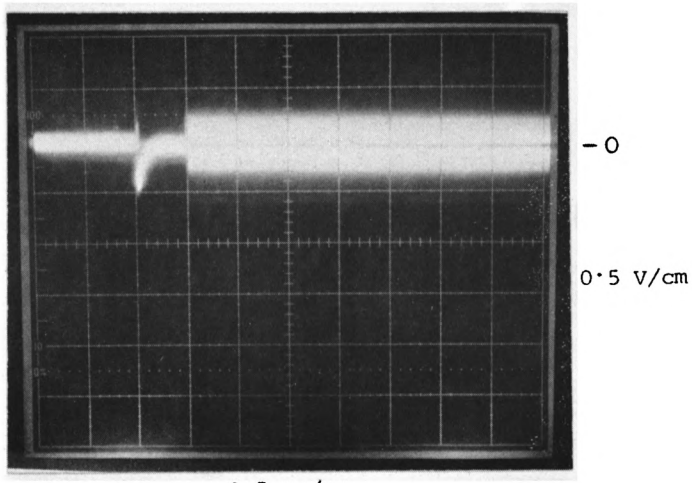
Oscillogram 15 - 1200 MHz ϕ-Error L14 @ L11 MON. 1



0·5 ms/cm

Trigger on L11 Control T/H

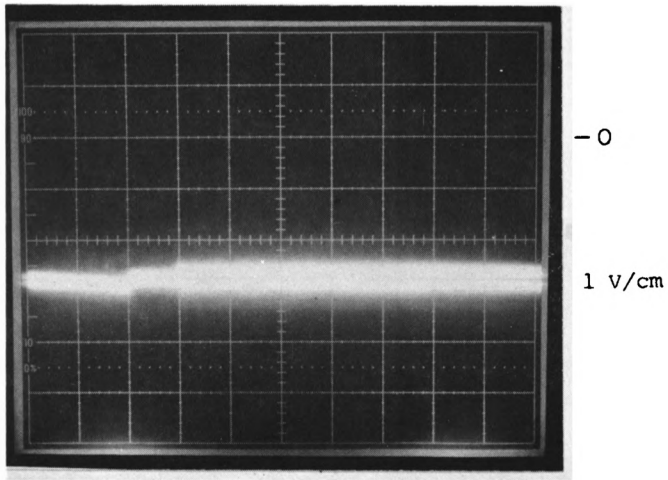
Oscillogram 16 - 1200 MHz VCO Control L14 @ L11 MON. 2



0·5 ms/cm

Trigger on L11 Control T/H

Oscillogram 17 - 1800 MHz ϕ-Error L14 @ L11 MON. 3



0·5 ms/cm

Trigger on L11 Control T/H

Oscillogram 18 - 1800 MHz VCO Control L14 @ L11 MON. 4

4.0 DISCUSSION OF SPECTRA AND OSCILLOGRAMS

4.1 Remarks on Spectra

Serial No.	Sp. No.	Description	Remarks
1	1	100 MHz @ Rack B	-54 dBc @ +50 MHz, -60 dBc @ -50 MHz
2	3	200 MHz @ Rack B	-58 dBc @ -50 MHz
3	5	600 MHz @ Rack B	-64 dBc @ +5 MHz, -68 dBc @ -15 MHz
4	6	600 MHz @ Rack B	-66 dBc @ ~-18 MHz ?
5	10,11	50 MHz Comb @ Rack B	Comb line @ 750 MHz -4 dB from allowed tolerance
6	14	2400 MHz	-54 dBc @ ± 50 kHz, -64 dBc @ ±100 kHz
7	15	3000 MHz	Most of the spurious lines due to spectrum analyzer
8	16	3000 MHz	-58 dBc @ -100 MHz, -65 dBc @ +50 MHz
9	17	3000 MHz	$\lesssim$-54 dBc @ ±50 kHz, -65 dBc @ ±100 kHz
10	20	L6A @ Rack B; f_o = 3560	-50 dBc @ ±100 kHz and ~-150 kHz; -54 dBc @ ±50 kHz
11	22	L6C @ Rack B; f_o = 3310	$\lesssim$-52 dBc @ harmonics of ±50 kHz
12	23	3200 MHz from F2	Most of the spurious lines due to spectrum analyzer
13	24	3200 MHz from F2	-54 dBc @ ±100 kHz, -58 dBc @ ±50 kHz, etc.
14	25	L6A: 10·1 MHz IF @ FP	Noise modulation -52 dBc @ ±100 kHz, -62 dBc @ ±50 kHz
15	26	L7A: 10·1 MHz @ FP	-55 dBc @ ±100 kHz
16	27	L6C: 10·1 MHz IF @ FP	$\lesssim$-54 dBc @ harmonics of ±50 kHz, $\lesssim$-66 dBc @ ±60, 120 kHz
17	29-33	L6A and L6C FP IF	Due to computer command problems?
18	40	L7A, L7C 10·1 MHz FP CR. RCVD. IF @ T2 FP	Spurious responses at 1120, 1385 and 1980 all -30 dBc or below each L.O. Carrier; spectrum analyzer
19	46,47	VR RCVD. 1200 @ T2 FP	-30 dBc @ ±50 kHz, -42 dBc @ ±100 kHz; $\lesssim$-42 dBc FM due to ~7 kHz
20	49	VR XMIT. 1200 @ T2 FP	-62 dBc @ ±50 kHz, -72 dBc @ +150 kHz

21	51,52 53	CR RCVD. 1200 @ T2 FP	-30 dBc @ ±50 kHz, -42 dBc @ ±100 kHz and ≤-42 dBc due to FM ~7 kHz
22	58	VR RCVD. 1800 @ T2 FP	-38 dBc @ ±5 MHz
23	59,60 61	VR RCVD. 1800 @ T2	-30 dBc @ ±50 kHz, -42 dBc @ ±100 kHz; ≤-42 dBc due to FM ~ 7 kHz
24	66,	CR RCVD. 1800 @ T2	-30 dBc @ ±50 kHz, -42 dBc @ ±100 kHz; ≤-42 dBc due to FM ~ 7 kHz
25	72	600 MHz @ L4 FP	-54 dBc @ -30 kHz, -58 dBc @ -60 kHz, -65 dBc @ +30 kHz
26	76	600 MHz @ L14 FP	-52 dBc @ ±30 kHz, -54 dBc @ ±60 kHz, <-56 dBc @ ±100 kHz
27	79	CR Modem IF @ FP	-48 to -52 dBc @ ~±30 kHz and ~±150 kHz
28	80, 81	VR Modem IF @ FP	-40 to -48 dBc @ ±50, ±100 kHz; -58 dBc @ ±500 kHz
29	82	1200 @ T4A Input	-58 dBc @ ±5 MHz
30	83	1200 @ T4A Input	-52 dBc @ ±500 kHz
31	84	1200 @ T4A Input	See remarks for spectra 51, 52, 53
32	85	1800 @ T4B Input	-50 dBc @ ±500 kHz
33	86,87	1800 @ T4B Input	-30 dBc @ ±50 kHz, -42 dBc @ ±100 kHz, ≤-42 dBc due to FM by ~7 kHz
34	93	T5 L.O. @ 1300	See remarks for spectra 51, 52, 53
35	94	T5 L.O. @ 1400	See remarks for spectra 51, 52, 53
36	95	T5 L.O. @ 1550	See remarks for spectra 51, 52, 53
37	105, 107	Ch. C IF @ Baseband T5 FP Mon.	Large passband ripple ~5 to 6 dB p-p roughly 2 cycles of ripple in 50 MHz.

4.2 Spurious Signals and Noise

Phase stability of the local oscillator signals depend on the reference 600 MHz generated by combining the received 1800

and 1200 MHz in L4 at VR and in L14 at CR. Any spurious signals at these frequencies will effect the phase stability of the 600 MHz. Undesired signals near these frequencies may also effect the 600 MHz depending upon their frequencies and phases. It is important to remember that the phase-lock loop at antenna, though has roughly one Hz bandwidth, is sampled at 19·2 Hz and therefore spurious signals outside this bandwidth may also be aliased into the loop bandwidth by the sampling. Further at CR the 1800 and 1200 MHz are also used to translate the IF signals from the channel frequencies to baseband (from 0 to 50 MHz).

Undesired signals and noise introduced in the modems are mostly due to frequency modulation of the modem Gunn oscillators by noise and spurious signals on the reference signals to the modems or power supply lines within the modem phase-lock loop bandwidth. However these spurious signals should not effect the phase stability of the system because they influence the 1800, 1200 and IF signals equally at any time. Therefore the recovered 600 MHz as well as the IF signals at baseband should be uneffected. Here a word of caution - the loop bandwidths of the 1800 and 1200 MHz phase-lock loops have to be limited because of the data modulation on 1800 MHz carrier and other practical considerations. Any modulation outside the loop bandwidth may effect the IF signals.

From the spectra of the received 1800 and 1200 MHz at both VR and CR (spectra 46, 47; 52, 53; 60, 61; and 66, 67) one can see that large sidebands at ±50 kHz, ±100 kHz as well as frequency modulation due to a signal at about 7 kHz are present. Though in each case undesired signals are -30 dB of the desired signal and therefore the system phase performance should not degrade significantly any increase in their strength may not be acceptable. The ±50 kHz and ±100 kHz sidebands appear due

to L7 and L8 modules pumping these signals on Rack B. The signal around 7 kHz appears from DCS system.

4.3 Intermodulation Products

It was recognized that intermodulation of 1·8 and 1·2 GHz signals cause undesired signals generated by $mf_1 \pm nf_2$. The effect of these undesired signals could be kept small if the IF reference for the two modems at VR and CR are offset slightly. However for reciprocity of the waveguide path to be nearly true the offset has to be small compared to possible fine scale structure in the waveguide transmission. Therefore the undersized signals due to the intermodulation components should be kept minimum. Also these undesired intermodulation components, depending upon where they are generated, may influence only 1800 and 1200 MHz but not the IF signals. This will effect the IF signals at basebands. Therefore it was decided to modify signal levels at various stages in the system to keep the intermodulation products low. To keep the effect on the phase due to undesired signal to less than $0.^{\circ}1$, the undesired signal should be -54 dBc of the desired signal if the two were at the same frequency. If the undesired signal is offset in frequency from the desired signal the ratio could be smaller. It has been decided that we will have a small offset between IF reference signals to the two modems.

The offset between the two modems was 30 kHz. CR modem reference was 10·03 MHz from a Fluke Synthesizer and VR modem reference was 10·00 MHz from the L1 module. The intermodulation components are produced at ±30, ±60 kHz on the recovered 600 MHz at both VR and CR. Spectra 72 and 76 show the effect of the intermodulation components. The intermodulation products are more than 50 dB below the desired signal in both cases.

4.4 Effect Due to Data Modulation

There has been some concern about phase stability of the 600 MHz due to presence of data modulation on 1800 MHz. Oscillogram-10 shows the 600 MHz phase error as measured at L5 monitor point 3 with system normal. The phase error during the 1 ms period due to presence of data appears to be $<0^{\circ}.1$ (not measurable; <20 mV in 10 V/rad scale). However in some cases the phase error, as much as 1°, due to data modulation has been observed. Cause for this problem is not understood.

4.5 IF Passband Ripple

IF passband ripple to channel C IF at baseband is very large, 5·5 dB peak-to-peak (see spectrum 107). From a comparison of spectra 103 and 107 it is clear that the passband ripple over the 50 MHz passband up to T2 output is less than 2 dB peak-to-peak and most of the ripple is introduced in the IF Receiver T5. This could be due to a defective T5 module and need be checked.

5.0 PHASE STABILITY MEASUREMENTS

5.1 Introduction

Phase stability of the IF signals from an antenna depends on the stability of local oscillator signals provided at the antenna. L.O. signals at any antenna are derived from the 600 MHz reference generated by combining 1800 and 1200 MHz received from CR. Further at CR the received IF signals are translated to baseband by using 1800 or 1200 MHz received from VR. Therefore phase of the measured visibility is effected by variations in phase of the 600 MHz reference delivered at an antenna and path length changes in the returned IF signals from the antenna. Variations of the returned 600 MHz phase (600 MHz generated at CR by combining 1800 and 1200 MHz received from VR) is used to determine the waveguide length changes by assuming the waveguide path is reciprocal and non-dispersive over the modem channel passband and variations of electronics effect equally both forward and return paths. This information is used to correct the phase of the visibility to account for variations of the 600 MHz reference phase and waveguide length changes.

Electronics in the forward and the return 600 MHz path is not identical due to other design considerations. Therefore stability of the returned 600 MHz phase (ϕ_{600RT}) with VR temperature variation is important. Also phase of 5 MHz at antenna (ϕ_{5ANT}, phase between two 5 MHz signals - one from antenna L1 and second from demodulating 1·2 GHz received from CR) is important. For if it exceeds $\pm 1^{\circ}.5$ limit, the loop will push or retard the 600 MHz generated at antenna by 1 cycle to bring this phase error to within the $\pm 1^{\circ}.5$ limit. We have measured variations of ϕ_{600RT} and ϕ_{5ANT} with time over several days and also with VR temperature variation. Also calibration radio sources have been observed at both C-Band and L-Band to determine fringe phase stability.

5.2 Variations of 600 MHz Round-Trip and Antenna 5 MHz Phases

5.2.1 The 5 MHz phase at antenna, ϕ_{5ANT} appears to exceed $\pm 1^{\circ}.5$ limit in several cases. For example see Figure 5.1 a and b. This phase variation forces the 600 MHz at the antenna to slip by a cycle to reduce the ϕ_{5ANT} to within $\pm 1^{\circ}.5$. It appears to be caused by ripple in the waveguide transmission characteristic with a spacing of about 5 to 10 MHz and of the order of a 0·3 to ·5 dB peak-to-peak. The cause for the ripple is not fully understood and is under investigation.

5.2.2 The 600 MHz round-trip phase, ϕ_{600RT}, varies by about 20° over a day. This variation is diurnal and most of it appears due to 20 mm waveguide length changes because of outside temperature variations (see Figure 5.2).

5.2.3 Temperature coefficient for ϕ_{600RT} and ϕ_{5ANT} with VR temperature (T_{VR}) have been measured. During observations of calibration radio sources, antenna 5 VR temperature was varied by about $\pm 5^{\circ}$ C around its normal value of about 22° C (72° F). Figure 5.3 shows temperature variation monitored by two sensors, one mounted in rack B at L2 and other mounted on F4 IF channel filters in rack A. Corresponding variations of ϕ_{600RT} and ϕ_{5ANT} are shown in Figures 5.4 and 5.5 respectively. The ϕ_{600RT} had some instability when VR temperature was high and could be due to a bad connector or maladjustment of one of the 1200 or 1800 MHz phase-lock loops in L3.

Also for stationary antenna 3 VR temperature was varied by $\pm 5^{\circ}$ C to measure the phase variations of ϕ_{600RT} and ϕ_{5ANT}. The results in both cases are similar and are as follows:

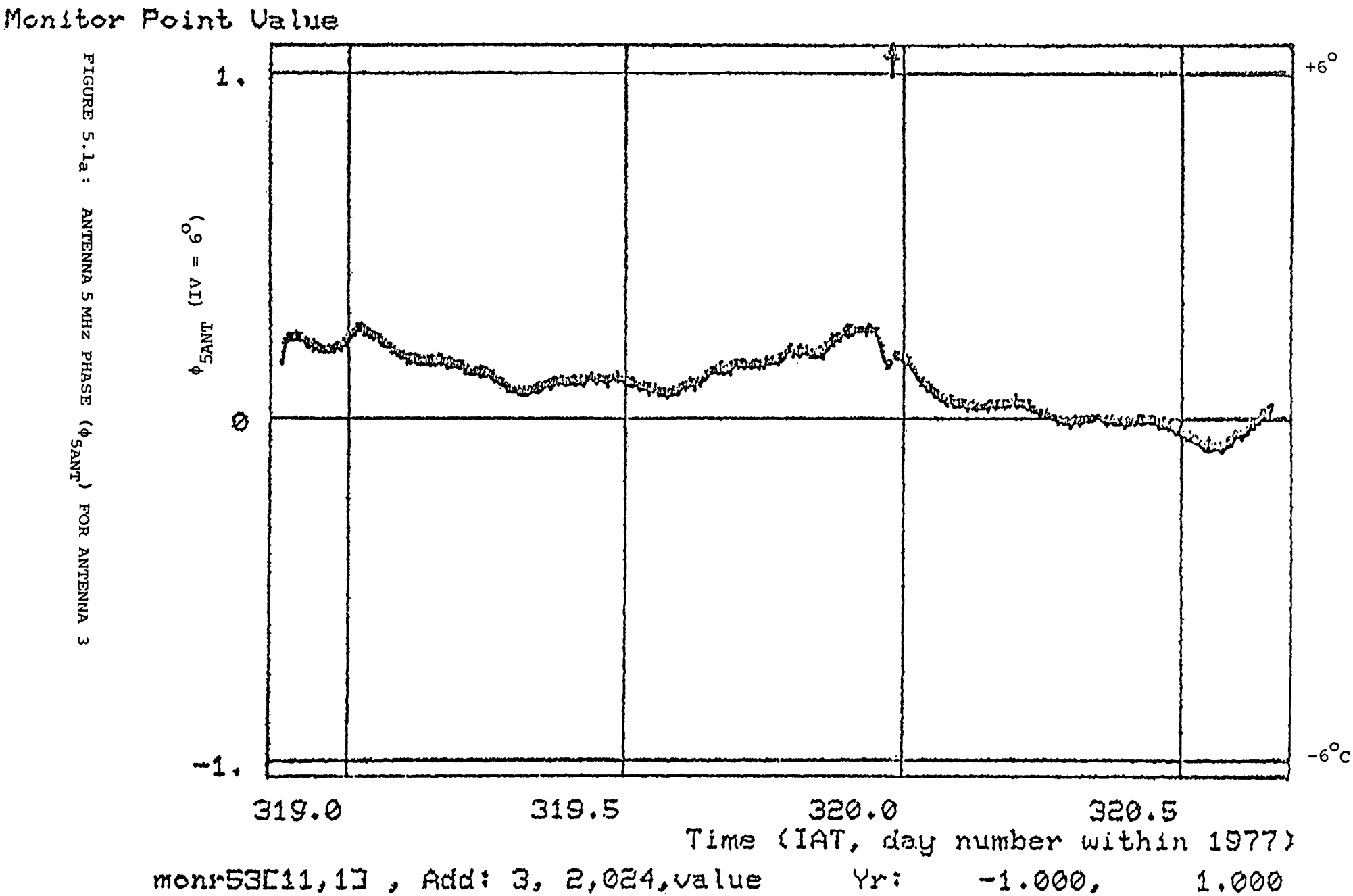


FIGURE 5.1a: ANTENNA 5 MHz PHASE (ϕ_{5ANT}) FOR ANTENNA 3

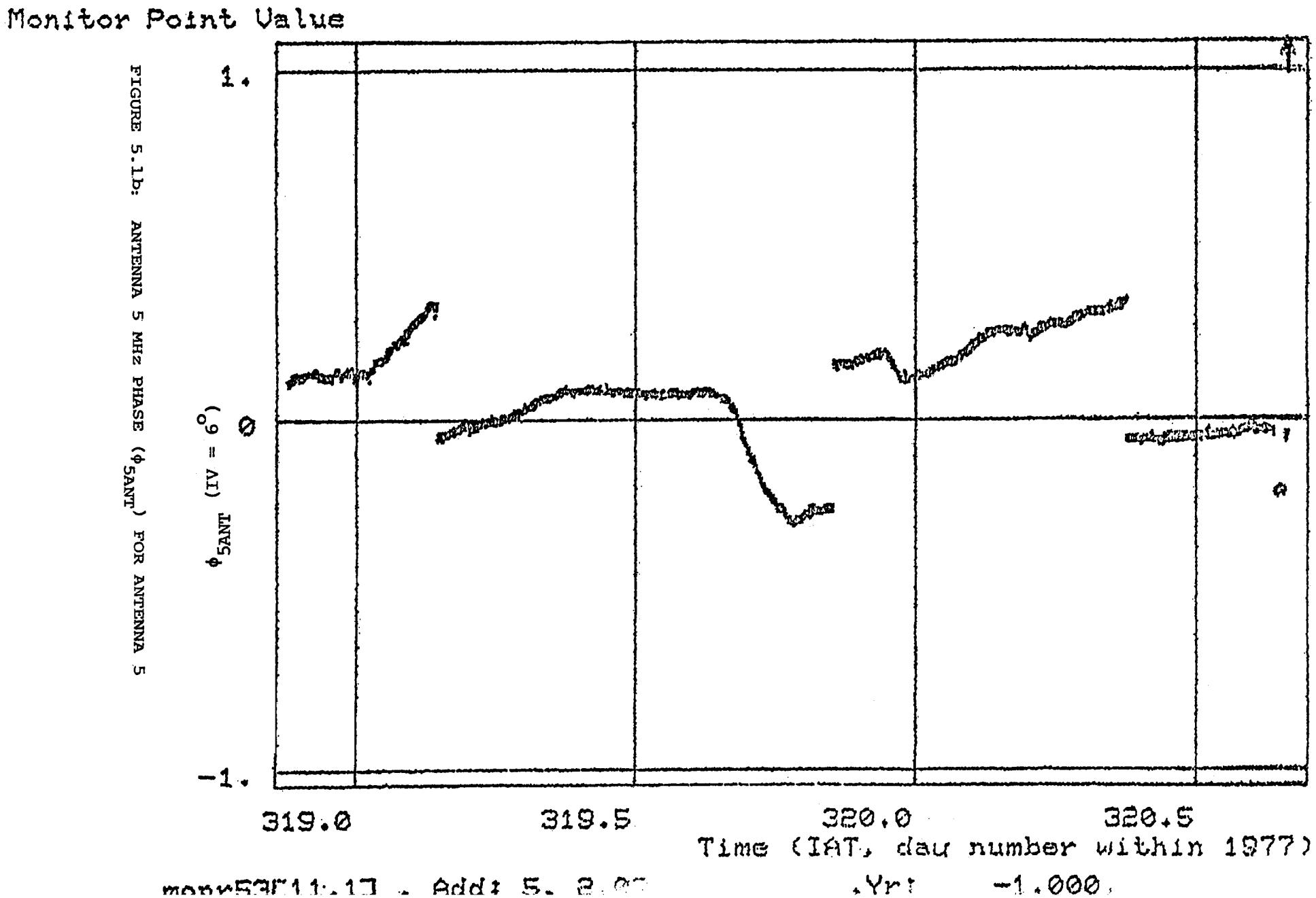


FIGURE 5.1b: ANTENNA 5 MHz PHASE (ϕ_{5ANT}) FOR ANTENNA 5

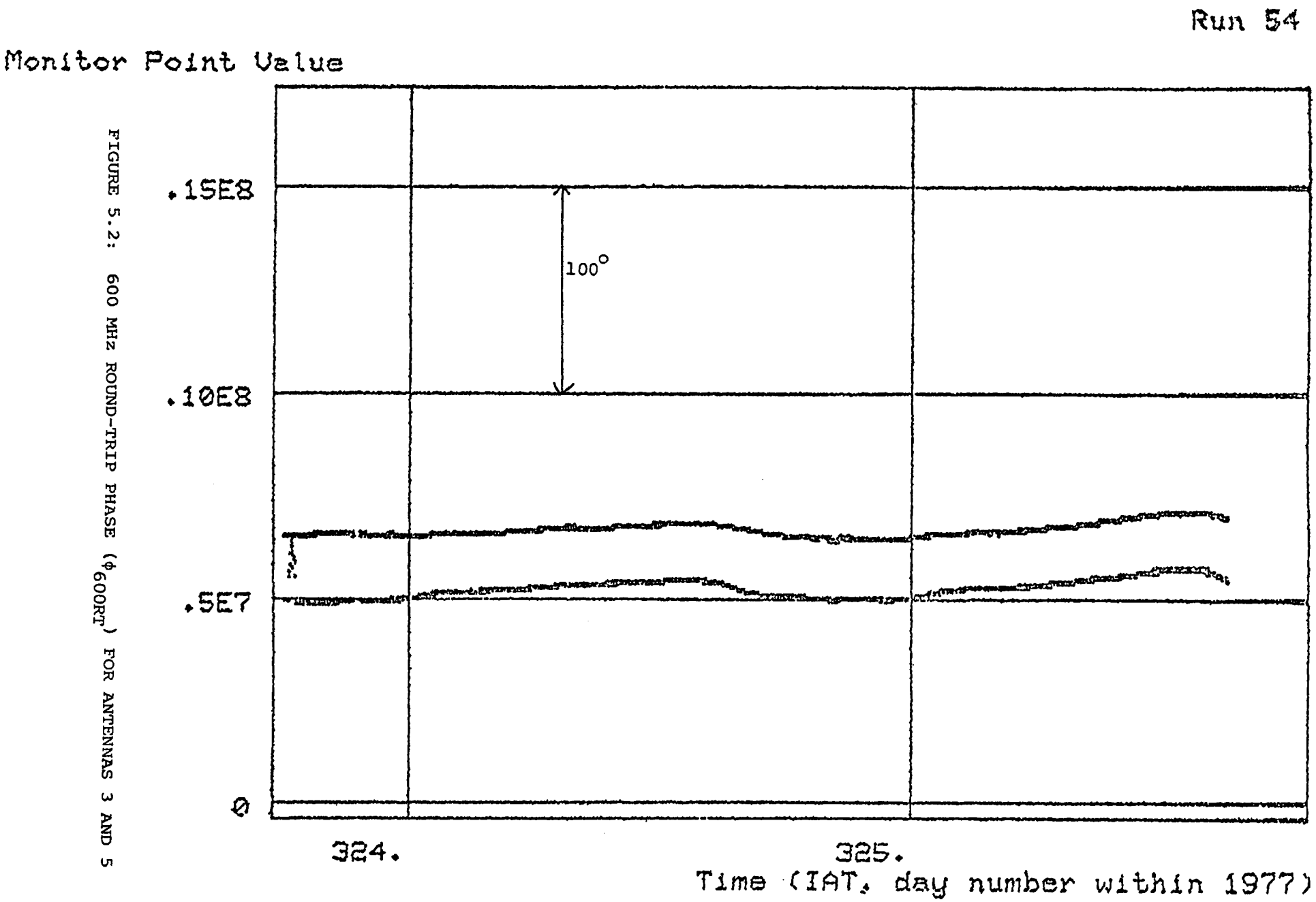


FIGURE 5.2: 600 MHz ROUND-TRIP PHASE (ϕ_{600RT}) FOR ANTENNAS 3 AND 5

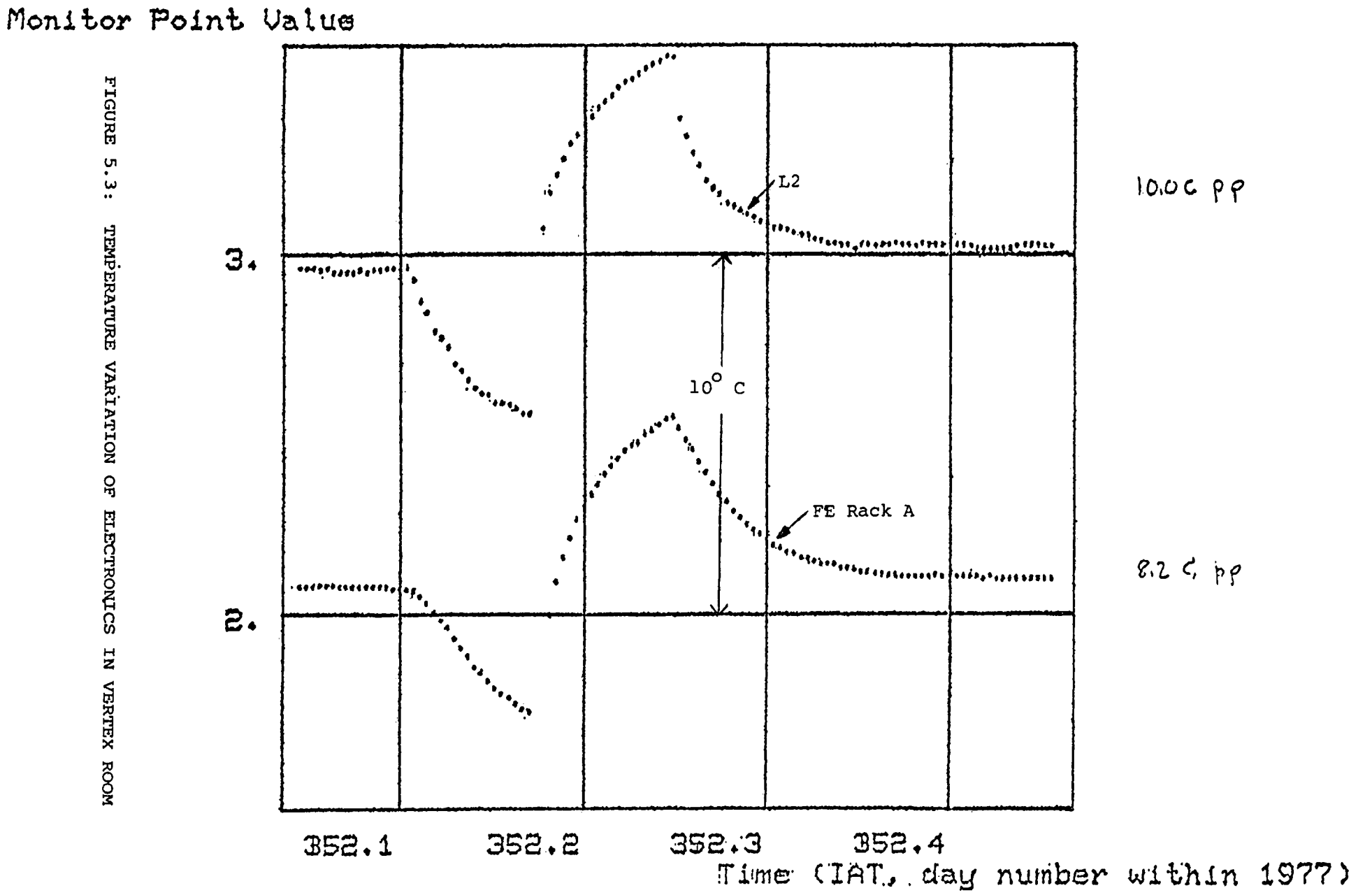


FIGURE 5.3: TEMPERATURE VARIATION OF ELECTRONICS IN VERTEX ROOM

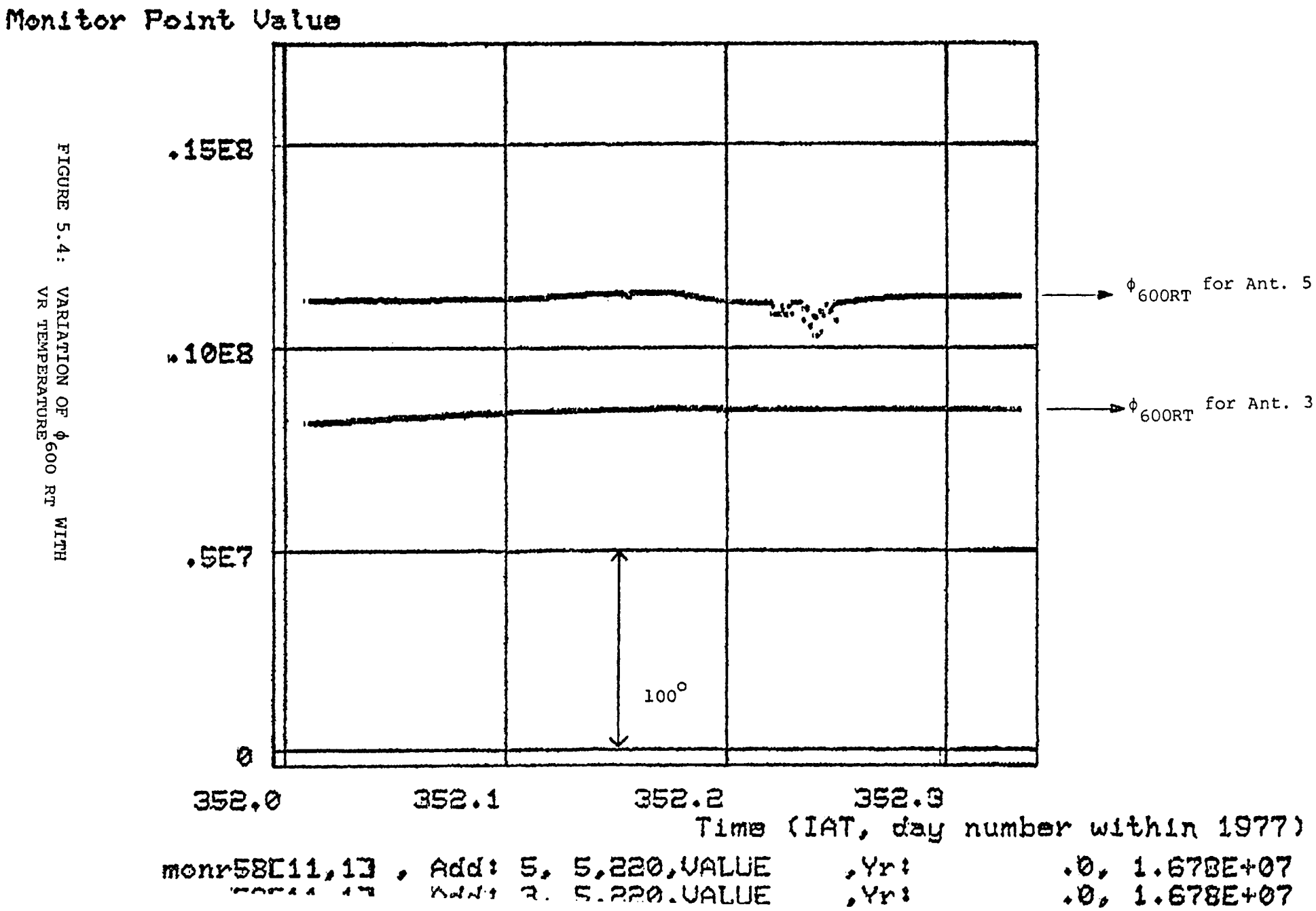


FIGURE 5.4: VARIATION OF $\phi_{600\ RT}$ WITH VR TEMPERATURE

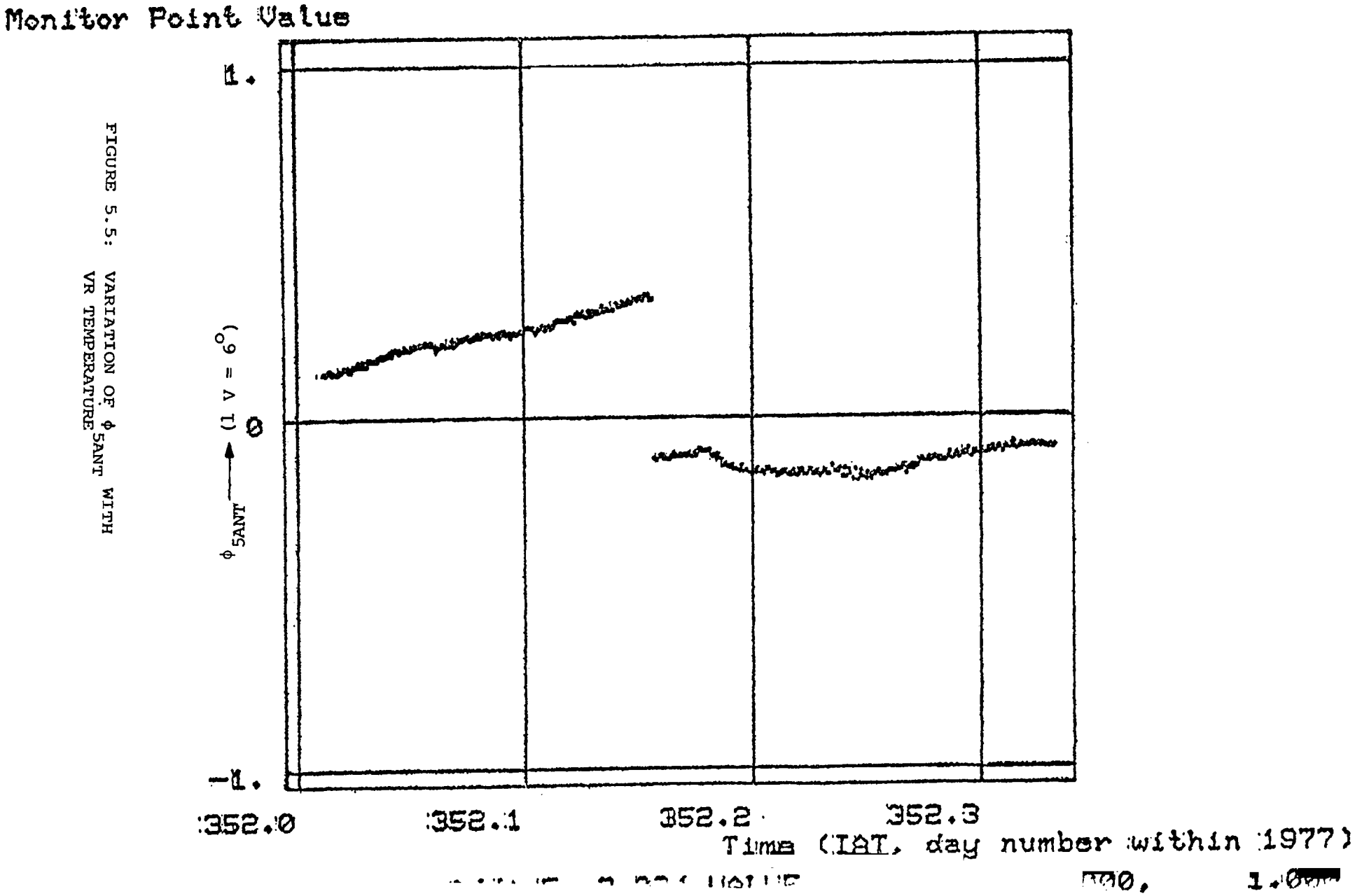


FIGURE 5.5: VARIATION OF ϕ_{5ANT} WITH VR TEMPERATURE

$$\Delta\phi_{600RT}/\Delta T_{VR} \sim 0{\cdot}5^{\circ}/^{\circ}C$$

$$\Delta\phi_{5ANT}/\Delta T_{VR} \sim 0{\cdot}1^{\circ}/^{\circ}C$$

Effect on visibility phase due to variation of ϕ_{600RT} with temperature should largely get corrected when the 600 MHz round-trip phase correction is applied to the observed visibility. Considerable care has been given during design that part of ϕ_{600RT} variation due to unsymmetry in electronics of forward and return path is much smaller than the total variation due to VR changes. Therefore effect due to variations of ϕ_{600RT} with VR temperature should be much smaller than the requirement of $\pm 1^{\circ}$/GHz of observing frequency.

Variation of ϕ_{5ANT} with VR temperature should be acceptable for $\pm 1^{\circ}$ C of VR temperature variation as this is more than an order of magnitude smaller than overall $\pm 1^{\circ}{\cdot}5$ limit which may cause 600 MHz to slip a cycle. Further if this variation is mostly due to VR temperature changes, it could effect phase of 10 MHz used for Fringe Generators. For L-Band observations this could be appreciable, specially if the temperature changes at L1 module are larger than VR free air.

5.3 Fringe Visibility on Calibration Sources

Four radio sources 3C84, 4C39·25, 3C345 and 3C454·3 which are more or less equally spaced in right ascension have been observed for testing phase stability of the system. Each source is observed for about six hours around meridian so that the antenna elevation is always more than 30°. Also for these tests a small baseline (~48 m) is used so that the two antennas are essentially looking through same atmosphere.

These sources have been observed on several occasions at both C-Band (4900 MHz) and L-Band (1480 MHz) to determine phase stability of the fringes formed by the interferometer consisting of antennas 3 and 5. For each average of 5 minutes the phase stability of visibility shows about 15° peak-to-peak variation for more than one day (actually about 30 hours) of observing at both C-Band and L-Band. For example see Figure 5.6 This is before removing phase jump due to 600 MHz cycle slip when ϕ_{5ANT} exceeds $\pm 1^{\circ}.5$ limit.

Visibility phases were also recorded when antenna 5 VR temperature was varied during the observations of the calibration radio sources. The fringe visibility phases for (a) Ch. A IF, (b) Ch. C IF for observations at (i) C-Band and (ii) L-Band are shown in Figures 5.7a and 5.7b and 5.8a and 5.8b respectively. Antenna 5 Vertex Room temperature variation, by $\pm 5^{\circ}$ C around 22° C during the observations, shows a coefficient of $2^{\circ}.8/^{\circ}$C for measured visibility at both C-Band and L-Band and also for both IF channels A and C. VR temperature variation is expected to be $\lesssim 1^{\circ}$ C. Therefore at C-Band a $2^{\circ}.8/^{\circ}$C variation should be acceptable as this will contribute less than 1°/GHz requirement on the system phase stability. However at L-Band neither the 15° peak-to-peak variation over a day nor a temperature coefficient of $2^{\circ}.8/^{\circ}$C is acceptable. Causes for these large variations at L-Band are under investigation.

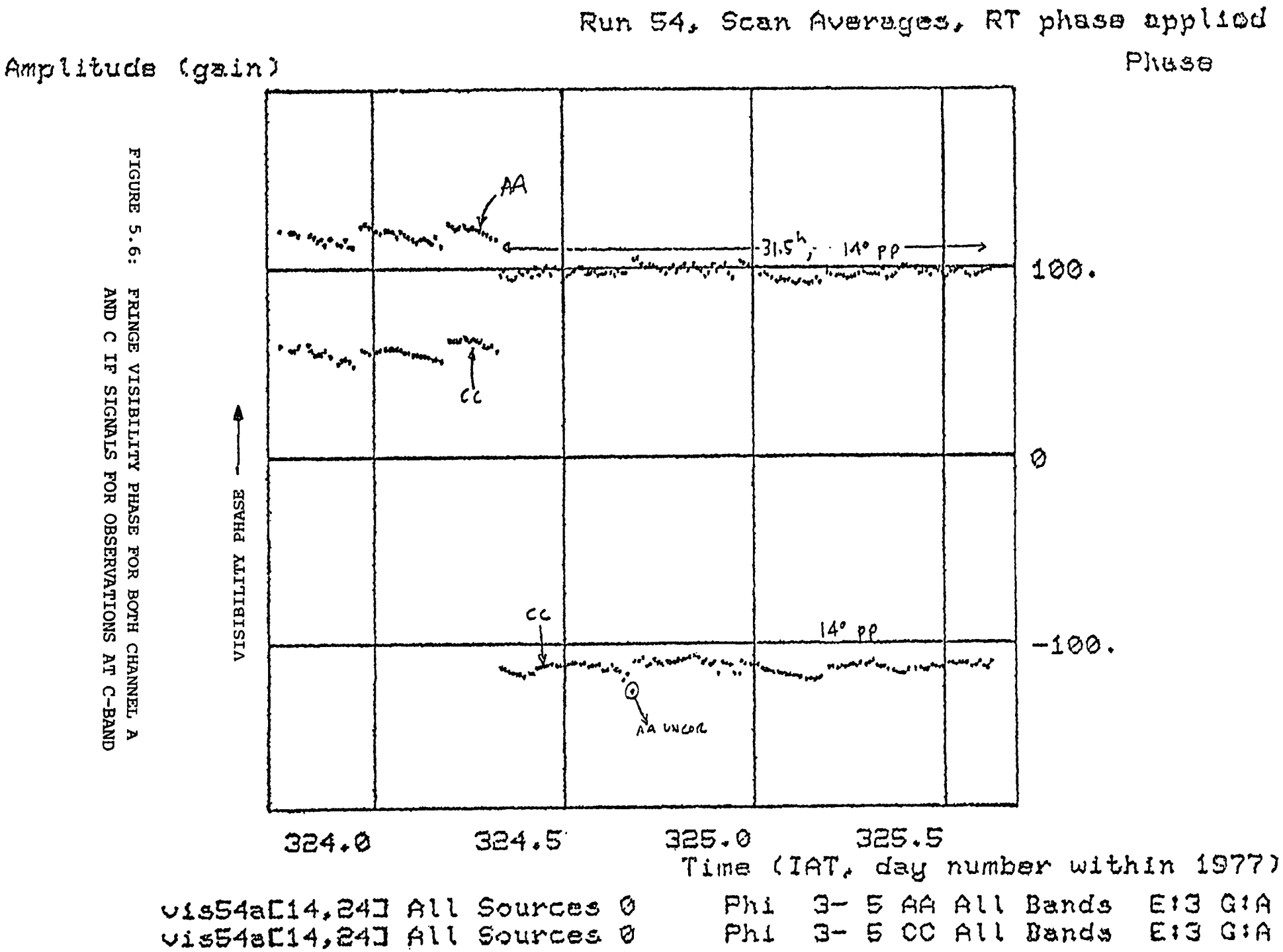
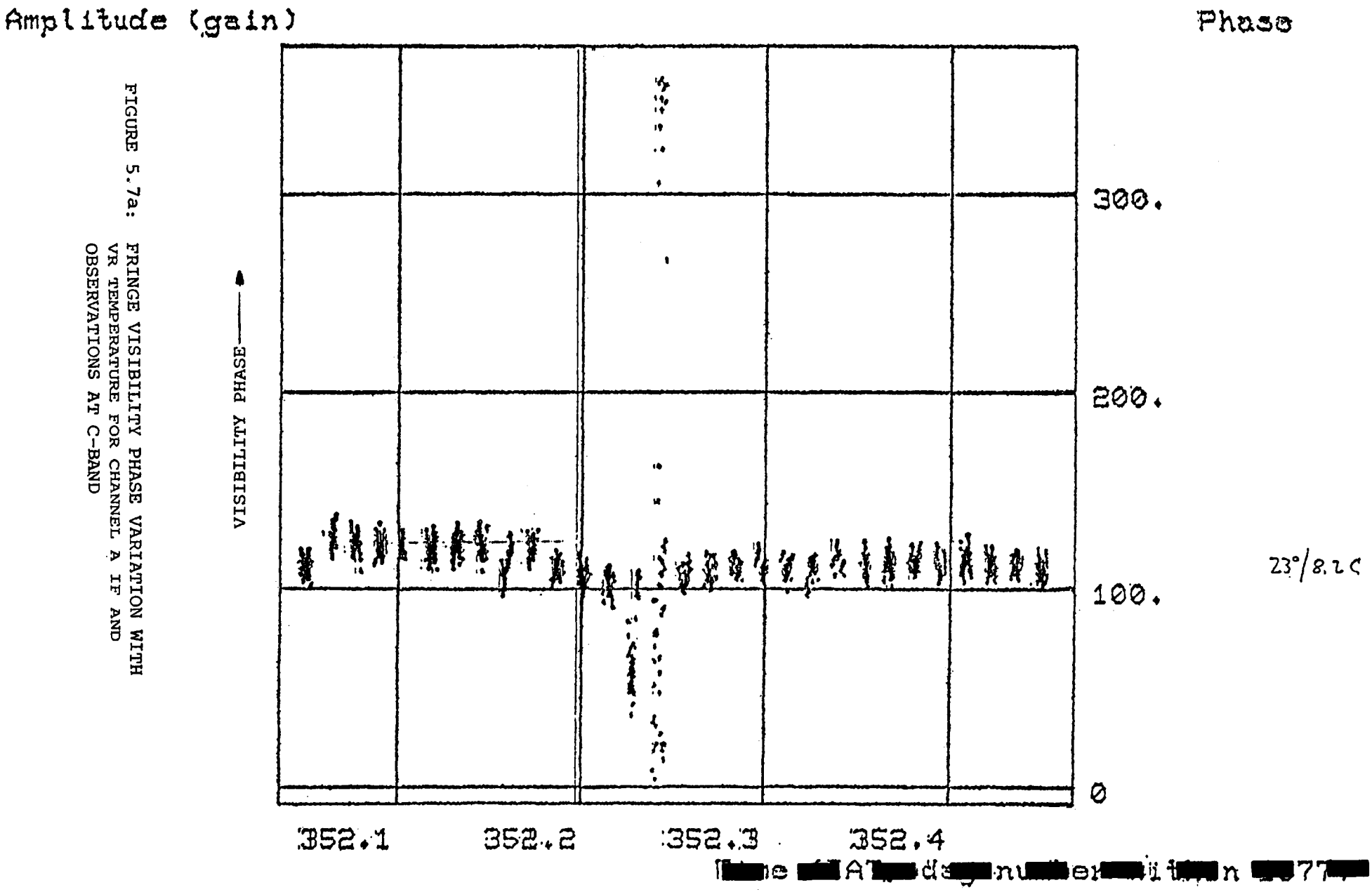


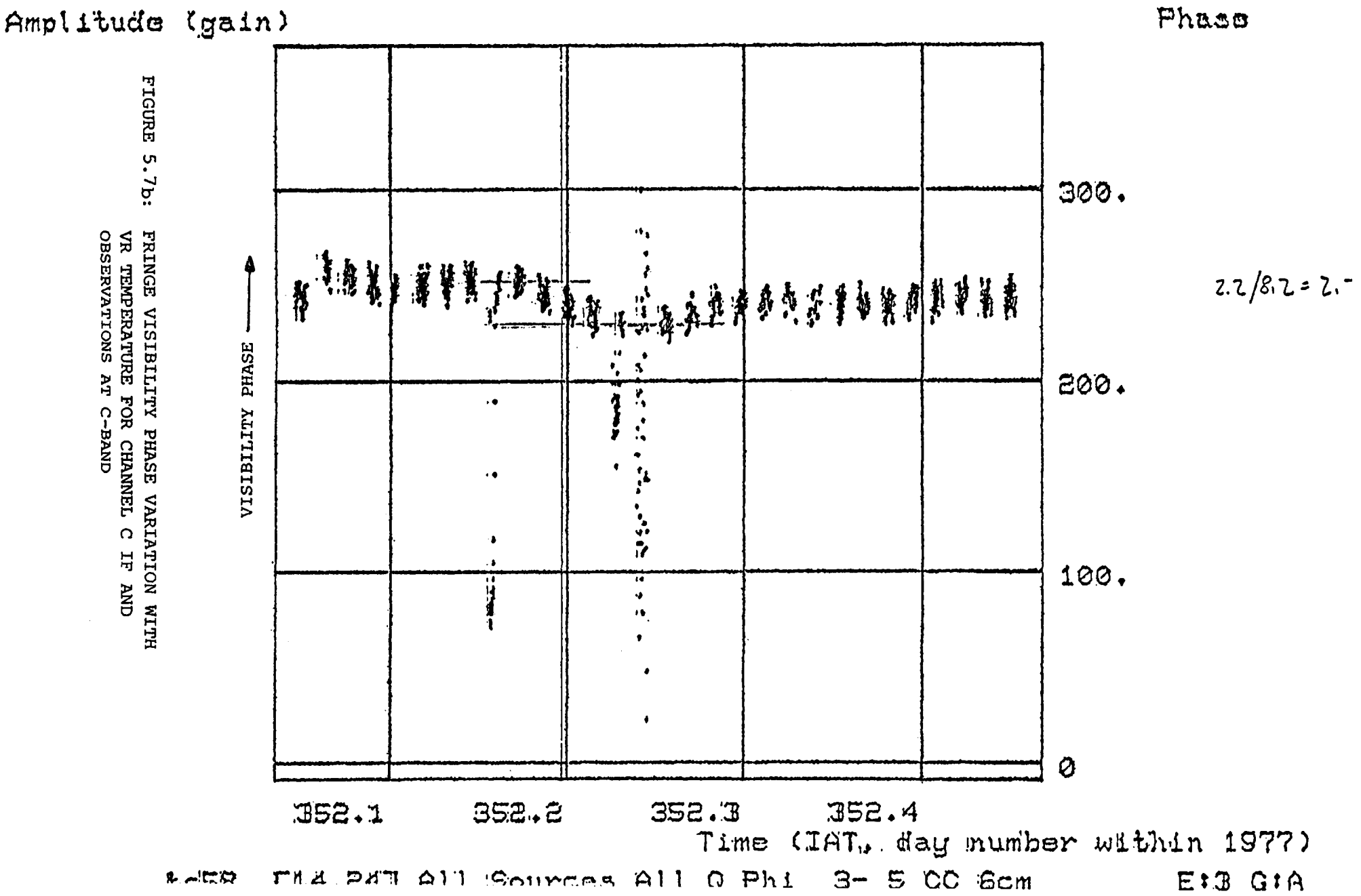
FIGURE 5.6: FRINGE VISIBILITY PHASE FOR BOTH CHANNEL A AND C IF SIGNALS FOR OBSERVATIONS AT C-BAND

(PHASE JUMP AT 352.15 REMOVED)



23°/8.2° = 2

FIGURE 5.7a: FRINGE VISIBILITY PHASE VARIATION WITH VR TEMPERATURE FOR CHANNEL A IF AND OBSERVATIONS AT C-BAND



2.2/8.2 = 2.-

FIGURE 5.7b: FRINGE VISIBILITY PHASE VARIATION WITH VR TEMPERATURE FOR CHANNEL C IF AND OBSERVATIONS AT C-BAND

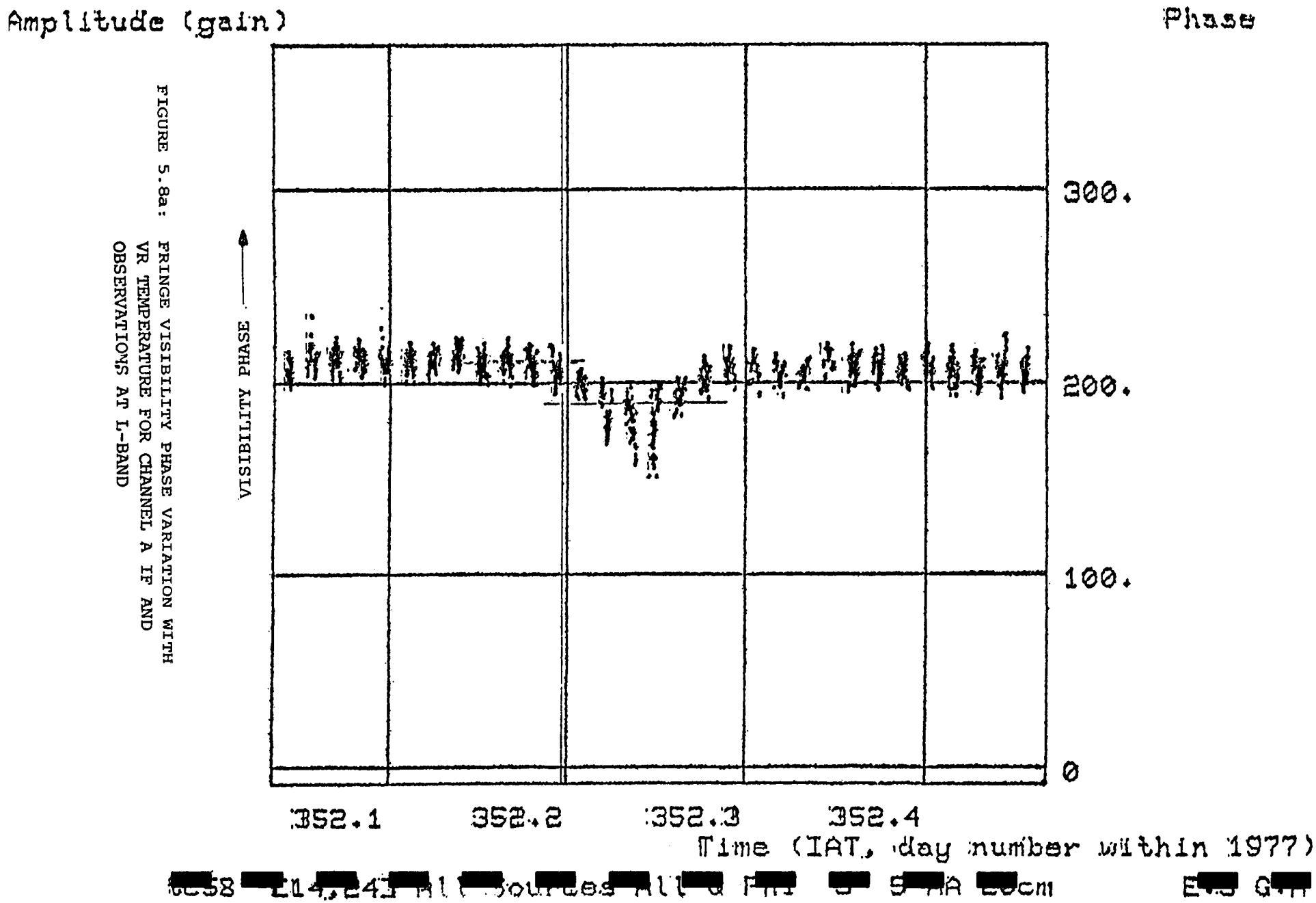


FIGURE 5.8a: FRINGE VISIBILITY PHASE VARIATION WITH VR TEMPERATURE FOR CHANNEL A IF AND OBSERVATIONS AT L-BAND

2.7

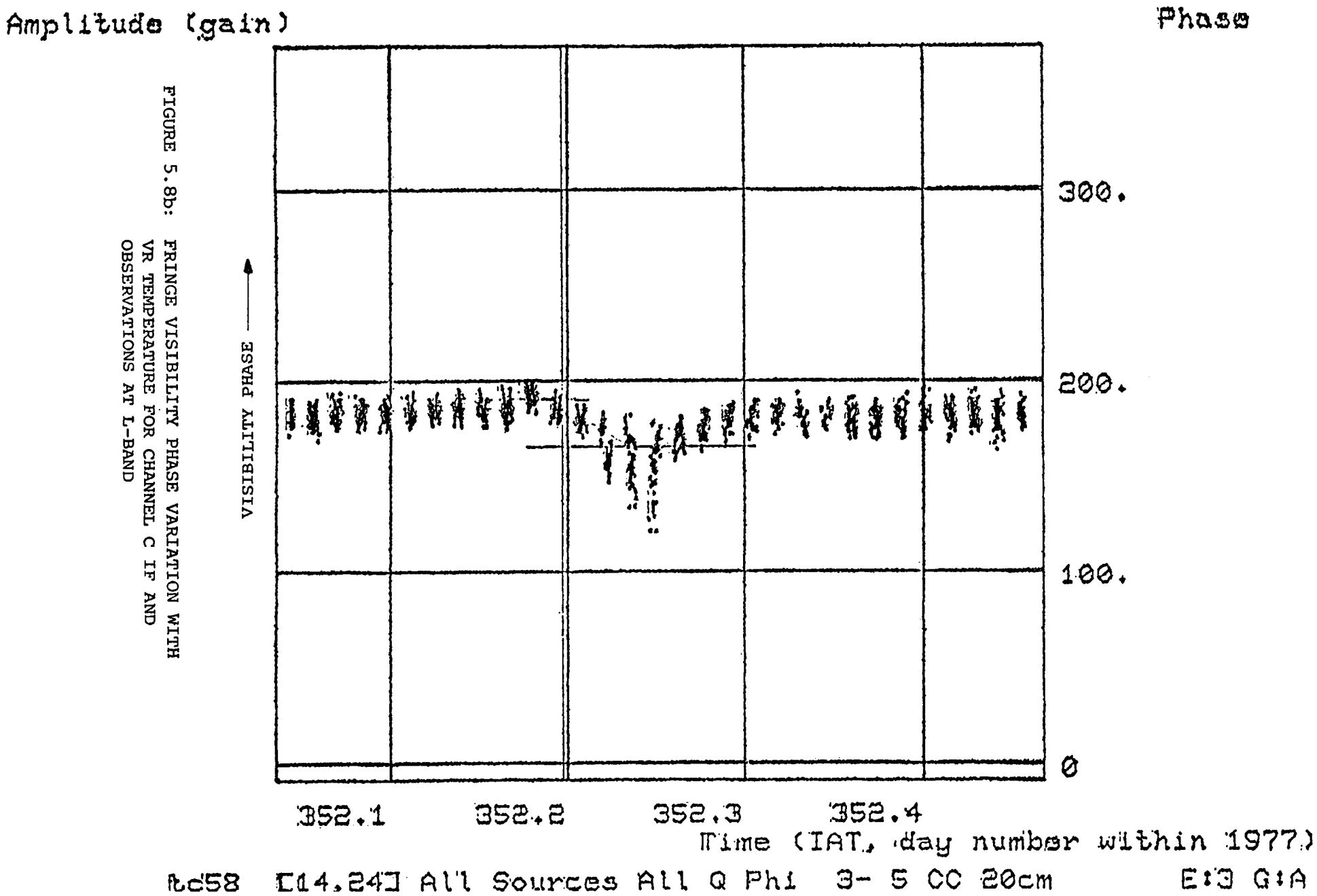


FIGURE 5.8b: FRINGE VISIBILITY PHASE VARIATION WITH VR TEMPERATURE FOR CHANNEL C IF AND OBSERVATIONS AT L-BAND

3.0

6.0 MISCELLANEOUS

6.1 L-Band Birdies

At VR large levels of harmonics of 50 MHz are generated in 50 MHz Harmonic Generator. Also large power levels of 1200, 1800 and 2400 MHz are produced elsewhere in the system. It has been observed that these signals are radiated from the L.O. and Modem modules and are picked up by L-Band feed and the waveguide feeding to the front-ends. This causes spurious signals to appear at harmonics of 50 MHz while observing at L-Band. RFI shielding of L2 and L3 modules has reduced the interference signals considerably at most of the frequencies in the range of L-Band due to 50 MHz harmonics. At most frequencies the interference is in the noise limit for 1 hour of observing in 1·5 MHz bandwidth at North pole (≈10 mJy) for antennas 3 and 5. However large interference signals of about 40 Jy and 1 Jy are observed corresponding to 1400 and 1600 MHz respectively. These could be due to the following reasons.

1. Harmonics of 200 MHz which could be leaking to upconverters along its pump or bias lines.
2. Harmonics of beat, between 3200 MHz upconverter pump and 3000 MHz reference used for generating the pump, generated in the upconverters.
3. Either 2400 MHz or its second harmonic is picked up by front-end electronics and the interference appears at 4800 MHz. This is also seen while observing at C-Band. When antenna modem reference is changed from 2400 MHz from the system to an external oscillator, this interference signal as observed at baseband in CR is reduced considerably. During L-Band observations this interference signal will look as if a 1600 MHz interference was present.
4. Second harmonic of pump beating with 1800 MHz will

give rise to 4600 MHz (i.e., 3200 x 2 - 1800 = 4600 MHz) which will appear as 1400 MHz interference while observing at L-Band.

All of these mechanisms appear to be contributing to the observed interference and need further investigation to solve the problem. Also during observation of North pole large signal of about 1 Jy strength at 1550 MHz in 1·5 MHz bandwidth has been observed. Corresponding to 1550 MHz we do not see any noticeable interference to a limit of about 20 mJy on the spectrum analyzer (looking at IF at baseband in CR). Thus it appears that there is some other spur or external interference around this frequency which is causing this problem.

6.2 Waveguide Passband Ripple

As much as 0·5 dB peak-to-peak ripple in the transmission characteristic of the waveguide system have been observed. These ripples have a periodicity of about 5 to 10 MHz. With outside temperature variation the 20 mm waveguide length changes causing the ripple to move and thus effecting phase of the received 5 MHz at VR. This could also effect phase of 600 MHz and IF signals when converted to baseband. A 0·1 dB peak ripple could cause a phase change of about $0\overset{\circ}{.}8$. Therefore for the desired phase stability of the system, specially at L-Band, and also for ϕ_{5ANT} to be within $\pm 1\overset{\circ}{.}5$ limit the ripple has to be much less than 0·5 dB.

6.3 Oscillator Noise and 600 MHz Loop Bandwidth at VR

Loop noise bandwidth for the 600 MHz phase-lock loop at VR is <1 Hz and therefore any noise outside this bandwidth will be due to 5 MHz VCXO at VR. From the manufacturers specification for the 5 MHz VCXO used in L1 modules the signal-to-single sideband phase noise in 1 Hz bandwidth at 1 Hz offset and

beyond can be approximated by following expression:

$$\text{signal/phase noise per Hz} = 10^{-8\cdot 3} f_{offset}^{-3\cdot 7} \text{ for } 1 \leq f_{offset} \leq 10 \text{ Hz}$$

$$= 10^{-12} \left(\frac{f}{10}\right)^{-2} \text{ for } 10 \leq f_{offset} \leq 100 \text{ Hz}$$

$$= -145 \text{ dB at } f_{offset} = 1000 \text{ Hz}$$

where f_{offset} = offset from 5 MHz.

Thus in a 300 Hz bandwidth (beyond which noise should be due to 50 MHz VCXO of L2) signal-to-single sideband noise due to the VCXO at 5 MHz is about 83 dB. When this signal is multiplied to 18 GHz the ratio reduces to about 12 dB and is not adequate. However if the loop noise bandwidth is increased to at least 5 Hz this ratio will be about 30 dB. A 30 dB signal-to-phase noise ratio may be marginally acceptable.

6.4 Short Term Phase Stability

During observations of calibration radio sources phase of the observed visibility for 10 second averages varied by more than 20° peak-to-peak from one average to another. Part of this variation was traced by L.R. D'Addario to a marginal speed IC in Fringe Generators. This was fixed by changing the IC to a higher speed IC. However still about 12 to 13° p-p phase variations remain (see Figure 6.1). Most of it could be explained by finite delay resolution and sampler phase accuracy.

$\phi_{AA} - \phi_{CC}$

Run 54, Scan Averages, RT phase applied

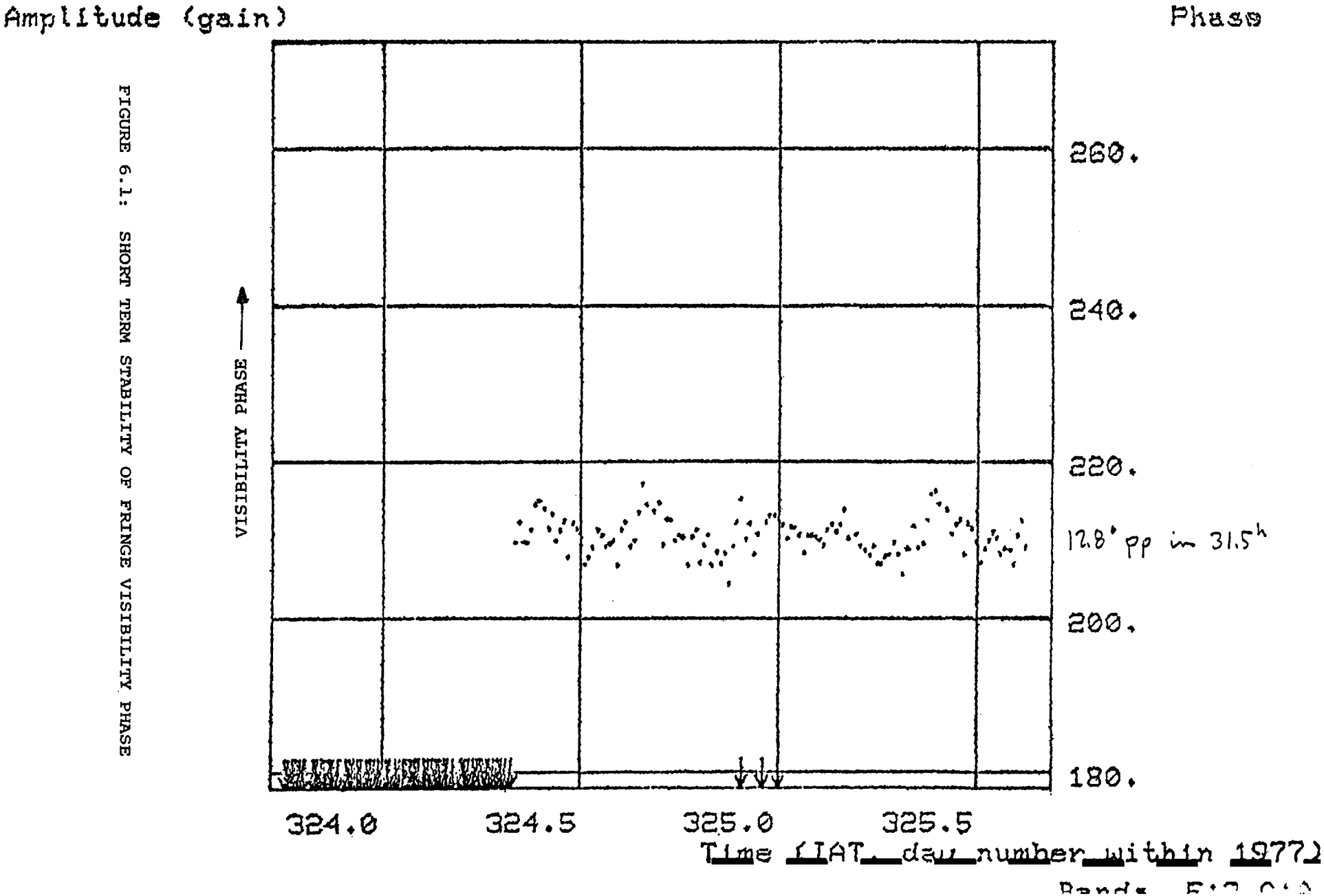


FIGURE 6.1: SHORT TERM STABILITY OF FRINGE VISIBILITY PHASE