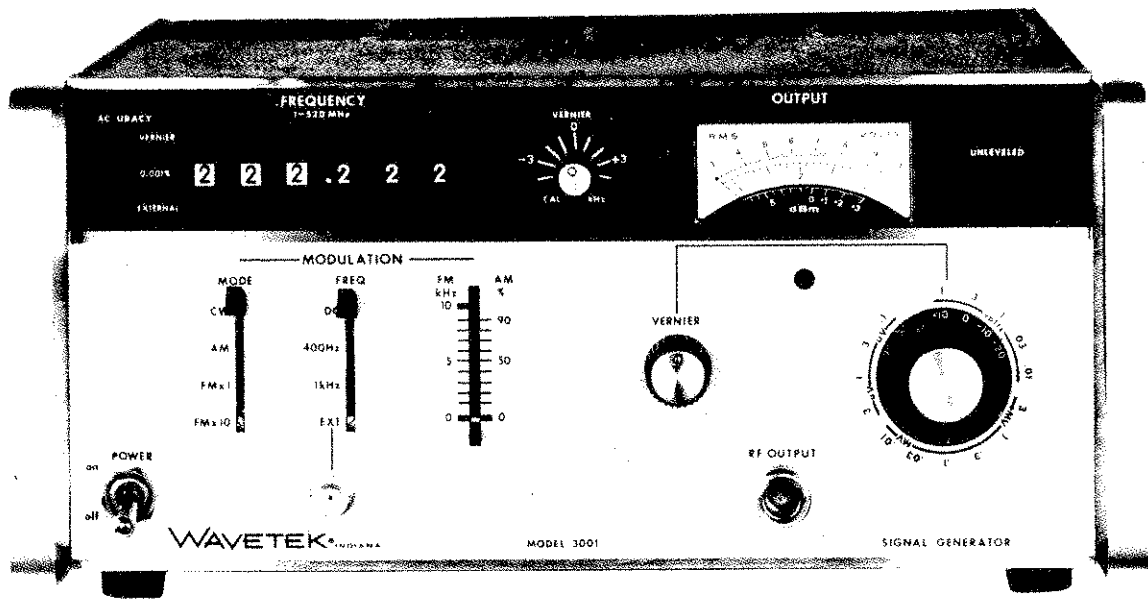


INSTRUCTION MANUAL  
MODELS 3001/3002  
SIGNAL GENERATOR

*52688*



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## SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of the WAVETEK Model 3001 and 3002 Signal Generators.

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# SECTION 1

## GENERAL INFORMATION

### 1.1 INTRODUCTION

The Wavetek Models 3001/3002 are rugged, completely solid-state Signal Generators covering the frequency range of .001 or 1 to 520 MHz. The output can be amplitude or frequency modulated, and the level can be set between +13 and -137 dBm.

#### 1.1.1 FREQUENCY CHARACTERISTICS

The frequency of the instrument is set via 6 front-panel Lever/Indicator switches which yield a resolution of 1 kHz. In addition, remote frequency programmability is standard. Series 3900 programmers are available to facilitate semi-automatic or GPIB programming of both frequency and output level.

The accuracy of the instrument is based on a crystal-controlled oscillator that serves as a stable frequency reference that enables the instrument to provide high stability signals to an accuracy of 0.001% over its specified frequency range. This accuracy includes possible errors due to short term drift, long term drift, incidental FM, and variations due to line voltage changes and temperature changes. With the FREQUENCY VERNIER out of the CAL position, the frequency is accurate to 0.001%  $\pm$ 10 kHz.

The accuracy of the instrument can be improved by using the optional External Reference input or the optional Internal/External Reference or High Stability Internal Reference. An Auxiliary RF Output option is also available to drive a counter. (See Section 1.3, Options.)

#### 1.1.2 MODULATION

These instruments also feature both internal and external amplitude and frequency modulation capabilities. Internal modulation frequencies of 400 Hz and 1 kHz are standard. In the FM mode of operation, peak deviations to 100 kHz are attainable. In the AM mode, amplitude modulation to 90% is attainable.

With the MODULATION MODE switch in the AM position and the MODULATION FREQUENCY switch in the DC position, the output amplitude can be varied by the MODULATION FM/AM control. This provides a reference attenuator for variation of a signal level around a specific point of interest. This operation can also enable the user to obtain greater than 20 milliwatts of power over portions of the band. The frequency can also be continuously varied with this control over a 100 kHz range.

#### 1.1.3 OUTPUT LEVEL FEATURES

The output power is indicated on a front-panel meter calibrated in both dBm and VRMS. A fifteen-position, 10 dB/step Attenuator used in conjunction with an 11 dB VERNIER control provides the user with a range of +13 dBm to -137 dBm. Two programmable attenuator options (1A and 1B), see Section 1.3.1) are available.

The calibrated output of each instrument is leveled to within  $\pm$ 0.75 dB across the complete frequency range of the instrument.

Reverse power protection is also available as an option.

## 1.2 SPECIFICATIONS

### 1.2.1 FREQUENCY

RANGE	1 MHz (Model 3001) or 1 kHz (Model 3002) to 520 MHz selectable in 1 kHz steps.
READOUT	6 digit Lever/Indicator switches
RESOLUTION	1 kHz
ACCURACY	All modes (CW, AM and FM) $\pm 0.001\%$ after 15 min. (Typ $\pm 0.002\%$ after 2 hours within 3 months of calibration). ( $\pm 0.001\%$ $\pm 10$ kHz when FREQUENCY VERNIER is not in CAL position. FREQUENCY VERNIER range is $\pm 5$ kHz.)
STABILITY	All modes (CW, AM and FM) $< 0.2$ ppm/hour (500 Hz per 10 min when FREQUENCY VERNIER is not in CAL position.)
PROGRAMMABILITY	Frequency is programmable via rear-panel input connector using BCD-coded TTL voltages or BCD-coded contact closures (negative true logic).

### 1.2.2 RF OUTPUT

POWER LEVEL RANGE	+13 dBm to -137 dBm (1 to .03 $\mu$ VRMS)
LEVEL CONTROL	Continuously adjustable in 10 dB steps with an 11 dB VERNIER. Output level is indicated on a front-panel METER calibrated in volts RMS and dBm.
TOTAL LEVEL ACCURACY	+13 to -7 dBm $\pm 1.25$ dB                    (Typ $\pm 0.75$ dB) -7 to -77 dBm $\pm 1.95$ dB                    (Typ $\pm 1.25$ dB) -77 to -137 dBm $\pm 2.75$ dB                    (Typ $\pm 1.5$ dB)
Accuracy Breakdown	Flatness (+13 to -7 dBm) $\pm 0.75$ dB (Typ $\pm 0.5$ dB) Output METER $\pm 0.5$ dB Step Attenuator $\pm 0.5$ dB to 70 dB ( $\pm 0.2$ dB calibration error) $\pm 1.0$ dB to 130 dB ( $\pm 0.5$ dB calibration error)
IMPEDANCE	50 ohms
SWR	$< 1.2$ at RF output levels below 0.1 VRMS
OUTPUT CONNECTOR	Type N
RFI LEAKAGE	$< 1$ $\mu$ V is induced in a two-turn, one-inch diameter loop which is held one inch away from any surface. Loop feeds a 50 ohm receiver.

### 1.2.3 SPECTRAL PURITY

HARMONIC OUTPUT	$< -30$ dBc from 10 to 520 MHz and from 1 kHz to 1 MHz (Model 3002) $< -26$ dBc from 1 to 10 MHz
SUB-HARMONICS	None detectable

NON-HARMONICS	Fundamental (MHz)	Non-Harmonic (MHz)	Non-Harmonic Level (dBc)
	below 3	below 3	< -60
	3 to 250	3 to 250	< -65
	3 to 350	3 to 350	< -55
	3 to 520	3 to 1000	< -35
RESIDUAL AM	< -65 dBc in a 50 Hz to 15 kHz post-detection bandwidth.		
RESIDUAL FM	< 200 Hz in 50 Hz to 15 kHz post-detection bandwidth (Typ < 100 Hz). < 100 Hz in 300 Hz to 3 kHz post-detection bandwidth (Typ < 50 Hz).		
1.2.4 AMPLITUDE MODULATION	NOTE: These specifications apply for a carrier level $\leq +3$ dBm. AM is possible above +3 dBm if the peak output does not exceed +13 dBm.		
FREQUENCY INTERNAL	400 Hz and 1 kHz $\pm 5\%$ (Typ $\pm 3\%$ )		
EXTERNAL	DC to 20 kHz, (3 dB bandwidth). Input level required = 10 Vpp into 600 ohms to provide calibrated % modulation control.		
RANGE	0 to 90%		
DISTORTION	3% distortion to 70% AM (5% to 90% AM) at a frequency of 1 kHz (Typ 1.5% to 30% AM).		
MODULATION CONTROL	Calibrated from 0 to 90%		
ACCURACY	$\pm (5\% + 5\%$ of reading) at a frequency of 1 kHz		
1.2.5 FREQUENCY MODULATION			
FREQUENCY INTERNAL	400 Hz and 1 kHz, $\pm 5\%$		
EXTERNAL	50 Hz to 25 kHz, (1 dB bandwidth). Input level required = 10 Vpp into 600 ohms to provide calibrated deviation control. (DC to 25 kHz when FREQUENCY VERNIER is not in CAL position.)		
DEVIATION PEAK	Two bands, 0 to 10 kHz, and 0 to 100 kHz		
DEVIATION CONTROL	Calibrated from 0 to 10 kHz, x1 and x10		
ACCURACY	$\pm 500$ Hz on x1 range $\pm 5$ kHz on x10 range		
DISTORTION	< 2% (10 kHz to 100 kHz deviation) at a frequency of 1 kHz. < 4% (3 kHz to 10 kHz deviation) at a frequency of 1 kHz.		
1.2.6 GENERAL			
OPERATING TEMPERATURE	25°C $\pm 5^\circ$ C, all specifications apply 25°C $\pm 15^\circ$ C, with slight degradation of specifications		
POWER	115/230 V $\pm 10\%$ , 50 to 400 Hz, 40 VA		
DIMENSIONS	30.3 cm wide x 13.4 cm high x 34.9 cm long (12" x 5¼" x 13¾")		

WEIGHT

11.4 kg (25 lb) net  
13.6 kg (30 lb) shipping

1.3 OPTIONS

Options 1A, 1B, 4, and 7 are factory installed. Options 3, 5, 5A, and 6 may be either factory or field installed. Options available for each instrument are:

Model 3001

(1A or 1B or 3) + 4 + (5 or 5A) + 6 + 7

Model 3002

(1A or 1B or 3 or 4) + (4 or 6) + (5 or 5A) + 7

1.3.1 RF LEVEL PROGRAMMING

Option 1A Program Level Range: 0 to 109.9 dB in .1 dB steps (programmed via rear-panel plug). 0 dB reference is +13 dBm. Front-panel level range: Continuously adjustable from +13 dBm to -97 dBm in 10 dB steps and an 11 dB VERNIER. Reverse power protection is also provided by this option.

Option 1B Program Level Range: 0 to 90 dB in 10 dB steps (programmed via rear-panel plug). 0 dB reference is set by front-panel attenuators. Remote control of CW/AM mode is also provided. Front-panel level range: See Section 1.2.2. Reverse power protection is also provided by this option.

NOTE

For both Options 1A and 1B, the instruments are calibrated for +13 dBm at 50 MHz as for a standard unit, but due to greater losses in programmable attenuators, a calibrated output is guaranteed only to +12 dBm.

1.3.2 REVERSE POWER PROTECTION

Option 3 prevents damage to the instrument if RF (50 W max) or DC (100 V max, Model 3001 only) voltages are accidentally applied to the RF OUT connector.

1.3.3 AUXILIARY RF OUTPUT

Option 4 provides a leveled (-10 dBm) signal available from a rear-panel BNC connector (normally used to drive a frequency counter). (NOTE - 1 to 520 MHz only.)

1.3.4 EXTERNAL REFERENCE

Option 5 provides a rear-panel BNC input for accepting an external frequency reference. This input is used to improve the accuracy of the instrument from 10 ppm to that of the external source. The external source frequency can be 1, 2, 2.5, 5, or 10 MHz with an accuracy of 1 ppm or better with a minimum level of 50 mV into a 1 k $\Omega$  load.

1.3.5 INTERNAL/EXTERNAL REFERENCE

Option 5A provides a rear-panel BNC input for accepting an external frequency reference (5 or 10 MHz, .5 to 5 VRMS), which is used to improve the instrument accuracy from 10 ppm to that of the external source. Option 5A also includes an internal TCXO (accuracy =  $\pm 1$  ppm) which can be used in lieu of the external source, and can also be used to drive other devices which require a high stability TTL input.

1.3.6 HIGH STABILITY REFERENCE  
Option 5 is required with Option 6.  
If Option 6 cannot be installed, use Model 2102 (see Section 1.4).

Option 6 provides a high stability rear-panel output which can be used to drive the rear-panel input of Option 5. This high stability TTL output can also be used to drive other devices which require a high stability reference input. Maximum fan-out is four.



Output Frequency	5 MHz
Output Level	TTL
Temp Stability (1 hr warm-up) over 10° to 40°C range	0.05 ppm
Aging	0.005 ppm/day 0.05 ppm/month .3 ppm/year
Typical Overall Accuracy (within 3 months of calibration)	0.2 ppm

### 1.3.7 LOW LEAKAGE

Option 7 reduces the instrument RFI leakage by a factor of 10.  $< 0.1 \mu V$  is induced in a two-turn, one inch diameter loop which is held one inch away from any surface. Loop feeds a 50 ohm receiver.

## 1.4 ACCESSORIES

Furnished with instrument

Instruction Manual  
Rear-panel PROGRAMMING plug and pins

Additional Accessories

Rack Mount Kit, K108  
Programmeters for single push-button or GPIB control of selected frequencies and output levels, Series 3900. High-stability frequency source (5 MHz, TTL) useable to drive Option 5, Model 2102.  
Module Service Kit, K004

# SECTION 2 OPERATION

## 2.1 INTRODUCTION

This section provides complete installation and operating instructions for the Wavetek Models 3001/3002. The instructions include information on mechanical installation, electrical installation, front and rear panel features, installation checks and operating procedures.

## 2.2 MECHANICAL INSTALLATION

### 2.2.1 INITIAL INSPECTION

After unpacking the instrument, visually inspect external parts for damage to knobs, connectors, surface areas, etc. The shipping container and packing material should be saved in case it is necessary to reship the unit.

### 2.2.2 DAMAGE CLAIMS

If instrument received has been damaged in transit, notify carrier and either the nearest Wavetek area representative or the factory in Indiana.

Retain shipping carton and packing material for the carrier's inspection.

The local representative or the factory will immediately arrange for either replacement or repair of your instrument without waiting for damage claim settlements.

### 2.2.3 RACK MOUNTING (K108)

CONTENTS (See Figure 2-1).

ITEM	QTY	PART NO.
A (Insert)	2 ea	1410-00-4650
B (Side)	2 ea	1410-00-5260
C (Screw)	8 ea	2810-17-8108
D (Screw)	4 ea	2810-17-8110

### PROCEDURE

Remove the screws from one side panel. Mount items A and B against side panel of the instrument and secure with screws provided. Repeat for other side of unit. If rack mount kit is removed from unit, use screws originally installed in side panels to avoid possible internal damage.

## 2.3 ELECTRICAL INSTALLATION

The Wavetek Models 3001/3002 can operate from either 115 VAC or 230 VAC supply mains. The rear-panel AC LINE switch selects which of these operating voltages is being used, and adjusts the Power Supply accordingly. The Power Supply is designed to operate over an AC supply frequency range of 50 to 400 Hz.

Instruments are shipped from the factory set up for 115 VAC operation unless otherwise specified.

### NOTE

Before operating the instrument, check that the rear-panel AC LINE fuse is the correct value for the supply voltage (see Section 2.5).

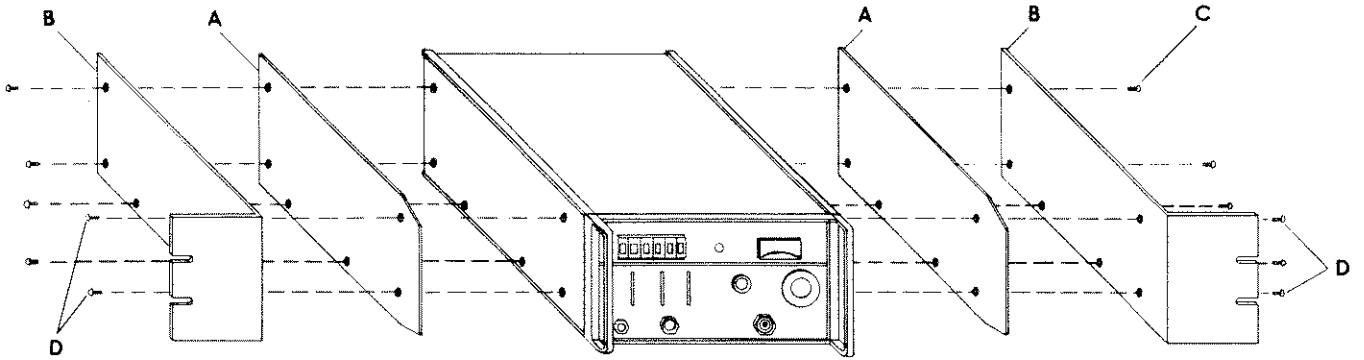


Figure 2-1. K108 Rack Mount

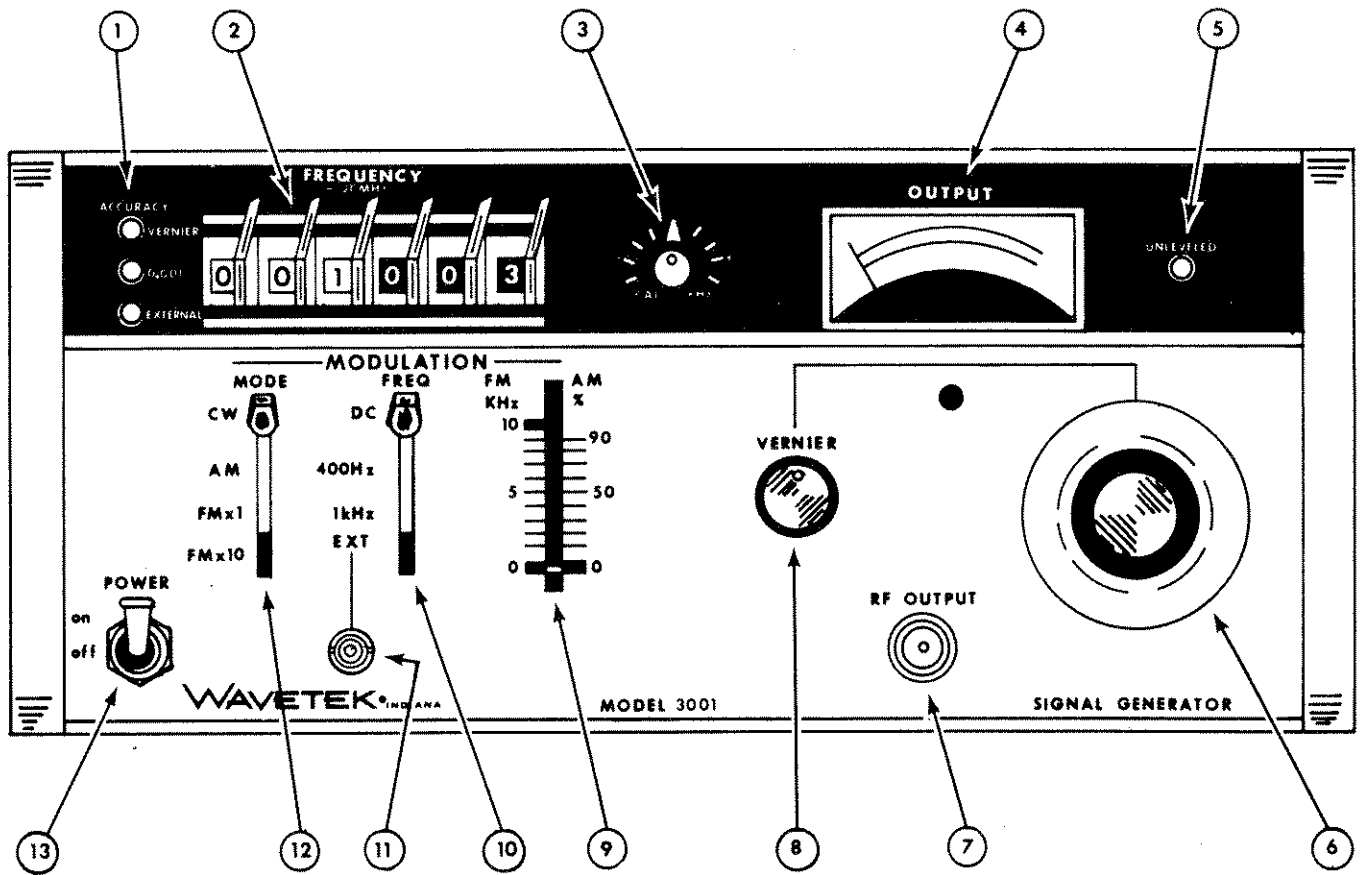


Figure 2-2. Front Panel

## 2.4 DESCRIPTION OF FRONT PANEL

Refer to Figure 2-2.

(1) ACCURACY lamps indicate the frequency accuracy of the instrument.

"VERNIER" indicates  $\pm 0.001\% + 10$  kHz

"0.001%" indicates  $\pm 0.001\%$

"EXT" indicates accuracy of external source

Typically, the lamp will flash for a few seconds after the instrument is turned on. Normally, a steady light indicates that the instrument is phase-locked and the frequency accuracy indicated is valid. A continuously flashing light indicates that one or more of the phase-locked loops is open.

(2) Lever/Indicator switches select and indicate output frequency.

(3) FREQ VERNIER shifts output frequency over a 10 kHz range (-5 kHz to +5 kHz).

With the FREQ VERNIER in CAL, the instrument accuracy is  $\pm 0.001\%$ . When the FREQ VERNIER is not in CAL, the instrument accuracy is  $\pm 0.001\% + 10$  kHz.

(4) OUTPUT METER indicates RF output level over a 10 dB range in VRMS and dBm.

(5) UNLEVELED lamp lights when the OUTPUT METER reading is not valid.

(6) OUTPUT Step Attenuator controls the RF output level over a 140 dB range from +10 to -130 dBm in 10 dB steps. The Attenuator dial indicates both dBm and VRMS.

(7) RF OUT provides the RF output signal from the instrument (type N connector).

(8) OUTPUT VERNIER controls the RF output level over an 11 dB range.

(9) MODULATION FM/AM slider determines the depth of amplitude modulation or peak frequency deviation depending on the setting of the MODULATION MODE switch (when the MODULATION MODE switch is set to CW, the FM/AM slider has no function).

(10) MODULATION FREQ switch selects the frequency of the signal used to modulate the RF output. The instrument has internal 400 Hz and 1 kHz sources, and a DC source for manual amplitude or frequency control. There is also provision for an external modulating signal.

(11) EXT MODULATION INPUT accepts external modulating signals as follows:

AM	DC to 20 kHz
FM (FREQ VERNIER in CAL)	50 Hz to 25 kHz
FM (FREQ VERNIER not in CAL)	DC to 25 kHz

A 10 Vpp signal into 600 ohms is required for FM/AM slider calibration to be correct. A smaller input voltage will result in proportional calibration of the FM/AM slider, thus, a 1 Vpp signal into 600 ohms will result in a full scale calibration of 10% AM, 1 kHz peak deviation in FMx1, or 10 kHz peak deviation in FMx10.

(12) MODULATION MODE switch selects CW, AM, FMx1, or FMx10 operation.

(13) POWER switch provides AC power to Power Supply.

## 2.5 DESCRIPTION OF REAR PANEL

(1) AC LINE switch enables unit to operate from either 115 VAC or 230 VAC supply mains.

(2) AC LINE Fuse (time-delay); 1.0 amp for 115 VAC operation; 0.5 amp for 230 VAC operation.

(3) AC LINE Cord provides connection to AC mains via 3 prong plug.

(4) PROGRAMMING JACK provides connection for remote programming of frequency.

(5) MOD TP provides convenient connection for monitoring amplitude and/or frequency of internal modulating signal.

## 2.6 INSTALLATION CHECKS

The following procedure is used to determine that the instrument is operating properly. Performance testing and calibration procedures for the instrument are contained in other sections of this manual. If it is determined that the unit is not operating properly, refer to these sections.

### 2.6.1 TURN ON

Verify that the power-transformer primary is matched to the available line voltage, and that the proper fuse is installed (see Section 2.5). Turn the POWER switch to ON. One of the front-panel ACCURACY lamps will indicate operation. No warmup is needed for the following checks.

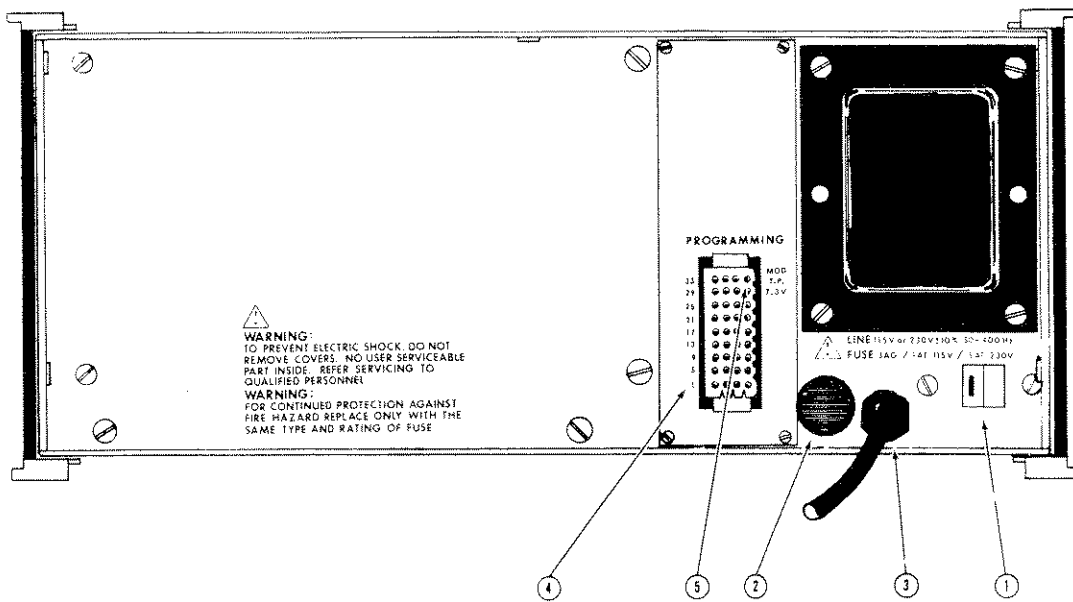


Figure 2-3. Rear Panel

Figure 2-4. Test Set-up

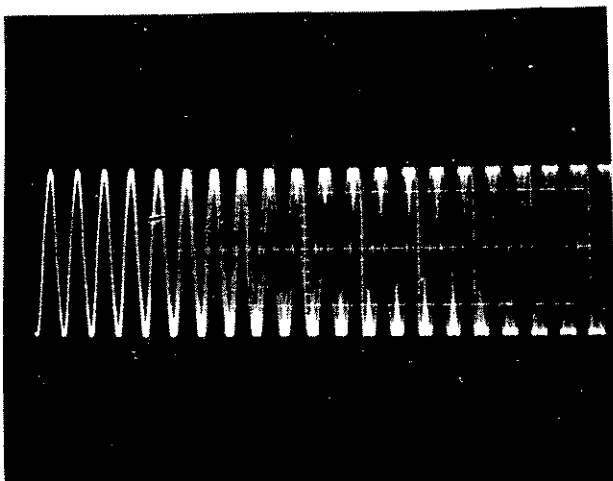
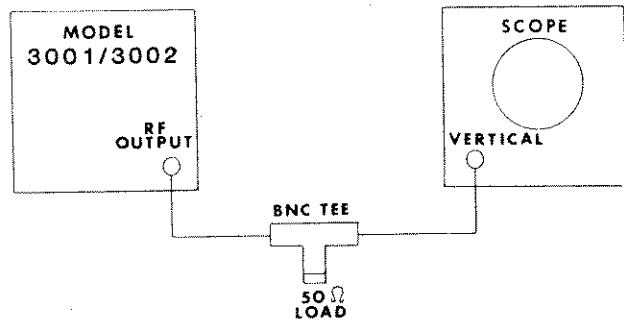


Figure 2-6. Frequency Modulation

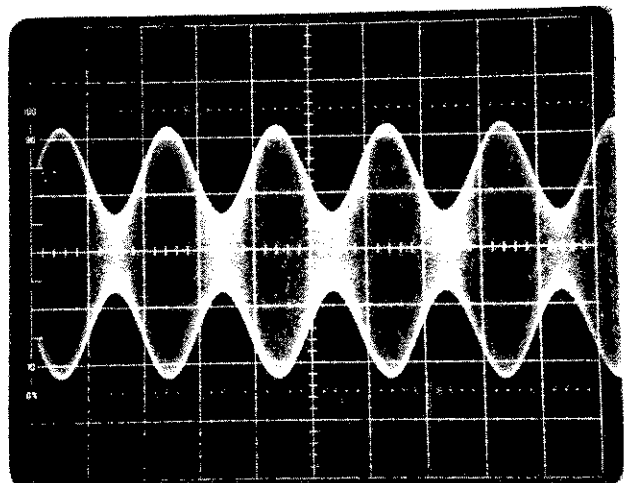


Figure 2-5. Amplitude Modulation

## 2.6.2 INITIAL CONTROL ADJUSTMENT

Set the instrument front-panel controls as follows:

Lever/Indicator switches	010.000
FREQ VERNIER	CAL
MODULATION MODE	CW
MODULATION FREQ	1 kHz
MODULATION FM/AM	0
OUTPUT Step	0 dBm
OUTPUT VERNIER	full cw

## 2.6.3 RF OUTPUT CHECK

Connect the equipment as shown in Figure 2-4. The 10 MHz signal should be  $\sim 0.9$  Vpp. (A high-frequency oscilloscope must be used for these checks.)

## 2.6.4 AM MODULATION CHECK (1000 Hz)

Set the MODULATION MODE switch to AM. Move the MODULATION FM/AM slider up to its 50% modulation point. Verify that the AM envelope displayed on the oscilloscope shows a peak-to-valley voltage difference of  $\sim .45$  V and a period of 1 msec (see Figure 2-5).

## 2.6.5 AM MODULATION CHECK (400 Hz)

Set the MODULATION FREQ switch to its 400 Hz position. Verify that the AM envelope period is 2.5 msec.

## 2.6.6 FMx1 CHECK

Set the MODULATION MODE switch to FMx1. Move the MODULATION FM/AM slider up and down. Verify that oscilloscope shows an FM display (see Figure 2-6).

## 2.6.7 FMx10 CHECK

Set the MODULATION MODE switch to FMx10 and repeat the above check.

## 2.6.8 MODULATION FM/AM SLIDER CHECK (FREQUENCY)

Set the FREQ VERNIER to "0 kHz". While leaving the MODULATION MODE switch in the FMx10 position, set the MODULATION FREQUENCY switch to DC. Verify that moving the MODULATION FM/AM slider from 0 to 10 kHz shows an increase in frequency on the oscilloscope.

## 2.6.9 MODULATION FM/AM SLIDER CHECK (OUTPUT)

Set the MODULATION MODE switch to AM. Verify that moving the MODULATION FM/AM slider from 0 to 50 shows an increase in output amplitude.

## NOTE

The UNLEVELED light may come on during this test.

## 2.6.11 FREQ VERNIER CHECK

Switch the FREQ VERNIER out of CAL position. The .001% lamp should go out, and the VERNIER lamp should light. Moving the VERNIER from -5 kHz to +5 kHz should show a slight change in frequency on oscilloscope.

## 2.7 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial installation checks contained in Section 2.6. To insure that the instrument will perform as stated in the specifications, the instrument should have a two-hour warmup before using.

### 2.7.1 TURN ON

Turn the POWER switch to ON. One of the front-panel ACCURACY lamps will light, indicating an operating condition. A flashing light indicates an unlocked condition. This should cease in a matter of seconds.

If the unit is not going to be used to the extreme limits of its specifications, it can be used immediately.

## CAUTION

When working with active circuits, transceivers, etc., care must be used to keep DC voltage or RF power from being applied to the RF OUT connector, otherwise damage may occur to the output circuitry of the instrument.

### 2.7.2 FREQUENCY SELECTION

Select the frequency desired with the six Lever/Indicator switches on the front-panel. A frequency between 1 kHz (Model 3002) or 1 MHz (Model 3001) and 520 MHz can be selected with 1 kHz resolution.

### 2.7.3 OUTPUT LEVEL SELECTION

Set the OUTPUT Step and VERNIER controls for the desired output level. The output is continuously adjustable over a +13 to -137 dBm range. The RF output equals the level shown on the Step Attenuator dial algebraically added to the METER indication.

### 2.7.4 AMPLITUDE MODULATION – INTERNAL

Set the MODULATION MODE switch to AM and the MODULATION FREQUENCY switch to either 400 or 1000. Adjust the MODULATION FM/AM slider for the desired modulation depth.

## 2.7.5 AMPLITUDE MODULATION – EXTERNAL

### CAUTION

Input voltages greater than  $\pm 10$  VDC or 10 VRMS should not be applied to the EXT MOD INPUT connector, or damage may occur to the instrument.

Set the MODULATION MODE switch to AM and the MODULATION FREQ switch to EXT. Apply a 10 Vpp signal into 600 ohms to the EXT MOD INPUT connector. This calibrates the MODULATION FM/AM slider. The desired modulation depth can then be set. The upper frequency limit of this input is 20 kHz.

### NOTE

When AM modulating, care must be taken not to exceed the +13 dBm maximum level or excessive distortion and an unlevelled condition can exist. In some cases, a high % AM may cause the UNLEVELED light to come on when the OUTPUT VERNIER control is at minimum. This is caused by "bottoming" of the PIN diode leveler which, in turn, can cause an increase in distortion. If this is the case, add 10 dB of fixed attenuation, and turn the OUTPUT VERNIER control toward maximum. The UNLEVELED light should then go out.

## 2.7.6 FREQUENCY MODULATION – INTERNAL

Set the MODULATION MODE switch to FMx1 or FMx10 and the MODULATION FREQ switch to either 400 or 1000. Adjust the MODULATION FM/AM slider to the desired peak deviation.

## 2.7.7 FREQUENCY MODULATION – EXTERNAL

### CAUTION

Input voltages greater than  $\pm 10$  VDC or 10 VRMS should not be applied to the EXT MOD INPUT connector, or damage may occur to the instrument.

Set the MODULATION MODE switch to FMx1 or FMx10 and the MODULATION FREQ switch to EXT. Apply a 10 Vpp signal to the EXT MOD INPUT connector (600 ohms). This calibrates the MODULATION FM/AM slider. The desired peak deviation can now be set. For FM modulation, the upper frequency limit is 25 kHz; the lower limit is 50 Hz with the FREQ VERNIER in CAL, or DC with the FREQ VERNIER not in CAL position.

## 2.7.8 MODULATION FM/AM SLIDER – AM

Set the MODULATION MODE switch to AM and the MODULATION FREQ switch to DC. Using the MODU-

LATION FM/AM slider, the output amplitude can be varied. It also enables more than 20 mW of power to be obtained over portions of the band.

## 2.7.10 FREQ VERNIER

When the FREQ VERNIER is in CAL, output frequencies having an accuracy of  $\pm 0.001\%$  may be selected by the Lever/Indicator switches with a resolution of 1 kHz. When the FREQ VERNIER is not in CAL, the selected output frequency can be shifted  $\pm 5$  kHz with the FREQ VERNIER control. The output frequency at the "0" kHz position of the FREQ VERNIER corresponds closely to the output frequency in CAL.

## 2.7.11 PROGRAMMING

Frequency is programmable via a rear-panel input connector using standard 8-4-2-1 BCD contact closure or TTL signals. (Logic "0" = open =  $\geq 2.2$  V. Logic "1" = closed =  $\leq 0.4$  V.) The rear-panel PROGRAMMING jack pins are in parallel with the front-panel Lever/Indicator switches; thus, if rear-panel programming is to be implemented, the front-panel switches must indicate all zeroes.

Example - To program 130.152 MHz (refer to Figure 2-7):

FREQ DIGIT	1	3	0	1	5	2
GND PINS	4	7,8	-	16	18,20	23

CONNECTION	PIN
N.C.	1
400	2
200	3
100	4
80	5
40	6
20	7
10	8
8	9
4	10
2	11
1	12
.8	13
.4	14
.2	15
.1	16
.08	17
.04	18
.02	19
.01	20
.008	21
.004	22
.002	23
.001	24
ground	25
N.C.	26 - 31
7.3V	32
N.C.	33 - 35
MOD. T.P.	36

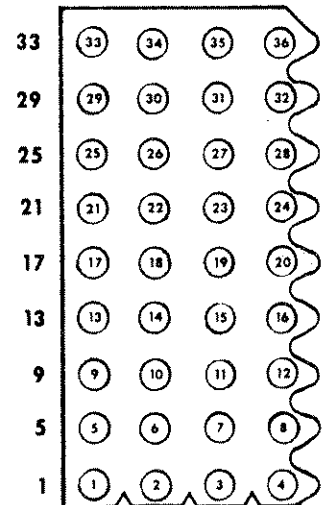


Figure 2-7. Pin Identification

# SECTION 3

## THEORY OF OPERATION

### 3.1 INTRODUCTION

Section 3.2 presents a block diagram analysis to enable the reader to get a brief overall view of the operation of the entire instrument. Sections 3.3 - 3.16 contain more detailed descriptions of each subassembly.

For actual wiring of the chassis and subassemblies, refer to the schematics in Section 7 of the manual.

### 3.2 OVERALL BLOCK DIAGRAM

The instrument is essentially a voltage-controlled oscillator to which phase-locked loops and a crystal reference have been added for the high frequency resolution.

The discussion will first deal with the basic signal generator, then it will describe how the phase-locked loops provide the additional accuracy.

The numbers within the block diagram symbols refer to the particular assembly in which the circuit is located.

#### 3.2.1 BASIC SIGNAL GENERATOR

This discussion briefly describes how the RF is generated and how its frequency is controlled, and also how the signal is amplified, leveled and amplitude modulated.

Refer to Figure 3-1 for a block diagram of the basic signal generator without phase locking.

#### RF GENERATION

The RF output frequency is generated by two UHF oscillators and a mixer. The outputs of the two oscillators are heterodyned in the mixer. The difference frequency is amplified and fed to the Output Amplifier.

The frequencies of these oscillators are controlled by DC voltages applied to their varactor diodes. The Narrow Oscillator yields a single frequency. The Wide Oscillator can be programmed over a range which extends from the frequency of the Narrow Oscillator to 520 MHz higher than the Narrow Oscillator frequency.

#### RF FREQUENCY CONTROL

The RF output frequency is determined by programming the frequency of the Wide Oscillator. The Wide Oscillator is ultimately controlled by the front-panel Lever/Indicator switches. The BCD output of these switches is converted to an analog voltage which programs the oscillator in 1 MHz steps. This analog signal can provide approximately 3 MHz accuracy.

#### RF AMPLIFICATION AND LEVELING

The RF power is amplified by a multi-stage, wide-band amplifier. The flat output is maintained by a closed-loop leveling system around this Output Amplifier.

The leveler includes a monitor diode, an error amplifier and a voltage-variable attenuator. The monitor detects the peak of the output of the Output Amplifier. This detected level is compared to a DC reference by the error amp. The output of the error amp is fed to a PIN diode (voltage-variable) attenuator, which changes the input level to the Output Amplifier until the monitored signal produces a DC level equal to the reference level.

#### LEVEL CONTROL AND AM

The circuitry for controlling the RF output level is directly related to the above leveling system because changing the DC level reference changes the RF output level.

Of the 150 dB output range, 130 dB is passive attenuation. The remaining 20 dB is controlled by changing the level reference. The OUTPUT VERNIER has a 10 dB range. The remaining 10 dB is provided by switching the level reference range. This range switch is provided so that when AM is not required, the Output Amplifier can provide a carrier at the highest possible power.

Since the RF level can be voltage controlled, AM can be accomplished by applying the modulating signal to the OUTPUT VERNIER. This causes the reference voltage to the error amp to change at the frequency of the modulating signal. The modulating signal is taken from one of two internal oscillators, a DC voltage, or from an external source.



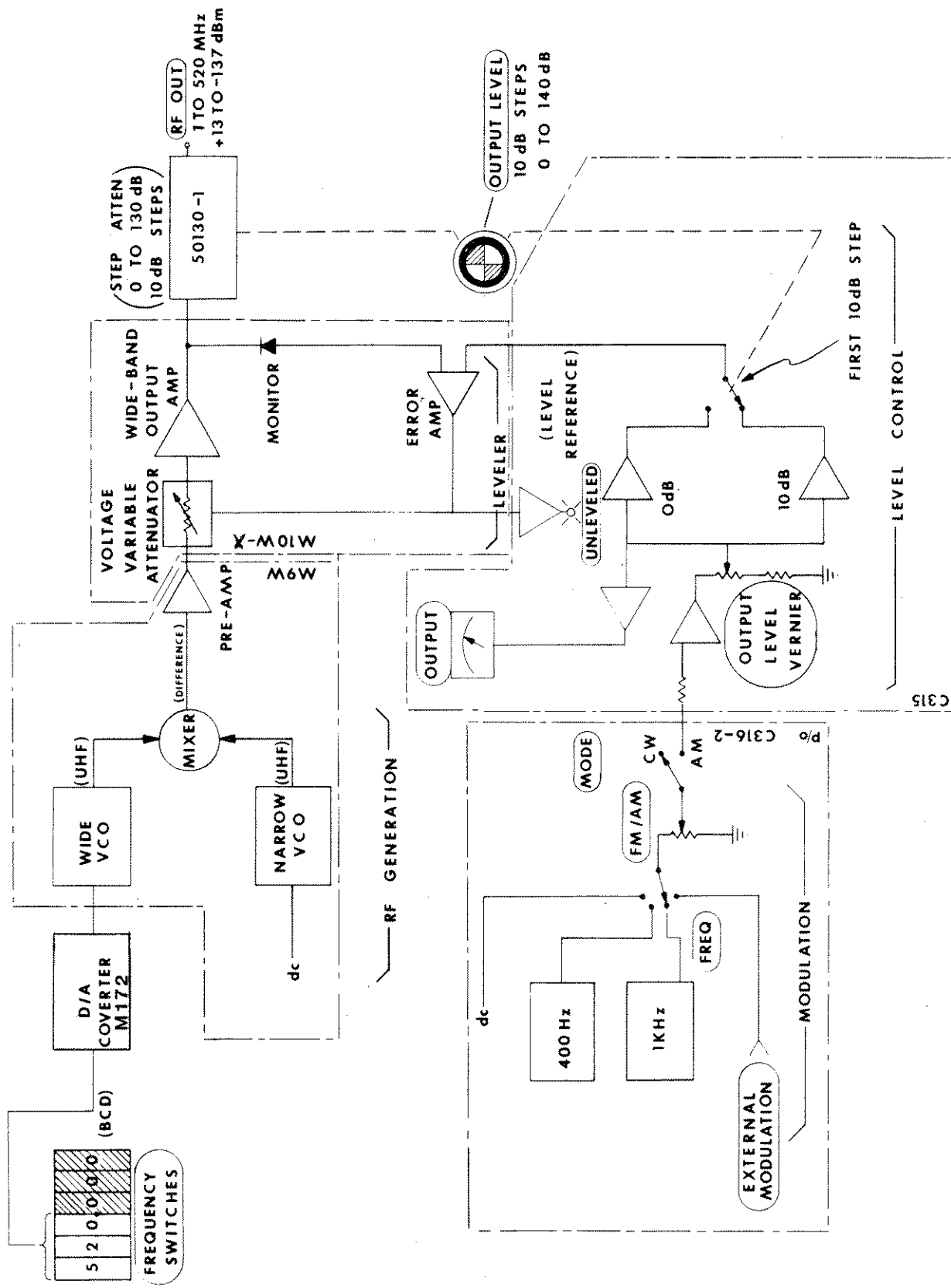


Figure 3-1. Basic Block Diagram

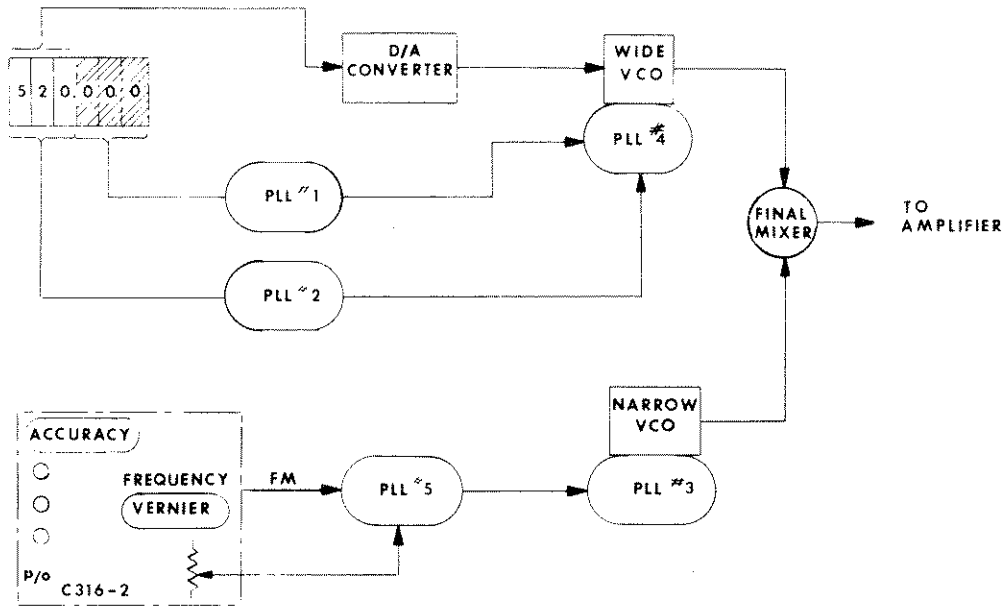


Figure 3-2. PLL Relationships

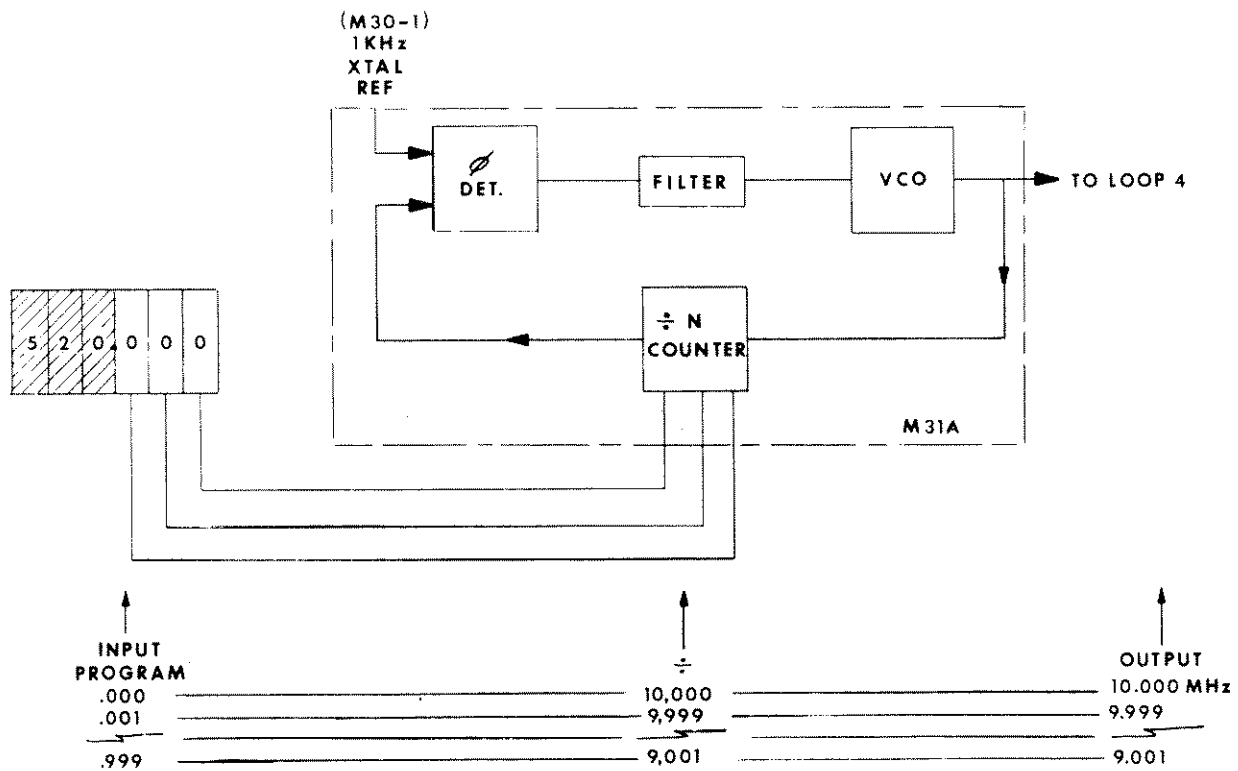


Figure 3-3. PLL 1

### 3.2.2 PHASE-LOCKED LOOPS

The basic signal generator discussed in Section 3.2.1 has a frequency range of 1 to 520 MHz, has an output voltage which is leveled and adjustable and has the ability to be amplitude modulated. With the above circuitry, however, the frequency accuracy is only 3 MHz with 1 MHz resolution. To achieve the desired 1 kHz resolution and .001% accuracy, the instrument includes five phase-locked loops.

A down-conversion (Model 3002 only) system enables the instrument to output frequencies less than 1 MHz. Its operation will be covered in Section 3.16.

PLL 1, 2, and 4 are used to stabilize the Wide Oscillator and tune it in 1 kHz steps. The Wide VCO is part of PLL 4. PLL 1 and 2 convert the Lever/Indicator switch setting to reference frequencies for PLL 4.

PLL 3 and 5 provide stabilization and allow FM operation. The Narrow VCO is part of PLL 3. PLL 5 converts a modulating signal (if present) to a reference frequency for PLL 3.

Figure 3-2 illustrates the relationship between the five numbered loops and the basic signal generator.

#### PLL 1

The purpose of PLL 1 is to generate a CW signal which changes in 1 kHz steps from 10.000 to 9.001 MHz as the front-panel frequency selector is switched from .000 MHz to .999 MHz. This signal will be used as a reference signal for PLL 4.

Figure 3-3 shows a simplified block diagram of PLL 1. It includes a voltage controlled oscillator capable of frequencies from 9 to 10 MHz, a phase detector, and a  $\div N$  counter. A sample of the output signal from the VCO is fed to a programmable counter. The divisor of the counter is controlled by the three front-panel "kHz" selector switches. The output from the counter is fed to a phase detector where it is compared to a 1 kHz crystal reference signal. If the two input signals to the phase detector are not the same frequency, an error signal is produced. This error voltage corrects the frequency of the VCO until the phase detector input from the counter is exactly 1 kHz. See Section 3.12 for a more detailed explanation.

#### PLL 2

The purpose of PLL 2 is to generate a CW signal which changes in 1 MHz steps from 1448 to 1487 MHz when the front-panel frequency selector is switched from 001 to 039 MHz. These CW steps are then repeated every 40 MHz throughout the entire 1 to 520 MHz range. The use of this signal to control the Wide Oscillator will be discussed in the description of PLL 4.

Figure 3-4 shows a simplified block diagram of PLL 2. PLL 2 operates in the same manner as PLL 1 with one exception. The circuit includes a mixer and band-pass amplifier. The purpose of this additional circuitry is to offset the 1448 to 1487 MHz output from the VCO to 8 to 47 MHz. This offset is necessary in order to make the frequency compatible with the programmable counter and phase detector circuits. The other circuits in this loop operate the same as those in PLL 1. In this case, the programmable counter is controlled by the three "MHz" selector switches and the loop reference frequency is 1 MHz. For a more complete description, see Section 3.13.

#### PLL 4

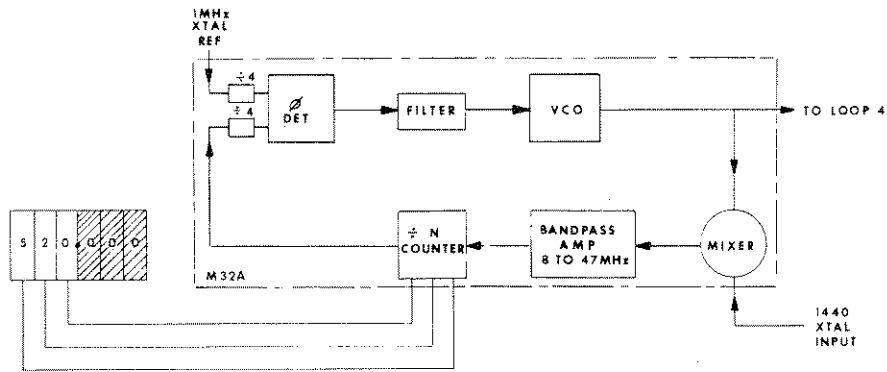
The purpose of PLL 4 is to adjust the Wide Oscillator in 1 kHz steps from 1198 MHz to 1718 MHz as the front-panel frequency selector is adjusted from 1 to 520.000.

The Wide Oscillator frequency is offset by mixers 1 and 2 and compared to the reference (from PLL 1) by the phase detector. A difference in phase or frequency causes an error signal to tune the Wide Oscillator until both phase detector inputs are identical. How this loop locks on a particular frequency can best be explained in three steps: 1) phase locking at 40 MHz intervals across the band, 2) phase locking at 1 MHz intervals, 3) phase locking at 1 kHz intervals. Figure 3-5 is a simplified block diagram of PLL 4.

To understand locking at 40 MHz intervals, assume temporarily that the reference frequencies from PLL 1 and PLL 2 are fixed (10 MHz and 1448 MHz respectively). Figure 3-5 shows the frequencies throughout the loop for this discussion. This step of the PLL 4 explanation can be described more clearly by considering the entire Wide Oscillator range rather than discussing single frequencies. The Wide Oscillator covers the range of 1198 to 1718 MHz as the output frequency changes from 0 to 520 MHz (Figure 3-5, lines A and C).

When the Wide Oscillator range is heterodyned in mixer 1 with 1448 MHz, the difference frequency produced ranges from 250 to 0 to 270 MHz (Figure 3-5, line E). This signal is then mixed with a 40 MHz comb (all harmonics of 40 MHz) in mixer 2 (Figure 3-5, line F). Taking the difference between lines E and F yields the repetitive frequency range of from 0 to 20 to 0 MHz as shown in line G. This signal is fed to the phase detector.

The reference to the phase detector is 10 MHz, but the loop will not lock on every 10 MHz output of mixer 2. The only 10 MHz signals which will produce lock are those which would decrease in frequency if the Wide VCO tried to drift higher. Therefore, at every 40 MHz interval of the output frequency, an input to the phase detector would allow the loop to lock. Section 3.2.1 explains that an analog signal drives the Wide Oscillator to within three MHz of the



INPUT PRCG. MHz	$\div$	MIXER OUTPUT MHz	OUTPUT FREQ. MHz
000.	8	8	1448
001.	9	9	1449
039.	47	47	1487
040.	8	8	1448
041.	9	9	1449

Figure 3-4. PLL 2

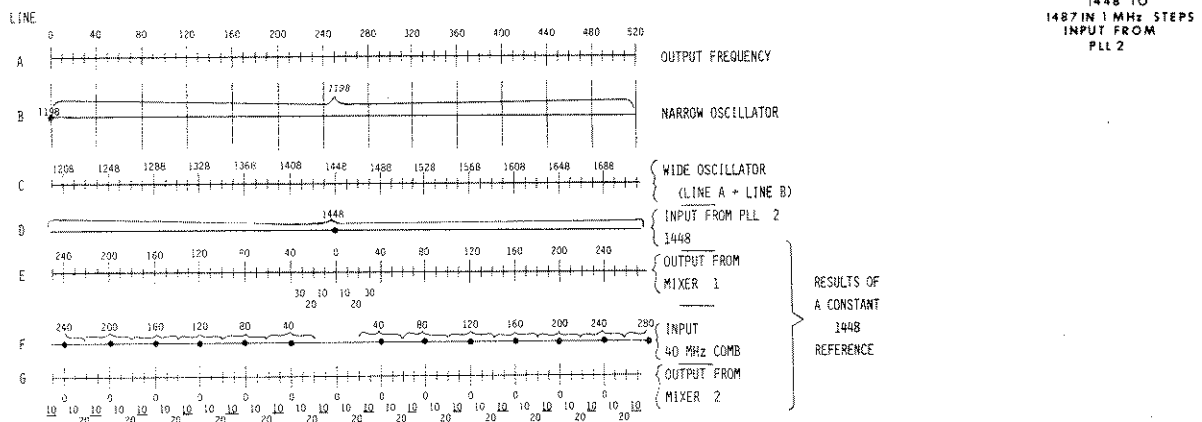
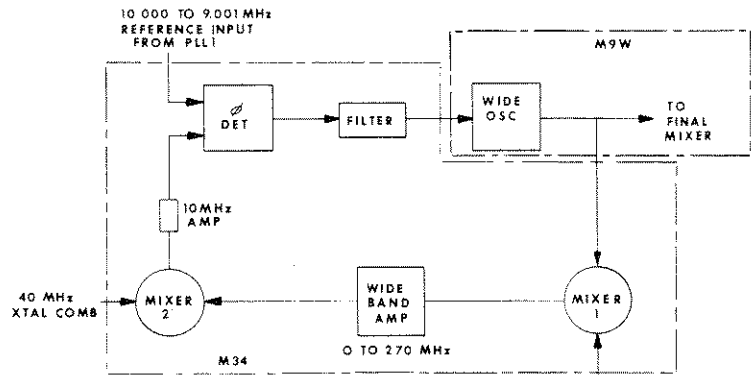


Figure 3-5. PLL 4

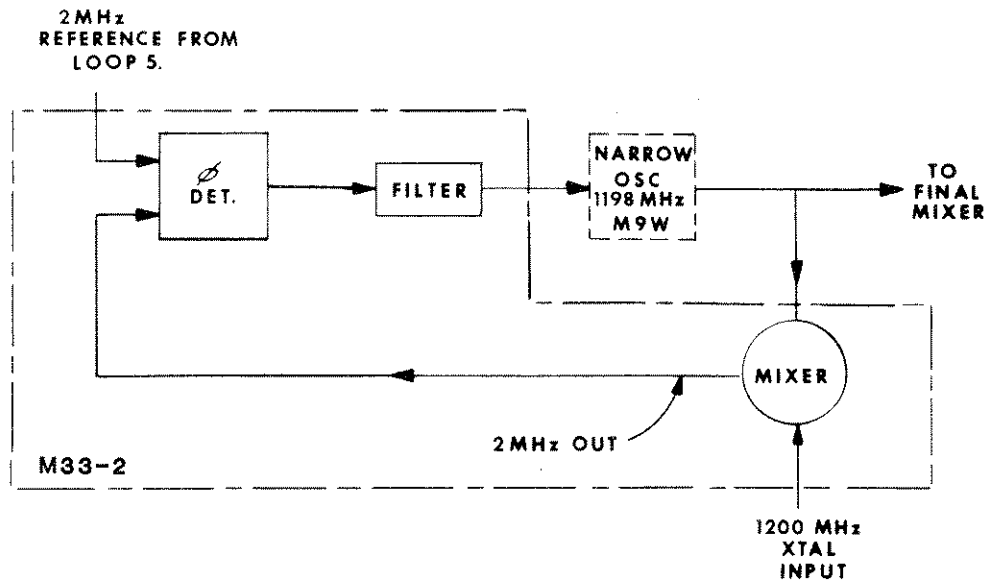


Figure 3-6. PLL 3

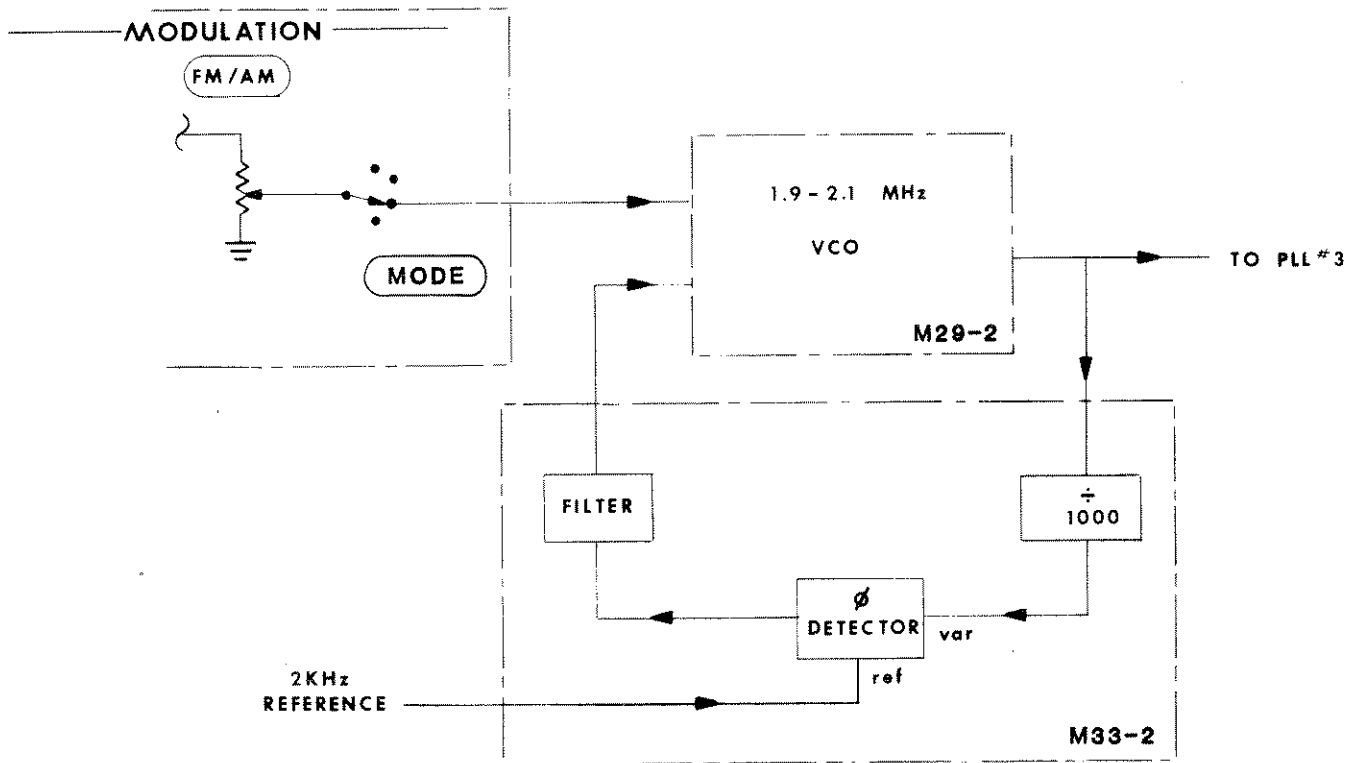


Figure 3-7. PLL 5

proper frequency. Therefore, although there are 14 possible lock points on line G, the only one selected will correspond to the analog-tuned frequency of the Wide Oscillator. The unit as described so far is capable of phase-locked output at 0, 40, 80, . . . 520 MHz. The following is an explanation of locking at 1 MHz intervals.

To allow phase locking at 1 MHz intervals, the reference frequency to mixer 1 is made adjustable in 1 MHz steps over a 40 MHz range (1448-1487 MHz).

If, for example, this reference frequency to mixer 1 were 1449 MHz, the input range to the phase detector would look the same except the entire range would be shifted 1 MHz to the right. Lock points would then be possible at output frequencies of 1, 41, 81 MHz, etc.

Being able to change this reference in 1 MHz steps allows phase locking from 0 to 520 MHz in 1 MHz steps.

To provide phase locking in 1 kHz steps, the PLL 4 phase detector's reference from PLL 1 is adjustable in 1 kHz steps (10.000 to 9.001 MHz). This causes the Wide Oscillator frequency to change in 1 kHz steps in order to keep the loop locked.

### PLL 3

The purpose of PLL 3 is to stabilize the Narrow Oscillator at a frequency of 1198 MHz.

Figure 3-6 shows a simplified block diagram of PLL 3. This loop operates in the same manner as PLL 1 and PLL 2, except that it does not require the use of a programmable counter. The 1198 MHz output from the Narrow Oscillator is combined in a mixer with a 1200 MHz crystal controlled signal. This produces a 2 MHz difference signal. This signal is fed to a phase detector where it is compared to a 2 MHz reference. Any difference in the input signals will produce an error voltage which is applied to the Narrow Oscillator (VCO) to correct the frequency error.

### PLL 5

PLL 5 supplies the reference for PLL 3. Unlike a standard phase-locked loop, the VCO can be modulated. In AM and CW, the VCO is locked on 2 MHz. In the FM mode, the VCO is modulated, but the loop ignores modulation which is faster than 50 Hz; thus the center frequency remains locked.

The loop includes a voltage-controlled oscillator, a divider for reducing the frequency from 2 MHz to 2 kHz, a phase detector, and a filter for the phase detector output. If the variable input to the phase detector deviates from the reference frequency (slower than 50 Hz), the phase detector sends an error signal to the VCO to correct the frequency.

## CRYSTAL REFERENCE

All the reference frequencies for the phase-locked loops are derived from a single 40 MHz crystal source by means of appropriate multiplication or division.

### 3.2.3 SUBASSEMBLY DESCRIPTIONS

The overall block diagram discussed in this section describes basically how the instrument functions as a unit. The unit is made up of 12 module assemblies and three printed circuit card assemblies. These can be identified in Figure 5-6. Sections 3.3 thru 3.17 describe the operation of each subassembly. The name of the subassembly describes, to an extent, the primary function it performs.

## 3.3 C315 – METER BOARD

The primary function of this assembly is to provide the program voltage to the leveler circuit for the RF amplifier. It also includes the RF output level METER which appears through the instrument front panel (see Figure 3-8).

### 3.3.1 LEVEL PROGRAM

During CW operation of the instrument, the level program is controlled by the OUTPUT VERNIER on the front panel. The output of this control goes to two range calibration circuits which convert the voltage from the OUTPUT VERNIER to a voltage level appropriate to drive the leveler circuit in the Output Amplifier module.

The "low" circuit provides the program for all ranges of the dented power output dial except +10 dBm. At "+10", the level program is taken from the "high" circuit. The "high" level program enables the full gain capabilities of the Output Amplifier to be used when the output is not amplitude modulated.

### 3.3.2 MODULATION

The modulating signal from assembly C316-2 is applied to the OUTPUT VERNIER which ultimately causes the RF level to change. The leveler in the Output Amplifier does not cause the RF level to respond linearly to changes in the level program voltage. To compensate for this, a stage is included to shape the modulation signal before it is applied to the OUTPUT VERNIER.

### 3.3.3 METER

The front-panel METER is controlled by the level program when the METER switch is set to OUTPUT. The METER and its driver circuits are calibrated to display a reading corresponding to the actual RF level from the Output Amplifier module.

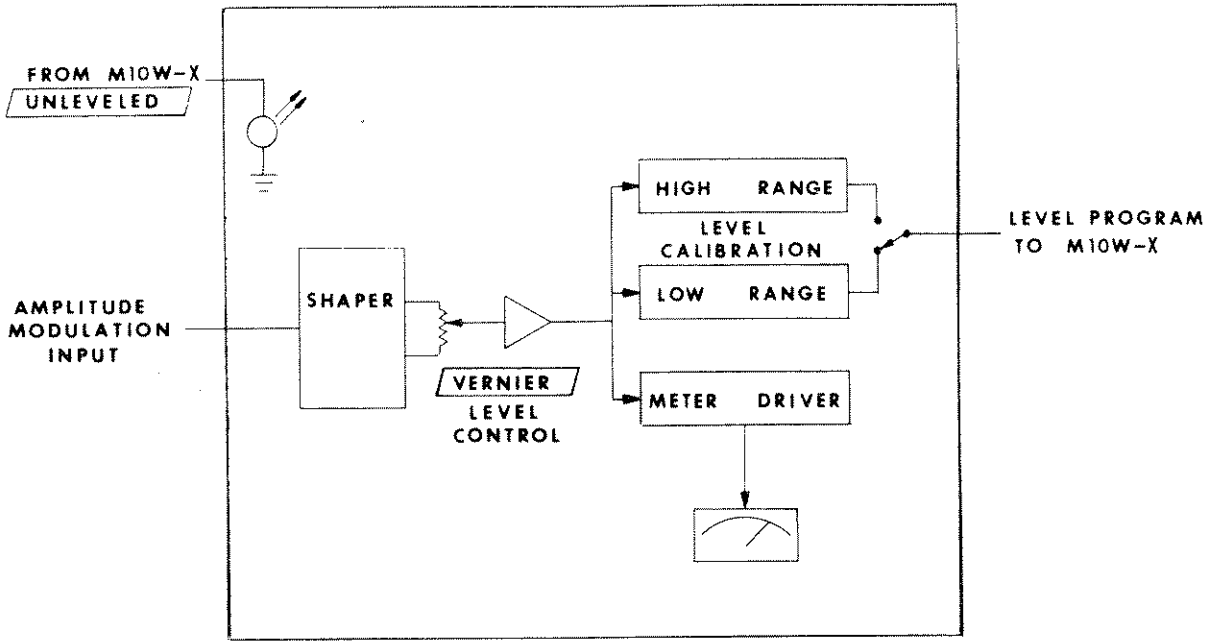


Figure 3-8. C315 Meter Board

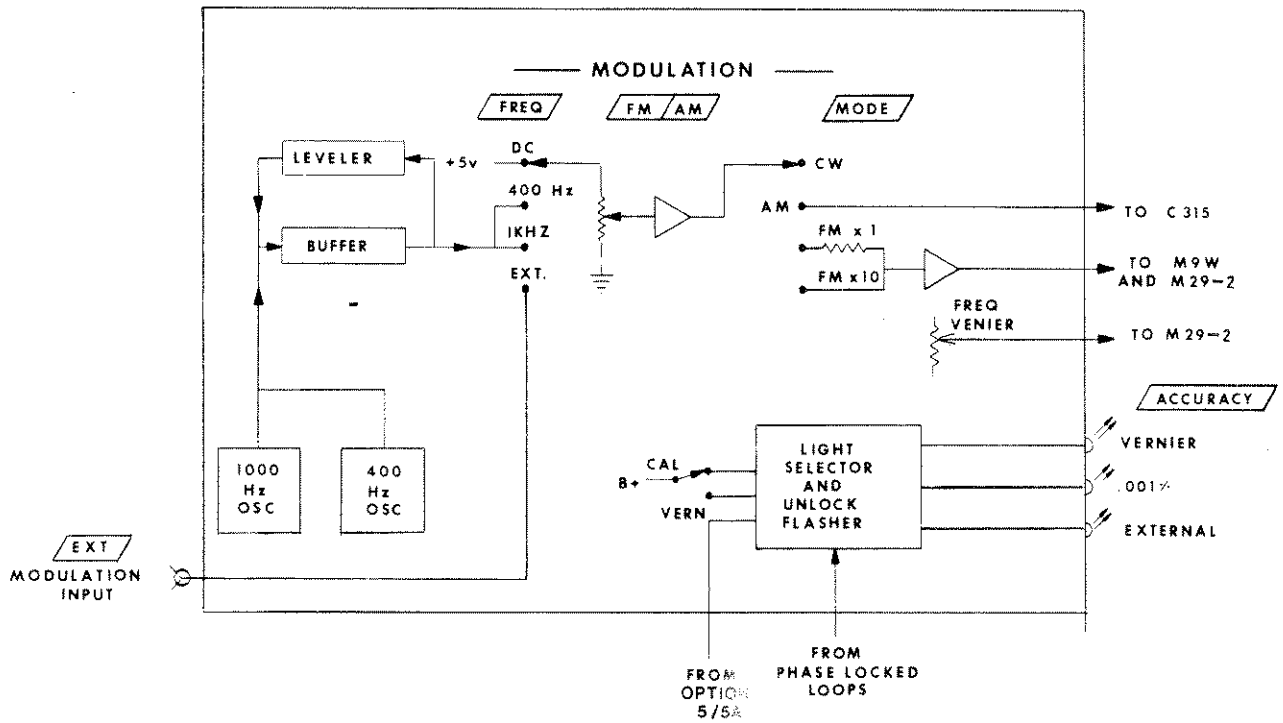


Figure 3-9. C316-2 Modulation Board

### 3.3.4 UNLEVELED LIGHT

A light emitting diode is mounted on this assembly and appears on the front panel of the instrument. Refer to the Output Amplifier module description for an explanation of the circuit driving this light.

## 3.4 C316-2 – MODULATION BOARD

This assembly provides the modulating signals used in the AM and FM modes. The front-panel ACCURACY lights and associated circuitry are also on this assembly (see Figure 3-9).

### 3.4.1 MODULATING SIGNALS

The AM or FM modes are achieved by simply routing essentially the same signal to the appropriate circuitry by means of the front-panel MODULATION MODE switch.

The front-panel MODULATION FREQ switch selects one of four sources of modulating frequency, one external and three internal. The internal signal can be selected from one of two CW oscillators or a manually variable DC control.

The two internal oscillators are amplified/leveled by the same circuit for simplicity, but separately energized by the MODULATION FREQ switch. The oscillators are twin T oscillators, one is at 400 Hz, the other is at 1 kHz.

### 3.4.2 ACCURACY LIGHTS

The CAL switch on the FREQUENCY VERNIER (or an input from Option 5 or 5A) determines which lamp is lit. If any of the phase-locked loops unlock, the energized LED is made to flash by an IC timer activated by a DC level from any of the phase-locked loops in the instrument.

## 3.5 DPS2A – POWER SUPPLY

The DPS2A provides DC power for the rest of the instrument (see Figure 3-10).

### 3.5.1 TRANSFORMER & FILTERS

The transformer steps down the line voltage to appropriate levels for the three circuits. Full wave rectifiers and filter capacitors convert this voltage to DC.

### 3.5.2 +18 V SUPPLY

The +18 V circuit has a temperature-compensated precision voltage reference. This reference is compared to the output voltage by an error amplifier which corrects any error in the output voltage.

### 3.5.3 -18 V SUPPLY

The -18 V circuit compares the +18 V and -18 V outputs and holds the difference in their magnitudes to zero.

### 3.5.4 +7.3 V SUPPLY

The +7.3 V circuit uses a three-terminal adjustable voltage regulator IC to provide a pre-regulated +7.3 V output. This voltage supplies other voltage regulators throughout the instrument.

## 3.6 DELETED

## 3.7 M9W – SWEEP OSCILLATOR

The M9W is the origin of the instrument's RF output frequency. This frequency is generated by heterodyning the signals from two higher frequency voltage-controlled oscillators (see Figure 3-12).

### 3.7.1 MIXER

The Narrow Oscillator applies a signal of 1198 MHz to the mixer. The Wide Oscillator provides between 1199 and 1718 MHz. The difference (1-520 MHz) is applied to a wide band pre-amp and then sent to the Output Amplifier.

### 3.7.2 WIDE OSCILLATOR

The wide range of oscillation is achieved by applying an analog signal which is dependent upon the setting of the Lever/Indicator switches on the instrument's front panel to varactor diodes in the tank circuit. An additional signal is applied to the VCO from the phase detector in M34. This is the fine tuning signal which locks the Wide Oscillator on the proper frequency.



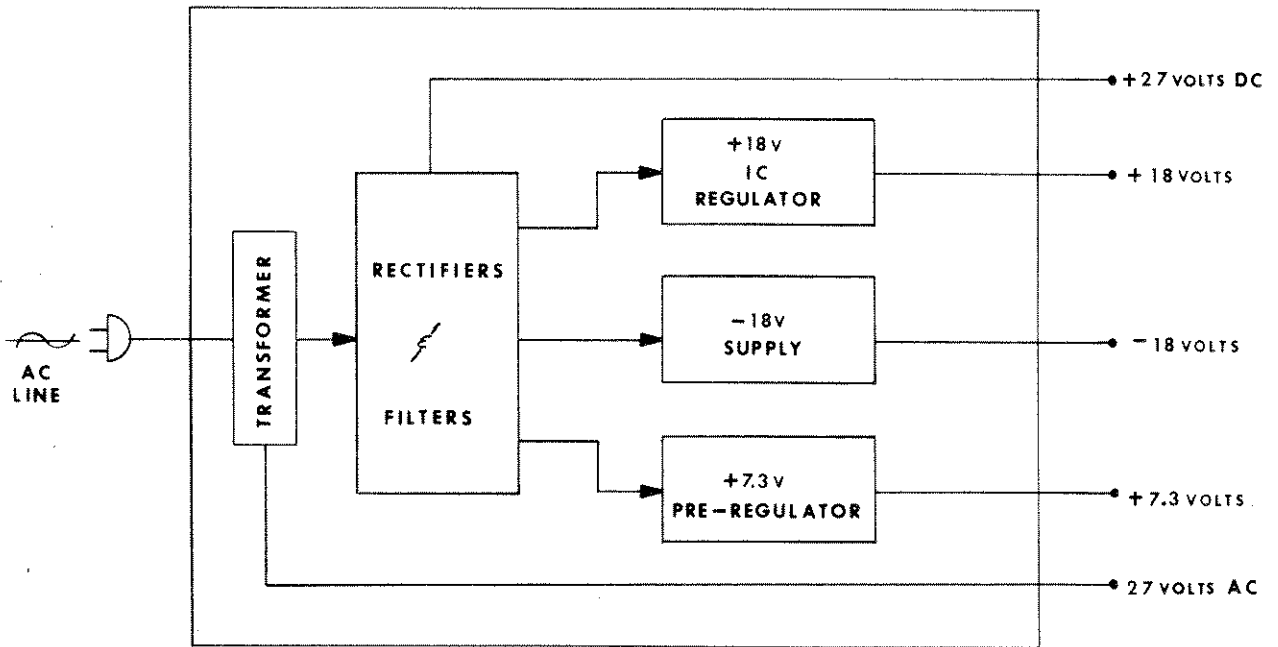


Figure 3-10. DPS2A Power Supply

Figure 3-11 is deleted

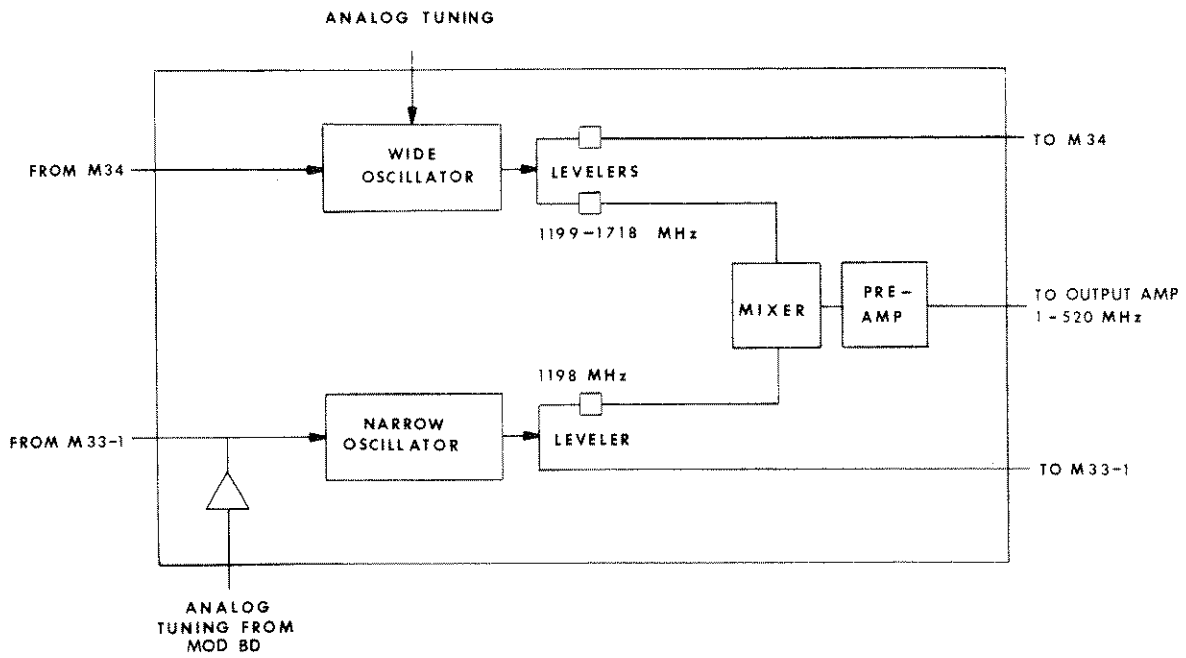


Figure 3-12. M9W Sweep Oscillator

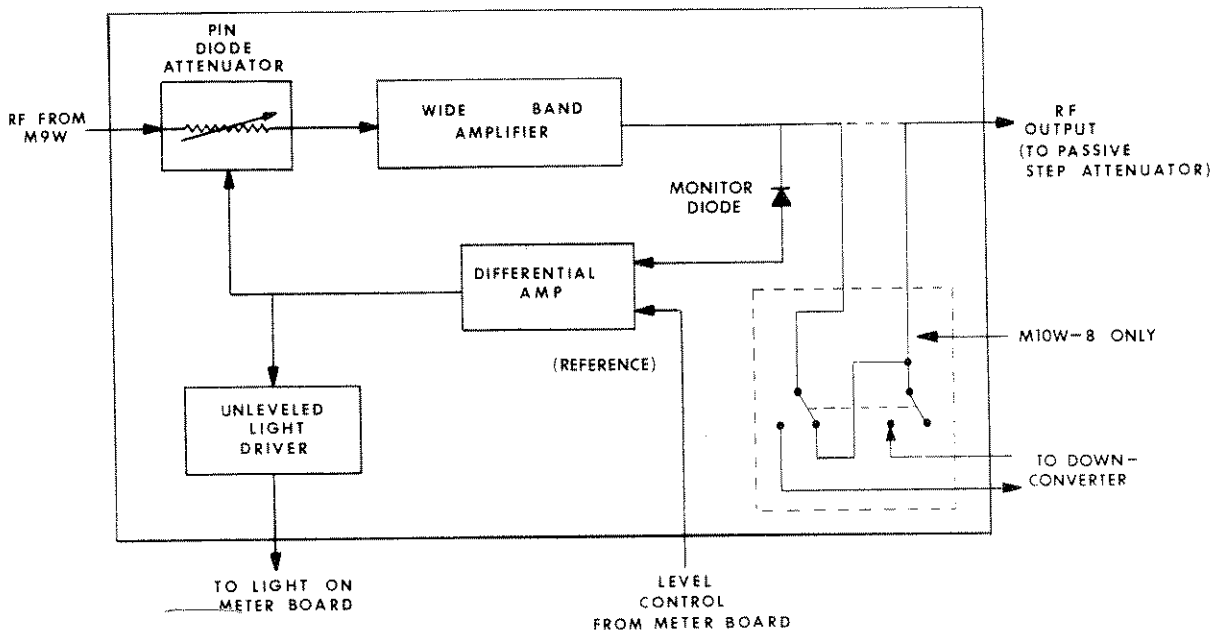


Figure 3-13. M10W-6/8 Output Amplifier

### 3.7.3 NARROW OSCILLATOR

This oscillator also uses a varactor diode so that the frequency can be voltage controlled for phase locking and for FM operation.

The coarse modulating signal (FM) is applied to the varactor from the Modulation Board (C316-2). The frequency of this oscillator is further controlled by a "fine tuning" bias voltage from the M33-2 phase detector. The deviation can be controlled up to 100 kHz.

### 3.7.4 LEVELERS

This module contains three RF leveling circuits as shown in the diagram. These maintain a constant amplitude RF over the frequency range and with temperature variation. The output of a peak detector is compared to a constant DC level. Any error is amplified and applied to a PIN diode attenuator in series with the RF signal.

### 3.8 M10W-6/M10W-8 – OUTPUT AMPLIFIER

Model 3001 uses an M10W-6 Output Amplifier module, while Model 3002 uses an M10W-8.

The main function of the M10W-6 and M10W-8 Output Amplifier modules is to amplify the RF signal from the M9W to a level programmable between -7 and +13 dBm. A leveler circuit maintains a constant amplitude output signal over the wide frequency range. The UNLEVELED light driver causes the front-panel light to glow when the leveler circuit exceeds its proper operating range (see Figure 3-13).

The M10W-8 (Model 3002) also contains a switch which routes the RF output to either the Step Attenuator or the M115 for down-conversion.

#### 3.8.1 SWITCH (M10W-8)

The switch is normally set to route the output signal to the Step Attenuator; however, when the front-panel "MHz" Lever/Indicator switches are set to "000.", the logic signal from the M115 into pin 5 of the M10W-8 triggers the switch (relay K1) and routes the RF signal to the M115.

#### 3.8.2 AMPLIFIER

This section is a four-transistor, wide band amplifier which can increase the RF by about 23 dB.

#### 3.8.3 LEVELER

The leveler uses a peak detector, differential amplifier, and PIN diode attenuator. The peak detector is fed from the

RF output. The resulting level is compared to a DC (or AM) reference by the differential amp which supplies the control current to the PIN diode attenuator. If the detected RF output deviates from the reference level, the signal to the PIN diode causes the input to be decreased or increased.

In addition to providing a flat frequency response, the leveler allows for electronic control of the RF output amplitude by varying the DC reference. The reference comes from the Meter Board (C315).

### 3.8.4 UNLEVELED LIGHT DRIVER

When the differential amp in the leveler circuit is putting out a voltage which would cause the PIN diode attenuator to be at its high or low resistance limit, the leveling circuit can no longer be effective. These extreme voltage levels, which are applied to the UNLEVELED light driver, are adequate to turn on a source of current for the indicator which appears through the front panel.

### 3.9 M172 – SWEEP DRIVE/DAC

This module provides two output voltages. One is linear from 0 V to -5 V as the frequency goes from 0 to 39 MHz, repeating every 40 MHz; the other varies from +7 V to -8 V as the frequency goes from 0 to 520 MHz. The second voltage is shaped to linearize the VCO in the M9W Sweep Oscillator.

Two digital-to-analog converter ICs, programmed by the front-panel Lever/Indicator switches, provide the 0 to 520 MHz voltage. This is shaped in the next section of the module. A third DAC provides the repeating 0 - 40 MHz voltage. Since the state of the 20's line depends on the 100's line, the 20's line is inverted when the 100's line is high.

The analog tuning signal from the M172 is "shaped" before driving the M9W wide oscillator. The shaper is an inverting DC amplifier which amplifies the input by a smaller factor for smaller magnitude inputs. Shaping this analog voltage compensates for the non-linear change in capacitance of the varactor diodes in the oscillator circuit.

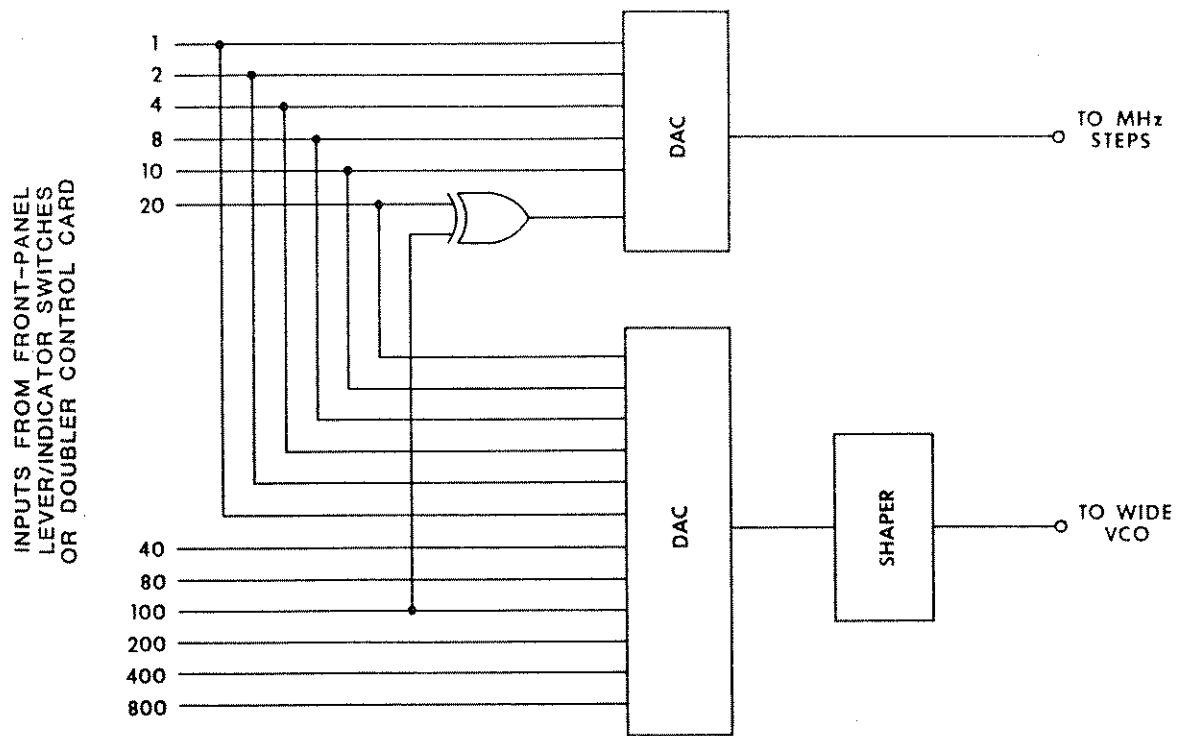


Figure 3-14. M172 Sweep Drive/DAC

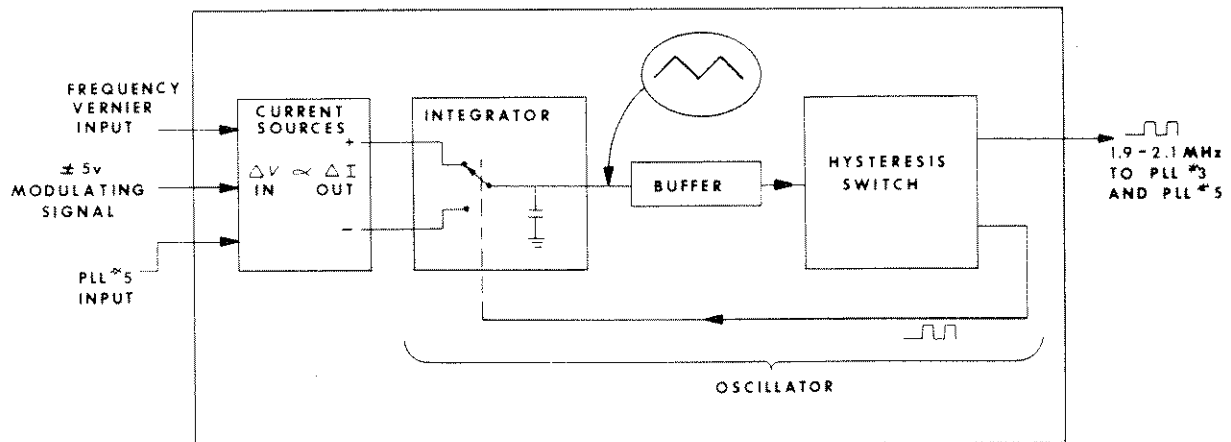


Figure 3-15. M29-2 FM Reference

### 3.10 M29-2 — FM REFERENCE

The M29-2 is a voltage to frequency converter, the output of which is used as a phase lock reference in the M33-2. The module includes a voltage variable current source which feeds (determines the frequency of) a square wave oscillator (see Figure 3-15). Zero volts in yields 2 MHz out.

The M29-2 is the VCO for PLL 5. The input to the M29-2 from the phase detector is essentially added to the modulation input. The FREQUENCY VERNIER voltage is also added here. (The FREQUENCY VERNIER input becomes zero volts when the VCO is locked).

#### 3.10.1 CURRENT SOURCES

This circuit provides both a positive and a negative source of current. The positive source is referenced to the negative source so that the instantaneous currents in both sources are equal.

The change in output current is directly proportional to the change in input voltage to the circuit. The input voltage may vary between -5 and +5 volts. The circuit is designed for a very linear graph of current out vs. voltage in.

#### 3.10.2 OSCILLATOR

The square wave output is produced by the combination of an integrator and a hysteresis switch. The integrator converts a square wave to a triangle wave. The triangle wave causes the hysteresis switch to produce the square wave which is fed back to the integrator.

The integrator is made up of a current switch and a capacitor. The square wave applied to the current switch causes a square current signal to be applied to the capacitor.

Positive constant current produces an increasing voltage ramp on the capacitor and negative constant current produces a decreasing voltage ramp. For a square wave input, therefore, the output is a triangle wave.

Changing the magnitude of the "currents", by changing the input voltage to the module, changes the rate at which the capacitor charges and discharges to the hysteresis points, thus changing the frequency of oscillation.

### 3.11 M30-1 — CRYSTAL REFERENCE

This module supplies reference frequencies at 1 kHz, 2 kHz, 1 MHz, 10 MHz, 40 MHz and its harmonics, 1200 MHz (from a 120 MHz comb), and 1440 MHz to the phase-locked loops in the instrument. These signals are produced by a 40 MHz crystal oscillator and a series of dividers and multipliers (see Figure 3-16).

#### 3.11.1 30 MHz OSCILLATOR

This crystal oscillator is the heart of the accuracy of the frequency determining circuits in the instrument. It is temperature compensated for frequency stability. A varactor diode is included to enable this oscillator to be phase locked to a high stability reference. A leveler circuit causes the oscillator output level to be the same in all M30-1 modules.

#### 3.11.2 DIVIDERS

The frequencies below 40 MHz are produced by a series of TTL counters. A "divide by 4" produces the 10 MHz output for the phase-locked loop in Option 5 or 5A. This frequency is further divided as shown in Figure 3-16 to provide the 1 MHz, 2 kHz, and 1 kHz outputs.

#### 3.11.3 MULTIPLIERS

The 40 MHz CW is fed to a harmonic generator which produces the "comb" output.

From the 40 MHz comb, 120 MHz is selected and applied to another harmonic generator. A sample of the 120 MHz comb output is also fed to a filter which provides the 1440 MHz output.

### 3.12 M31A - kHz STEPS

The input to this module is the BCD data from the front-panel "kHz" switches (to the right of the decimal point). The output frequency is  $(10 \text{ MHz} - S_k \text{ kHz})$ , where  $S_k$  is the number indicated by the kHz switches. If the frequency is set to 428.333 MHz, for example, the M31A output is 9.667 MHz. The block diagram of the M31A is shown in Figure 3-17.

#### 3.12.1 VCO

The output frequency is generated by a voltage-controlled oscillator which is tuneable from 9.001 to 10.000 MHz.

#### 3.12.2 PHASE-LOCKED LOOP

Including the VCO in a phase-locked loop permits accurate programmability. The VCO tuning voltage comes from the phase/frequency detector circuit. A 1 kHz signal from the Crystal Reference is applied to one input of the phase detector (IC9). A sample of the VCO output is divided by the programmable divider, and the result is applied to the other input of the phase detector. Any difference in phase or frequency in the signals applied to the phase detector inputs produces an error voltage at the phase detector output, which controls the VCO. The system is stable only when the phase and frequency error is zero, so that the

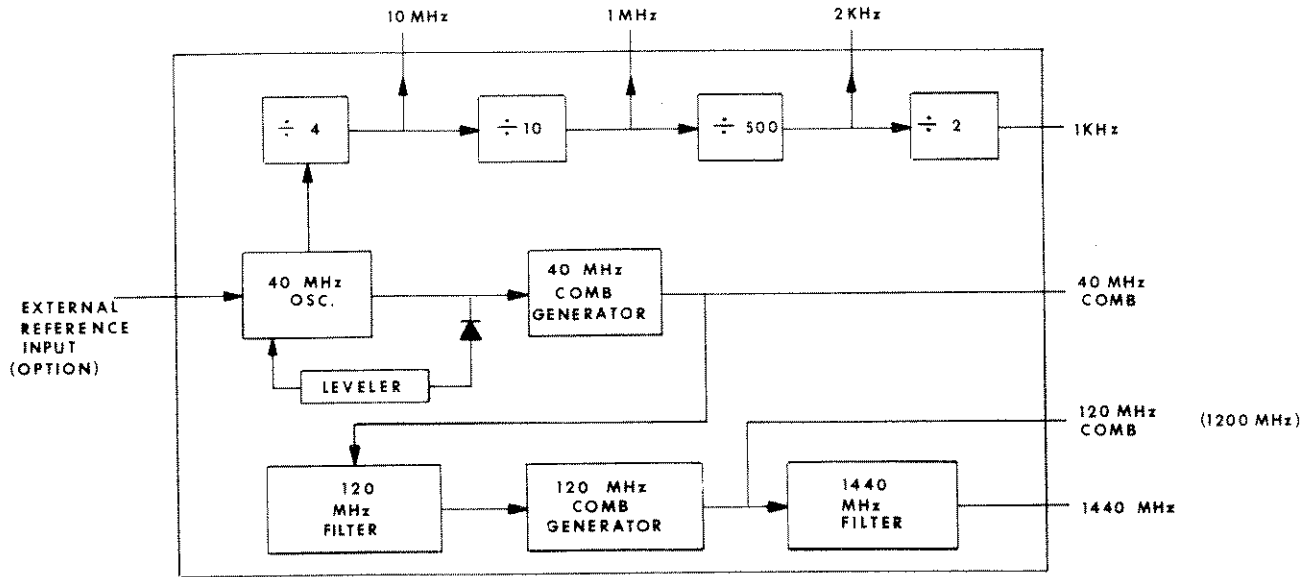


Figure 3-16. M30-1 Crystal Reference

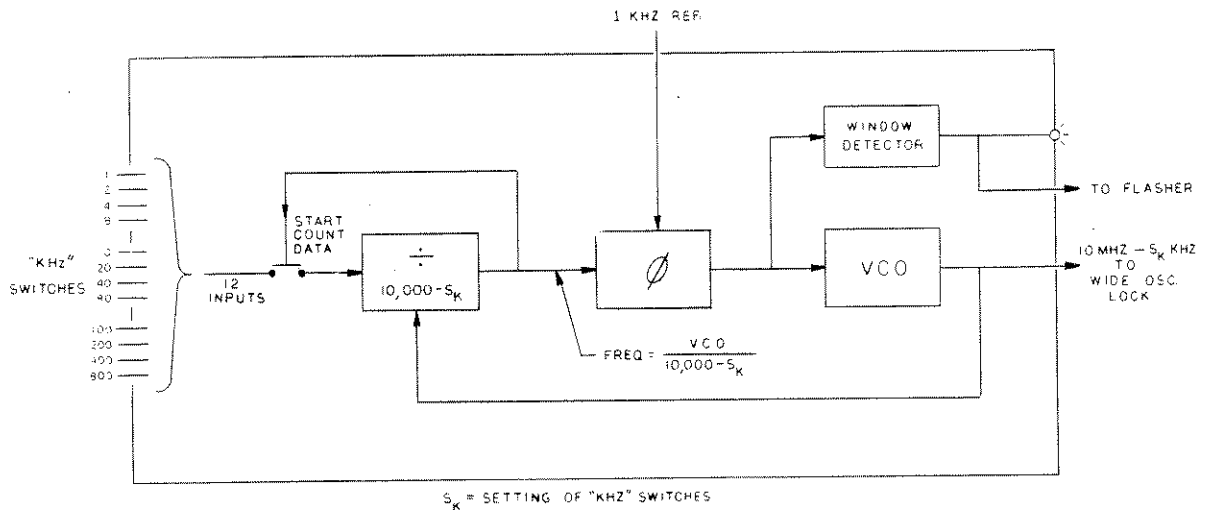


Figure 3-17. M31A kHz Steps

output frequency is phase locked to the 1 kHz reference signal.

### 3.12.3 PROGRAMMABLE DIVIDER

In order for the M31A to perform properly, the divider is designed to divide the VCO frequency by  $(10,000 - S_k)$  where  $S_k$  is the number set on the "kHz" switches. The divider counts the number of cycles at its input and puts out a pulse when the count reaches 10,000. The starting count is the number shown on the "kHz" switches. For example, if the instrument is set for 222.500 MHz, this circuit would divide by 9,500 (count from 500 to 10,000). Therefore, the variable input to the phase detector would be correct (1 kHz) only if the VCO output were 9,500 MHz.

### 3.12.4 UNLOCK INDICATOR

When the phase-locked loop is unlocked, the LED on top of the module will light and the front-panel ACCURACY lights will flash.

A window detector monitors the voltage level which is being fed from the phase detector to the VCO. If the voltage exceeds the normal operating range, power is applied to the module light and the flasher circuit on the Modulation Board.

## 3.13 M32A – MHz STEPS

The M32A provides, for the M34, a reference frequency which corresponds to the setting on the "MHz" switches (see Figure 3-18). The M32A output range is 1448 to 1487 MHz, which repeats itself with every 40 MHz change of the "MHz" switch setting. Any specific M32A output relates to the "MHz" switch setting ( $S_m$ ) by the equation (Output =  $(1448 + R)$  MHz), where R is the Remainder of dividing  $S_m$  by 40. If the front-panel Lever/Indicator switches are set, for example, to 333.000, R would be 13 ( $333 \div 40 = 8$  with a Remainder of 13). The output of the M32A would then be  $1448 + 13 = 1461$  MHz.

### 3.13.1 VCO

The output of the M32A is produced by a voltage controlled oscillator. This VCO is coarsely tuned by the repeating analog output of the M172. Fine tuning is the result of including the VCO in a phase-locked loop. In addition to the VCO, the phase-locked loop includes a phase detector and programmable divider.

### 3.13.2 PROGRAMMABLE DIVIDER

A sample of the VCO output is mixed with the 1440 MHz signal from the Crystal Reference producing a difference frequency of from 8 to 47 MHz, which is then shaped into TTL pulses and applied to the programmable divider.

The divider counts the falling edges of the 8-47 MHz input pulses, resetting each time a count of 47 is reached. The reset pulse is applied to one input of the phase detector. By controlling the starting count of the programmable divider, the effective divisor can be controlled.

The starting count of the programmable divider is selected by a read only memory, which is programmed to provide the correct "R" information for each "Sm" setting. This "R" is then applied to the programmable divider as the starting count. Thus, as the starting count varies from 0 to 39, the effective divisor varies from 47 to 8.

When the VCO is running at the correct frequency, the programmable divider reset pulse rate will be 1 MHz.

### 3.13.3 PHASE DETECTOR

One input to the phase detector is the reset pulse from the programmable divider. The other input is a 1 MHz fixed reference signal from the Crystal Reference. The phase detector output is a voltage determined by the difference in phase at the phase detector inputs, and is used to correct any error in the VCO frequency or phase.

If the VCO output frequency is too high, for example, the phase detector output becomes more negative, thus increasing the VCO varactor diode tuning capacitance and lowering the VCO frequency. If the VCO frequency is too low, the reverse occurs. Thus, the loop will tend to maintain zero phase or frequency error. A voltage-controlled attenuator between the phase detector circuit and the VCO keeps the open-loop gain of the phase-locked loop relatively constant over the programmed frequency range, allowing the loop noise to be minimized.

### 3.13.4 UNLOCKED INDICATOR

When the phase-locked loop is unlocked, the LED on top of the module will light and the front-panel ACCURACY lights will flash.

A window detector monitors the voltage level being fed from the phase detector to the VCO. If the voltage exceeds the normal operating range, power is applied to the module light and the flasher circuit on the Modulation Board.

## 3.14 M33-2 – NARROW OSCILLATOR LOCK

The M33-2 contains the circuits to phase lock the Narrow Oscillator in the M9W (PLL 3) and the M29-2 FM Reference (PLL 5). As explained in Section 3.2.2, PLL 5 provides the reference frequency for PLL 3.

### 3.14.1 PHASE DETECTOR FOR PLL 3

This circuit compares the reference frequency to the variable frequency which represents the M9W VCO output.

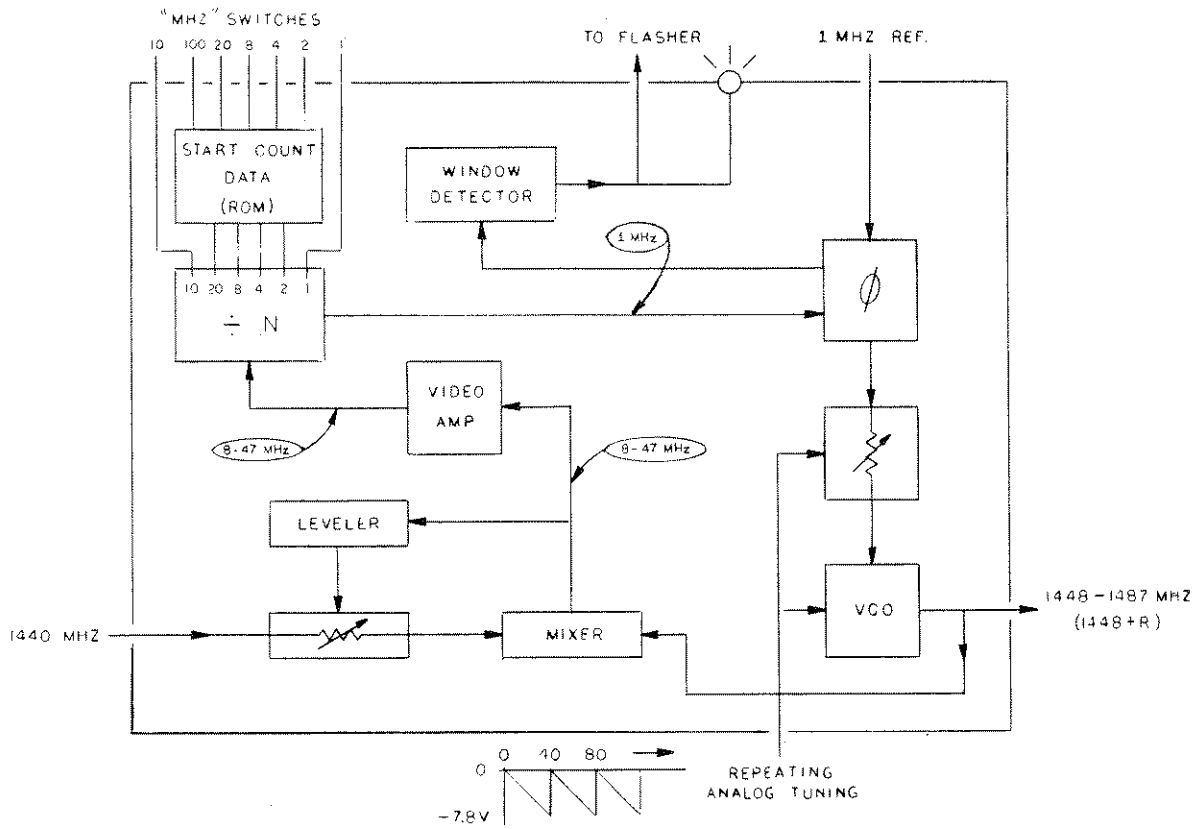


Figure 3-18. M32A MHz Steps

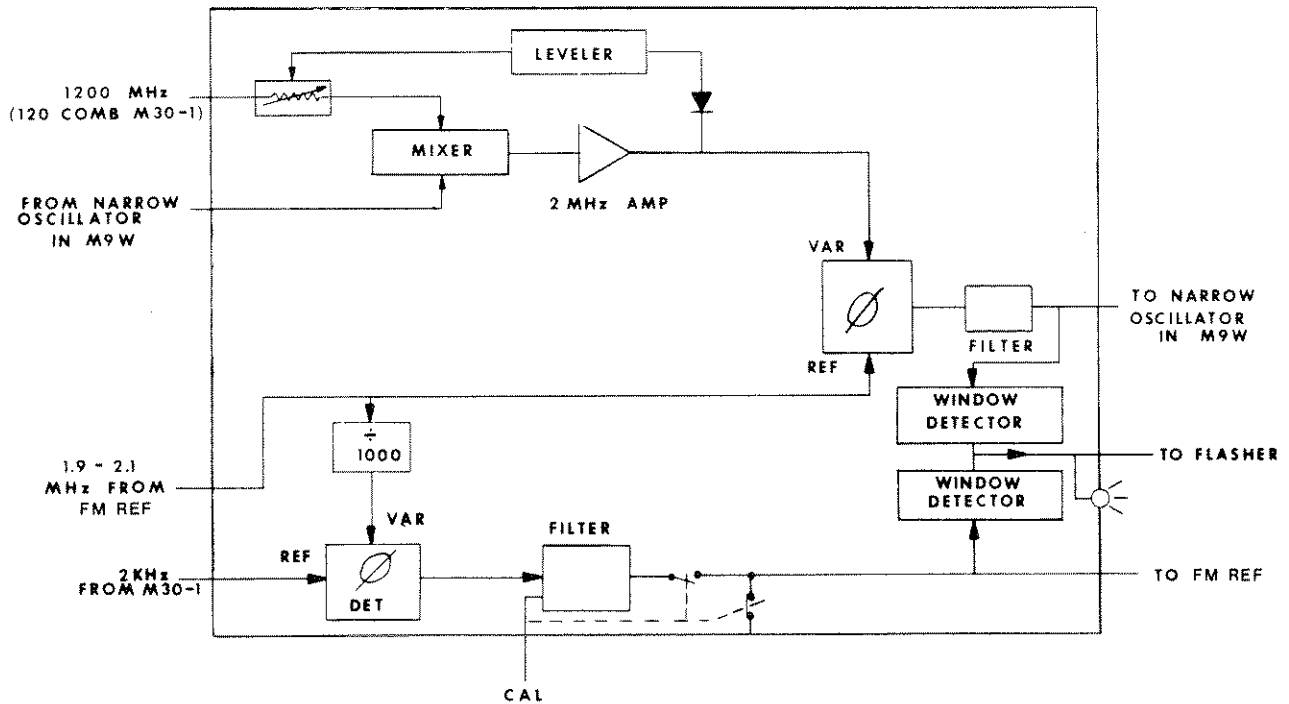


Figure 3-19. M33-2 Narrow Oscillator Lock



If the VCO is too high, for example, the phase detector puts out a more positive voltage which is filtered and inverted by an integrator and applied to the VCO (Narrow Oscillator) to lower the frequency.

### 3.14.2 MIXER

The phase detector cannot operate at UHF frequencies, so the VCO is mixed with 1200 MHz CW. This provides an offset frequency which is the variable input to the phase detector. The deviation of this variable signal from 2 MHz is precisely the same as the deviation of the VCO from 1198 MHz.

### 3.14.3 PHASE DETECTOR FOR PLL 5

This circuit compares the 2 kHz reference from the M30-1 to the variable frequency which is the M29-2 output divided by 1000 so that even when the M29-2 is frequency modulated, the variable frequency will remain in the capture range of the phase detector. Any frequency modulation (above 50 Hz) is filtered out by the integrator filter and the error voltage is fed to the M29-2.

### 3.14.4 UNLOCK INDICATOR

Window detectors are fed by the integrator outputs. If the integrators put out a voltage outside their normal operating range, the window detectors apply voltage to the module's unlock indicator and to the flasher circuit on the Modulation Board.

## 3.15 M34 – WIDE OSCILLATOR LOCK

This module provides the fine tuning program for the Wide Oscillator in the M9W. Figure 3-20 is the block diagram of the M34. The letters A thru F relate the signals at the associated points in the module to the graphs A thru F in Figures 3-21 and 3-22. The M34 phase locks the VCO to 1198 MHz plus the frequency indicated on all six front-panel switches. The frequency offset circuit converts the frequency of the VCO to a lower frequency which retains the frequency error information for use by the phase detector. In addition to the frequency offset circuit and the phase detector, several auxiliary circuits are included.

### 3.15.1 PHASE DETECTOR

The phase detector compares the "offset" VCO frequency to the reference frequency from the M31A. (Refer to the description of the M31A for a more detailed description of this 10.000 - 9.001 MHz reference.)

The phase detector output voltage goes positive or negative to ultimately drive the Wide Oscillator higher or lower in frequency until both inputs to the phase detector are the same frequency. The integrator serves as a low pass filter for the phase detector.

### 3.15.2 FREQUENCY OFFSET CIRCUIT

The VCO error information must be converted to a frequency useable by the phase detector. This conversion is made by mixer 1, a 270 MHz low pass filter, mixer 2, and a 10 MHz low pass filter. Refer to Figures 3-20, 3-21, and 3-22 for descriptions of signals.

Mixer 1 heterodynes the VCO frequency with the "MHz steps" reference frequency (1448 + R MHz). The difference frequency,  $|1448 + R - \text{VCO}|$ , is below 270 MHz. This signal is sent to mixer 2 where it is heterodyned with the 40 MHz comb. For any output frequency, graph D in Figure 3-21 shows only the comb frequency which will yield the desired output (below 20 MHz) of mixer 2. If the loop is locked, mixer 2 will produce a 10 MHz difference as shown in Figure 3-21 (assuming the "kHz" switches are set for 000). Figure 3-22 shows signals A thru F for a case when the kHz switches are not 000.

The filter after mixer 2 blocks all the outputs of the mixer except the lower frequency signal containing the VCO error information. When the unit is unlocked, the filter passes up to 20 MHz (to be able to capture over the 20 MHz range allowed for analog tuning). Once the loop is locked, the filter decreases to 10 MHz to further eliminate phase-locked loop-related spurious signals.

### 3.15.3 AUXILIARY CIRCUITS

The "speed-up circuit" is activated when the phase-locked loop becomes unlocked. The output of this circuit is sent to the M9W to cause the VCO to be tuned faster by the analog voltage.

The "unlock" amp monitors both the tuning voltage from the phase detector and the leveler voltage to detect an unlocked condition of the M34. When unlock occurs, it sends a voltage to the flasher circuit.

The leveler circuit maintains a constant input amplitude to the phase detector by controlling the amplitude of the input from the M9W Wide Oscillator. The input to the phase detector (about 10 MHz) is peak detected and compared to a DC reference in the leveler circuit. The leveler circuit controls a PIN diode attenuator which is between the VCO input and mixer 1.

## 3.16 M115 – DOWN-CONVERTER (MODEL 3002)

This module takes the RF output from the M10W-8 (when the front-panel "MHz" selector switches are set to "000.") and converts it to the proper 1 to 999 kHz output frequency.

The BCD signals from the front-panel "MHz" selector switches are fed into a 13-input NAND gate. (Two of the inputs are held high.) This gate determines whether the

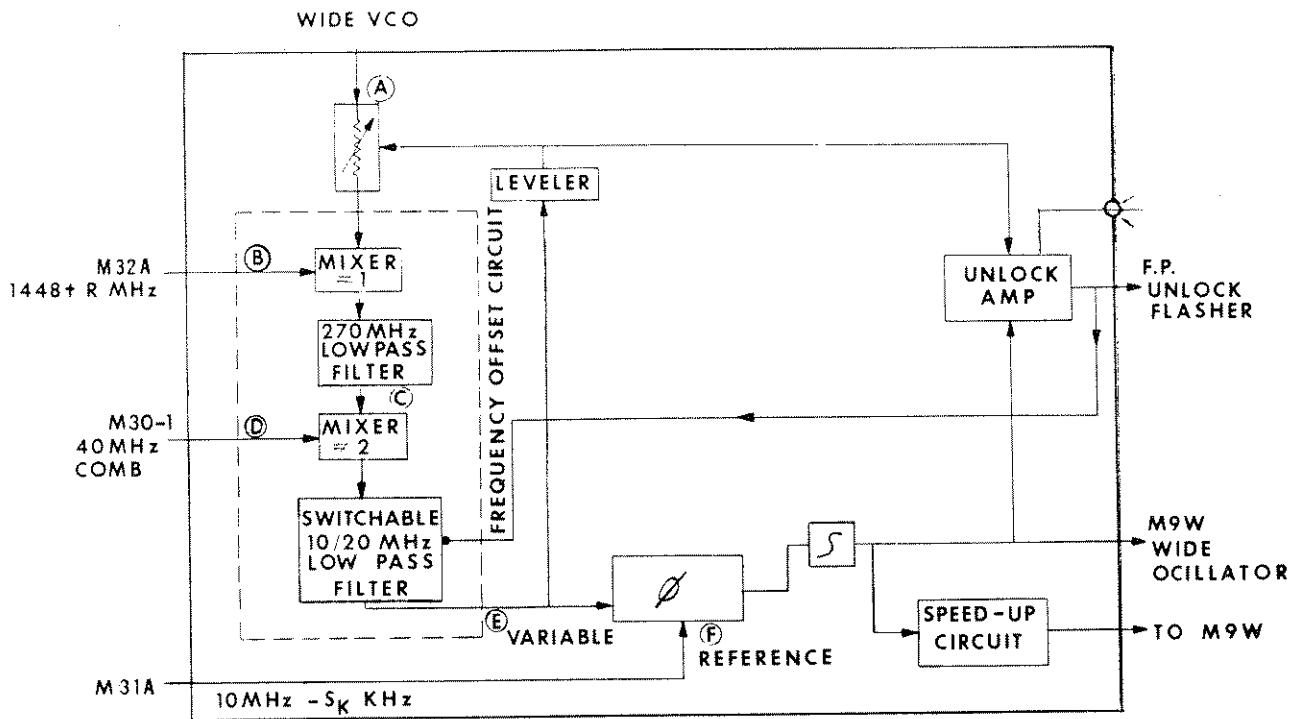


Figure 3-20. M34 Wide Oscillator Lock

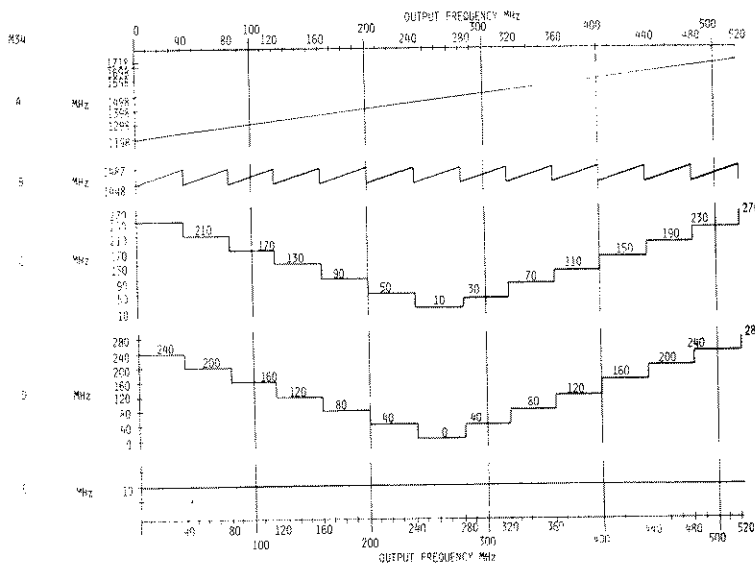


Figure 3-21. M34 Frequencies

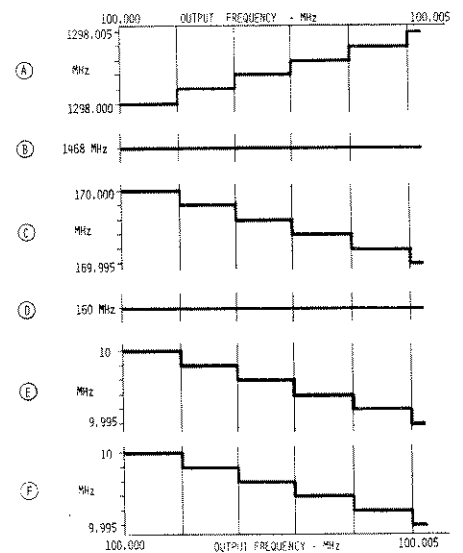


Figure 3-22. M34 Frequencies (Expanded)

switches are set for "000.", and, if so, triggers a hex inverter to send out a logic "true" to the M10W-8 and activates the 10 MHz line to the M172 and M32A. This programs the M9W for 10 MHz plus the "kHz" switch setting, and this signal is fed into the M10W-8. At this point, however, the signal is routed to the M115 (see Section 3.8), where it is mixed with the 10 MHz reference signal from the M30-1 Crystal Reference. The difference frequency from this mixing is simply the "kHz" switch setting, and is output back to the M10W-8 and on to the Step Attenuator.

The M115 also contains a 20 dB attenuation pad for the input from the M10W-8, and an RF amplifier for the 10 MHz reference signal. The effect of these stages is to allow the mixer output to be directly proportional to the output from the M10W-8. The mixer output is then fed

into a 3-stage amplifier with complementary push-pull output to restore the output to the proper (-7 to +13 dBm) level. Potentiometer R3 and trimcap C20 fine adjust the gain and frequency response of the module.

If the front-panel "MHz" switches are not set to "000.", the M115 has no function except that the 10 MHz program line from the switches to the M172 and M32A passes through the M115.

**NOTE**

If the M115 is removed for servicing, the instrument may still be used; however, the frequency range is reduced from .001-520 MHz to 1-520 MHz. In this case, pins 1 and 9 of the M115 module socket must be jumpered together.

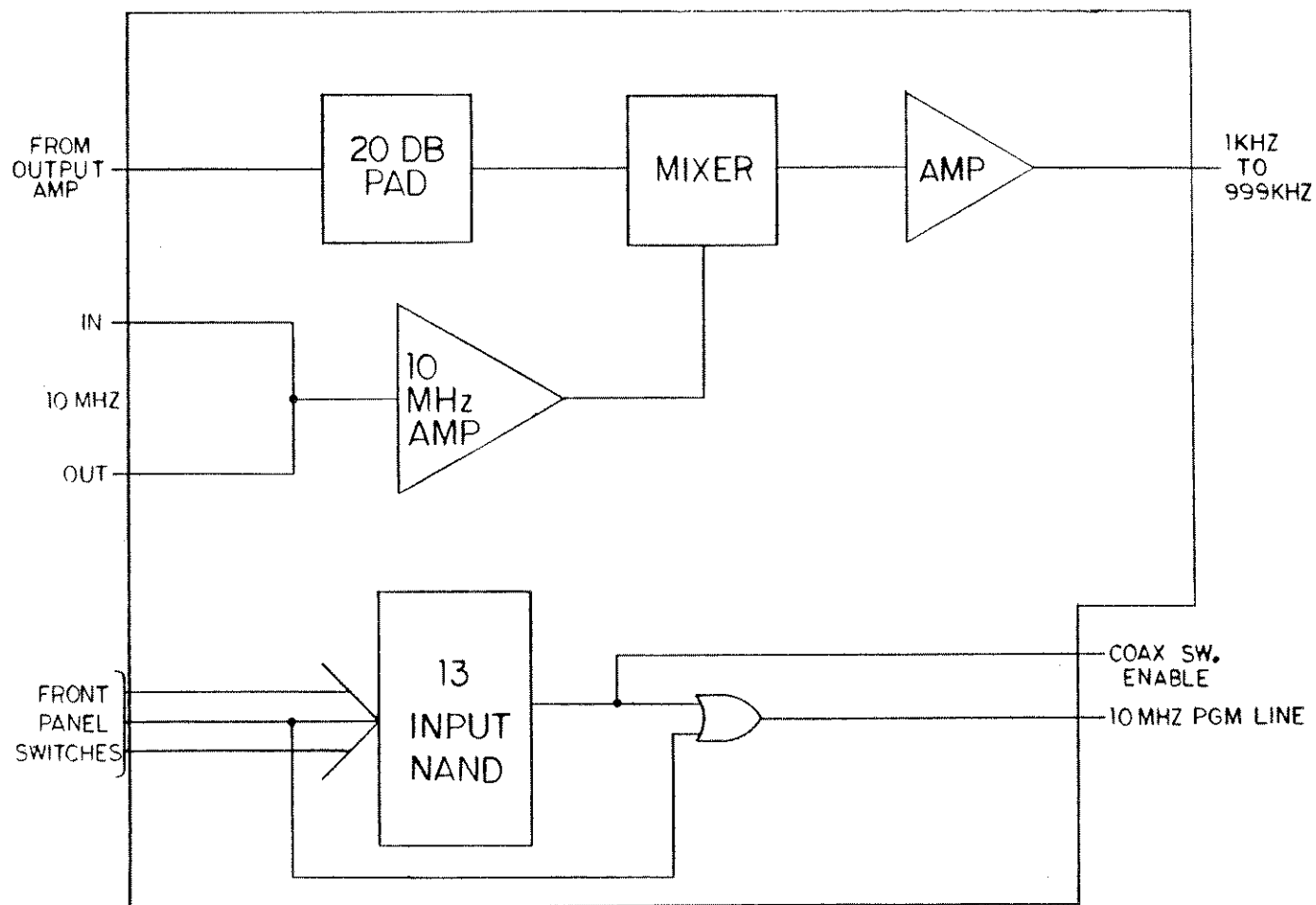


Figure 3-23. M115 Down Converter

# SECTION 4

## PERFORMANCE TESTS

### 4.1 INTRODUCTION

The purpose of the performance tests in the following sections is to verify that the Signal Generator meets its published specifications (Section 1.2). Individual performance tests consist of: the specification to be verified, the method of testing, a list of equipment required, and a detailed test procedure including, in some cases, a simplified setup drawing. If optional features are installed in the instrument, refer to Section 8 for possible changes to the performance test procedure.

Critical specifications for each item of test equipment are listed in Table 4-1, Recommended Test Equipment. Except as detailed settings of test equipment apply to performance test procedures, all other test equipment operating details are omitted.

The Signal Generator should have its top and bottom covers installed for the performance tests. All of the tests can be performed without access to the internal controls. Before applying power to the Signal Generator, see Section 2 for details of electrical installation. The line voltage should be maintained at 115 or 230 VAC  $\pm 10\%$ , 50 to 400 Hz throughout the tests. The performance test procedures are begun after a two-hour minimum warmup of the Signal Generator in a +20 to +30° C ambient temperature range.

A copy of the Performance Test Record (PTR) is provided at the end of this section for convenience in recording the performance of the instrument during performance tests. It can be filled out and used as a permanent record for incoming inspection or it can be used as a guide for routine performance testing. The PTR lists the section, test, and specification limits. All tests refer to this test record.

**TABLE 4-1. RECOMMENDED TEST EQUIPMENT  
FOR PERFORMANCE TESTS**

INSTRUMENT	CRITICAL REQUIREMENT	RECOMMENDED
(1) Digital Multimeter	10 VDC: $\pm(0.07\%R+0.02\%FS)$	Dana 4200
(2) Distortion Analyzer	Range: 5 Hz to >25 kHz	HP334A
(3) Frequency Counter	Range: to 525 MHz	HP530B/5303B
(4) Function Generator	Level: 10 Vpp sine wave into 600 ohm load Range: >0.2 Hz to >25 kHz Distortion: <1%	Wavetek 130
(5) Power Meter	Range: 10 to >520 MHz Input Level: -7 to +13 dBm Accuracy: $\pm 1\%$ FS	HP435A/8481A
(6) Modulation Meter	Range: 5 to >520 MHz Residual FM: <100 Hz (RMS) (quiet room) Residual AM: $\pm 0.1\%$ (RMS) (in CW) AM Accuracy: $\pm(2\%R+1\%FS)$	AFM2 Radiometer
(7) Oscilloscope	Range: DC to 2 MHz Sensitivity: 2 V/cm (AC coupled)	Tektronix D10/ 5A18N/5B10N
(8) Spectrum Analyzer	Range: 1 kHz to 1200 MHz Display: 2 dB log and 10 dB log	HP8558B/182T
(9) Precision Attenuator Pads	10, 20, 30, and 40 dB	Weinschel 50-10 50-20, 50-30 and 50-40
(10) Wideband Amplifier	Range: 1 to 520 MHz Gain: 26 dB Impedance: 50 ohm	HP8447D
(11) Signal Generator	Range: 1 to 520 MHz	Wavetek 3000
(12) VSWR Bridge	5 to 525 MHz, 50 ohm 50 dB directivity	Wiltron 60N50
(13) Coaxial Short	Type N female	HP11511A
(14) Coaxial Termination 50 ohm	Type N male, 1.05 SWR	HP908A
(15) 50 ohm Load	-----	HP11593A
(16) Loop Probe	-----	See Figure 4-6

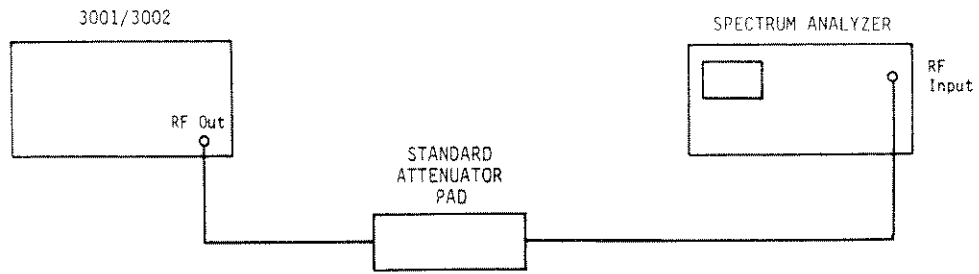


Figure 4-1. Test Set-up

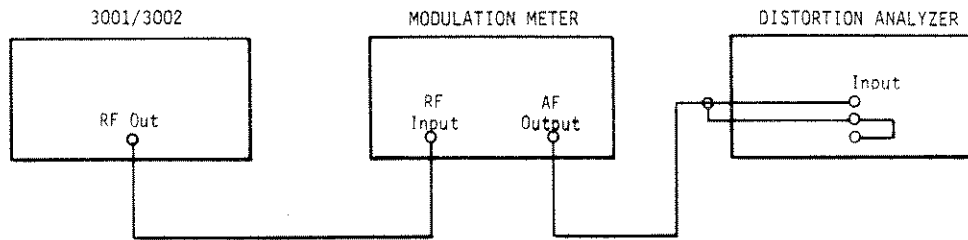


Figure 4-2. Test Set-up

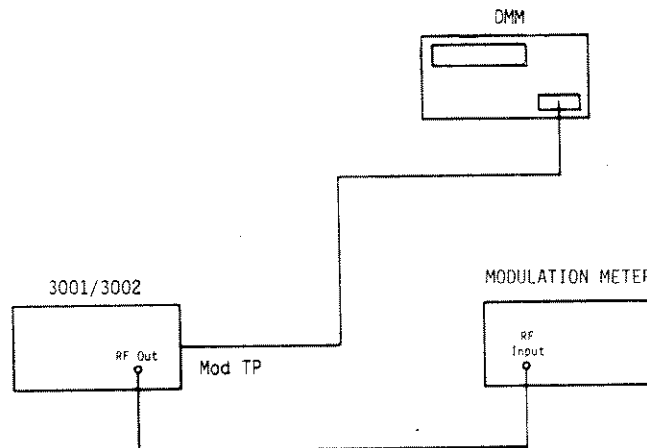


Figure 4-3. Test Set-up

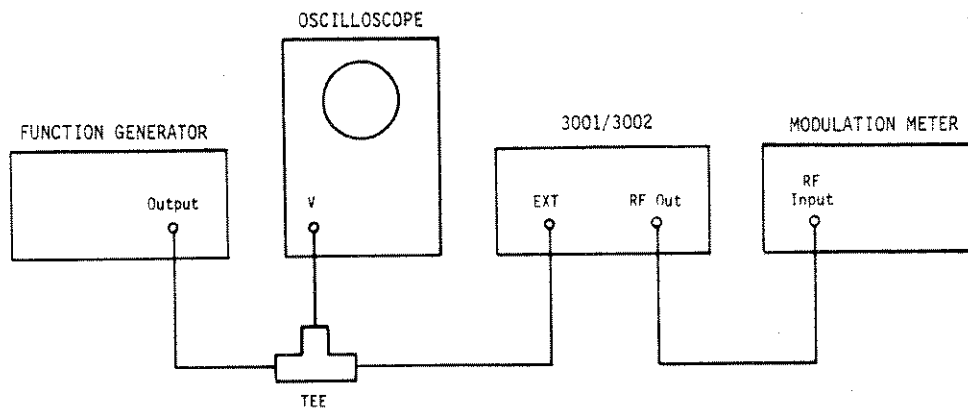


Figure 4-4. Test Set-up

## 4.2 FREQUENCY RANGE AND RESOLUTION TEST

### SPECIFICATION

Model 3002 1 kHz to 520 MHz selectable in 1 kHz steps with 1 kHz resolution.  
Model 3001 1 MHz to 520 MHz selectable in 1 kHz steps with 1 kHz resolution.

### METHOD

A frequency counter is used to measure the frequency range and the frequency resolution. Each digit of the Lever/Indicator switches (a total of 56) will be tested.

### EQUIPMENT

(3)

### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	050.000
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the front-panel RF OUT connector to the 50 ohm input of the frequency counter. Set the counter resolution to 100 Hz.

3. Observe the frequency counter reading. Increase the output frequency setting in 1 kHz steps and verify that the frequency counter reading increases by 1.00 kHz  $\pm 1$  count for each step increase from 1 through 9 kHz. The foregoing procedure verifies the 1 kHz resolution specification.

4. Repeat the procedure in step 3 for all other step increases indicated in the table below, beginning with the 10 kHz digits. If the actual counter frequency increase per step is equal to the allowable increase per step  $\pm 1$  count for each of the steps indicated in the table, place a check mark in the applicable space on line 1 of the PTR.

LEVER/INDICATOR SWITCH SETTINGS	COUNTER RESOLUTION	INCREASE/STEP ( $\pm 1$ COUNT)
050.000-050.009	100 Hz	1.00 kHz
050.000-050.090	100 Hz	10.000 kHz
050.000-050.900	1 kHz	100.0 kHz
050.000-059.000	1 kHz	1.000 MHz
100.000-190.000	1 kHz	10.000 MHz
020.000-520.000	1 kHz	100.000 MHz

5. Set the Lever/Indicator switches to 000.001 (Model 3002) or 001.000 (Model 3001) and verify the low end of the frequency range.

## 4.3 FREQUENCY ACCURACY TEST

### SPECIFICATION

All modes (CW, AM and FM)  $\pm 0.001\%$  after 15 minutes.  
( $\pm 0.001\% + 10$  kHz when FREQUENCY VERNIER is not in CAL.)  
(FREQUENCY VERNIER range is  $\pm 5$  kHz.)

### METHOD

A frequency counter is used to measure frequency accuracy. With the FREQ VERNIER in CAL, all carrier frequencies are derived from a single

crystal-controlled oscillator. The instrument will be tested at one CW frequency to verify that the crystal-controlled oscillator operates within specified limits.

When the FREQ VERNIER is not in CAL, the carrier frequencies are derived from a voltage-controlled oscillator in addition to the crystal-controlled oscillator. Frequency accuracy with the FREQ VERNIER not in CAL will be measured by utilizing DC modulation equal to maximum peak sinusoidal modulation in both FM modes. The FREQ VERNIER range will be tested in CW mode.

## EQUIPMENT

(3)

## PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	040.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the 50 ohm input of the frequency counter to the RF OUT connector.

3. The counter should read between 39,999.60 and 40,000.40 kHz. Record the counter reading to seven places on line 2 of the PTR.

4. Set the instrument controls as follows:

FREQ VERNIER	0 kHz
Frequency selector	001.000 MHz
MODULATION MODE	FMx1
MODULATION FREQ	DC
MODULATION FM/AM	10 kHz

5. The frequency counter should read between 999.99 and 1,020.01 kHz. Record the counter reading to six places on line 3 of the PTR.

6. Set the MODULATION MODE to FMx10.

7. The frequency counter should read between 1,089.99 and 1,110.01 kHz. Record the counter reading to six places on line 4 of the PTR.

8. Set the frequency selector to 002.000 MHz.

9. Set the FREQ VERNIER to +3 kHz, and make a note of the counter reading in Hz.

10. Set the FREQ VERNIER to 0 kHz, and subtract the frequency counter reading in Hz from the reading in step 9. The difference should be between 2500 and 3500 Hz. Record the difference on line 5 of the PTR.

11. Set the FREQ VERNIER to -3 kHz, and subtract the frequency counter reading in Hz from the reading at 0 kHz in step 10. The difference should be as in step 10. Record the difference in Hz on line 6 of the PTR.



#### 4.4 FREQUENCY STABILITY TEST

##### SPECIFICATION

All modes (CW, AM and FM) < 0.2 ppm/hour  
(500 Hz per 10 min when FREQ VERNIER is not in CAL.)

##### METHOD

The frequency stability is measured with a frequency counter at the indicated time intervals after a 2-hour-minimum warm-up.

##### EQUIPMENT

(3)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the 50 ohm input of the frequency counter to the RF OUT connector.

3. Allow the instrument to warm up for two hours minimum. Record the frequency counter readings to nine places at 15-minute intervals for a one-hour period. The difference between the maximum and minimum readings in the one-hour period should not exceed 104 Hz. Record the difference between the maximum and minimum readings in Hz on line 7 of the PTR.

4. Set the FREQ VERNIER to 0 kHz, the MODULATION MODE to FMx1, the MODULATION FREQ to DC, and the MODULATION FM/AM slider to 10 kHz.

5. After a one-minute interval, record the frequency counter readings to nine places at five-minute intervals for a ten-minute period. The difference between the maximum and minimum readings in the ten-minute period should not exceed 500 Hz. Record the difference between the maximum and minimum frequency readings in Hz on line 8 of the PTR.

#### 4.5 OUTPUT LEVEL ACCURACY TESTS

##### SPECIFICATION

Power Level: +13 to -137 dBm (1 VRMS to 0.03  $\mu$ VRMS)

Attenuator Range: Continuously adjustable in 10 dB steps and an 11 dB VERNIER. Output level is indicated on a front-panel METER calibrated in dBm and volts RMS.

Total Level Accuracy:  $\pm 1.25$  dB (+13 to -7 dBm),  $\pm 1.95$  dB (-7 to -77 dBm),  $\pm 2.75$  dB (-77 to -137 dBm).

Accuracy Breakdown: Flatness;  $\pm 0.75$  dB (+13 to -7 dBm), Output METER;  $\pm 0.5$  dB, Step Attenuator;  $\pm 0.5$  dB to 70 dB ( $\pm 0.2$  dB calibration error),  $\pm 1.0$  dB to 130 dB ( $\pm 0.5$  dB calibration error).

##### METHOD

The  $\pm 1.25$  dB level accuracy between +13 and -7 dBm consists of the sum of the output METER error ( $\pm 0.5$  dB) and the flatness ( $\pm 0.75$  dB). Both errors are measured with a power meter.

The output METER error is measured at 50 MHz in two 10 dB output ranges (+13 to +3 dBm and +3 to -7 dBm).

The flatness is measured relative to 50 MHz in 10 MHz steps between 10 and 520 MHz at +12, +3, and -7 dBm output levels.

The level accuracy below -7 dBm depends upon the OUTPUT Step Attenuator error in addition to the output METER error and the flatness.

The OUTPUT Step Attenuator is a combination of pi-pad sections of 10, 20, 30, 30, and 40 dB. These five pi-pads are programmed by cams to provide 0 to 130 dB of attenuation in 10 dB steps as shown in the table below.

OUTPUT STEP ATTENUATOR POSITION	ACTIVE STEP ATTENUATOR PADS (X)				
	<u>10 dB</u>	<u>20 dB</u>	<u>30 dB</u>	<u>30 dB</u>	<u>40 dB</u>
<u>dBm</u>					
+ 10					
0					
- 10	x				
- 20		x			
- 30			x		
- 40	x		x		
- 50		x	x		
- 60			x	x	
- 70	x		x	x	
- 80		x	x	x	
- 90		x		x	x
-100			x	x	x
-110	x		x	x	x
-120		x	x	x	x
-130	x	x	x	x	x

Note that no Step Attenuator pads are active in the +10 dBm and 0 dBm positions. A leveled PIN diode attenuator reduces the output level by 10 dB in all positions of the OUTPUT Step Attenuator below +10 dBm. The output level over the entire range of +13 dBm to -137 dBm including an 11 dB VERNIER is controlled by the PIN leveler system.

The OUTPUT Step Attenuator error is measured by an RF substitution method. Each of the five pads in the OUTPUT Step Attenuator is measured at 520 MHz. The second 30 dB pad and the 40 dB pad are measured in combination with other pads. A reference output level is set with a power meter. A reference trace is obtained with a spectrum analyzer and a standard attenuator pad. The standard pad is removed and the OUTPUT Step Attenuator position to be measured is substituted. The spectrum analyzer trace is returned to the reference level by resetting the output level. The resulting instrument output level is measured and compared to the original power meter reference level. A 26 dB RF amplifier is required to boost signal levels below the -60 dBm level.

#### 4.5.1 OUTPUT METER ACCURACY TEST

##### EQUIPMENT

(5)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	050.000
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Calibrate the power meter and power sensor. Set the power meter to the +15 dBm range. Connect the power sensor to the front-panel RF OUT connector. (When reading the power meter, set the range switch so that the meter indicates between 0 and -5 dBm).

**NOTE:** The indicated output level of the instrument is equal to the sum of the output METER reading and the Step Attenuator setting. The difference between the actual power meter reading and the indicated output level is the output METER error. For example, the indicated output level is +13 dBm for an output METER reading of +3 dBm and an OUTPUT Step Attenuator setting of +10 dBm. If the power meter reading is +13.15 dBm, the output METER error is +0.15 dB.

3. Adjust the front-panel OUTPUT VERNIER for a +3 dBm output METER reading. Observe the power meter reading and make a note of the output METER error to the nearest 0.05 dB (¼ division). Continue to adjust the OUTPUT VERNIER for output METER reading increments of 1 dB between +3 and -7 dBm, and note the output METER error at each reading. As the test progresses, make a note of the maximum output METER error to the nearest 0.05 dB. The allowable error is ±0.5 dB. Record the maximum output METER error on line 9 of the PTR.

4. Set the instrument OUTPUT Step Attenuator to 0 dBm and repeat step 3 above. Record the maximum output METER error on line 10 of the PTR.

#### 4.5.2 FLATNESS TEST

##### EQUIPMENT

(5)

##### PROCEDURE

1. Set the instrument controls as in Section 4.5.1.

2. Set the power meter to the +15 dBm range. Connect the power sensor to the front-panel RF OUT connector.

3. Adjust the front-panel OUTPUT VERNIER for a +12 dBm power meter reading.

4. Set the instrument frequency selector in 10 MHz steps between 10 and 520 MHz and observe the maximum change in the power meter readings from the +12 dBm reading in step 3. The maximum allowable change is ±0.75 dB. Record the maximum change to the nearest 0.05 dB (¼ division) on line 11 of the PTR.

5. Set the Lever/Indicator switches to 050.000 MHz and adjust the OUTPUT VERNIER for a +3 dBm power meter reading.

6. Repeat step 4 above except observe the maximum change in the power meter readings from the +3 dBm reading in step 5. Record the maximum change from the +3 dBm reading to the nearest 0.05 dB on line 12 of the PTR.

7. Set the Lever/Indicator switches to 050.000 MHz and the OUTPUT Step Attenuator to 0 dBm. Adjust the OUTPUT VERNIER for a -7 dBm power meter reading.

8. Repeat step 4 above except observe the maximum change in the power meter readings from the -7 dBm reading in step 7. Record the maximum change from the -7 dBm reading to the nearest 0.05 dB on line 13 of the PTR.

#### 4.5.3 STEP ATTENUATOR ACCURACY TEST

##### EQUIPMENT

(5) (8) (9) (10)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000
MODULATION MODE	AM
MODULATION FREQ	DC
MODULATION FM/AM	0% AM
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	0 dBm

2. Set the power meter to the +5 dBm range. Connect the power sensor to the RF OUT connector.

3. Adjust the OUTPUT VERNIER control for a +3 dBm power meter reading.

4. Disconnect the power sensor from the front-panel RF OUT connector. Connect a standard 10 dB attenuator pad to the RF OUT connector. Connect the output of the attenuator pad to the spectrum analyzer as shown in Figure 4-1.

5. Set the spectrum analyzer to 520 MHz, the bandwidth to 10 kHz, the frequency span per division to 2 kHz, and the tuning stabilizer switch on. Set the video filter to 100 Hz and the vertical display to 2 dB per division.

6. Use the log reference controls to obtain a peak trace one division below the log reference line of the spectrum analyzer display. Center the trace in the display with fine tuning.

7. Set the OUTPUT Step Attenuator to -10 dBm.

8. Disconnect the 10 dB attenuator pad from the setup and reconnect the spectrum analyzer to the RF OUT connector.

9. Adjust the MODULATION FM/AM slider to realign the peak of the trace one division below the log reference line as in step 6.

10. Disconnect the cable from the front-panel RF OUT connector. Connect the power sensor and set the OUTPUT Step Attenuator to 0 dBm.

11. Observe the difference between the actual power meter reading and the +7 dBm reference setting in step 3. The difference or error should be  $\pm 0.7$  dB maximum. Record the error on line 14 of the PTR.

12. Repeat steps 3 through 11 using the standard attenuator pads and the instrument OUTPUT Step Attenuator settings indicated in the following table.

Steps 4 and 8 Attenuator pad (dB)	Step 7 OUTPUT Step Attenuator setting (dBm)	Step 11 Record Error on Line of PTR
20	-20	15
30	-30	16
60	-60	17
90	-90	18

**NOTE:** To test the OUTPUT Step Attenuator below -60 dBm, an RF amplifier ( $> 20$  dB gain) is required. Insert the amplifier between the standard attenuator pad and the spectrum analyzer (Figure 4-1). The allowable error for the -90 dBm setting (step 11) is  $\pm 1.5$  dB. The OUTPUT Step Attenuator can be tested down to the -130 dBm position if a 40 dB RF amplifier is used and if precautions are taken to properly shield the RF output from the instrument proper.

#### 4.6 HARMONICS TEST

##### SPECIFICATION

$< -30$  dBc from .001 to 1 MHz (Model 3002) and 10 to 520 MHz  
 $< -26$  dBc from 1 to 10 MHz

##### METHOD

A spectrum analyzer is used to measure harmonics in the frequency range of the instrument at +13 and +3 dBm output levels.

##### EQUIPMENT

(8)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	001.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the instrument RF OUT connector to the RF input of the spectrum analyzer.

3. Set the spectrum analyzer to measure harmonic distortion for fundamental frequencies between 1 and 10 MHz. Set the bandwidth to 100 kHz, the frequency span per division to 5 MHz, and the display to 10 dB/div. Locate the zero reference at the left edge of the graticule, and adjust the fundamental amplitude to the log reference line (0 dB) in the display.

4. Increase the setting of the frequency selector in 1 MHz steps between 1 and 10 MHz while observing the spectrum analyzer display. The harmonics should be >26 dB below the fundamental. Record the maximum harmonic observed in the display in dB below the fundamental on line 19 of the PTR.
5. Set the OUTPUT Step Attenuator to 0 dBm, and repeat steps 3 and 4 at the +3 dBm output level. Record the maximum harmonic observed in dB below the fundamental on line 20 of the PTR.
6. On Model 3002, repeat steps 1 through 5 for Lever/Indicator switch settings between 000.001 and 000.999, incremented in 10 kHz steps. Note the harmonic levels, but do not record them in the PTR as yet.
7. Set the frequency selector to 10 MHz and the OUTPUT Step Attenuator to +10 dBm.
8. Set the spectrum analyzer to measure harmonic distortion for fundamental frequencies between 10 and 520 MHz. Set the bandwidth to 300 kHz and the frequency span per division to 100 MHz.
9. Increase the setting of the frequency selector in 10 MHz steps between 10 and 520 MHz while observing the spectrum analyzer display. The harmonics should be >30 dB below the fundamental. Record the maximum harmonic observed in the display in dB below the fundamental on line 21 of the PTR.
10. Set the OUTPUT Step Attenuator to 0 dBm and repeat steps 7 and 8 at the +3 dBm output level. Record the maximum harmonic observed in dB below the fundamental on line 22 of the PTR.

#### 4.7 NON-HARMONICS TEST

SPECIFICATION	<table border="0"> <thead> <tr> <th style="text-align: left;">Fundamental Range (MHz)</th> <th style="text-align: left;">Non-harmonic Range (MHz)</th> <th style="text-align: left;">Non-harmonic level (dBc)</th> </tr> </thead> <tbody> <tr> <td>below 3</td> <td>below 3</td> <td>&lt; -60</td> </tr> <tr> <td>3 to 250</td> <td>3 to 250</td> <td>&lt; -65</td> </tr> <tr> <td>3 to 350</td> <td>3 to 350</td> <td>&lt; -55</td> </tr> <tr> <td>3 to 520</td> <td>3 to 1000</td> <td>&lt; -35</td> </tr> </tbody> </table>	Fundamental Range (MHz)	Non-harmonic Range (MHz)	Non-harmonic level (dBc)	below 3	below 3	< -60	3 to 250	3 to 250	< -65	3 to 350	3 to 350	< -55	3 to 520	3 to 1000	< -35
Fundamental Range (MHz)	Non-harmonic Range (MHz)	Non-harmonic level (dBc)														
below 3	below 3	< -60														
3 to 250	3 to 250	< -65														
3 to 350	3 to 350	< -55														
3 to 520	3 to 1000	< -35														
METHOD	A spectrum analyzer is used to measure the level of non-harmonics at the maximum specified output level of +13 dBm.															
EQUIPMENT	(8)															
PROCEDURE	<p>1. Set the instrument controls as follows:</p> <table border="0"> <tr> <td style="vertical-align: top;">FREQ VERNIER</td> <td style="vertical-align: top;">CAL</td> </tr> <tr> <td style="vertical-align: top;">Frequency selector</td> <td style="vertical-align: top;">001.000 MHz (Model 3001) 000.001 MHz (Model 3002)</td> </tr> <tr> <td style="vertical-align: top;">MODULATION MODE</td> <td style="vertical-align: top;">CW</td> </tr> <tr> <td style="vertical-align: top;">MODULATION FREQ</td> <td style="vertical-align: top;">N/A</td> </tr> <tr> <td style="vertical-align: top;">MODULATION FM/AM</td> <td style="vertical-align: top;">N/A</td> </tr> <tr> <td style="vertical-align: top;">OUTPUT VERNIER</td> <td style="vertical-align: top;">Full cw</td> </tr> <tr> <td style="vertical-align: top;">OUTPUT Step Attenuator</td> <td style="vertical-align: top;">+10 dBm</td> </tr> </table>	FREQ VERNIER	CAL	Frequency selector	001.000 MHz (Model 3001) 000.001 MHz (Model 3002)	MODULATION MODE	CW	MODULATION FREQ	N/A	MODULATION FM/AM	N/A	OUTPUT VERNIER	Full cw	OUTPUT Step Attenuator	+10 dBm	
FREQ VERNIER	CAL															
Frequency selector	001.000 MHz (Model 3001) 000.001 MHz (Model 3002)															
MODULATION MODE	CW															
MODULATION FREQ	N/A															
MODULATION FM/AM	N/A															
OUTPUT VERNIER	Full cw															
OUTPUT Step Attenuator	+10 dBm															

2. Connect the RF OUT connector to the RF input of the spectrum analyzer.
3. Set the spectrum analyzer to measure the non-harmonic content of the output below 3 MHz. Set the bandwidth to 30 kHz, the frequency span per division to 1 MHz, and the display to 10 dB/div. Locate the zero reference at the left edge of the graticule, and adjust the fundamental to the log reference line (0 dB) in the display.
4. Increase the setting of the frequency selector in 1 MHz steps up to 3 MHz. The non-harmonics below 3 MHz should be at least 60 dB below the fundamental (<60 dBc). Record the maximum non-harmonic observed in the display in dB below the fundamental on line 23 of the PTR.
5. Set the spectrum analyzer to measure the non-harmonic content of the output between 3 and 250 MHz. Set the bandwidth to 300 kHz and the frequency span per division to 100 MHz.
6. Increase the setting of the frequency selector in 1 MHz steps between 3 and 10 MHz and in 10 MHz steps between 10 and 520 MHz while observing the spectrum analyzer display. Use the table below to determine the maximum non-harmonic level in each of the frequency ranges shown. Record the maximum non-harmonic level observed in each range indicated in the table on the applicable line of the PTR:

FUNDAMENTAL RANGE (MHz)	NON-HARMONIC RANGE (MHz)	NON-HARMONIC LEVEL (dBc)	PTR LINE NUMBER
3-250	3-250	<65	24
3-350	3-350	<55	25
3-520	3-1000	<35	26

#### 4.8 RESIDUAL AM TEST

##### SPECIFICATION

<65 dBc in a 50 Hz to 15 kHz post-detection bandwidth.

##### METHOD

A modulation meter operating in AM mode is used to demodulate the output at the minimum leveler point where AM noise is maximum. A distortion analyzer (operating in level mode) is used to increase the resolution of the demodulated output of the modulation meter. The system is calibrated at a 10% AM level. The 10% AM is removed and the residual AM is read in dB below the calibrated 10% AM level. 20 dB is added to the reading to relate residual AM to the carrier.

##### EQUIPMENT

(2) (6)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	500.000 MHz
MODULATION MODE	AM
MODULATION FREQ	1 kHz
MODULATION FM/AM	0% AM
OUTPUT VERNIER	-7 dB
OUTPUT Step Attenuator	0 dBm

2. Connect the equipment as shown in Figure 4-2.

3. Set the modulation meter to read %AM at 500 MHz. Set the RF input attenuation to 10 dB, the IF bandwidth to  $\pm 400$  kHz, the meter response to fast, the function switch to +AM, the meter range switch to 10, and the filter bandwidth to 50 Hz – 15 kHz.

4. Adjust the MODULATION FM/AM control for a modulation meter reading of 10% AM. NOTE: 10% AM is obtained at a full-scale reading of 100 with the modulation meter range switch set to 10.

5. With the distortion analyzer operating in level mode, calibrate it for a 0 dB meter reading. The system is now calibrated at a reference level 20 dB below the carrier. Since the modulating signal and carrier amplitudes are equal at 100% AM, it follows that at 10% AM the modulating signal is 20 dB below the carrier.

6. Set the MODULATION MODE to EXT.

7. Without disturbing the instrument and modulation meter controls, set the distortion analyzer to read residual AM. Set the range switch so that the meter reads between 0 and -10 dB. First, read the residual AM below the 0 dB reference level in step 5. Then add 20 dB to the above reading to obtain the residual AM below the carrier. (For example, a 48 dB residual AM below the 0 dB reference +20 dB = 68 dB residual AM below the carrier, or -68 dBc.) The residual AM should be <65 dBc. Record the residual AM in dBc on line 27 of the PTR.

As many other carrier frequencies may be tested as desired.

#### 4.9 RESIDUAL FM TEST

##### SPECIFICATION

<200 Hz in a 50 Hz to 15 kHz post-detection bandwidth.  
<100 Hz in a 300 Hz to 3 kHz post-detection bandwidth.

##### METHOD

A modulation meter which is set to read frequency deviation is used to measure residual FM. The test is performed at maximum frequency and output level. The instrument is operated in an FM mode where the residual FM is greatest.

The residual FM is measured in an environment where the noise level <60 dB relative to  $2 \times 10^{-4}$   $\mu$ bar.

##### EQUIPMENT

(6)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	FMx10
MODULATION FREQ	EXT
MODULATION FM/AM	0 kHz
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the RF OUT connector to the 50 ohm RF input of the modulation meter.

3. Set the modulation meter to read FM deviation at 520 MHz. Set the



meter range switch to 3, the RF input attenuation to 20 dB, the IF bandwidth to  $\pm 400$  kHz, the meter response to fast, and the filter bandwidth to 50 Hz – 15 kHz.

4. Measure the average level of the FM deviation on the modulation meter (disregard occasional peaks). The residual FM should be  $< 200$  Hz. Read the residual FM with the function switch set to +FM and -FM. Record the greater of the two readings in Hz on line 28 of the PTR.

As many other frequencies may be tested as desired.

#### 4.10 INTERNAL MODULATION FREQUENCY TEST

SPECIFICATION 400 Hz and 1 kHz  $\pm 5\%$

METHOD A frequency counter is used to measure modulation frequency at the instrument rear-panel MOD TP. Since the internal 400 Hz and 1 kHz oscillators are used for both the AM and FM modes, this test will suffice for both modes.

EQUIPMENT (3)

PROCEDURE 1. Set the instrument controls as follows:

FREQ VERNIER	N/A
Frequency selector	N/A
MODULATION MODE	N/A
MODULATION FREQ	400 Hz
MODULATION FM/AM	Mid-range
OUTPUT VERNIER	N/A
OUTPUT Step Attenuator	N/A

2. Connect the low frequency input of the frequency counter to the MOD TP (pin 36 of rear-panel PROGRAMMING jack J101) and the cable shield to ground (pin 25 of J101). (See Figure 2-3 and Schematic 1).

3. The counter should read between 380 and 420 Hz. Record the counter reading on line 29 of the PTR.

4. Set the MODULATION FREQ control to 1 kHz.

5. The counter should read between 950 and 1050 Hz. Record the counter reading on line 30 of the PTR.

#### 4.11 PERCENT AM ACCURACY TEST

SPECIFICATION  $\pm(5\% + 5\%$  of reading) at a frequency of 1 kHz. NOTE: This specification applies for output limits  $\leq +3$  dBm. AM is possible above +3 dBm if the peak of the modulated output does not exceed +13 dBm.

METHOD The %AM accuracy is measured with a modulation meter after the front-panel MODULATION FM/AM control error, which is  $\pm 4\%$ , is subtracted out. The MODULATION FM/AM slider accuracy, which consists of the control linearity and the modulation scale errors, is measured in terms of the DC voltage at the rear-panel MOD TP. The calibration of the voltage across the control at maximum position is checked initially.

The remaining %AM accuracy, which is  $\pm(5\%$  of the reading + 1% of full scale), is measured by the modulation meter with accurately measured voltage applied to the modulation system. The measurement uncertainty is 2% of the reading + 1% of full scale.

EQUIPMENT

(1) (6)

PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	CW
MODULATION FREQ	DC
MODULATION FM/AM	0% AM
OUTPUT VERNIER	-3 dB
OUTPUT Step Attenuator	0 dBm

2. Connect the equipment as shown in Figure 4-3. Connect the center conductor of the cable between the high terminal of the digital multimeter and the MOD TP (pin 36 of rear-panel PROGRAMMING jack J101). Connect the cable shield between the low terminal of the digital multimeter and ground (pin 25 of J101).

3. Set the MODULATION FM/AM slider to its full up position.

4. The digital multimeter should read  $5.000 \pm 0.020$  VDC. If the voltage is within limits, continue to step 5. If not, recalibrate (Section 5.3.9).

5. Set the MODULATION FM/AM slider to 30% AM.

6. The digital multimeter should read between 1.300 and 1.700 VDC. Record the reading on line 31 of the PTR.

7. Set the MODULATION FM/AM slider to 90% AM.

8. The digital multimeter should read between 4.300 and 4.700 VDC. Record the reading on line 32 of the PTR. NOTE: This concludes the MODULATION FM/AM control accuracy test. As many other points may be tested as desired.

9. Adjust the MODULATION FM/AM slider to 0% AM.

10. Set the modulation meter to read %AM at 520 MHz. Set the meter range switch to 100, the RF input attenuation to 10 dB, the IF bandwidth to  $\pm 400$  Hz, the meter response to fast, the function switch to +AM, and the filter bandwidth to 50 Hz – 15 kHz.

11. Adjust the MODULATION FM/AM slider for a reading of  $1.500 \pm 0.003$  VDC on the digital multimeter. Set the MODULATION FREQ switch to 1 kHz and the MODULATION MODE switch to AM.

12. Make a note of the modulation meter reading in %AM. Set the modulation meter function switch to -AM, and note the modulation meter %AM reading as before. Compute the average of the two readings. The average %AM should be between 27.5 and 32.5%. Record the average %AM to the nearest 0.5% on line 33 of the PTR.

13. Set the MODULATION MODE switch to CW and the MODULATION FREQ switch to DC.

14. Adjust the MODULATION FM/AM control for a reading of 4.500  $\pm$ 0.003 VDC on the digital multimeter. Set the MODULATION FREQ switch to 1 kHz and the MODULATION MODE switch to AM.

15. Make a note of the modulation meter reading in %AM. Set the modulation function switch to +AM and note the modulation meter %AM reading as before. Compute the average of the two readings. The average %AM should be between 84.5 and 95.5% AM. Record the average %AM to the nearest 0.5% on line 34 of the PTR.

As many other points may be tested as desired.

## 4.12 AM BANDWIDTH TEST

### SPECIFICATION

DC to 20 kHz (3 dB bandwidth), input level required = 10 Vpp into 600 ohms to provide calibrated %AM control.

### METHOD

The measurement is made with a modulation meter operating in AM mode and a function generator. The function generator supplies an external sine wave to amplitude modulate the instrument. The system is calibrated at -6 dB on the modulation meter dB scale (approximately 50% AM). The external modulation frequency is increased from 1 kHz to 20 kHz and the AM bandwidth is measured as the change in dB from the calibration level.

### EQUIPMENT

(4) (6) (7)

### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	050.000 MHz
MODULATION MODE	AM
MODULATION FREQ	EXT
MODULATION FM/AM	0% AM
OUTPUT VERNIER	+3 dB
OUTPUT Step Attenuator	0 dBm

2. Connect the equipment as shown in Figure 4-4.

3. Set the modulation meter to read %AM at 50 MHz. Set the RF input attenuation to 20 dB, the IF bandwidth to  $\pm$ 400 kHz, the meter response to fast, the function switch to +AM, the meter range switch to 100, and the filter bandwidth to 75 kHz.

4. Set the function generator for a 1 kHz sine wave output and the attenuator controls for a 10 Vpp sine wave on the oscilloscope.

5. Adjust the FM/AM control for a modulation meter reading of -6 dB (approximately 50% AM).

6. Maintain the 10 Vpp output level and increase the function generator frequency from 1 to 20 kHz. Observe the modulation meter scale. It should read between -6 and -9 dB. Note the change in dB from the -6 dB calibration level.

7. Repeat steps 4 through 6 with the modulation meter function switch set to -AM. Note the change in dB from the -6 dB setting as in step 6.
8. Record the larger of the two changes obtained in steps 6 and 7 on line 35 of the PTR.

#### 4.13 AM DISTORTION TEST

##### SPECIFICATION

3% distortion to 70% AM (5% to 90% AM) at a frequency of 1 kHz. Note: This specification applies for output limits  $\leq +3$  dBm. AM is possible above +3 dBm if the peak of the modulated output does not exceed +13 dBm.

##### METHOD

The measurement is made with a modulation meter and a distortion analyzer which measures the distortion of the demodulated AM from the modulation meter. The measurement is made at the minimum leveler point where the AM distortion is normally worst-case.

##### EQUIPMENT

(2) (6)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQUENCY VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	AM
MODULATION FREQ	1 kHz
MODULATION FM/AM	0% AM
OUTPUT VERNIER	-7 dB
OUTPUT Step Attenuator	0 dBm

2. Connect the equipment as shown in Figure 4-2.

3. Set the modulation meter to read %AM at 520 MHz. Set the RF input attenuation to 10 dB, the IF bandwidth to  $\pm 400$  kHz, the meter response to fast, the function switch to +AM, the meter range switch to 100, and the filter bandwidth to 50 Hz to 15 kHz.

4. Adjust the MODULATION FM/AM slider for a modulation meter reading of 70% AM. Set the modulation meter function switch to -AM, and observe the modulation meter reading. Readjust the MODULATION FM/AM slider until the average of the two modulation meter readings in +AM and -AM positions of the modulation meter function switch is equal to 70% AM.

5. Calibrate the distortion analyzer and measure the distortion. The distortion should be less than 3%. Record the distortion on line 36 of the PTR.

6. Adjust the MODULATION FM/AM slider as in step 4 until the average of the modulation meter readings in +AM and -AM positions of the modulation function switch is equal to 90% AM.

7. Calibrate the distortion analyzer and measure the distortion. The distortion should be less than 5%. Record the distortion on line 37 of the PTR.

#### 4.14 FM DEVIATION ACCURACY TEST

- SPECIFICATION**  $\pm 500$  Hz on FMx1 range;  $\pm 5$  kHz on FMx10 range.
- METHOD** The deviation is measured in both FM modes using an internal DC voltage equal to the peak of the internal sine wave voltages. A frequency counter is used to measure the maximum deviation in both FM modes.
- EQUIPMENT** (3)
- PROCEDURE**
1. Set the instrument controls as follows:

FREQ VERNIER	0 kHz
Frequency selector	050.000 MHz
MODULATION MODE	FMx1
MODULATION FREQ	DC
MODULATION FM/AM	10 kHz on FM scale
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm
  2. Connect the 50 ohm input of the frequency counter to the RF OUT connector.
  3. Read the frequency counter and record the reading to 8 places on line 38 of the PTR.
  4. Adjust the MODULATION FM/AM slider to 0 kHz deviation on the FM scale.
  5. Read the frequency counter and record the reading to 8 places on line 39 of the PTR.
  6. Subtract the reading obtained in step 5 from the reading obtained in step 3. The difference between the two readings should be between 9.500 and 10.500 kHz. Record the difference in kHz on line 40 of the PTR.
  7. Set the MODULATION MODE TO FMx10 and adjust the MODULATION FM/AM slider to 10 kHz deviation of the FM scale.
  8. Read the frequency counter and record the reading to 6 places on line 41 of the PTR.
  9. Adjust the MODULATION FM/AM slider to 0 kHz deviation on the FM scale.
  10. Read the frequency counter and record the reading to 6 places on line 42 of the PTR.
  11. Subtract the reading obtained in step 10 from the reading obtained in step 8. The difference between the two readings should be between 95.0 and 105.0 kHz. Record the difference in kHz on line 43 of the PTR.

#### 4.15 FM BANDWIDTH TEST

- SPECIFICATION** External, 50 Hz to 15 kHz, (1 dB bandwidth), input level required = 10 Vpp into 600 ohms to provide calibrated deviation control.  
(DC to 25 kHz when FREQ VERNIER is not in CAL position.)

METHOD

The measurement is made with a modulation meter and a function generator. The function generator supplies an external sine wave to frequency modulate the instrument. The system is calibrated with a 1 kHz external sine wave at an indicated deviation 1 dB below the 0 dB reference on the modulation meter dB scale (approximately 90 kHz deviation). The external modulation frequency is varied from 1 kHz to 50 Hz, and from 1 kHz to 25 kHz, and the FM bandwidth is measured as the change in dB from the calibrated level.

EQUIPMENT

(4) (6) (7)

PROCEDURE

1. Set the instrument controls as follows:

FREQUENCY VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	FMx10
MODULATION FREQ	EXT
MODULATION FM/AM	0 kHz
OUTPUT VERNIER	+3 dB
OUTPUT Step Attenuator	+10 dBm

2. Connect the equipment as shown in Figure 4-3.

3. Set the modulation meter to read FM deviation at 520 MHz. Set the RF input attenuation to 20 dB, the IF bandwidth to  $\pm 400$  kHz, the meter response to fast, the function switch to +FM, the meter range switch to 300, and the filter bandwidth to 75 kHz.

4. Set the function generator for a 1 kHz sine wave output and the attenuator controls for a 10 Vpp sine wave on the oscilloscope.

5. Adjust the MODULATION FM/AM slider for a modulation meter reading of -1 dB (approximately 90 kHz deviation).

6. Maintain the 10 Vpp external input level during this step. Slowly decrease the function generator frequency from 1 kHz to 50 Hz, and then slowly increase the frequency to 25 kHz while observing the dB scale on the modulation meter. It should read between 0 and -2 dB. Note the maximum change from the -1 dB reference (step 5) to the nearest 0.25 dB.

7. Repeat steps 4 through 6 with the modulation meter function switch set to -FM. Note the change from -1 dB reference as in step 6. Record the larger of the two changes in dB (in this step and in step 6) on line 44 of the PTR.

4.16 FM DISTORTION TEST

SPECIFICATION

2% (10 kHz to 100 kHz deviation) at a frequency of 1 kHz.  
4% (3 kHz to 10 kHz deviation) at a frequency of 1 kHz.

METHOD

The measurement is made with a modulation meter and a distortion analyzer which measures the distortion of the demodulated FM from the modulation meter. Distortion below 3 kHz deviation increases because of residual FM noise. The distortion at 3 kHz deviation is measured in an environment where the noise level  $< 60$  dB relative to  $2 \times 10^{-4}$   $\mu$ bar.

EQUIPMENT

(2) (6)

PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	FMx1
MODULATION FREQ	1 kHz
MODULATION FM/AM	3 kHz
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

2. Connect the equipment as shown in Figure 4-2.

3. Set the modulation meter to read FM deviation at 520 MHz. Set the RF input attenuation to 20 dB, the IF bandwidth to ±400 kHz, the meter response to fast, the function switch to +FM, the meter range switch to 3, and the filter bandwidth to 50 Hz – 15 kHz. The modulation meter should read approximately 3 kHz.

4. Calibrate the distortion analyzer and measure distortion. The distortion should be less than 4%. Record the distortion on line 45 of the PTR.

5. Set the meter range switch of the modulation meter to 300. Set the MODULATION MODE to FMx10.

6. Adjust the MODULATION FM/AM for a reading of 30 kHz deviation on the modulation meter.

7. Calibrate the distortion analyzer and measure the distortion. The distortion should be less than 2%. Record the distortion on line 46 of the PTR.

4.17 IMPEDANCE TEST

SPECIFICATION

50 ohms, VSWR 1.2 at RF output levels below 0.1 VRMS.

METHOD

The measurement is made with a VSWR bridge and the return loss is displayed on a spectrum analyzer. An RF signal from a signal generator is fed to the input of the bridge. A reference level is established by shorting the bridge output port. The short is replaced by the RF impedance of the instrument. The signal generator is tuned throughout its range and the return loss versus frequency is displayed.

EQUIPMENT

(8) (11) (12) (13)

PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	520.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	N/A
OUTPUT VERNIER	+3 dB
OUTPUT Step Attenuator	-10 dBm

2. Use the setup in Figure 4-5. Connect the signal generator to the input port, the spectrum analyzer to the reflected output port and the coaxial short to the device-under-test port of the VSWR bridge.

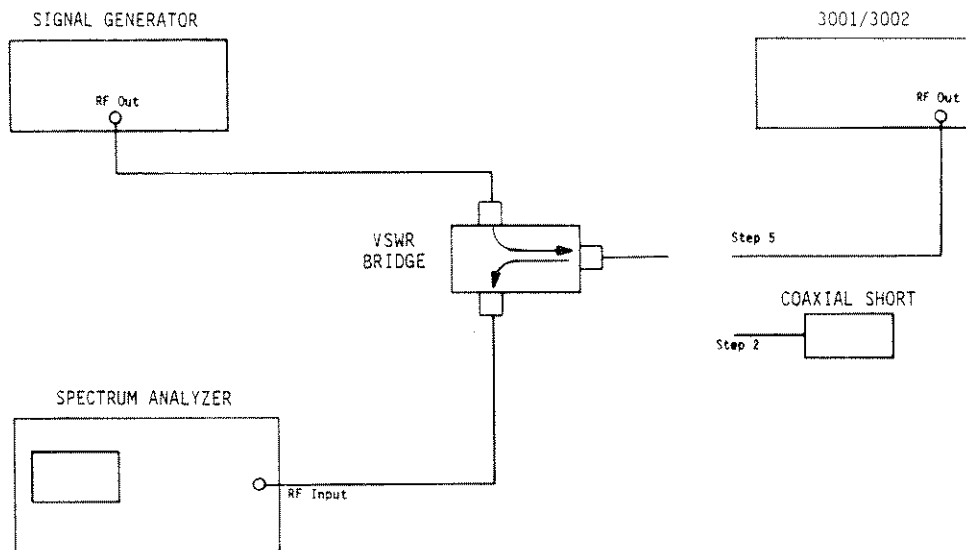
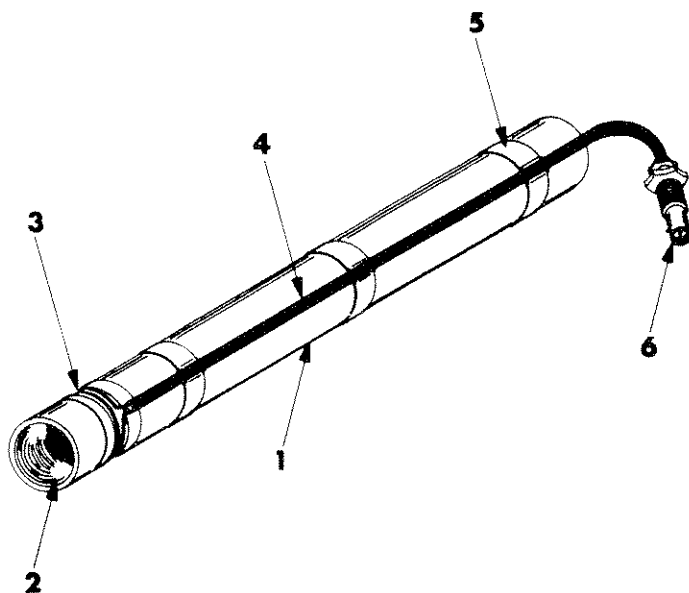


Figure 4-5. Test Set-up



1. Rexolite Rod: 1.25 in. dia. by 11 in.
2. Hole: 1.00 in dia. by 0.80 in. deep.
3. Groove: 0.120 in wide by 0.125 in deep 1.00 in from end of rod.
4. Coaxial Cable: (RG-174/U) 0.110" diameter by 19" long. Strip shield for 7 in, and cut off shield to  $\frac{1}{4}$  in length. Strip insulation from center conductor  $\frac{1}{4}$  in. Wind 2 turns of insulated center conductor in groove of rod. Solder shield to center conductor, and insulate the solder joint.
5. Wind mylar tape around the two-turn loop, and around the rod (three places).
6. BNC male connector.

Figure 4-6. Loop Probe

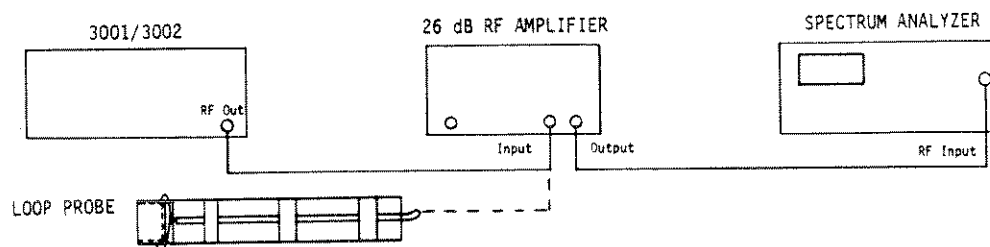


Figure 4-7. Test Set-up



3. Set the signal generator output level to -10 dBm, the mode to CW, and the frequency to 250 MHz.
4. Set the spectrum analyzer to span 0 to 500 MHz and the bandwidth to 300 kHz. Use the log reference level controls to calibrate the 250 MHz signal at the top line (0 dB reference) of the display graticule.
5. Disconnect the coaxial short and connect the device-under-test port of the VSWR bridge to the RF OUT connector. Tune the signal generator throughout the instrument's range and verify that the signal level in the display is 21 dB below the 0 dB reference. Disregard the signal at 520 MHz. Record the reading in dB below the reference on line 47 of the PTR.

#### 4.18 RFI TEST

##### SPECIFICATION

< 1.0  $\mu$ V is induced in a two-turn, one-inch diameter loop which is held one inch away from any surface. Loop feeds a 50 ohm receiver.

##### METHOD

A 50 ohm receiver consisting of a 26 dB amplifier and a spectrum analyzer are calibrated at a 1  $\mu$ V level using the instrument. A loop probe is then connected to the receiver and the leakage is measured at a one-inch distance from the external surfaces of the instrument with the RF OUT connector terminated in 50 ohms. A screen room may be required for this measurement.

##### EQUIPMENT

(8) (10) (14) (15) (16)

##### PROCEDURE

1. Set the instrument controls as follows:

FREQ VERNIER	CAL
Frequency selector	500.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
OUTPUT VERNIER	+3 dB
OUTPUT Step Attenuator	-110 dBm

2. Connect the equipment as shown in Figure 4-7.
3. Set the spectrum analyzer bandwidth to 100 kHz, the scan width to 0.5 MHz/division, the video filter to 100 Hz, the input attenuation to 0 dB and the log reference level to -50 dBm with a 10 dB/division vertical scale. Center the signal in the display using the center frequency control. Calibrate the analyzer for the -107 dBm signal at the -31 dBm graticule using the log reference controls.
4. Disconnect the RF amplifier from the instrument and connect the 50 ohm coaxial terminal to the RF OUT connector of the instrument. Tighten the termination to minimize RF leakage.
5. Set the OUTPUT Step Attenuator to -10 dBm and the OUTPUT VERNIER for a +3 dBm reading on the output METER.
6. Connect the loop probe to the input of the RF amplifier. Move the loop probe over the surfaces of the instrument with the two-turn loop at a one-inch distance. The signal plus noise should be less than the -107 dBm reference (step 2). Record the maximum reading in dBm on line 48 of the PTR.

# SECTION 5

## MAINTENANCE

### 5.1 INTRODUCTION

This section provides information for disassembly, calibration, and troubleshooting the Wavetek Models 3001/3002 Signal Generators.

Measurements and adjustments will be facilitated by placing the instrument on its right side, as access is required to the top and bottom of the unit for adjustments and test points.

### 5.2 SERVICE INFORMATION

#### 5.2.1 DISASSEMBLY INFORMATION

Refer to Figure 5-1. The side panels form part of the support for the top and bottom covers; therefore these covers should be removed before removing either side panel. The covers and panels can be removed as indicated below.

#### NOTE

**One side panel must remain on the instrument to secure the front-panel assembly to the chassis.**

**REMOVAL OF BOTTOM COVER** — Remove the two rear feet (A) and lift the cover off with a slight rear movement. Reinstall the cover by reversing the removal procedure.

**REMOVAL OF FRONT-TOP RAIL** — The top rail may be removed to facilitate removal of the Meter Board or Modulation Board assembly. The rail is removed by removing the three screws (D) and lifting the rail upward.

**REMOVAL OF SIDE PANEL** — Either side panel can be removed to provide better access by removing the six screws (E) holding the side panel to the instrument.

#### CAUTION

**To prevent possible damage when reinstalling side panels, use only the original screws or equivalent. Longer screws in the bottom two holes can cause damage to wiring.**

#### 5.2.2 MODULE SERVICING

**REMOVAL OF MODULE** — A module may be removed by removing any cables attached to top of the module and removing the hold-down screw (C) from the bottom. Rock the module slightly while lifting upward to free it from its chassis socket.

**REINSTALLING MODULE** — Before installing the module, check that all module pins are straight and properly aligned; then carefully seat the module pins into the chassis socket. Replace the module hold-down screw (C) to insure a good ground connection between the module and chassis, and replace any cables attached to the top of the module. Module cable connections are shown in Figure 5-6.

#### NOTE

**If a module is replaced with a new module, it will be necessary to calibrate the phase-locked loop or other circuits involved (see Table 5-3).**

**MODULE PIN NUMBERING SYSTEM** — The module pins are numbered as shown in Figure 5-2. The off-center index stud prevents the module's being plugged in backwards, and also provides a method for locating pin 1.

#### NOTE

**All 16 pins are not required in each module. Only the pins actually used are installed, but the numbering system remains the same.**

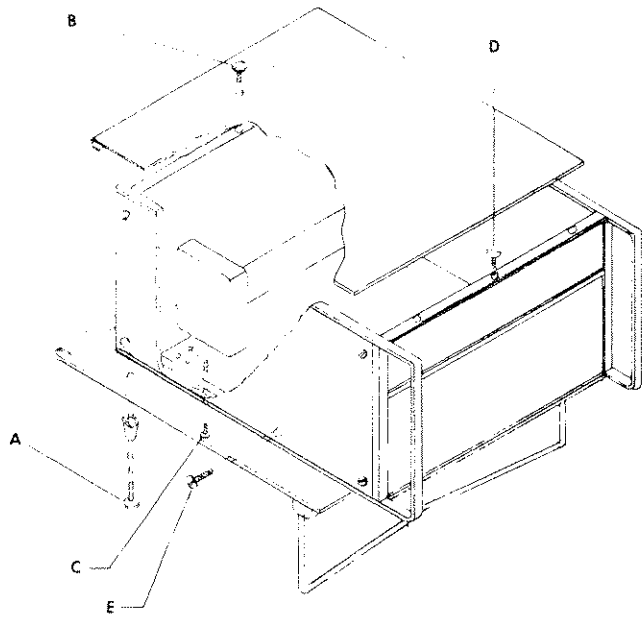


Figure 5-1. Dissassembly

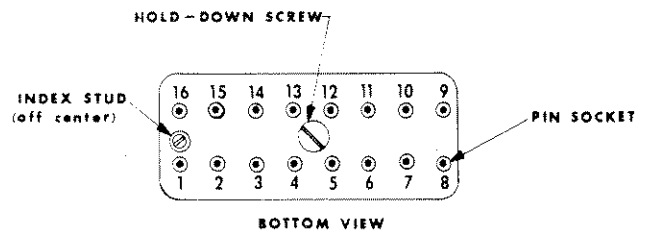


Figure 5-2. Module Pin Numbering System

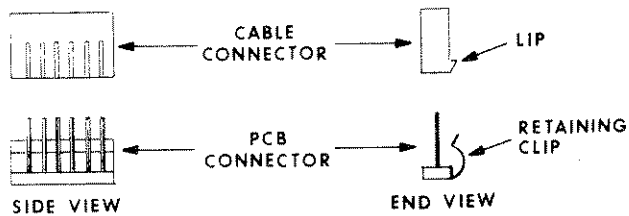


Figure 5-3. Connector Alignment

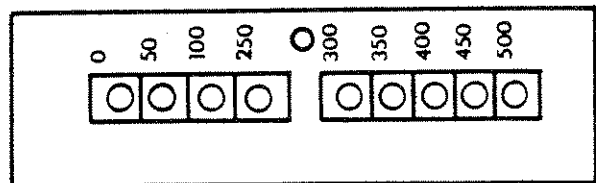


Figure 5-4. M172 Controls

## 5.2.3 PRINTED-CIRCUIT BOARD SERVICING

**PRINTED-CIRCUIT BOARD CONNECTORS** — When reinstalling a cable connector on a printed-circuit board, be sure the connector is properly aligned with the board connector pins and that the connector faces the proper direction (see Figure 5-3).

**METER BOARD (C315) REMOVAL** — Removal of the Meter Board assembly requires that the Attenuator dial, OUTPUT VERNIER knob and potentiometer retaining nut, and front top rail be removed. The Meter Board is secured to front panel by three screws — one through the front panel (behind Attenuator dial) and one at each top corner of Meter Board. Remove these three screws and disengage all slip-on wire connectors from the Attenuator mounted switch. The Meter Board assembly can then be moved toward the rear until the VERNIER potentiometer shaft, UNLEVELED lamp, and METER case clear the front panel. The board can then be lifted from the instrument.

The Meter Board is reinstalled by reversing the removal procedure. When installing the Meter Board, use care not to damage the UNLEVELED lamp.

**MODULATION BOARD (C316-2) REMOVAL** — The Modulation Board assembly can be removed by the following procedure: Disengage the slip-on connectors from the six BCD Lever/Indicator switches; disengage the twelve-pin connector from the Modulation Board; unsolder the wire from EXT modulation connector and remove retaining nut from the backside of this BNC connector; remove the black spring-loaded knobs from MODULATION MODE and FREQ switches; remove the knob from the FREQ VERNIER pot shaft; remove the front-top rail; then remove one screw from the top-left corner of the Modulation Board and one screw from the top-left corner of the Meter Board. The Modulation Board assembly can now be angled until the switch levers clear the front panel. The assembly then can be lifted from instrument.

The assembly is reinstalled by reversing the removal procedure.

### NOTE

**When placing connectors on Lever/Indicator switches, be sure each connector is on correct switch; the switch cables break out of the main harness in the same order that the switches appear.**

**POWER SUPPLY BOARD REMOVAL** — The Power Supply board and heatsink can be removed by removing the four screws which secure the printed circuit board to the instrument rear panel. After removal of the connecting harness, the board can be carefully lifted from the instrument.

## CAUTION

The Power Supply board may be raised far enough to allow checking of many components with the harnesses still connected; however, power must NOT be applied to the instrument unless the negative (ground) side of C10 is connected to the instrument chassis ground and to the positive (ground) side of C9 (jumper wires are sufficient).

The Power Supply board is reinstalled by reversing the removal procedure.

## 5.2.4 RECOMMENDED TEST EQUIPMENT

The test equipment numbered (1) through (8) in Table 4-1 is recommended for servicing, troubleshooting and calibrating the instrument.

## 5.3 CALIBRATION PROCEDURE

Remove the instrument top and bottom covers. Allow a two-hour warmup period before calibrating.

In general, calibration should be performed in the sequence given. Refer to Figures 5-4, 5-5 and 5-6 for test point and adjustment locations.

### NOTE

**All measurements are made with reference to chassis ground.**

### 5.3.1 +18 VOLT ADJUSTMENT

Connect the digital voltmeter to the orange +18 volt line on pin 3 of module M30-1. Set +18 V Adj on the Power Supply to produce +18.00 V.

### 5.3.2 -18 VOLT CHECK

Connect the digital voltmeter to the yellow -18 volt line on pin 4 of module M30-1. Set -18 V Adj on the Power Supply to produce -18.00 V.

### 5.3.3 +7.3 VOLT CHECK

Connect the digital voltmeter to the green +7.3 volt line on pin 2 of module M30-1. The reading must be +7.3 V  $\pm$ 150 mV.

### 5.3.4 CRYSTAL FREQUENCY ADJUSTMENT M30-1

Connect a frequency counter with a 50 ohm input to the instrument RF connector. Set the signal generator Lever/Indicator switches to a high frequency which is within the

counter's range, such as 500 MHz. Set the front-panel controls as follows:

FREQ VERNIER	CAL
MODULATION MODE	CW
MODULATION FREQ	EXT
MODULATION FM/AM	minimum
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm
METER FUNCTION	OUTPUT

Adjust the M30-1 Frequency Adjust trimmer (Figure 5-5) for a minimum-frequency indication on the counter, then carefully turn the Frequency Adjust trimmer clockwise until the counter indicates the frequency selected by Lever/Indicator switches. Disconnect the counter from the RF OUT connector. A final frequency check will be covered in Section 5.3.12.

### 5.3.5 PHASE-LOCKED LOOP 1 ADJUSTMENT M31A

No adjustment of module M31A is necessary.

### 5.3.6 PHASE-LOCKED LOOP 2 ADJUSTMENT M32A

See Figure 5-5 for location of M32A test points and Figure 5-6 for adjustment controls. Set the Lever/Indicator switches to 200.000 MHz and all other front-panel controls as in Section 5.3.4. Connect a digital voltmeter to M32A pin 14, and carefully adjust both Crystal Reference trimmers (A and B) to produce a minimum reading on the voltmeter. This voltage should be between +0.5 and +3.0 VDC. Set the Lever/Indicator switches to 239.000 MHz and note that the DVM reading is still within the above limits.

Set the Lever/Indicator switches to 200.000 MHz and connect the scope vertical input (DC, 1 V/division) to M32A pin 15. Adjust M32A control (A) for a 0 V scope indication. Set the Lever/Indicator switches to 239.000 MHz and adjust M32A control (B) to again produce a 0 V scope indication.

### 5.3.7 PHASE-LOCKED LOOP 3 ADJUSTMENT

PLL 3 consists of two modules: The M33-2 and the M9W. The test point is on module M33-2 (Figure 5-5), while the adjustment controls are on module M9W (Figure 5-6). Set the Lever/Indicator switches to 250.000 MHz and all other front-panel controls as in Section 5.3.4. Connect the scope vertical input (DC, 1 V/division) to M33-2 pin 5. Adjust M9W control (D) for a 0 V scope indication.

Set the front-panel controls as follows:

MODULATION MODE	FMx10
MODULATION FREQ	1 kHz

MODULATION FM/AM Full up

Set the scope vertical input (on M33-2 pin 5) for AC, 50 mV/division. Adjust M9W control (C) for minimum (null) indication of the 1 kHz sine wave on the scope.

### 5.3.8 PHASE-LOCKED LOOP 4 ADJUSTMENT

Calibration of PLL 4 involves three modules: M172, M9W, and M34. Test points are located on modules M172 and M34 (see Figure 5-5), while adjustment controls are located on modules M172 and M9W (see Figures 5-4 and 5-6).

Set the Lever/Indicator switches to 250.000 MHz and all other front-panel controls as in Section 5.3.4. Connect a digital voltmeter to M172 pin 1; then, adjust M172 250 MHz Adj for a 0.00 V reading on the voltmeter. The voltmeter may now be disconnected.

Connect a frequency counter to the RF OUT connector and connect the scope vertical input (DC, 1 V/division) to M34 pin 8. Adjust M9W control (A) for  $0 \pm 1$  V on the scope. The counter should indicate a frequency of 250 MHz.

#### NOTE

**Due to the way the M34 locks on harmonics of 40 MHz, it is possible to adjust M9W control (A) for 0 V at multiples of 40 MHz offset from 250 MHz. If this happens, it will be necessary to readjust M9W control (A) several turns to break lock and relock at the next multiple of 40 MHz until  $0 \pm 1$  V can be obtained with a 250 MHz counter reading.**

Set the output frequency to 300 MHz and adjust M172 300 MHz Adj for  $0 \pm 3$  V on the scope with a counter reading of 300 MHz. Repeat this step, using the applicable M172 Adj for frequencies of 350, 400, and 450 MHz.

Set the Lever/Indicator switches to 500.000 MHz. Adjust M172 500 MHz Adj for a scope reading near 0 V. Increase the Lever/Indicator switch setting to 520.000 MHz and note the scope indication; then, adjust M172 500 MHz Adj to give scope indications at 500.000 and 520.000 MHz that are symmetrical about 0 V.

Set the Lever/Indicator switches to 100.000 MHz and adjust M172 100 MHz Adj for  $0 \pm 3$  V on the scope and a counter reading of 100 MHz. Repeat using the appropriate M172 Adj for frequencies of 50 and 0 MHz. (Set Lever/Indicator switches to 001.000 MHz for 0 MHz adjustment.)

Connect the digital voltmeter to M34 pin 14 (Leveler TP). Step through the frequency range from 1 to 520 MHz in 10 MHz steps to find the frequency having the highest leveler voltage, then adjust M9W control (B) for +1.0 VDC at this frequency setting.

### 5.3.9 PHASE-LOCKED LOOP 5 ADJUSTMENT

Adjustment controls for PLL 5 are located on Modulation Board C316-2 and module M29-2 (Figure 5-6), while the MOD TP is located on under side of the chassis (Figure 5-5). Connect a frequency counter to the front-panel RF OUT connector and a digital voltmeter to the MOD TP. Set the front-panel controls as follows:

FREQ VERNIER	0 kHz
Frequency selector	2.000 MHz
MODULATION MODE	FMx10
MODULATION FREQ	DC
MODULATION FM/AM	Full up
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

#### NOTE

Modulation Board C316-2 contains a Size Adj (C) and a Balance Adj (D) which are factory adjustments. DO NOT change the settings of these two controls.

Adjust Modulation Board control (A) for a +5.00 ±0.1 V reading on the voltmeter. Set the MODULATION FM/AM slider full down. The voltmeter should indicate 0 V ±20 mV. Disconnect the voltmeter from the MOD TP.

Adjust M29-2 control (B) to produce a frequency counter reading of 2.000 MHz ±100 Hz. Set the MODULATION FM/AM slider full up and adjust M29-2 control (A) for a counter reading of 2.100 MHz ±100 Hz.

Set the MODULATION MODE to FMx1 and adjust Modulation Board control (B) for a counter reading of 2.010 MHz ±100 Hz.

### 5.3.10 METER BOARD CALIBRATION – C315

To adjust the output METER, the unit must rest on its bottom surface (normal operating position). Momentarily turn off power to the instrument and mechanically zero the output METER with the front-panel zero adjust screw. The METER needle should bisect the dot at the left end of the METER scale. Restore power to the instrument and allow it to stabilize.

Set the OUTPUT VERNIER fully ccw; then, adjust Meter Board pot (B) until the METER needle again bisects the dot at the left end of the METER scale. See Figure 5-6 for the locations of the Meter Board pots. Set the OUTPUT VERNIER completely cw and adjust Meter Board pot (A) for a +3 dBm output METER reading.

Set the front-panel controls as follows:

FREQ VERNIER	CAL
Frequency selector	50.000 MHz

MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	minimum
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	+10 dBm

Calibrate the power meter and its thermistor or power sensor. Set the power meter to the +15 dBm range; then connect the thermistor or sensor to the instrument RF OUT connector.

Adjust Meter Board pot (F) for a +13 dBm power meter reading. Set the OUTPUT VERNIER for a -7 dB reading on the output METER and set the power meter to the +5 dBm range. Adjust Meter Board pot (E) for a +3 dBm power meter reading. Again set the power meter to the +15 dBm range and turn the OUTPUT VERNIER fully cw. Repeat this procedure until the +13 and +3 dBm power meter readings are obtained without further adjustment of Meter Board pots (E) and (F).

Set the OUTPUT Step Attenuator to 0 dBm and the power meter to the +5 dBm range. With the OUTPUT VERNIER completely cw, adjust Meter Board pot (C) for a +3 dBm power meter reading. Set the OUTPUT VERNIER for a -6 dBm reading on the output METER and set the power meter to the -5 dBm range. Adjust Meter Board pot (D) for a -6 dBm power meter reading. Repeat this procedure until the +3 and -6 dBm power meter readings are obtained without further adjustment of Meter Board pots (C) and (D).

Set instrument front-panel controls as follows:

Frequency selector	100.000 MHz
MODULATION MODE	AM
MODULATION FREQ	DC
MODULATION FM/AM	Full down
OUTPUT Step Attenuator	0 dBm

Set the power meter to its 0 dBm range and adjust the OUTPUT VERNIER for a -3 dBm reading on power meter. Set the power meter to the +5 dBm range and slide the MODULATION FM/AM slider fully up. Adjust Meter Board pot (G) for a +3 dBm reading on the power meter. This dB increase corresponds to 100% AM.

### 5.3.11 DOWN-CONVERSION ADJUSTMENT – M115 (MODEL 3002 ONLY)

Set the instrument front-panel controls as follows:

FREQ VERNIER	CAL
Frequency selector	001.000 MHz
MODULATION MODE	CW
MODULATION FREQ	N/A
MODULATION FM/AM	minimum
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	0 dBm

Connect a power meter, spectrum analyzer, RF detector, AC voltmeter, or oscilloscope — accurate in the vicinity of 1 MHz — to the instrument RF OUT connector. Note the output level reading. Set the Lever/Indicator switches to 000.999 MHz, and adjust the M115 Gain control such that the output level exactly matches the level noted at 001.000 MHz.

#### 5.3.12 FINAL FREQUENCY CHECK — M30-1

Connect frequency counter to the instrument RF OUT connector, and set the front-panel controls as specified in Section 5.3.4. Note the frequency reading on the counter. If it does not agree with the selected frequency within accuracy specifications, very carefully adjust the M30-1 Frequency Adjust trimmer (see Figure 5-5) until the desired frequency is obtained.

### 5.4 TROUBLESHOOTING

Effective troubleshooting requires a thorough understanding of the block diagrams and circuit description located in Section 3 of this manual; then the Performance Tests in Section 4 and Calibration Procedures in Section 5 will aid in localizing the trouble symptom to a particular module or PC board. Once this has been accomplished, the module or board can be replaced, or repaired with aid of the proper schematic and parts layout diagram. In general, it is preferable to replace a defective module or PC board assembly.

Equipment troubles are frequently due simply to improper control settings; therefore, before engaging in a troubleshooting procedure, be sure front-panel controls are set in proper operating position. Refer to the operating instructions in Section 2 of this manual for a complete explanation of each control's function along with typical operating instructions.

After verifying that the trouble is not improper setting of the controls or test setup, make a thorough visual inspection of the instrument for such obvious defects as loose or missing screws, broken wires, defective module-pin sockets, loose RF cables, and burned or broken components.

After localizing the problem, voltage and resistance checks will help locate the defective component.

For troubleshooting purposes, it is permissible to operate the instrument with any of the plug-in modules or RF cables removed; however, the instrument should be turned off when removing or installing modules. If substitute modules are available, possibly from another Model 3001 or 3002, this provides an easy method of verifying if a suspected module is defective.

RF cables can be disconnected from the module output connectors, and a power meter or spectrum analyzer connected directly to the module connector for power level or frequency measurements. Fabrication of a short coax adapter cable, terminated in a mating connector for the modules on one end and a BNC connector on the other, will facilitate connection of test equipment. (The SMC to BNC adapter cable in Module Service Kit K004 is designed for this purpose.)

The front-panel ACCURACY lamps together with the four internal module "unlock indicator" lamps aid in troubleshooting phase-locked loop problems. One module in each loop contains an indicator lamp which lights to indicate when that loop is unlocked. The lamps indicate only which loops are unlocked, not which module is at fault.

A problem in the Power Supply may cause many symptoms pointing to other areas and should be checked when the symptom does not clearly indicate a specific problem. Loss of the -18 V supply, for example, will cause the ACCURACY lamp to flash; while loss of the +18 V supply will extinguish all lamps. The +18, -18, and +7.3 V supplies comprise the DPS2A Power Supply which forms the rear panel of the instrument. Performance of these supplies is indicated in the Calibration Procedure.

#### 5.4.1 TROUBLESHOOTING HINTS

Following is a list of several typical symptoms, accompanied by the possible cause(s) or a troubleshooting procedure. It is assumed the instrument has been properly calibrated previously, and that a warmup period will precede troubleshooting.

**INTERMITTENT OPERATION — Defective module-pin sockets or loose RF cables.**

**LOW RF OUTPUT (+10 dBm RANGE) —** If power is 10 dB low on this range, but is correct on the 0 dBm range, micro-switch S1 mounted on the Step Attenuator is defective, is not being actuated by the Attenuator shaft, or a switch wire is disconnected.

**LOW OR NO RF OUTPUT (ANY RANGE) —** Defective Attenuator or RF cables connecting to input or output of Attenuator, defective Meter Board, defective module M10W-6/8 or M9W.

Check the voltage on pin 15 of module M10W-6/8. With the OUTPUT VERNIER fully clockwise, the voltage should be approximately as follows: -2.5 VDC on the +10 dBm range; -0.7 VDC on the 0 dBm range. These voltages indicate proper operation of the Meter Board; while other values, particularly positive voltages, indicate a defective IC or other problem on the Meter Board.

Next, check RF power directly at the M10W-6/8 output. If it is correct, the trouble lies in the Attenuator or its RF cables. If the module M10W-6/8 output is low, measure the module M9W RF output — this should be approximately -10 to -11 dBm. If this level is correct, module M10W-6/8 is defective; while if the level is low, Sweep Oscillator M9W is defective.

**OUTPUT METER DOES NOT MOVE** — If the METER is pegged at either end of scale, the trouble is probably a defective component on Meter Board C315; while if the METER remains at mechanical zero, the METER movement may be open or a Meter Board component may be defective.

**UNLEVELED LAMP ON** — RF OUT connector not terminated in 50 ohm load, AM percentage set so that peak of modulated output exceeds +13 dBm, defective module M10W-6/8, defective Attenuator or connecting RF cables.

Connect a power meter directly to the M10W-6/8 output. Set the OUTPUT Step and VERNIER controls for a +13 dBm reading on the power meter at 50.000 MHz. Step through the 10 to 520 MHz frequency range in 10 MHz steps. A power meter reading of +13 dBm  $\pm$ 0.5 dB with the UNLEVELED lamp off indicates proper operation of module M10W-6/8. If the output is correct at M10W-6/8, but the UNLEVELED lamp is on, the trouble is probably a defective lamp driver circuit in module M10W-6/8. With proper operation of module M10W-6/8, connect the power meter directly to the Step Attenuator output and repeat the above steps. If the Attenuator output is correct, the trouble is due to a defective RF cable or possibly a poor ground connection at RF OUT connector.

**ACCURACY LAMP FLASHES CONTINUOUSLY** — A steady light in CW mode but flashing in FM modes indicates a defective M29-2 or M33-2 module. If the ACCURACY lamp flashes in all modes, one or more of the phase-locked loops is open; see Phase-Locked Loop Troubles below.

#### NOTE

**Above the normal frequency range of the instrument (in the vicinity of 560 MHz), it is normal for phase-locked loop 4 to unlock, causing the ACCURACY lamp to flash.**

**PHASE-LOCKED LOOP TROUBLES** — An open or unlocked loop, indicated by a lighted module lamp, can be caused by a number of factors, including: low AC input voltage, low DC supply voltages, improper phase-locked loop DC voltages, an open or shorted RF cable, or a defective module.

A defective RF cable or module can have a "chain-reaction" effect that causes two or more loops to unlock. For example, loss of the 1 kHz signal to module M31A will

cause PLL 1 to unlock; thus, module M31A may not supply a proper signal to module M34, causing PLL 4 to unlock. Failure of the 40 MHz Crystal Oscillator in module M30-1 will cause all loops to unlock, since all six reference frequencies will be lost.

Table 5-1 lists typical RF signal-input levels for each of the phase-locked loops. Those signals having a TTL level or 1 V level may be measured with a high-frequency oscilloscope; the other signals are best measured with a spectrum analyzer (dBm), or a 50 ohm detector and calibrated scope (mV).

#### NOTE

**The TTL waveform shown in Table 5-1 is for illustration of voltage values only, and does not necessarily represent the observed wave-shape.**

**PHASE-LOCKED LOOP 1** — Unlocking of this loop may be caused by a defective module M31A, module M30-1 or RF cable connecting M30-1 to M31A.

If the M31A unlock indicator is on, check the 1 kHz signal as listed in Table 5-1. If the 1 kHz signal is correct, module M30-1 is operating properly. Check the RF cable between M30-1 and M31A. If the proper 1 kHz signal is being applied to the M31A, check for +7.3 V on pin 6, +18 V on pin 7, and -18 V on pin 8 of M31A. If the input signal and DC voltages are correct, module M31A is defective.

**PHASE-LOCKED LOOP 2** — Unlocking of loop 2 can be caused by defective modules M172, M30-1, M32A or RF cables connecting M30-1 to M32A.

Connect a digital voltmeter to M32A pin 11 and observe the readings while stepping through the 200 to 239 MHz frequency range in 1 MHz steps. The voltmeter reading should change -0.2 V per MHz from 0 V at 200 MHz to -7.8 V at 239 MHz. These voltages indicate proper operation of module M172.

Module M30-1 can be checked by measuring the 1 MHz and 1440 MHz signals directly at the M30-1. The levels specified in Table 5-1 indicate proper operation of module M30-1. Check connectors and RF cables connecting M30-1 to module M32A. Check for +18 V on pin 7, -18 V on pin 8, and +7.3 V on pin 9 of M32A. If all input signals and DC voltages to module M32A are normal, but the M32A LED is on, module M32A is defective.

**PHASE-LOCKED LOOPS 3 and 5** — The LED indicator on module M33-2 serves both PLL 3 and PLL 5. If the M33-2 LED is on, determine which loop is defective by switching the FREQUENCY VERNIER out of CAL position. If the M33-2 LED goes off, the trouble is in PLL 5; if the LED stays on, the trouble is in PLL 3.



PLL 3 consists of modules M33-2 and M9W. It is possible that PLL 3 can be restored to operation simply by recalibrating per Section 5.3.7, and this should be attempted. If adjusting M9W control (D) has no effect on the M33-2 pin 5 voltage, the problem is in module M33-2; however, if the pin 5 voltage changes but phase lock cannot be established, or if the pin 5 voltage cannot be set to within 5 volts of 0 V, the trouble is in module M9W. Measure the M33-2 Leveler TP (pin 14) voltage. If it is +0.5 to 5 VDC, the trouble is probably in module M33-2; however, if it is greater than 5 VDC, the trouble is probably in module M9W or M30-1. Check the M30-1 reference frequencies and M9W output level as shown in Table 5-1 to determine which module is defective.

PLL 5 consists of modules M29-2 and M33-2. With the **FREQ VERNIER** in **CAL** position, measure the PLL 5 voltage on M29-2 pin 6. Adjust M29-2 control (B) for 0 V on pin 6. If, while adjusting the M29-2 from 1.9 to 2.1 MHz this voltage does not move, the problem is in module M33-2. If the voltage adjusts, but will not stay locked, the trouble is in module M29-2.

**PHASE-LOCKED LOOP 4** — Unlocking of loop 4 may, under certain conditions, be caused by problems originating in the other loops. Therefore, loops 1, 2, and 3 should be operating properly before troubleshooting loop 4.

Unlocking of PLL 4 can be caused by defective modules M172, M9W, M30-1, M31A, M32A, M34, or connecting RF cables.

Connect a digital voltmeter to M172 pin 1. The voltmeter reading should be 0.00 V with the Lever/Indicator switches set to 000 MHz, -2.5 V at 250 MHz, and -5.0 V at 500 MHz. Connect the voltmeter to M172 pin 8. The M172 voltmeter reading should be +5 to +8 V at 000 MHz, 0 V at 250 MHz, and -6 to -10 V at 500 MHz. If these voltages are obtained, module M172 is operating properly.

Measure the Wide Oscillator signal at module M9W. The frequency will be between 1198 MHz and 1718 MHz, depending upon the Lever/Indicator switch setting. If the signal level is as specified in Table 5-1, module M9W is probably operating correctly.

Measure the 40 comb line at module M30-1. The 40 MHz harmonics from 40 MHz to 280 MHz should be fairly equal in amplitude and the level should be as specified in Table 5-1. This level indicates proper operation of the M30-1 module.

Measure the 1448 to 1487 MHz signal at module M32A. The exact frequency is dependent upon the "MHz" switch setting. If the level is as specified in Table 5-1, the M32A is operating properly.

Next, measure the 10 to 9.001 MHz output of the M31A module. The output frequency will be 10.000 MHz with the "kHz" switches set to 000, and will decrease to 9.001 MHz with the "kHz" switches set to 999. If the signal level is as specified in Table 5-1, module M31A is operating properly.

If the output of each of the above modules is correct, check the connectors and RF cables connecting modules M9W, M31A, M32A, and M30-1 to module M34. Check for +7.3 V on pin 2, +18 V on pin 3, and -18 V on pin 4 of module M34. If all input signals and DC voltages to module M34 are correct, but the M34 module lamp is on, module M34 is probably defective, but the trouble could be caused by module M9W.

A further check of the M34 can be made by monitoring M34 pin 8 with a digital voltmeter while stepping through the 10 MHz to 520 MHz frequency range in 10 MHz steps. The voltmeter reading should be  $0 \pm 3$  V; however, a defective M34 may give a voltage reading of 12 to 16 V.

**LEVER/INDICATOR SWITCHES** — Troubles in the BCD switch circuits may be caused by a defective switch, a loose or disengaged switch connector, a broken switch wire, or, possibly, a defective M115.

Five of the switches utilize four wires plus a ground to select decimal digits from 0 through 9. The 100's MHz switch uses three wires plus ground, since it needs only to select digits between 0 and 5. A "BCD Truth Table", applicable to each of the six switches, is given in Table 5-2.

Suspected switch problems can be checked by referring to Table 5-2 and the instrument Wiring Diagram to determine which module pins are grounded for a particular frequency. For example, to select a frequency of 200.5000 MHz, M172 pin 3 is grounded by selecting digit 2 on the 100's MHz switch, and M31A pins 2 and 4 are grounded by digit 5 on the 100's kHz switch.

If only the 10 MHz programming is in error, the trouble may be a defective IC3 in module M115 (Model 3002).

**DOWN-CONVERSION TROUBLES** (Model 3002) — Problems in the down-conversion circuitry (modules M115 and M10W-8) can cause a variety of problems.

If the instrument operates properly from 1 to 520 MHz, but not from 1 to 999 kHz, the problem probably lies in either module M115 or M10W-8. Check for the TTL "turn-on" signal at pin 5 of the M10W-8. If the signal is correct (0 V above 1 MHz, 3 V below 1 MHz), check to see that the RF signal is being switched to the M115 for output frequencies below 1 MHz. If the switch is working, the problem lies in either the M115 or a connecting cable. If the instrument output frequency is 10 MHz higher than

Table 5-1. PHASE-LOCKED LOOP RF-SIGNAL LEVELS

P.L.L.	MODULE	INPUT-SIGNAL FREQUENCY	INPUT-SIGNAL LEVEL dBm (mV)	MEASURED AT
1	M31A	1 kHz	TTL	M30-1 (W13)
2	M32A	1 MHz 1440 MHz	TTL -12 to -15 dBm (20 mV)	M30-1 (W12) M30-1 (W9)
3 & 5	M33-2	1198 MHz 1200 MHz (120 comb) 2 kHz 1.9 to 2.1 MHz	-10 dBm $\pm$ 3 dB (150 mV) -15 dBm $\pm$ 5 dB (75 mV) TTL 1 volt pp	M9W (W5) M30-1 (W10) M30-1 (W11) M29-2 (W7)
4	M34	1198 to 1718 MHz 1448 to 1487 MHz 40 to 280 MHz (40 comb) 10 to 9.001 MHz	-10 dBm $\pm$ 5 dB (25 mV) -2 dBm $\pm$ 3 dB (200 mV) -10 dBm $\pm$ 3 dB (1 V) TTL	M9W (W4) M32A (W8) M30-1 (W6) M32A (W14)

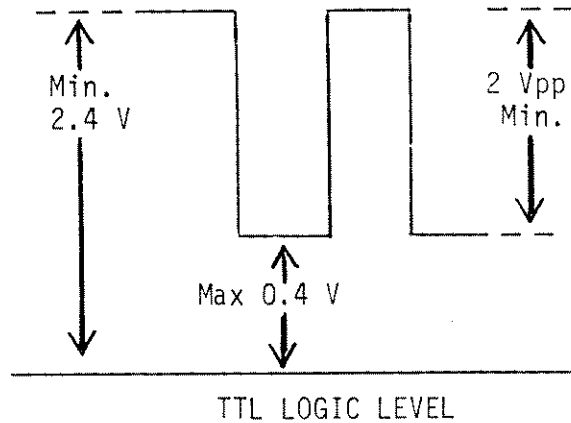


Table 5-2. BCD FREQUENCY SWITCHES

Decimal Digit	BCD Wires			
	8	4	2	1
0	-	-	-	-
1	-	-	-	0
2	-	-	0	-
3	-	-	0	0
4	-	0	-	-
5	-	0	-	0
6	-	0	0	-
7	-	0	0	0
8	0	-	-	-
9	0	-	-	0

NOTE: 0 = Wire Grounded by Switch.  
- = Wire NOT Grounded.

the programmed frequency (for example, 10.420 MHz instead of 420 kHz), and the TTL signal at pin 5 of module M10W-8 is correct, the switch is not working, and the problem lies in the M10W-8.

If the instrument operates properly from 1 to 999 MHz, but not above 1 MHz, check for the TTL signal at pin 5 of module M10W-8. If it is correct, the problem lies in the M10W-8.

If the RF output level from 1 to 999 kHz is too low, and cannot be corrected by recalibration, the problem lies in either the M115 or a connecting cable.

**MODULATION TROUBLES** — The Modulation Board (C316-2) is the most common cause of modulation problems, particularly when the modulating signal is lost. Non-linear amplitude modulation at higher-audio frequencies from an external source may be caused by the M10W-6/8 Output Amplifier.

Set the front-panel controls as follows to determine the presence of modulating signal:

FREQ VERNIER	CAL
MODULATION MODE	AM
MODULATION FREQ	400 Hz
MODULATION FM/AM	maximum
OUTPUT VERNIER	Full cw
OUTPUT Step Attenuator	0 dBm

Connect the oscilloscope vertical input to the rear-panel MOD TP. The scope should display a 10 Vpp sine wave at a frequency of 400 Hz (2.5 msec period). Set the MODULATION FREQ switch to 1 kHz. The scope display should be a 10 Vpp sine wave with a period of 1 msec. If the 10 V signals are not obtained, check for +7.3 V on pin 8, +18 V on pin 2, and -18 V on pin 2 of the C316-2 Modulation Board. If the DC voltages are normal, the Modulation Board is defective.

**AM TROUBLES** — Connect the scope vertical input to pin 3 of the C316-2 Modulation Board and check for a 10 Vpp

sine wave; then, connect the scope vertical input to pin 4 of Meter Board C315 and again check for a 10 V sine wave. Presence of the sine wave at this point indicates proper operation of the Modulation Board and its wiring.

Connect the scope vertical input to pin 2 of Meter Board C315 and check for a sine wave having an approximate amplitude of 1.75 Vpp. If the 1.75 V signal is not present, check for +18 V on pin 6 and -18 V on pin 5 of the Meter Board. If the DC voltages are normal, Meter Board C315 is defective or a wire is disconnected from Attenuator switch S1.

Check for a 1.75 Vpp sine wave on pin 15 of module M10W-6/8. If the sine wave is normal at this point, but amplitude modulation is abnormal, module M10W-6/8 is defective.

**FM TROUBLES** — Set the MODULATION MODE to FMx10 and check for a 10 Vpp sine wave on pin 6 of Modulation Board C316-2; then, connect the scope vertical input to pin 16 of module M29-2 and again check for a 10 V sine wave. A 400 Hz or 1 kHz 10 V sine wave at this point indicates proper operation of the Modulation Board and its wiring.

Remove the RF cable from the top of module M29-2, and check for a 1 Vpp 1.9-2.1 MHz signal at this connector. If this signal is not present, check for +18 V on pin 3 and -18 V on pin 4 of module M29-2. If the DC voltages are normal, FM problems are caused by a defective module M29-2. If the 1.9-2.1 MHz signal is present at the M29-2 connector, FM problems are probably caused by a defective M33-2 module.

#### 5.4.2 ASSEMBLY REPLACEMENT

While in many cases the instrument will work satisfactorily after simply replacing a defective assembly, to maintain the high accuracy of which the unit is capable, assembly replacement should be followed by calibration of the affected circuits. Table 5-3 lists each assembly and the adjustment needed.

Table 5-3.  
Assembly  
Replacement  
Calibration

<b>ASSEMBLY REPLACED</b>	<b>ADJUSTMENT REQUIRED</b> (See indicated sections in Calibration Procedure)
M9W Sweep Oscillator	Reset Phase-Locked Loops 3 and 4 (5.3.7 and 5.3.8)
M10W-6/8 Output Amplifier	Recalibrate C315 Meter Board (5.3.10)
M172 Sweep Drive/DAC	Reset Phase-Locked Loop 4 (5.3.8)
M29-2 FM Reference	Reset Phase-Locked Loop 5 (5.3.9)
M30-1 Crystal Reference	Adjust Crystal Frequency (5.3.4 and 5.3.12)
M31A kHz Steps	None required
M32A MHz Steps	Adjust Phase-Locked Loop 2 (5.3.6)
M33-2 Narrow Osc. Lock	Adjust Phase-Locked Loop 3 (5.3.7)
M34 Wide Osc. Lock	Set M34 pin 14 for +1.0 VDC (5.3.8)
M115 Down Converter	Adjust Gain Calibration (5.3.11)
C315 Meter Board	Adjust Meter Board Calibration (5.3.10)
C316-2 Modulation Board	Adjust Phase-Locked Loop 5 (5.3.9)
DPS2A Power Supply	Adjust ±18 V and check 7.3 V (5.3.1-5.3.3)