SECTION

INFORMATION &
SPECIFICATIONS

INSTALLATION

OPERATION

THEORY OF
OPERATION

MAINTENANCE
& SERVICE

ADJUSTMENTS
& CALIBRATION

PERFORMANCE
TESTS

PARTS LISTS

SCHEMATICS,
DESCRIPTIONS,
LOCATORS

OPTIONS

DANA
EIP

MODEL 371

Source Locking
Autohet Microwave Counter

Operating & Service Manual

Serial Prefix/CCN Group beginning:

EIP INCORPORATED
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Santa Clara, CA 95051
Tel: (408) 244 - 7975
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Manual Part Number: 5580012
Manual printed in U.S.A.
July 1977

DB

CERTIFICATION

EIP Incorporated certifies that this instrument was thoroughly inspected and tested, and found to be in conformance with the specifications noted herein at time of shipment from factory.

WARRANTY

EIP Incorporated warrants this counter to be free from defects in material and workmanship for one year from the date of delivery. Damage due to accident, abuse, or improper signal level, is not covered by the warranty. Removal, defacement, or alteration, of any serial or inspection label, marking, or seal, may void the warranty. EIP Incorporated will repair or replace at its option, any components of this counter which prove to be defective during the warranty period, provided the entire counter is returned PREPAID to EIP or its authorized service facility. In-warranty counters will be returned freight prepaid; out-of-warranty units will be returned freight COLLECT. No other warranty other than the above warranty is expressed or implied. EIP Incorporated and Danalab Incorporated, are not liable for consequential damages.

ASSISTANCE

For assistance, contact the EIP representative in your area, or EIP Incorporated.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF ILLUSTRATIONS

NOTE: The following Figures include the Component Locator, Circuit Description, and Schematic Diagram for the PCB Assemblies in this counter. All related sheets for a particular Assembly have the same figure number.

SECTION 1

GENERAL INFORMATION & SPECIFICATIONS

1-1. DESCRIPTION

1-2. The EIP 371 Source Locking Autohet Microwave Counter automatically measures the frequency of any CW signal within the range of 20 Hz to 18.0 GHz. This frequency range is covered in three bands: 20 Hz to 300 MHz, 100 MHz to 850 MHz, and 825 MHz to 18 GHz.

1-3. Measurements in Band I (20 Hz to 300 MHz) are made with a 300 MHz direct electronic counter. Band II (100 MHz to 850 MHz) uses a prescaler to divide the input signal by a factor of four into the frequency range of the 300 MHz direct counter. Band III (850 MHz to 18.0 GHz) measurements are made by heterodyning the input frequency with an automatically selected harmonic of an internal 200 MHz comb generator, producing a difference frequency which falls within the range of the 300 MHz direct counter. The inaccuracy of the indicated reading by the counter, is directly related to the quality of the time base oscillator over the entire operating range of the counter (see Sections 1 and 6).

1-4. The display on the 371 Counter provides a direct readout of the measured frequency over the entire operating range of the counter. The 371 Counter also includes automatic suppression of leading zeros, except during a no signal input condition.

1-5. The frequency readout of the 371 Counter is displayed in a fixed position format that is conveniently sectionalized in GHz, MHz, kHz, and Hz. Four gate times: 1 ms, 10 ms, 100 ms, and 1 second, are automatically selected depending upon the setting of the RESOLUTION switch.

1-6. For applications where less resolution is required, pushbutton display blanking (RESOLUTION) is provided to simplify the readout.

1-7. To assure trouble-free performance, the EIP 371 Counter is completely solid-state. For ease of repair and maintenance, the major portion of the counter circuitry is contained on plug-in printed circuit boards or in easily removed modules. Special test points allow monitoring of critical circuit functions.

1-8. INSTRUMENT IDENTIFICATION

1-9. The 371 Counter is identified by two number sets: the Model and Configuration Control Number (e.g. 371-CCN 1201), and a specific Serial Number (e.g. 12345). BOTH SETS OF NUMBERS should be noted in any correspondence or parts orders regarding the counter.

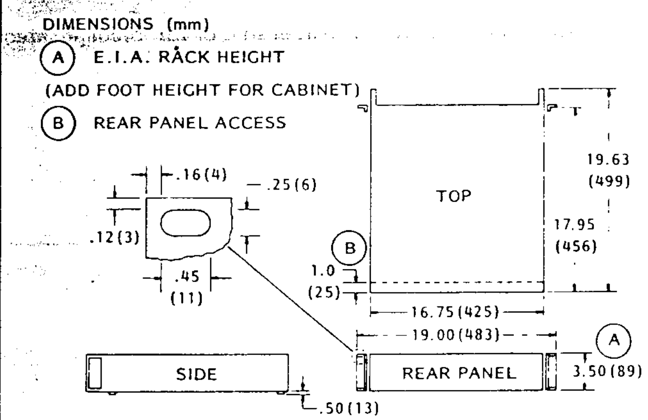
1-10. SPECIFICATIONS

1-11. EIP 371 Source Locking Microwave Counter specifications are given in Table 1-1.

NOTICE

GENERAL:

Frequency Range:	20 Hz - 18.0 GHz.
Accuracy:	±1 count ± time base accuracy.
Resolution:	1 Hz to 1 MHz in decade steps.
Gate Time:	1 sec (1 Hz), 0.1 s (10 Hz), 10 ms (100 Hz), 1 ms (1 kHz, 10 kHz, 100 kHz, 1 MHz). Band II gate times are expanded by four.
Sample Rate:	Controls time between measurements. Variable, 100 ms - 1 s (typ).
Display:	11 digit light-emitting diode (LED); sectionalized to read: GHz, MHz, kHz, and Hz.
Operation:	Completely automatic after setting input selector.
Acquisition Time:	In Band III, comb line acquisition requires 10 ms/GHz plus 50 ms (nominal). Once locked, readings can be taken at rate determined by Sample Rate control and selected gate time.
Operating Temp:	0° to +50°C.
Power:	115/230 Vac ±10%, 50-60 Hz, 90 watts (nominal).
Weight:	Shipping: 30.0 lbs (13.6 kg); Net: 25.5 lbs (11.6 kg).
Access. Furnished:	Detachable power cord, 8 ft (241 cm) long, with plug; Operating & Service manual; extender card.
Access. Available:	Rack Mount Kit: P/N: 2010008. Carrying Case: P/N: 5700001. Calibration Kit: P/N: 2000005.



All specifications subject to change at manufacturers discretion.

CONTROLS:

See Figures 3-1 and 3-2, and Tables 3-1 and 3-2.

TIME BASE (STANDARD):

Crystal Frequency:	10 MHz.
Stability:	
Aging Rate:	$< \lvert 3 \times 10^{-7} \rvert$/month.
Short Term:	$< 1 \times 10^{-9}$ rms for one second averaging time.
Temperature:	$< \lvert 2 \times 10^{-6} \rvert$ between 0° to +50°C.
Line Variation:	±10% line voltage change results in a frequency shift of $< \lvert 1 \times 10^{-7} \rvert$.
Warm-up Time:	None.
Output Freq:	10 MHz, square-wave, 1 V p-p minimum into 50 ohms.
Ext. Time Base:	Requires 10 MHz, 1 V p-p minimum into 300 ohms.

SIGNAL INPUTS:

BAND IA:

Frequency Range:	20 Hz - 135 MHz
Min. Sensitivity:	25 mV rms
Input Impedance:	1 megohm/20 pf
Maximum Input:	120 V rms (Note 1)
Max. Input without Damage:	150 V rms (Note 1)
Coupling:	AC
Connector:	BNC female

Note 1: Above 1 kHz maximum input decreases at 6 dB/octave rate to 3.0 V.

BAND IB:

Frequency Range:	10 MHz - 300 MHz
Min. Sensitivity:	-20 dBm (22 mV rms)
Input Impedance:	50 ohms nominal
Maximum Input:	+10 dBm (0.7 V rms)
Max. Input without Damage:	+27 dBm (5.0 V rms)
Coupling:	AC
Connector:	BNC female

TABLE 1-1. SPECIFICATIONS - 371 COUNTER

WAVEN TEK 904

Ø LOK EXT FM COARSE TUNE OP 28 Q 262

SIGNAL INPUTS (CONTINUED):

BAND II:

Frequency Range:	10 MHz - 850 MHz
Min. Sensitivity:	100 MHz - 150 MHz: -15 dBm (40 mV rms). 150 MHz - 850 MHz: -20 dBm (22 mV rms).
Maximum Input:	+10 dBm (0.7 V rms)
Max. Input without Damage:	+27 dBm (5.0 V rms)
Input Impedance:	50 ohms nominal
Coupling:	AC
Connector:	BNC female

BAND III:

Frequency Range:	825 MHz - 18.0 GHz.
Min. Sensitivity:	825 MHz - 1.1 GHz: -25 dBm (12 mV rms), 1.1 GHz - 12.4 GHz: -30 dBm (7 mV rms), 12.4 GHz - 18.0 GHz: -25 dBm (12 mV rms).
Maximum Input:	+7 dBm, +20 dBm typ.
Max. Input without Damage:	+33 dBm (2 watts).
Input Impedance :	50 ohms nominal.
Coupling:	AC.
Connector:	Type N Precision female.
VSWR:	2.5 : 1 typical.
FM Tolerance:	40 MHz p-p, worst case, for modulation rates from DC to 10 MHz.
YIG Preset:	
Selection:	Front panel keyboard input; indicated on 6-digit LED display.
Settability:	Set ≥ 400 MHz below lowest frequency to be measured. Sweep begins at preset and measures only frequencies ≥ 400 MHz above preset frequency.
Operation:	Preset desired frequency on keyboard in MHz (or GHz) at 200 MHz increments. Press PRESET button.

SOURCE LOCKING SPECIFICATIONS:

Freq. Coverage:	10 MHz - 18.0 GHz.
Resolution:	100 kHz (400 kHz in Band II).
Long Term Stability:	Equal to counter time base osc.
Minimum Lock Level:	Equal to counter sensitivity.
Lock Time:	0.1 - 3 s; dependent on source.
Accuracy:	Equal to counter.
Capture Range:	± 20 MHz min; ± 50 MHz typical unless limited by source characteristics or output current capability.
Bandwidth and Polarity:	Fully automatic selection.
Output Drive Capability:	± 10 V into 5 Kohm min, or ± 40 mA into 10 ohms max.
Output Connector:	Rear panel BNC female.
Residual FM Reduction:	See graph below for typical response.
Required Source Input Characteristics:	
Bandwidth:	4 kHz min for specified performance.
Modulation Sensitivity:	Voltage input (R_{in} > 5 Kohm): 2 to 200 MHz/V. Current input (R_{in} < 10 ohms): 0.1 to 10 MHz/mA.

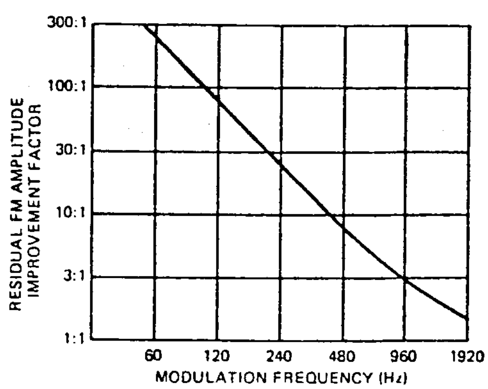


TABLE 1-1 (Continued). SPECIFICATIONS - 371 COUNTER

SECTION 2

INSTALLATION

2-1. UNPACKING

2-2. The EIP 371 Source Locking Autohet Microwave Counter arrives ready for operation. Carefully inspect the shipping carton before opening for any evidence of visible or concealed damage. If any seems apparent, ask that the shipper's agent be present when the instrument is unpacked.

2-3. Remove the packing carton and supports, being careful not to scar or damage the instrument. Make a complete visual inspection of the counter, checking for any damage or missing components. Check that all switches and controls operate mechanically. Report any damage to EIP immediately.

2-4. INSTALLATION

2-5. There are no special installation instructions for the 371 Microwave Counter. The unit is a self-contained bench or rack mounted instrument, which only requires connection to a standard, single-phase, 115/230 V, 50-60 Hz power line for operation. CAUTION: Check current rating of counter fuse and setting of rear panel 115/230 Vac slide switch before applying power to counter.

2-6. INCOMING OPERATIONAL CHECK

2-7. The following procedure outlines an operational check of the counter which may be conducted without special tools, signal generators, or test equipment. The internal TIME BASE CLOCK is used as the input signal to the 300 MHz counter, therefore it cannot check the operation of the Band II prescaler or the Band III comb generator.

a. Turn counter POWER switch off. Check fuse rating and setting of 115/230 switch (on rear panel).
b. Connect counter power cord to a source of 115 or 230 V, 50-60 Hz, single-phase power. The ground terminal on the power cord plug should connect to a reliable earth ground.
c. Press POWER switch (on front panel) to turn counter on. The counter display should light, and the internal cooling fan should operate.
d. Place the rear panel TIME BASE INT/EXT switch in the INT position.
e. Partially depress any one of the RESOLUTION switches and release it so no switch remains in the depressed position. All digits in the 11-digit display should indicate "0" (zero).
f. Depress the TEST switch on the front panel. The display should indicate 10 000 000 (10 MHz). Note that the three leading zeros are blanked (not lit).
g. Blank the 1 Hz digit by pressing the right hand RESOLUTION switch.
h. Depress the TEST button again. The display should still indicate 10 MHz, but with the final "0" blanked. Also note a decrease in the gate time evidenced by the shorter on-time of the GATE light.
i. Test each RESOLUTION switch in turn, starting with the 1 Hz digit. Note that the digit immediately above that switch, and all digits to the right of that switch, are blanked.
j. Unblank all display digits (see "e." above for procedure).
k. With no signal input, the entire display* should show all zeros in all bands.
l. Depress both the TEST and RESET switches simultaneously. All display digits* should show "8" (all segments of each display lighted).
m. Set counter to Band IB (10 MHz - 300 MHz range). Program the auxiliary display (through keyboard entry) to read "10.0" MHz. Press LOCK button. LOCK indicator should light for 2-3 seconds then go out.
n. Set counter to Band III (850 MHz - 18 GHz range). Program the auxiliary display (as above) to read "10". Press PRESET button. Auxiliary display readout should now read "10000.0 (10 GHz), and PRESET indicator should light. Press CLR (Clear) button.
o. This completes the counter confidence check. All CW signals within the frequency range of the counter may be counter and locked. Refer to Section 1 for proper signal levels. If the counter fails to perform as described above, refer to Section 5.

* Except those on the Auxiliary Display panel.

SECTION 3
OPERATION

3-1. INTRODUCTION

3-2. The 371 incorporates two microwave instruments in one package: a wide range frequency counter, and a source locking device (lockbox) operating in conjunction with a frequency source. Essentially all of the operations are completely automatic, however attention should be paid to this section to note the procedures required for optimum performance of the instrument.

3-3. CONTROLS, INDICATORS AND CONNECTORS

3-4. Front panel controls, indicators and connectors are shown in Figure 3-1 and described in Table 3-1. Rear panel controls and connectors are shown in Figure 3-2 and described in Table 3-2.

3-5. NUMERICAL DISPLAY BRIGHTNESS ADJUSTMENT

3-6. Apparent brightness of the 11-digit light-emitting-diode (LED) visual display may be varied by adjustment of A103R20. (R20 is located near the top front of PC board A103, and is accessible by removing the top cover of the counter.) Adjust R20 clockwise to increase display brightness, or counter-clockwise to reduce brightness.

3-7. COUNTER OPERATION

a. Turn counter power on. Counter will automatically select Band III (825 MHz - 18 GHz).

b. Pressing the BAND SELECT button once sets the counter to Band IA (20 Hz - 135 MHz). Pressing the button repeatedly will successively set the counter to Bands IB, II, III, IA, etc.

c. Select the desired operating band. Apply a signal to the appropriate input connector. If the signal is within counter specifications, the counter will automatically display the input frequency. See CAUTION notice regarding input level.

d. Select the desired sample rate and resolution (see Table 3-1).

CAUTION

DO NOT APPLY A SIGNAL EXCEEDING THE MAXIMUM INPUT SPECIFICATION TO ANY INPUT. EXTENSIVE DAMAGE NOT COVERED BY THE WARRANTY WILL OCCUR, WHETHER COUNTER IS TURNED ON OR OFF, OR APPEARS TO BE INOPERATIVE.

3-8. LOCKBOX OPERATION

a. Set up counter and signal source as described in paragraph 3-7.

b. Tune source within capture range of desired frequency (see Table 1-1, Specifications).

c. Keyboard desired frequency into Auxiliary Display (see Table 3-1). When the LOCK button is pressed, the Auxiliary Display will go out, and the LOCK indicator will glow brightly (during determination of loop polarity and gain). When the loop locks, the Auxiliary Display relights, while the LOCK indicator returns to its normal intensity. If the 371 cannot secure a lock, the LOCK indicator goes out, and the Auxiliary Display shows the programmed frequency. (If this situation occurs, compare the programmed frequency with the displayed input frequency. Check for an error in programming, input signal level or frequency, capture range limits exceeded, etc.)

d. When locking to a Band II input frequency (100 - 850 MHz), the signal source can be locked only at 400 kHz increments (due to Prescaler operation). To avoid the necessity of having the operator compute the valid frequencies, the counter automatically "rounds down" the input to the nearest frequency divisible by four. In Band II then, when the Auxiliary Display reappears after pressing the LOCK button, the frequency programmed may be different from that entered, whether or not a lock was obtained.

3-9. PRESET OPERATION

3-10. The YIG Preset function is available only in Band III (825 MHz - 18 GHz), and serves to initiate the counter's signal search at a higher start frequency than zero. This function serves to minimize signal acquisition time, and allows the Converter to ignore spurious or undesired signals below the one to be measured.

3-11. Keyboard the desired preset frequency into the Auxiliary Display and press the PRESET button. The counter will automatically justify the data entry to a multiple of 200 MHz, and begin its search at the frequency indicated. For example: If 12.5 GHz is entered via the keyboard, and the PRESET button is pressed, the Auxiliary Display will show 12400.0 MHz, the PRESET indicator will light, and the search will begin at 12.4 GHz. NOTE: Because data entries below 100 MHz are invalid, the 371 interprets entries between 1 - 99 MHz as 1 - 99 *GHz*.

(Continued on Page 3-4)

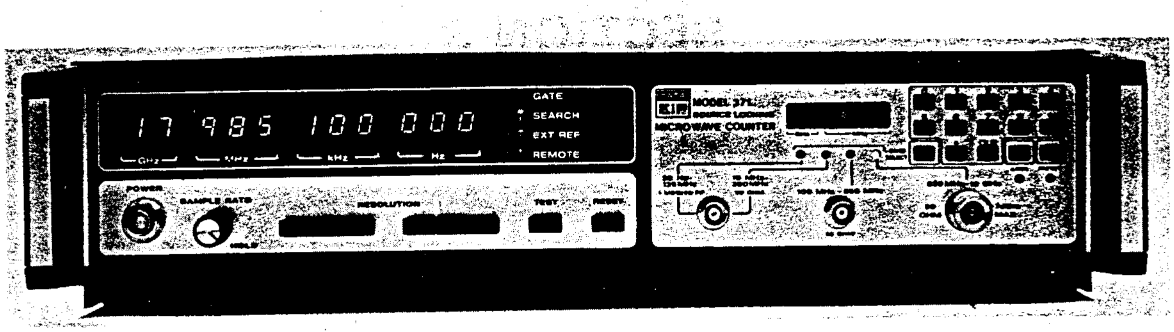


FIGURE 3-1. FRONT PANEL CONTROLS, INDICATORS AND CONNECTORS

POWER On/Off Switch

Turns counter power on and off.

SAMPLE RATE/HOLD Control

Varies time between measurements from 1/10 to 10 seconds (nominal) per reading. (Gate time is added to sample time, thus minimum reading time for 1 Hz resolution is 1.1 sec.) Last reading retained indefinitely in HOLD.

RESOLUTION Switches

Six pushbutton switches allow blanking (turning off) of the six least significant digits in the visual display. Each switch blanks the digit above and all digits to the right of that switch. Four gate times appropriate to the required resolution are also selected. 1 Hz resolution is achieved by partially depressing and releasing one of the switches (this action releases all the switches).

TEST Switch▲

Pressing the TEST switch places the counter in the self-test mode, with the test signal derived from the internal 10 MHz Time Base. Proper display is: 10 000 000 (10 MHz).

RESET Switch▲

This switch manually over-rides all controls, resets the counter and converter, and initiates a new reading.

Visual Display (left side of panel)

The 11-digit LED (light-emitting-diode) display provides a direct numerical readout of the input frequency. The display is sectionalized into GHz, MHz, kHz, and Hz.

GATE Indicator

Lights when signal gate is open.

SEARCH Indicator

Provides visual indication that the Converter is *not* locked to an input signal.

EXT REF Indicator

Lights when counter is set to EXT REF (External Time Base Reference) via rear panel switch. CAUTION: Lamp does not indicate level of external reference signal.

REMOTE Indicator

Used only with Option 07 (Remote Programming) and 17 (General Purpose Interface Bus). See Option section.

Keyboard Switches

Switches 0-9 enter numerical data into auxiliary display. Pressing the BAND SELECT pushbutton sets the counter to the next higher band, then repeats from the lowest band (e.g. II, III, IA, IB, II, etc.). Decimal point button designates the end of MHz data entry; following digit entered in .1 MHz position. LOCK button tells counter to lock the source being controlled to the frequency shown on the auxiliary display. PRESET button sets Band III start frequency to that shown on auxiliary display.

Auxiliary Display (right side of counter)

Six digit LED display indicates frequencies set by LOCK and PRESET buttons.

BAND SELECT Indicators

Indicate the operating range of the counter as determined by the keyboard BAND SELECT pushbutton switch.

LOCK and PRESET Indicators

Refer to Lockbox operation paragraphs in this section for a description of various indicator conditions.

Band I and Band II Input Connectors

Type BNC female. For measurements in the 20 Hz - 135 MHz (Band IA), 10 MHz - 300 MHz (Band IB), and 100 MHz - 850 MHz (Band II) frequency ranges.

Band III Input Connector

Type N precision female. For measurements in the 825 MHz - 18 GHz frequency range. See CAUTION notice in Section 3 regarding maximum input levels.

▲VISUAL DISPLAY TEST: Pressing *both* TEST and RESET switches simultaneously, will cause all numeric display digits to show the numeral "8". (all segments lighted).

TABLE 3-1. FRONT PANEL CONTROLS, INDICATORS AND CONNECTORS

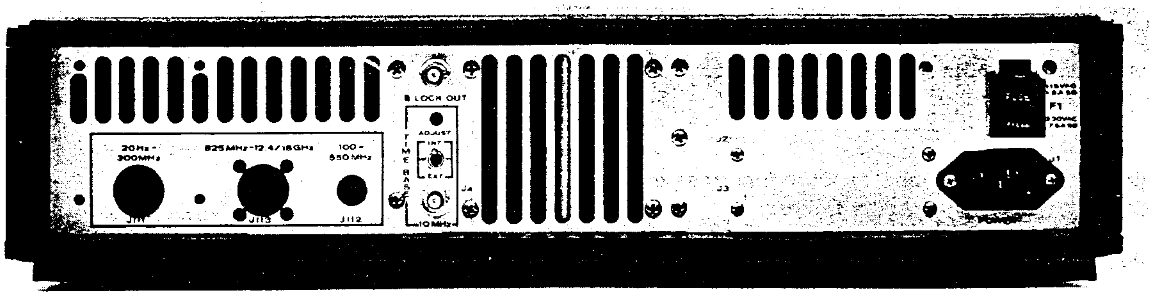


FIGURE 3-2. REAR PANEL CONTROLS AND CONNECTORS

Rear Panel Inputs

Openings allow simple modification for rear inputs.

ϕ LOCK OUT Connector

Provides output control signal to external frequency source when locking source to keyboard programmed frequency.

TIME BASE ADJUST Control

Used with Options 03, 04, or 05 only. Screwdriver adjustment allows tuning of the internal 10 MHz Oven Oscillator used with these options. Refer to Section O for complete description.

TIME BASE INT/EXT Switch

Allows use of internal Time Base Oscillator (TCXO or optional oven unit), or external 10 MHz reference.

TIME BASE 10 MHz Connector

Type BNC female. Allows monitoring of internal 10 MHz Time Base, or connection to external 10 MHz reference (3 V p-p maximum reference input level).

BCD OUTPUT Connector

Used with Option 09 - BCD Output. Refer to Section O - Options, for complete description.

REMOTE PROGRAMMING Connector

Used with Option 06 - Programmable Offsets, and Option 07 - Remote Programming. Refer to Section O - Options for complete descriptions.

AC POWER Connector

Accepts AC power cord supplied with counter.

FUSE Holder

Fuse provides overload protection for the counter. Use only a 1.5 A, Slow-Blow, 3AB/MDX type fuse for nominal 115 Vac operation, or 0.75 A, Slow-Blow, 3AB/MDL type fuse for nominal 230 Vac operation.

115/230 Switch

Sets operating voltage of counter to match power line. CAUTION: Be sure 115/230 switch setting and fuse rating match power line voltage.

TABLE 3-2. REAR PANEL CONTROLS AND CONNECTORS

IMPORTANT: Erroneous readings may result for signals within 275 MHz above and below the YIG Preset frequency. Set YIG Preset at least 275 MHz *below* lowest desired frequency to be counted.

3-12. To utilize both YIG Preset and lockbox functions of the counter simultaneously, proceed as follows:

a. Program YIG Preset frequency. Press PRESET button.

b. Wait for SEARCH indicator to go out.

c. Source may now be locked as described in paragraph 3-8c.

SECTION 4

GENERAL THEORY OF OPERATION

4-1. GENERAL

4-2. The EIP 371 Source Locking Microwave Counter automatically measures and displays the frequency of any CW signal from 20 Hz to 18.0 GHz. This frequency coverage is obtained in three bands: 20 Hz - 300 MHz (Band I), 100 MHz - 850 MHz (Band II), and 825 - 18 GHz (Band III). In addition, the 371 has the capability of locking a frequency modulatable source to any 100 kHz increment between 10 MHz and 18 GHz.

4-3. Measurements in Band I are made directly with a 300 MHz counter. This band is further divided into two channels: Channel A covers the 20 Hz - 135 MHz range with an input impedance of 1 megohm shunted by 20 pf. Channel B covers the 10 MHz - 300 MHz range with a 50 ohm input impedance.

4-4. Band II contains a prescaler which divides the input frequency by four. It operates over the frequency range of 100 MHz - 850 MHz with 50 ohm input impedance.

4-5. Band III covers the microwave frequencies from 825 MHz - 18 GHz with a 50 ohm input impedance. In this band, an Autohet Converter translates the input frequency downward into the frequency range of the 300 MHz Direct Counter. This is accomplished by mixing the input signal with a single known harmonic of the counter time base oscillator, to produce a difference frequency which can be counted directly. The frequency of the known harmonic is added to the counted signal to obtain the input frequency.

4-6. Figure 4-1 shows a block diagram of the complete 371 Counter. Figure 4-2 shows a block diagram of the Autohet Converter. Detailed theory and circuit descriptions of the Counter and Converter subassemblies are given in Section 9.

4-7. The operation of the 371 Counter is best described by separating the instrument into three distinct functions: the Direct Counter, the Autohet Converter, and the Lockbox circuitry. The Direct Counter and the Autohet Converter are interconnected in two significant areas: (1) presetting the counter to the appropriate harmonic number, and (2) counting the heterodyned difference frequency from the Converter by the Direct Counter.

4-8. 300 MHz DIRECT COUNTER

4-9. The measurement of frequency by the direct counter is accomplished by accumulating the number of input events (e.g: cycles of a sine wave), which occur within a precisely determined time interval. This time interval is based on the frequency of the Time Base Oscillator.

4-10. The 20 Hz - 300 MHz portion of the counter is separated physically into a number of subassemblies, designated A101 through A111 (refer to Figure 4-1, Block Diagram). The subassemblies are tied together via the Counter Interconnect Board A113. The counter is divided functionally in approximately the same manner as it is divided into subassemblies. Count Chain Boards A101, A102, and A103, operate functionally as a single unit, as do Control Boards A104 and A105. The principal interconnections between the units are shown in Figure 4-1.

4-11. Band I (20 Hz - 300 MHz) input has two operating modes. Band IA covers the 20 Hz - 135 MHz range, with 1 megohm/20 pf input impedance and 25 mV rms sensitivity. Band IB (10 MHz - 300 MHz) has a 50 ohm input impedance and -20 dBm sensitivity. Both Band IA and IB input signals are routed through Preamplifier A111, which contains an impedance converter section and a signal amplifier to drive the High Frequency board (A106).

4-12. The Band II (100 MHz - 850 MHz) input drives the Prescaler (A109), which divides the incoming frequency by four and routes it to the High Frequency Board.

4-13. The signal input to Band III (825 MHz - 18.0 GHz) is translated by the Autohet Converter into the range of 25 MHz - 275 MHz, and routed to the High Frequency board (A106).

4-14. The outputs of these three input signal processors thus fall between 20 Hz and 300 MHz; the frequency range of the direct counter. The individual assemblies which comprise the direct counter are described in general terms below, and in detail in Section 9.

4-15. The High Frequency Board (A106) receives the input signal from one of the processors, squares the signal, and forms it into a train of constant duration pulses. This pulse train frequency is then divided by ten, and sent to the Count Chain.

4-16. The Control 1 and Control 2 Boards (A104 and A105), contain circuitry to guide the counter through the steps necessary to acquire and display the input frequency. The circuits control the opening and closing of the signal gate in the High Frequency Board, and accept programming commands from the Converter, front panel controls (TEST, RESET, SAMPLE RATE), and the Remote Programming options.

4-17. The Count Chain Boards (A101, A102, and A103), accumulate the frequency from the High Frequency Board, store the accumulated information, and multiplex the stored information into a form usable by the Display Board (A110), which provides a visual display of the input frequency to the counter.

4-18. Reference Oscillator Buffer A108, produces a time base reference signal from either an internal 10 MHz oscillator, or an external 10 MHz source. All input frequencies to the counter are measured with respect to this signal.

4-19. The Power Supply (A107) provides regulated +12,

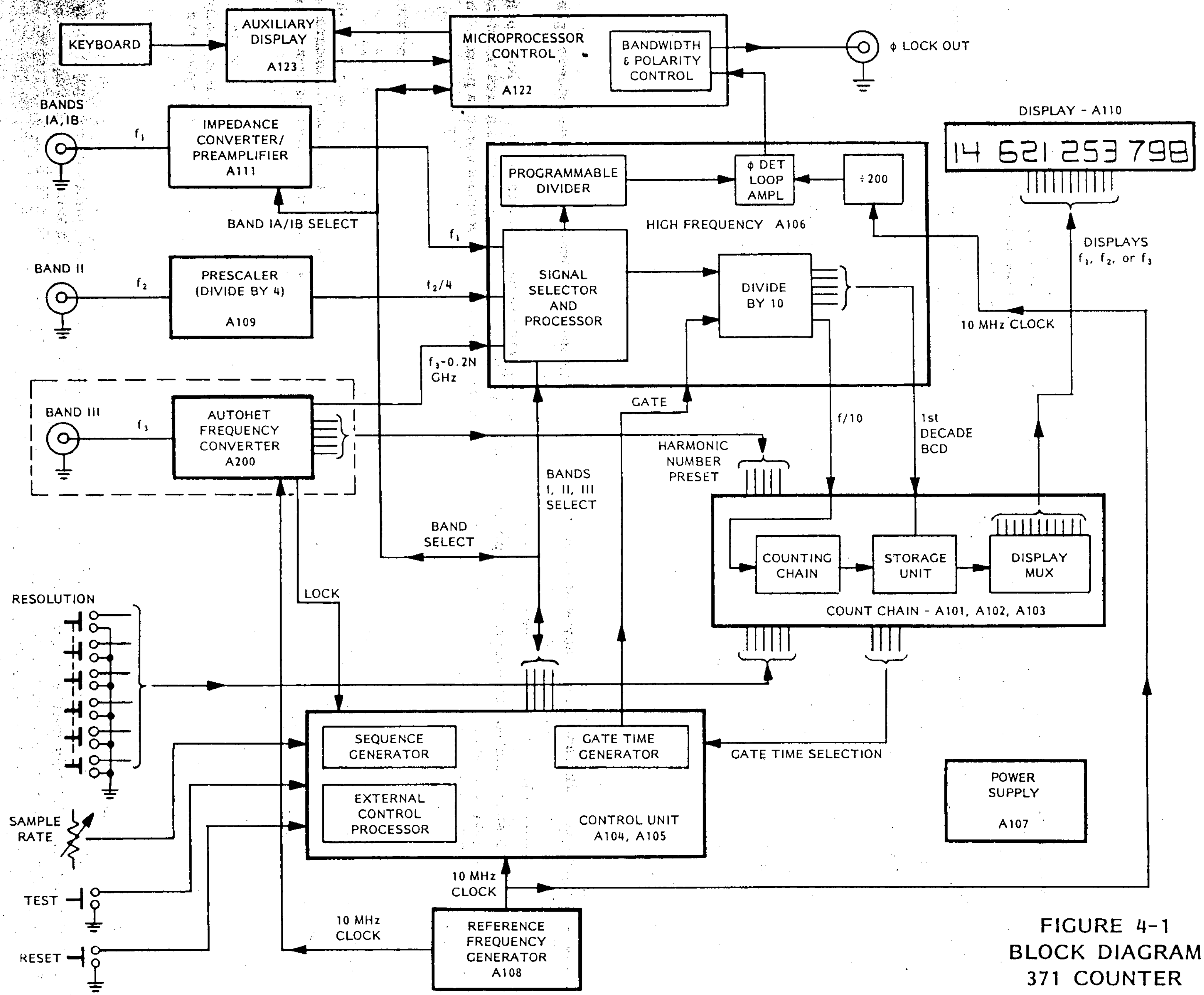


FIGURE 4-1
BLOCK DIAGRAM
371 COUNTER

-12, +5, -5.2 Vdc, and unregulated +18 Vdc. NOTE: This supply does not furnish the power for the oven stabilized Time Base Oscillators (Options 03, 04, or 05).

4-20. AUTOHET CONVERTER

4-21. The Autohet Converter is a self-contained assembly which performs the function of translating the microwave frequencies appearing at the Band III input, down into the range of the direct counter. This translation is accomplished by mixing the incoming signal with a known reference signal and then amplifying the difference frequency. The incoming frequency is then determined by counting the difference frequency and adding it to the known reference frequency. Refer to Figure 4-2, Converter Block Diagram.

4-22. The reference frequency is an integral multiple of 200 MHz which is derived from the 10 MHz Time Base Oscillator, thus maintaining the basic counter accuracy in the microwave band.

4-23. The Band III input signal passes through the PIN Diode Attenuator (A206) and is combined in the Mixer (A205) with the reference frequency from the YIG/Comb Generator.

4-24. The YIG/Comb Generator (A207) is an integrated assembly containing a Comb Generator and a YIG filter. The Comb Generator contains a step recovery diode to convert the 200 MHz sine wave input from the Source/-Amplifier (A201) into a train of narrow pulses containing all the harmonics of 200 MHz up to 18 GHz. This pulse train is then passed through a pair of YIG resonators which select the desired harmonic. The resonant frequency of the two stage filter is proportional to a magnetic field generated by passing current through a pair of coils within the structure. (A more comprehensive description of the operation of a YIG-tuned device is given later in this section.)

4-25. The Source Amplifier (A201) contains an LC oscillator operating at 200 MHz, which is phase-locked to the 10 MHz Time Base Oscillator (A116 or A112). This 200 MHz signal is amplified to produce up to one watt of output power to drive the Comb Generator section of A207.

4-26. The Mixer (A205) is an integrated microwave stripline assembly, containing a 3 dB hybrid coupler, a termination, a mixer diode, a matching network, a broadband DC return, and a bypass capacitor to separate the RF and IF signals. The Mixer produces two output signals: an IF signal with frequency equal to the difference of the reference and incoming signals, and a DC current resulting from rectification of the total power applied to the mixer diode.

4-27. Both the IF and DC signals from A205 enter Video Amplifier A204, where the IF signal is amplified, and the DC level used for control of PIN Diode Attenuator A206.

4-28. The circuitry required to control the Autohet Converter is located on two Converter Control Boards (A202 and A203). Their function is to set the YIG Filter within the YIG/Comb Generator (A207) to the correct harmonics of 200 MHz, and to provide both the IF frequency and the harmonic information to the Direct Counter.

4-29. To accomplish this, the YIG Filter passband is continuously tuned over the operating range until an appropriate signal is received from the Video Amplifier. The sweep is then stopped so the YIG Filter passband is centered on the desired harmonic. Converter Control 1 (A203) performs all the signal processing and provides digital commands to Converter Control 2 (A202) which contains the Digital to Analog Converters and the current driver necessary to tune the YIG Filter. A detailed operational sequence is described in Section 9 in the Converter Control 1 description (Figure 9-17).

4-30. LOCKBOX OPERATION

4-31. The source locking (lockbox) portion of the counter consists of three assemblies: the High Frequency board (A106), the Microprocessor board (A122), and the Auxiliary Display board (A123).

4-32. The High Frequency board selects the appropriate input signal, processes it, and divides it into two signals: one drives the gating and first stage of the frequency counting portion of the counter, while the other signal drives the phase locking portion.

4-33. The phase locking portion of the High Frequency board divides the selected signal down to 50 kHz in a programmable frequency divider. The 50 kHz signal is compared with a 50 kHz reference signal — derived from the 10 MHz time base clock — in a phase comparator, producing an error signal proportional to the phase (frequency) difference between the two signals. This error signal is sent to the Microprocessor board (A122) for amplification and processing, and then sent out to the signal source to correct for phase (frequency) errors.

4-34. The Microprocessor (A122) performs several tasks, including control of the Auxiliary Display board (A123). The Microprocessor interprets and processes the keyboard entries, and displays the appropriate data on the Auxiliary Display. It also controls the LOCK and PRESET indicators, and the BAND SELECT function (and indicators), in accordance with the appropriate keyboard entry commands.

4-35. In performing the YIG Preset function, the Microprocessor justifies the programmed frequency data to a multiple of 0.2 GHz, and then sends the data to the Converter Control 2 board (A202).

4-36. In performing the Lock command, the Microprocessor collects frequency information from the Converter and keyboard entries, and determines if a lock is possible. If so, it computes the IF frequency which should be present in the High Frequency board, and programs the frequency divider to generate the 50 kHz signal for the phase comparator. In Band II operation, it also justifies the frequency to be the proper multiple of 400 kHz (due to prescaler requirements).

4-37. Part of the lock operation is the selecting of loop gain (loop bandwidth) and polarity. The Microprocessor board perform this task by systematically programming gain and polarity information, and sampling the loop lock and bandwidth data. When the appropriate gain is reached, and both lock and bandwidth are correct, the processor returns to the keyboard/display scan. If a lock is not achieved, the processor returns to the keyboard/-display scan with the phase lock control voltage returned to zero volts.

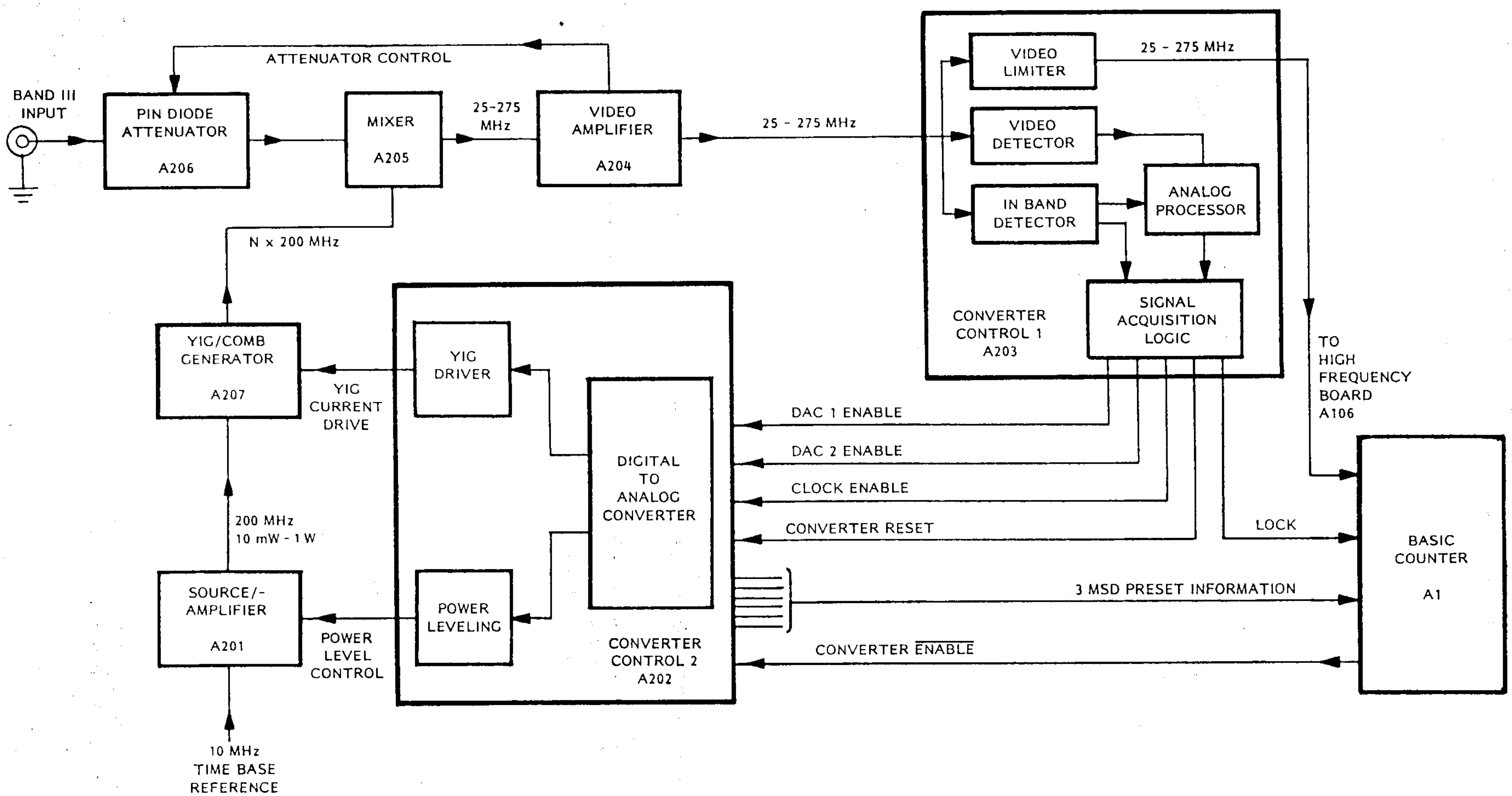


FIGURE 4-2
BLOCK DIAGRAM
AUTOHET CONVERTER

AN INTRODUCTION TO YIG FILTERS

Highly polished spheres of single crystal YIG (yttrium-iron-garnet), have a property called ferrimagnetic resonance. Basically, the ferrimagnetic resonance phenomenon can be explained in terms of spinning electrons creating a net magnetic moment in each molecule of a YIG crystal (see Figure A). Viewing the material macroscopically, there is no net effect because the magnetic dipoles associated with each molecule are randomly oriented (see Figure B). The application of an external magnetic biasing field, H_{DC}, causes the magnetic dipoles to be aligned in the direction of the biasing field (see Figure C).

An RF field can be used to create an orthogonal magnetic force. If the frequency of the RF field coincides with the natural precession frequency, there is a strong interaction called ferrimagnetic resonance (Figure D).

Figure E shows the basic elements of a YIG bandpass filter. The filter consists of a YIG sphere at the center of two loops. The two loops are perpendicular to each other and to the dc biasing field, H_{DC}. One loop carries the RF input and the other the RF output. When the RF signal frequency is the same as the natural precession frequency of the YIG, there is strong coupling between the input and output loops. Thus RF can only pass through the YIG filter at resonance. The resonant frequency is a linear function of the magnetic biasing field, H_{DC}. Generally, H_{DC} is provided by locating the YIG spheres between the poles of an electromagnet, and tuned by varying the current to the magnetic coils.

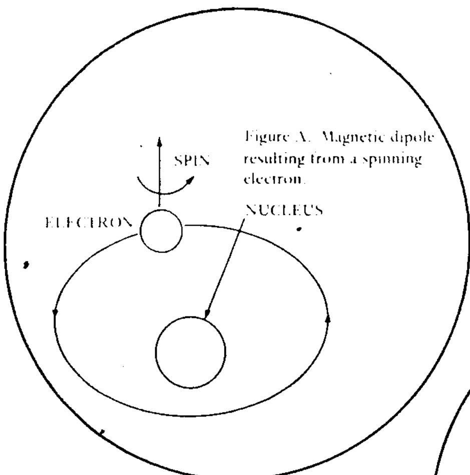


Figure A. Magnetic dipole resulting from a spinning electron.

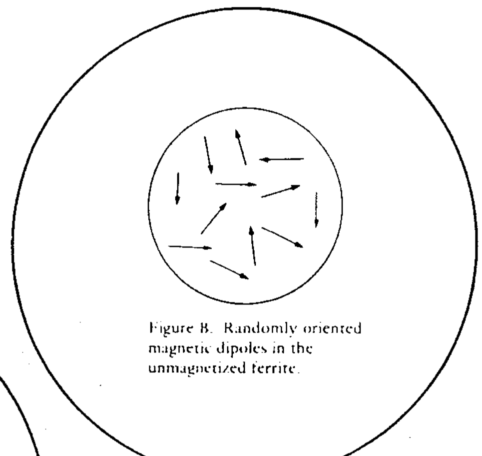


Figure B. Randomly oriented magnetic dipoles in the unmagnetized ferrite.

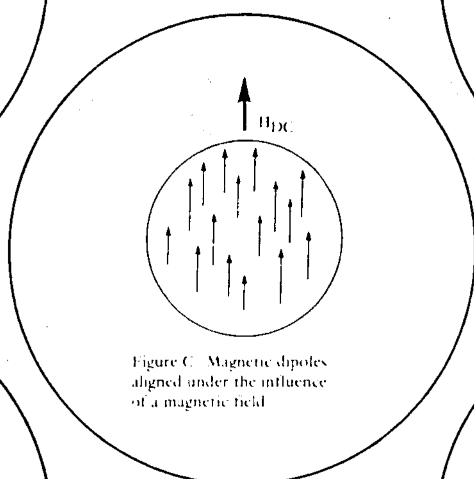


Figure C. Magnetic dipoles aligned under the influence of a magnetic field.

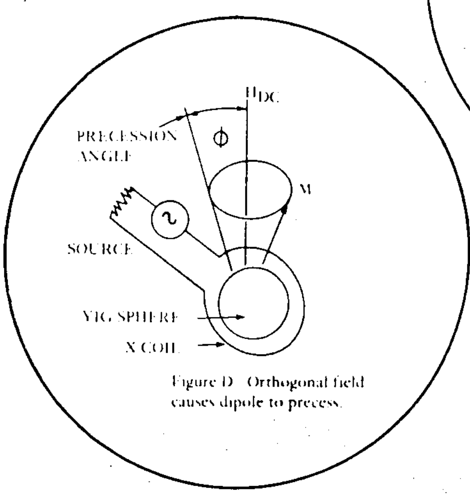


Figure D. Orthogonal field causes dipole to precess.

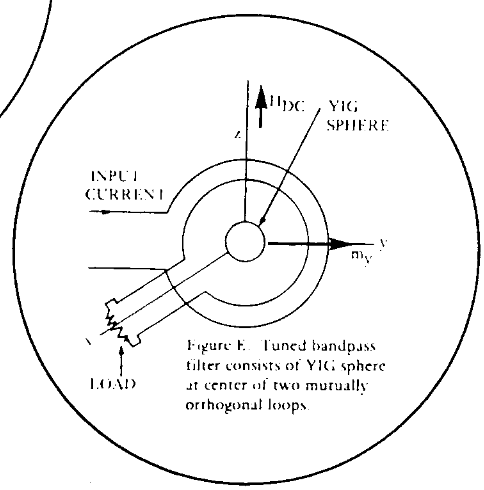


Figure E. Tuned bandpass filter consists of YIG sphere at center of two mutually orthogonal loops.

SECTION 5

MAINTENANCE & SERVICE

5-1. GENERAL

5-2. This section provides instructions, procedures, and information necessary to maintain, troubleshoot, and repair the EIP Autohet Microwave Counter.

5-3. FUSE REPLACEMENT

5-4. The counter uses one fuse, located on the rear panel. For proper operation, use only the fuse specified below: do not increase fuse rating or change fuse type. Set 115/230 slide switch on rear panel to match nominal power line voltage.

For 115 VAC operation: use a 1.5A, Slow-Blow, 3AB/MDX type fuse.

For 230 VAC operation: use a 0.75A, Slow-Blow, 3AB/MDL type fuse.

5-5. AIR CIRCULATION

5-6. During operation of the counter, the internal fan draws in cooling air through the vents in the enclosure. If these vents are blocked, the temperature inside the enclosure may rise to the point where counter stability is reduced, and component life shortened.

5-7. COUNTER SERVICING

5-8. Recommended Service Procedures:

a. To remove plug-in PC Boards: Ease board out of socket by lifting up on board handles. Remove carefully to avoid placing strain on any connecting cables.

b. To unplug flat ribbon cables: Turn off power to counter. Use an IC Extractor Tool (EIP Part 5000094 or equivalent) to unplug connector.

c. To remove PCB socket locating key: Key must be turned 90° before removal from or re-installation into socket, to avoid contact damage. Use long-nose pliers for removal or insertion.

d. A Troubleshooting Kit (EIP Part 2000005) is available to facilitate adjustments and repairs of the counter. Contents include PCB Extender Cards, IC Removal Tool, Summing Amplifier, adapter cables and connectors.

e. Internal cable and harness routing is shown both on a label attached to the top cover of the counter, and in Figure 9-2.

f. Circuit descriptions of PC Board and modular assemblies are shown on the same pages as the related schematic diagram and component locator in Section 9.

g. Troubleshooting Trees shown later in this section are intended only as a guide, and do not describe every possible failure situation. To speed troubleshooting of a board: replace the board with a known good one.

h. A listing of recommended test equipment for servicing, calibration, and performance testing, is given in Table 5-1. Other equipment may be used provided performance equals or exceeds that listed.

i. A Schematic Diagram of a Summing Amplifier used in certain counter tests, is shown in Figure 5-1. This unit may be constructed by the user, or may be purchased directly from EIP (Part Number 2010050).

5-9. Servicing Precautions

a. The Video Amplifier (A204) and the Source/Amplifier (A201) should be replaced rather than being serviced in the field, due to the specialized test equipment and procedures required for recalibration.

b. If Converter Control 2 (A202) is repaired either at EIP or in the field, recalibration in its associated counter will be required for proper counter operation.

CAUTION

DO NOT ATTEMPT REPAIR OR DISASSEMBLY OF THE FOLLOWING COMPONENTS: YIG/COMB GENERATOR (A207), MIXER (A205), INPUT ATTENUATOR (A206), OR TIME BASE OSCILLATOR (TCXO OR OVEN OPTION).

5-10. FACTORY SERVICE

5-11. If the counter is to be returned to EIP for service or repair, BE SURE TO INCLUDE THE FOLLOWING INFORMATION WITH THE SHIPMENT: *

a. Name and address of owner.

b. Model and complete serial number of counter.

c. A COMPLETE description of trouble (e.g: under

EQUIPMENT DESCRIPTION	MFR.	MODEL	Section 5 - Service	Section 6 - Calibration	Section 7 - Performance
Signal Source:					
(1) 20 Hz - 10 MHz	HP	651B	x		x
(2) 10 MHz - 1 GHz	Wavetek	2001B	x	x	x
(3) 1 GHz - 12.4/18 GHz	S-D	521-series	x	x	x
Oscilloscope (Main Frame)	HP	180C	x	x	
Dual Channel Ampl. (Plug-In)	HP	1801A	x	x	
Delayed Time Base (Plug-In)	HP	1821A	x	x	
Digital Voltmeter (4½ digit)	Dana	4800	x	x	
Power Meter	HP	432B	x	x	x
Thermistor Mount (10 MHz-18 GHz)	HP	8478	x	x	x
Frequency Standard	HP	105A		x	
VLF Comparator	HP	117A		x	
Summing Amplifier *	EIP	2010050*	x	x	
Variable 115 Vac Source	Staco	3PN501			x
Extender Card	EIP	2020021	x	x	
Adapter Cable (SMC to BNC)	EIP	2040015	x	x	
Misc. attenuators, adapters and cables			x	x	x

* See Figure 5-1.

TABLE 5-1. RECOMMENDED TEST EQUIPMENT

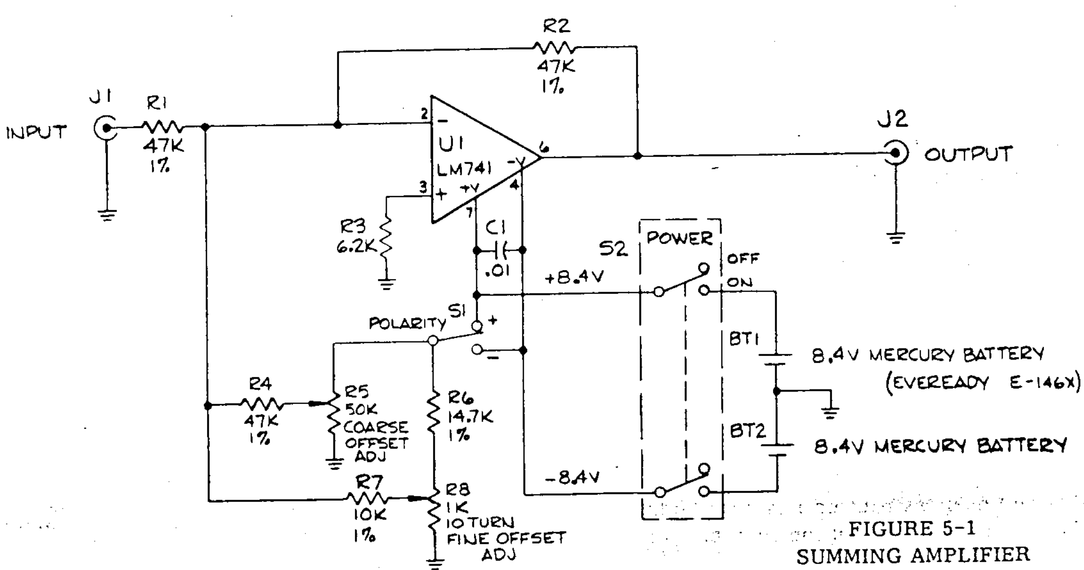


FIGURE 5-1
SUMMING AMPLIFIER

what conditions did trouble occur? What was the signal level? What associated equipment was attached or connected to the counter? Did that equipment fail too?)*

d. Name and telephone number of someone familiar with the problem, who may be contacted by EIP for any further information if necessary.

e. Shipping address to which counter is to be returned; include any special shipping instructions.

f. Pack the counter as follows:

(1) Wrap the counter in plastic or heavy kraft paper, and repack in the original shipping container (if still available) using the original packing material.

(2) If the original container and packing material are no longer available, use a heavy (275 lb. test) double-walled carton, with approximately 4" of suitable packing material between the inner and outer walls, with additional packing material as required between the counter and the inner carton. Seal with strong filamentary tape or strapping.

(3) Mark the shipping container to indicate that it contains fragile electronic instruments. Ship to EIP at address shown on title page of this manual.

* A COUNTER REPAIR AND RETURN FORM IS BOUND INTO THE BACK OF THIS MANUAL. IF THE FORM IS MISSING, PLEASE SUPPLY THE INFORMATION REQUESTED IN THE ABOVE PARAGRAPH.

5-12. TROUBLESHOOTING

5-13. MALFUNCTION AT TURN ON

5-14. If the counter fails to turn on (no display, no fan, etc.), make the following checks:

a. 115/230 switch at proper setting.

b. Power cord plugged into counter and into AC power source.

c. Correct AC power available at source.

d. Counter fuse good.

e. POWER switch at "On" position (button depressed and green indicator showing).

f. PC Boards and connectors are properly engaged.

g. Counter power supply voltages correct (measured on Counter Interconnect PC Board A113).

5-15. FAILURE TO INDICATE ALL ZEROS

5-16. If counter turns on, but fails to indicate all zeros with no applied signal, CHECK THAT:

a. No RESOLUTION switches are depressed.

b. INT/EXT switch is set to INT.

c. PC Boards and connectors are properly engaged.

d. Counter Power Supply (A107) voltages correct.

e. Perform Visual Display Test by pressing TEST and RESET switches simultaneously; display should show "8" in all decade positions.

f. If counter fails the Visual Display Test, refer to Troubleshooting Tree - Figure 5-2. If counter displays all eights but a digit is missing, refer to Figure 5-3. If the display does not show all zeros when it should, refer to Figure 5-4.

5-17. MALFUNCTION IN SELF TEST

5-18. If counter turns on, but fails to indicate a reading of 10 000 000 (10 MHz) in the TEST mode, CHECK THAT:

a. Counter indicates all zeros with no applied signal.

b. PC Boards and connectors are properly engaged.

c. Counter Power Supply (A107) voltages correct.

d. Counter passes Visual Display Test (para. 5-16).

e. Refer to Figure 5-5.

5-19. MALFUNCTION IN BAND IB (10 MHz to 300 MHz)

5-20. If counter fails to read frequency correctly, CHECK THAT:

a. Counter is set to Band IB (10 MHz - 300 MHz position).

b. A signal is applied to the Band I input connector. The signal level and frequency should be as specified for Band IB.

c. If signal input is correct, counter should indicate all zeros when signal is removed. If not, refer to paragraph 5-16.

d. Counter passes Visual Display Test (para.5-16).

e. Counter operates correctly in TEST mode. If not, refer to paragraph 5-18.

f. Refer to Figure 5-6.

5-21. MALFUNCTION IN BAND IA (20 Hz to 135 MHz)

5-22. If counter fails to read frequency correctly, CHECK THAT:

a. Counter is set to Band IA (20 Hz - 135 MHz position).

b. A signal is applied to the Band I input connector. The signal level and frequency should be as specified for Band IA.

c. If signal input is correct, counter should indicate all zeros when signal is removed. If not, refer to paragraph 5-16.

d. Counter passes Visual Display Test (para. 5-16).

e. Counter operates correctly in TEST mode. If not, refer to paragraph 5-18.

f. Counter operates properly in Band IB.

g. Refer to Figure 5-7.

5-23. MALFUNCTION IN BAND II (100 MHz to 850 MHz)

5-24. If counter fails to read frequency correctly, CHECK THAT:

a. Counter is set to Band II (100 MHz - 850 MHz position).

b. A signal is applied to the Band II input connector. The signal level and frequency should be as specified for Band II.

c. If signal input is correct, counter should indicate all zeros when signal is removed. If not, refer to paragraph 5-16.

d. Counter passes Visual Display Test (para. 5-16).

e. Counter operates correctly in TEST mode. If not, refer to paragraph 5-18.

f. Prescaler PC Board (A109) connector and co-ax cables properly engaged.

g. Counter operates properly in Band IB.

h. Refer to Figure 5-8.

5-25. MALFUNCTION IN BAND III (825 MHz to 18 GHz)

5-26. If counter fails to read frequency correctly, CHECK THAT:

a. Counter is set to Band III (825 MHz - 18 GHz position.

b. A signal is applied to the Band III input connector. The signal level and frequency should be as specified for Band III.

c. If signal input is correct, counter should indicate all zeros when signal is removed. If not, refer to paragraph 5-16.

d. Counter passes Visual Display Test (para. 5-16).

e. Counter operates correctly in TEST mode. If not, refer to paragraph 5-18.

f. Counter operates properly in Bands I and II.

g. Converter Control (A202 and A203) PC Board connectors and co-ax cables are properly engaged.

h. Refer to Figure 5-9.

5-27. LOCKBOX MALFUNCTION

5-28. If counter fails to lock, CHECK THAT:

a. Programmed frequency matches related counter operating band.

b. Programmed frequency is within specific capture range.

c. Phase Lock Out signal is connected to the FM or phase lock input of the source being locked.

d. Source being locked has an FM or phase lock input which meets the requirements of the 371.

e. Refer to Figure 5-10.

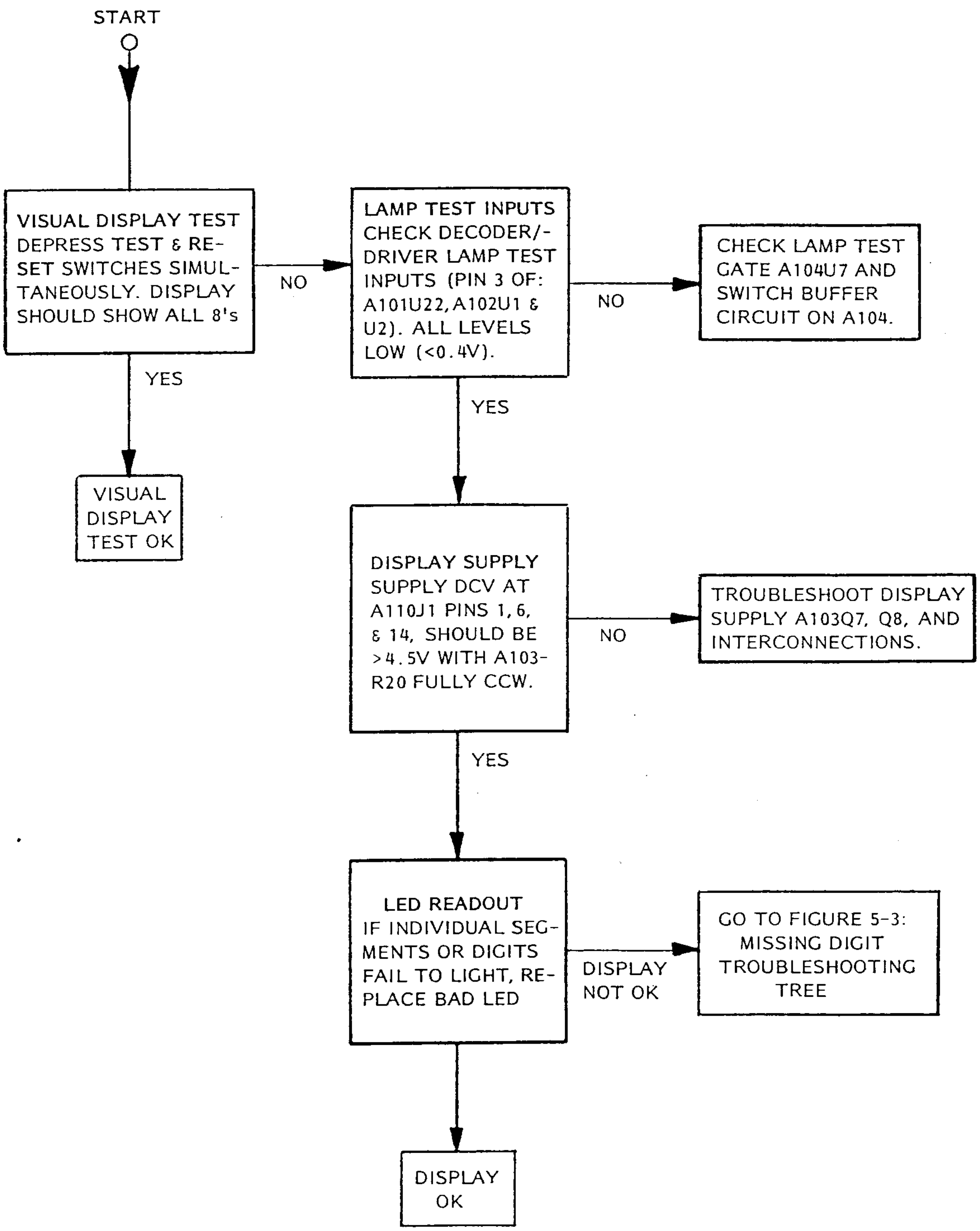
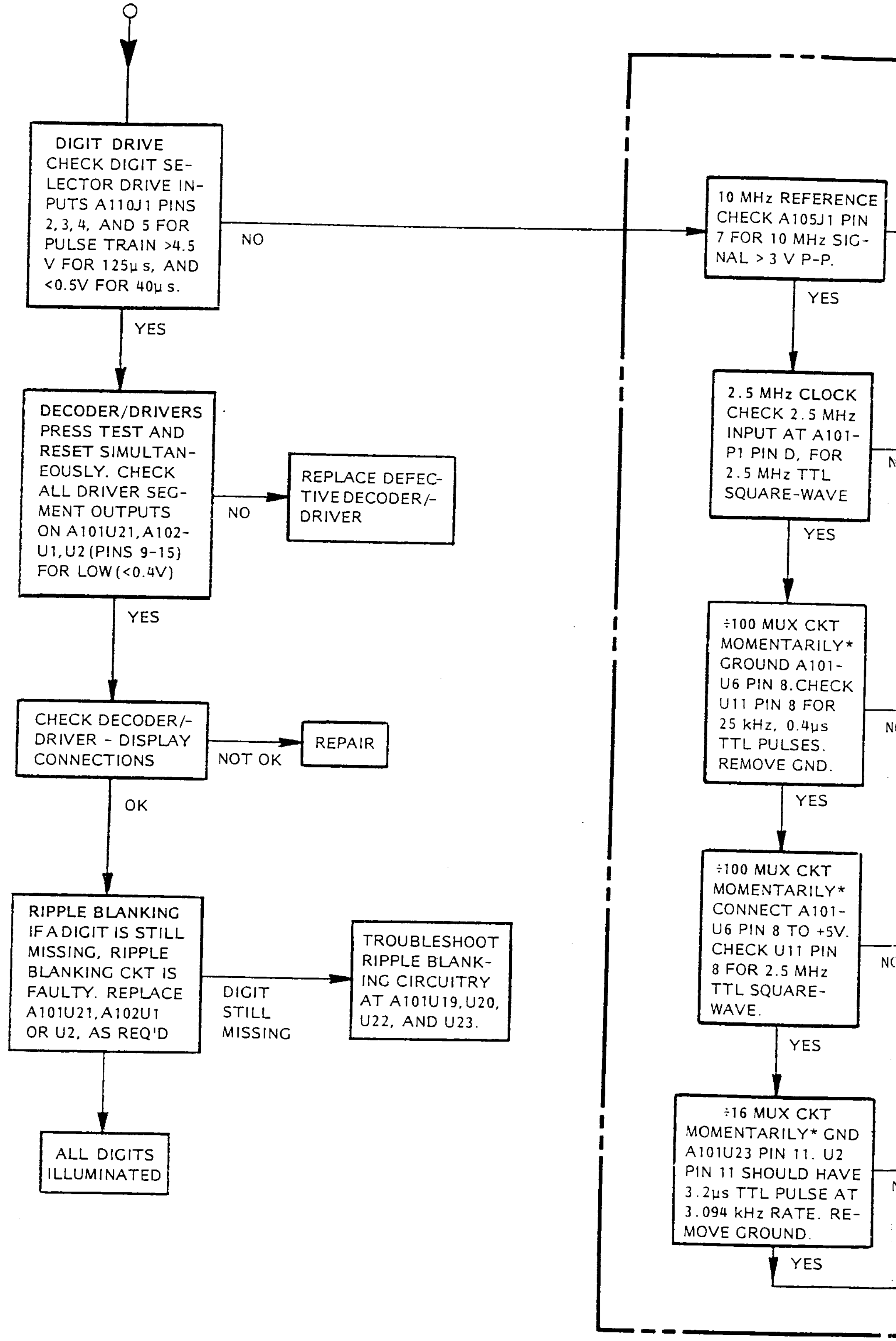
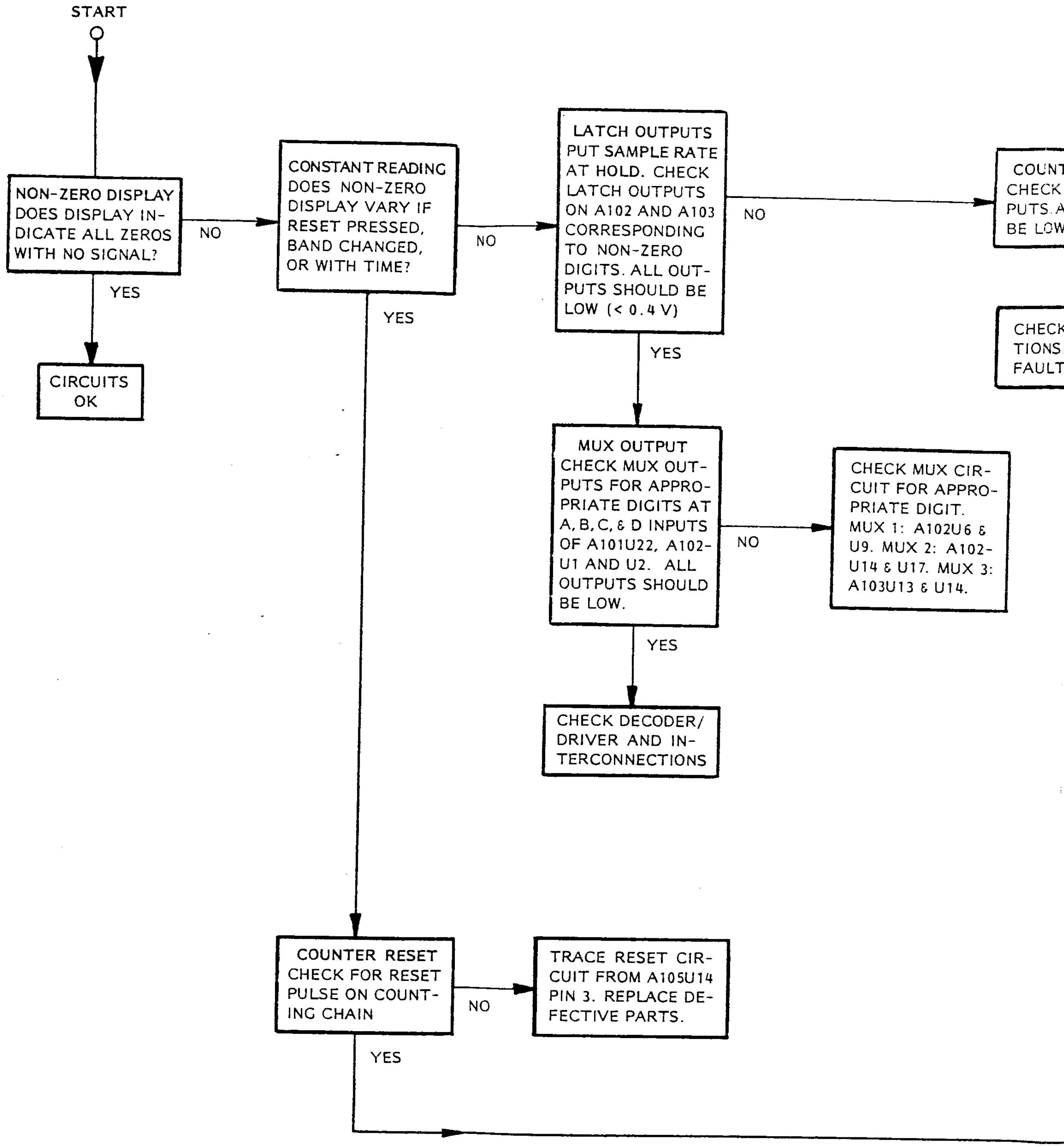
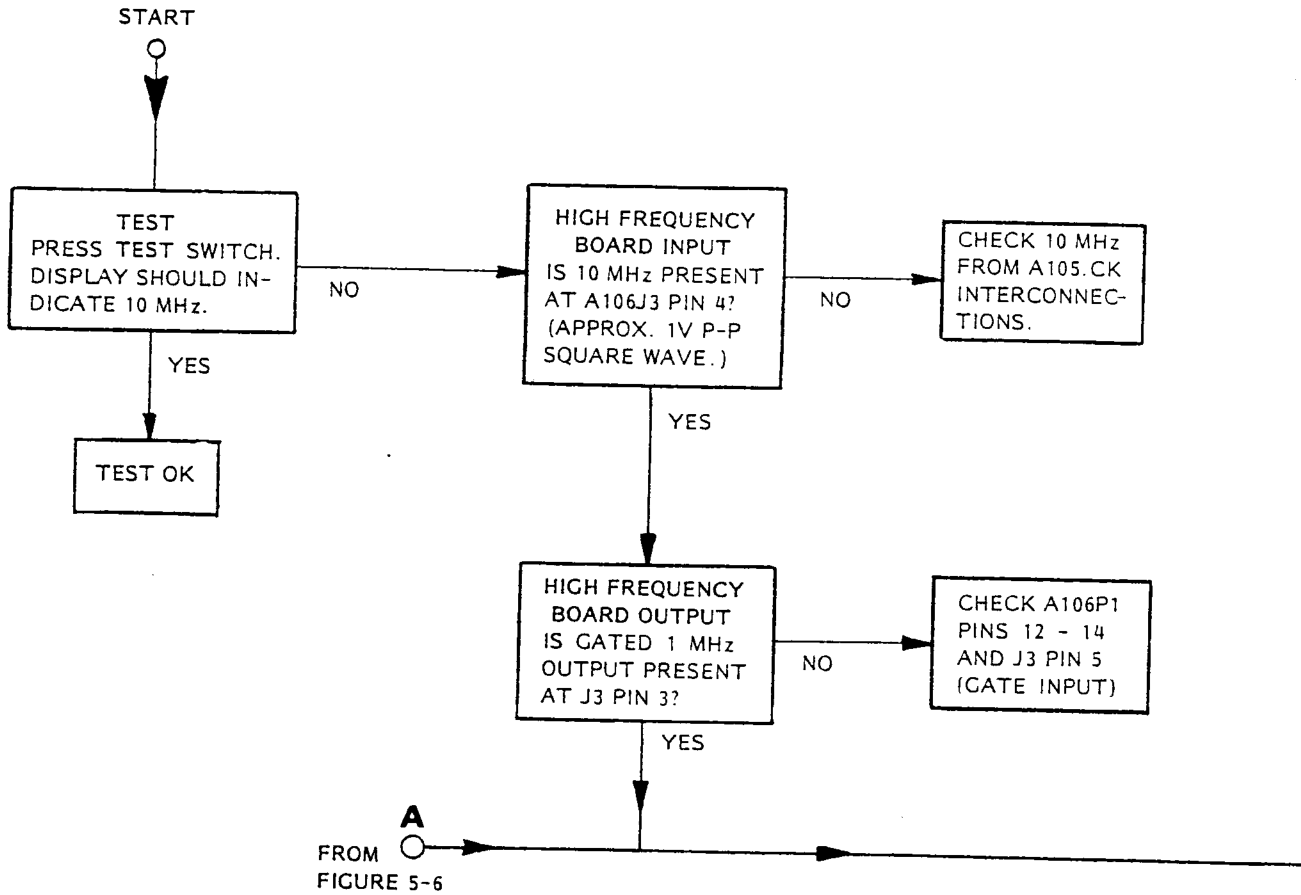
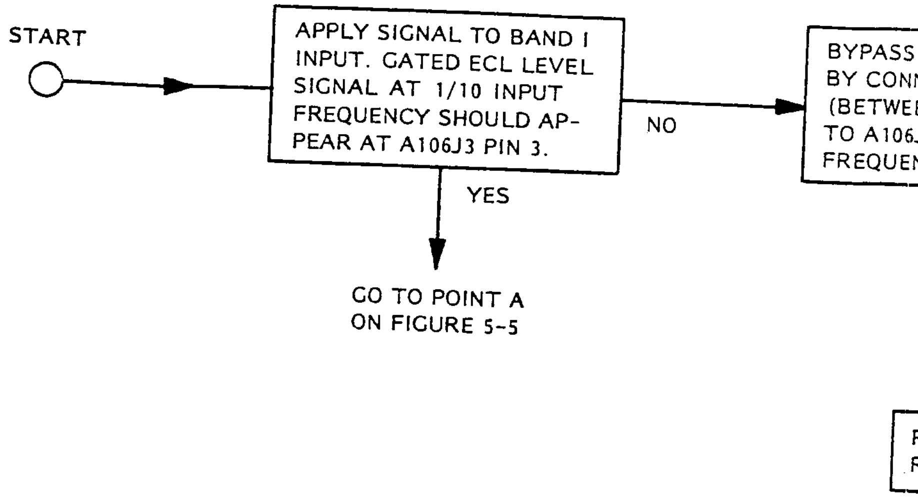


FIGURE 5-2
VISUAL DISPLAY TEST
TROUBLESHOOTING TREE


DIGIT DRIVE CHECK DIGIT SELECTOR DRIVE INPUTS A110J1 PINS 2, 3, 4, AND 5 FOR PULSE TRAIN >4.5 V FOR 125µs, AND <0.5V FOR 40µs.
NO
YES
DECODER/DRIVERS PRESS TEST AND RESET SIMULTANEOUSLY. CHECK ALL DRIVER SEGMENT OUTPUTS ON A101U21, A102-U1, U2 (PINS 9-15) FOR LOW (<0.4V)
NO
REPLACE DEFECTIVE DECODER/-DRIVER
YES
CHECK DECODER/-DRIVER - DISPLAY CONNECTIONS
NOT OK
REPAIR
OK
RIPPLE BLANKING IF A DIGIT IS STILL MISSING, RIPPLE BLANKING CKT IS FAULTY. REPLACE A101U21, A102U1 OR U2, AS REQ'D
DIGIT STILL MISSING
TROUBLESHOOT RIPPLE BLANKING CIRCUITRY AT A101U19, U20, U22, AND U23.
ALL DIGITS ILLUMINATED
10 MHz REFERENCE CHECK A105J1 PIN 7 FOR 10 MHz SIGNAL > 3 V P-P.
YES
2.5 MHz CLOCK CHECK 2.5 MHz INPUT AT A101-P1 PIN D, FOR 2.5 MHz TTL SQUARE-WAVE
YES
÷100 MUX CKT MOMENTARILY* GROUND A101-U6 PIN 8. CHECK U11 PIN 8 FOR 25 kHz, 0.4µs TTL PULSES. REMOVE GND.
YES
÷100 MUX CKT MOMENTARILY* CONNECT A101-U6 PIN 8 TO +5V. CHECK U11 PIN 8 FOR 2.5 MHz TTL SQUARE-WAVE.
YES
÷16 MUX CKT MOMENTARILY* GND A101U23 PIN 11. U2 PIN 11 SHOULD HAVE 3.2µs TTL PULSE AT 3.094 kHz RATE. REMOVE GROUND.
YES


START
NON-ZERO DISPLAY DOES DISPLAY INDICATE ALL ZEROS WITH NO SIGNAL?
NO
YES
CIRCUITS OK
CONSTANT READING DOES NON-ZERO DISPLAY VARY IF RESET PRESSED, BAND CHANGED, OR WITH TIME?
NO
YES
LATCH OUTPUTS PUT SAMPLE RATE AT HOLD. CHECK LATCH OUTPUTS ON A102 AND A103 CORRESPONDING TO NON-ZERO DIGITS. ALL OUTPUTS SHOULD BE LOW (< 0.4 V)
NO
YES
COUNT
CHECK
PUTS. A
BE LOW
CHECK
TIONS
FAULT
MUX OUTPUT CHECK MUX OUTPUTS FOR APPROPRIATE DIGITS AT A, B, C, & D INPUTS OF A101U22, A102-U1 AND U2. ALL OUTPUTS SHOULD BE LOW.
NO
CHECK MUX CIRCUIT FOR APPROPRIATE DIGIT. MUX 1: A102U6 & U9. MUX 2: A102-U14 & U17. MUX 3: A103U13 & U14.
YES
CHECK DECODER/ DRIVER AND INTERCONNECTIONS
COUNTER RESET CHECK FOR RESET PULSE ON COUNTING CHAIN
NO
TRACE RESET CIRCUIT FROM A105U14 PIN 3. REPLACE DEFECTIVE PARTS.
YES


START
TEST
PRESS TEST SWITCH.
DISPLAY SHOULD INDICATE 10 MHz.
NO
YES
TEST OK
HIGH FREQUENCY BOARD INPUT
IS 10 MHz PRESENT AT A106J3 PIN 4?
(APPROX. 1V P-P SQUARE WAVE.)
NO
CHECK 10 MHz FROM A105.CK INTERCONNECTIONS.
YES
HIGH FREQUENCY BOARD OUTPUT
IS GATED 1 MHz OUTPUT PRESENT AT J3 PIN 3?
NO
CHECK A106P1 PINS 12 - 14 AND J3 PIN 5 (GATE INPUT)
YES
A
FROM FIGURE 5-6



START
APPLY SIGNAL TO BAND I INPUT. GATED ECL LEVEL SIGNAL AT 1/10 INPUT FREQUENCY SHOULD APPEAR AT A106J3 PIN 3.
NO
YES
GO TO POINT A ON FIGURE 5-5
BYPASS

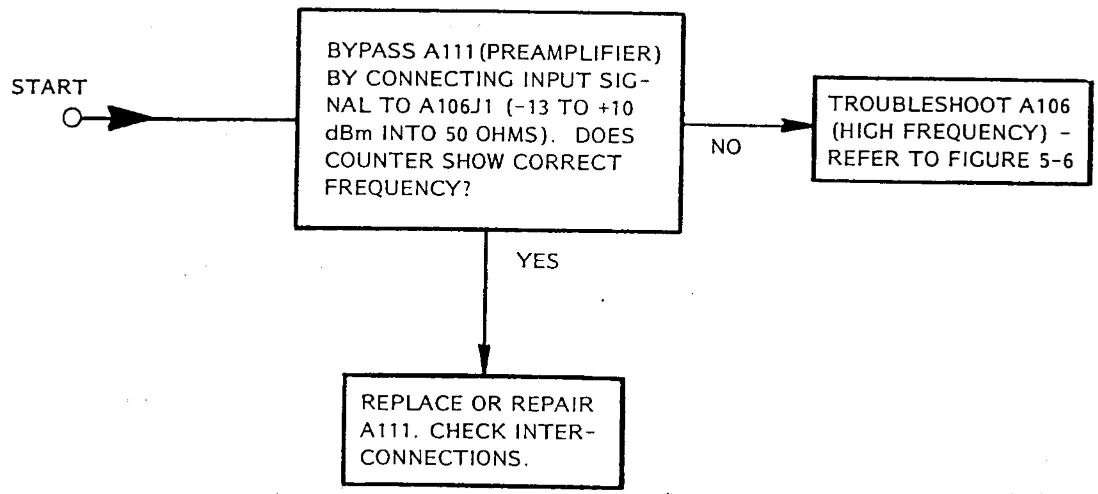
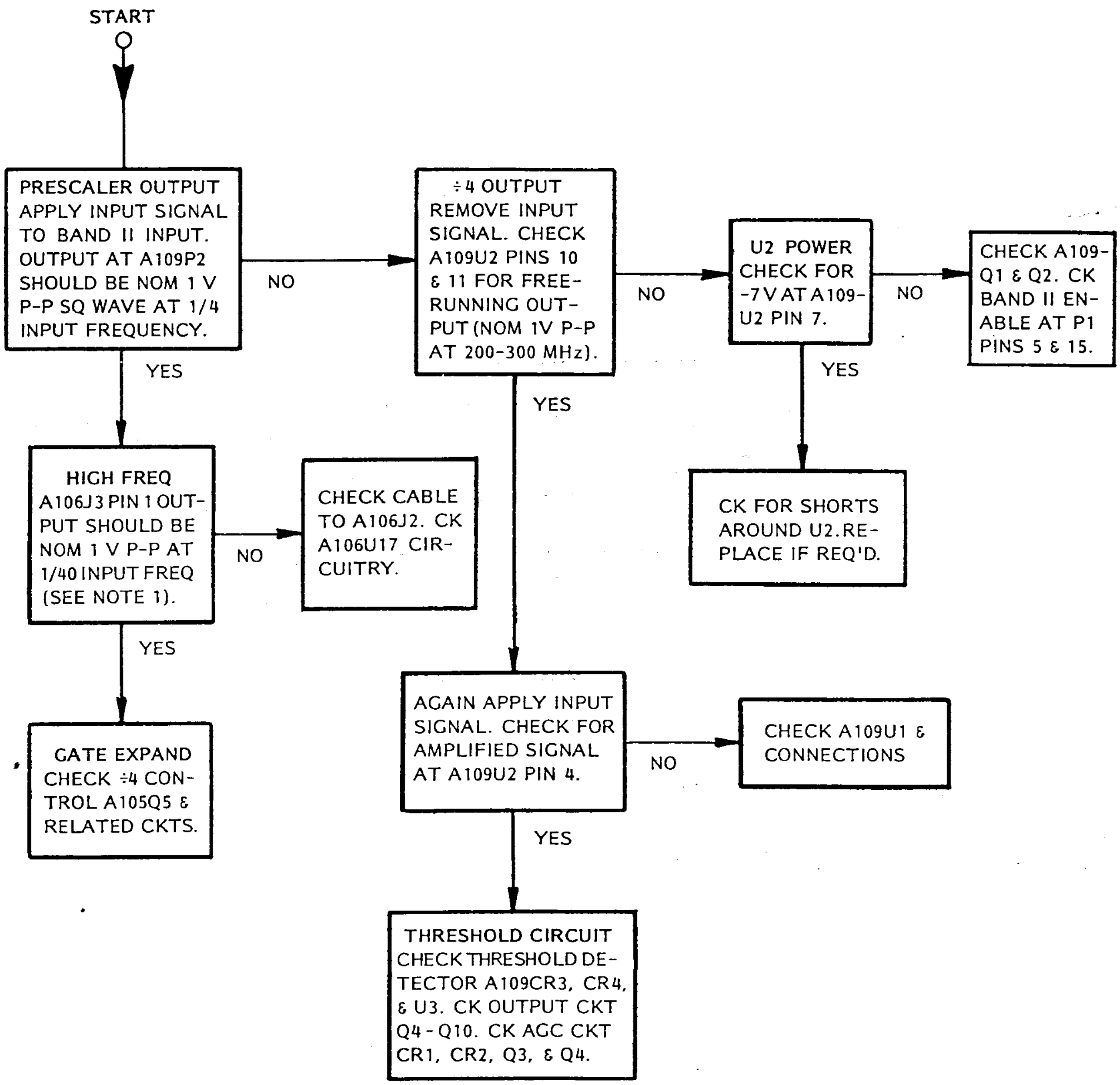
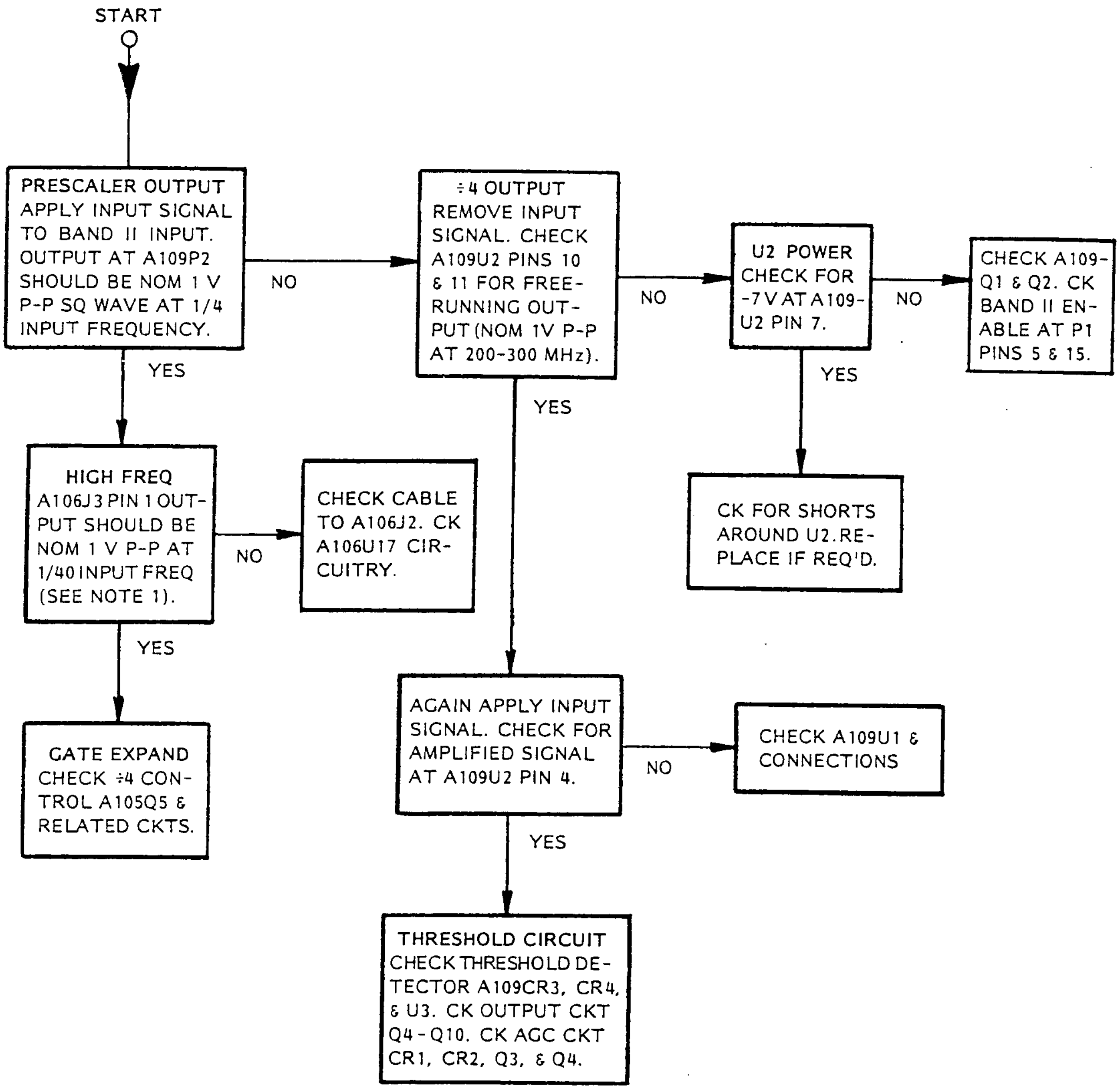


FIGURE 5-7
BAND IA
TROUBLESHOOTING TREE



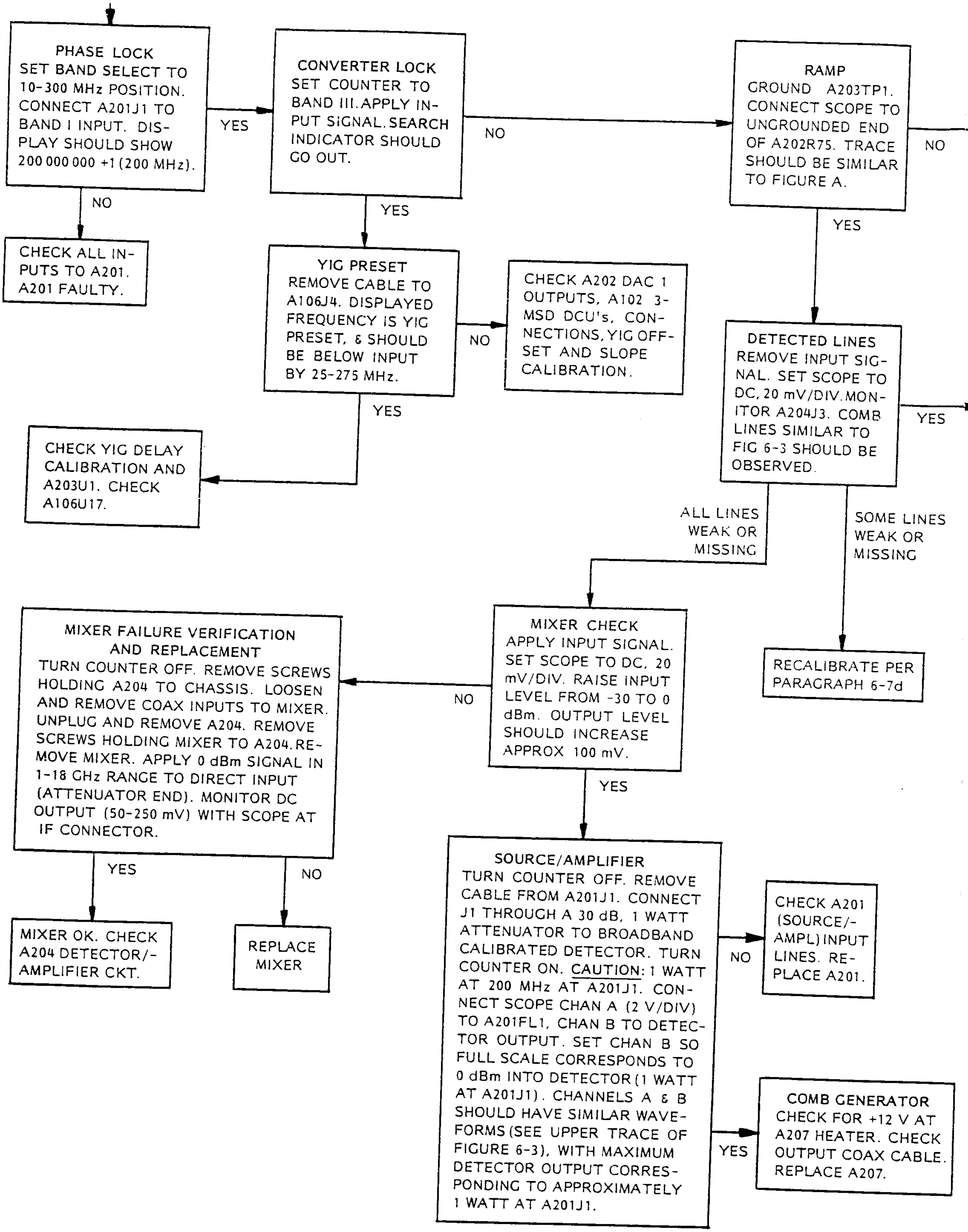
NOTE 1: TROUBLESHOOTING OF A106 REQUIRES USE OF A SAMPLING OSCILLOSCOPE WITH A 1 GHz OR GREATER BANDWIDTH. CARE MUST BE EXERCISED TO LOAD CIRCUIT JUNCTION LIGHTLY. MAXIMUM PROBE CAPACITANCE: 1 PF. MINIMUM RESISTANCE: 500 OHMS.

FIGURE 5-8
BAND II
TROUBLESHOOTING TREE



NOTE 1: TROUBLESHOOTING OF A106 REQUIRES USE OF A SAMPLING OSCILLOSCOPE WITH A 1 GHz OR GREATER BANDWIDTH. CARE MUST BE EXERCISED TO LOAD CIRCUIT JUNCTION LIGHTLY. MAXIMUM PROBE CAPACITANCE: 1 PF. MINIMUM RESISTANCE: 500 OHMS.

FIGURE 5-8
BAND II
TROUBLESHOOTING TREE


PHASE LOCK
SET BAND SELECT TO 10-300 MHz POSITION. CONNECT A201J1 TO BAND I INPUT. DISPLAY SHOULD SHOW 200 000 000 +1 (200 MHz).
YES
NO
CHECK ALL INPUTS TO A201. A201 FAULTY.
CONVERTER LOCK
SET COUNTER TO BAND III. APPLY INPUT SIGNAL. SEARCH INDICATOR SHOULD GO OUT.
NO
YES
YIG PRESET
REMOVE CABLE TO A106J4. DISPLAYED FREQUENCY IS YIG PRESET, & SHOULD BE BELOW INPUT BY 25-275 MHz.
NO
CHECK A202 DAC 1 OUTPUTS, A102 3-MSD DCU's, CONNECTIONS, YIG OFFSET AND SLOPE CALIBRATION.
YES
CHECK YIG DELAY CALIBRATION AND A203U1. CHECK A106U17.
RAMP
GROUND A203TP1. CONNECT SCOPE TO UNGROUNDED END OF A202R75. TRACE SHOULD BE SIMILAR TO FIGURE A.
NO
YES
DETECTED LINES
REMOVE INPUT SIGNAL. SET SCOPE TO DC, 20 mV/DIV. MONITOR A204J3. COMB LINES SIMILAR TO FIG 6-3 SHOULD BE OBSERVED.
YES
ALL LINES WEAK OR MISSING
SOME LINES WEAK OR MISSING
RECALIBRATE PER PARAGRAPH 6-7d
MIXER CHECK
APPLY INPUT SIGNAL. SET SCOPE TO DC, 20 mV/DIV. RAISE INPUT LEVEL FROM -30 TO 0 dBm. OUTPUT LEVEL SHOULD INCREASE APPROX 100 mV.
NO
MIXER FAILURE VERIFICATION AND REPLACEMENT
TURN COUNTER OFF. REMOVE SCREWS HOLDING A204 TO CHASSIS. LOOSEN AND REMOVE COAX INPUTS TO MIXER. UNPLUG AND REMOVE A204. REMOVE SCREWS HOLDING MIXER TO A204. REMOVE MIXER. APPLY 0 dBm SIGNAL IN 1-18 GHz RANGE TO DIRECT INPUT (ATTENUATOR END). MONITOR DC OUTPUT (50-250 mV) WITH SCOPE AT IF CONNECTOR.
YES
NO
MIXER OK. CHECK A204 DETECTOR/-AMPLIFIER CKT.
REPLACE MIXER
YES
SOURCE/AMPLIFIER
TURN COUNTER OFF. REMOVE CABLE FROM A201J1. CONNECT J1 THROUGH A 30 dB, 1 WATT ATTENUATOR TO BROADBAND CALIBRATED DETECTOR. TURN COUNTER ON. CAUTION: 1 WATT AT 200 MHz AT A201J1. CONNECT SCOPE CHAN A (2 V/DIV) TO A201FL1, CHAN B TO DETECTOR OUTPUT. SET CHAN B SO FULL SCALE CORRESPONDS TO 0 dBm INTO DETECTOR (1 WATT AT A201J1). CHANNELS A & B SHOULD HAVE SIMILAR WAVEFORMS (SEE UPPER TRACE OF FIGURE 6-3), WITH MAXIMUM DETECTOR OUTPUT CORRESPONDING TO APPROXIMATELY 1 WATT AT A201J1.
NO
CHECK A201 (SOURCE/-AMPL) INPUT LINES. REPLACE A201.
YES
COMB GENERATOR
CHECK FOR +12 V AT A207 HEATER. CHECK OUTPUT COAX CABLE. REPLACE A207.

SECTION 6

ADJUSTMENTS & CALIBRATION

6-1. GENERAL

6-2. This section describes the procedures to be followed to correctly adjust the EIP Counter. In general, adjustments should be made only if the instrument is not operating within specifications, or following replacement of components. Test equipment required is specified in Table 5-1. If adjustments do not result in the specified performance, refer to Section 5.

> **IMPORTANT**
>
> Many adjustments are dependent upon previous ones. It is essential that care be taken to perform adjustments in exactly the order presented below. Adjustment locations are shown in Figure 6-1.

6-3. POWER SUPPLY ADJUSTMENT

6-4. Prior to any power supply adjustments, the instrument should be allowed to warm-up for at least 20 minutes. All voltages are measured on Counter Interconnect board A113. Adjustments are made according to the following procedure:

a. Connect DVM to GND on A113.

b. Measure +12 VDC output. Adjust A107R7 until output is +12.000 ± .010 VDC.

c. Measure +5 VDC output. Adjust A107R15 until output is +5.000 ± .010 VDC.

d. Measure -12 VDC output. Adjust A107R21 until output is -12.000 ± .010 VDC.

e. Measure -5.2 VDC output. Adjust A107R31 until output is -5.200 ± .010 VDC.

6-5. BAND I ADJUSTMENTS (20 Hz to 300 MHz)

No Band I adjustments are required.

6-6. BAND II ADJUSTMENTS (100 MHz to 850 MHz)

a. Threshold:

(1) Set counter to the Band II (100 MHz - 850 MHz) position.

(2) Connect a 100 MHz, -15 dBm CW signal to the Band II input connector. Set A109R41 (on Prescaler) to maximum sensitivity.

(3) Reduce signal level until counter just begins to miscount.

(4) Adjust A109R41 until the reading just drops to all zeros.

6-7. BAND III ADJUSTMENTS (825 MHz to 12.4/18 GHz)

a. For all the following tests, set counter to the Band III (825 MHz - 12.4/18 GHz) position.

b. Video Detector Gain (see also Paragraph 6-7g.):

(1) Disconnect cable from output of Video Amplifier (A204J2).

(2) Connect a 150 MHz CW signal at -6 dBm to Cable A203P2 (W21).

(3) Connect DVM to Converter Control 1 Test Point A203TP6.

(4) Adjust A203R22 for 300 ± 20 millivolts.

c. In-Band Detector switching point:

(1) Connect sweep generator to A203P2. Set controls as follows:

Sweep	265 MHz downward to 245 MHz
Level	0 dBm
Markers	Every 10 MHz

(2) Connect dual trace oscilloscope as follows:

Horizontal	To sweep generator
Ch. A	A203TP4 via vertical output on sweep generator.

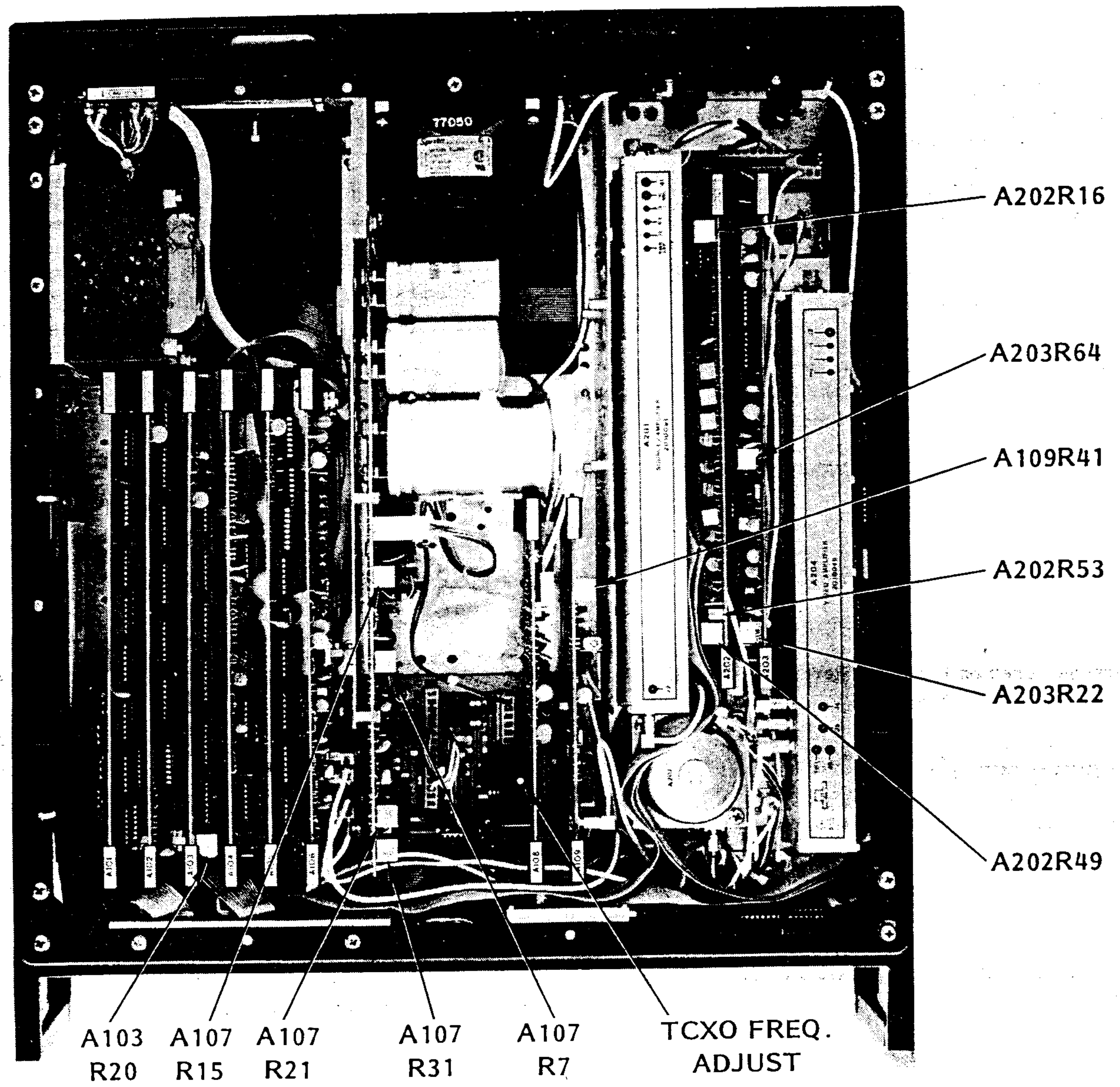


FIGURE 6-1
CALIBRATION
ADJUSTMENT
LOCATOR

(3) Adjust A203R64 so the switching spike is coincident with the 250 MHz marker as shown in Figure 6-2.

(4) Reconnect cable to A204J2.

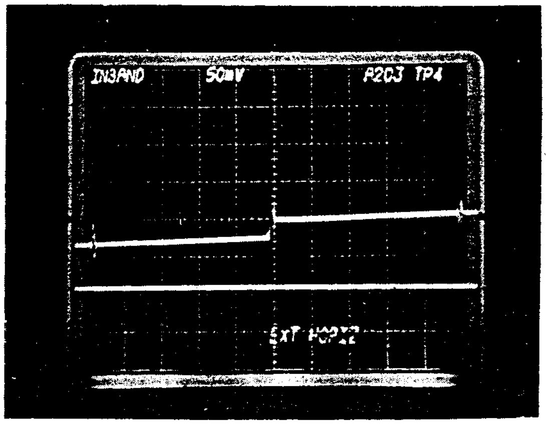


FIGURE 6-2
IN-BAND DETECTOR SWITCHING POINT

d. PIN Level Control Threshold:

(1) Unplug Source/Amplifier power plug A208J1.

(2) Connect a 3 dB pad to the Band III input connector. Apply a +3 dBm, 1.0 GHz, square-wave modulated signal to the pad.

(3) Observe the square-wave signal at A204TP1.

(4) Adjust A204R61 until the square-wave at TP1 is 90 to 100 mV in amplitude.

(5) Reconnect Source/Amplifier power plug.

e. YIG Driver Offset and Slope:

NOTE: For this adjustment a Summing Amplifier capable of providing a variable DC offset is recommended. One can be constructed as shown in Figure 5-1, or a dual trace oscilloscope with differential inputs (such as HP1200A) may be used if the signal is applied to one side of the differential input, and a variable DC power supply to the other input.

(1) Connect dual trace oscilloscope as follows:

Ch. A	A203TP6 (Video Detector Output)
Ch. B	A202J3 pin 1 (Ramp) via Summing Amplifier
Ext. Trig.	A203TP5 (CONVERTER RESET)

(2) Ground A203TP1.

(3) Apply a signal of approximately 1.1 GHz at -15 dBm to Band III input.

(4) Depress RESET switch.

(5) With no DC offset applied, adjust Channel B vertical sensitivity so each ramp step is two vertical divisions (approximately 10 mV/div). Set Channel A to 20 mV/div. Set time base to 5 ms/cm and set time base multiplier to X10. Oscilloscope display should appear as shown in Figure 6-3.

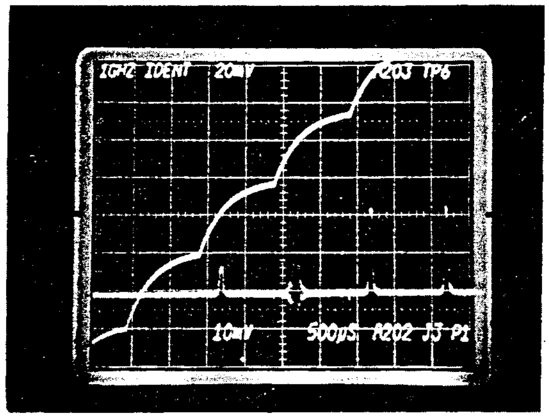


FIGURE 6-3
1 GHz COMB LINE IDENTIFICATION

(6) Reduce the input frequency to 1.0 GHz. When the input frequency is exactly 1 GHz, the center line of the three comb lines on Channel A should null. This identifies the 1 GHz comb line. The 800 MHz comb line is the line preceeding the 1 GHz line.

(7) Remove the ground from A203TP1 and place it on A203TP2. Depress the RESET switch.

(8) Adjust YIG Offset A202R49 so the ramp resets at 50% (1 div) of the fourth ramp step (See Figure 6-4).

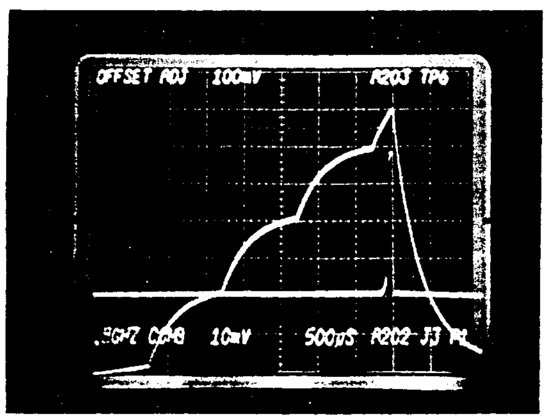


FIGURE 6-4
YIG DRIVER OFFSET ADJUSTMENT

(9) Tune slowly from 1 GHz to 18 GHz. As the frequency is changed, adjust the DC offset and the horizontal position control of the oscilloscope to maintain the upper portion of the ramp on the display. Above 10 GHz, the time base will need to be increased to 10 msec/div.

As the frequency is changed, adjust YIG slope with A202R53, so the ramp reset occurs in the range of 40 to 60% of the full step amplitude. At 18 GHz, adjust R53 so reset occurs at 60% of the step amplitude.

(10) Recheck YIG Offset A202R49 and readjust at 1 GHz if necessary. If A202R49 is readjusted, it will be necessary to reset YIG Slope A202R53 at 18 GHz.

f. YIG Delay Correction

(1) With connections as in paragraph 6.7e, set input frequency to 1 GHz at -15 dBm, and oscilloscope time base control to 10 ms/div., unexpanded.

(2) Adjust YIG Delay Correction A202R16 so display appears approximately as shown in Figure 6-5.

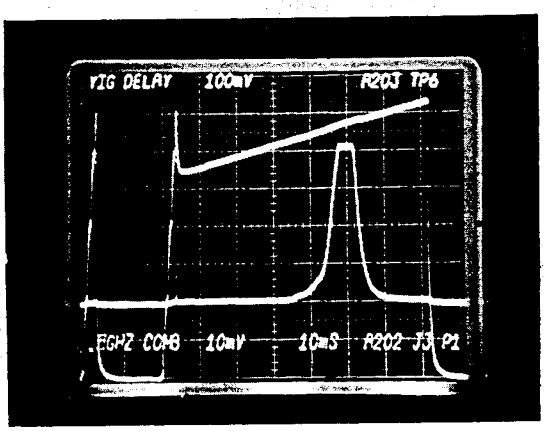


FIGURE 6-5
YIG DELAY CORRECTION 1

(3) Set time base to variable (approx. 5 ms/div) and externally trigger oscilloscope from A203P1 pin 12 (DAC 2 ENABLE). Adjust oscilloscope time base so DAC 2 ramp occupies the full screen.

(4) Adjust A202R16 so the 50% point of the leading edge of the video pulse occurs one division to the right of center of the DAC 2 ramp as shown in Figure 6-6. Note that the point marked "Ramp Start" is 3 ms after DAC 2 ENABLE, and that the point marked "Ramp Center" is *not* the center of of the display.

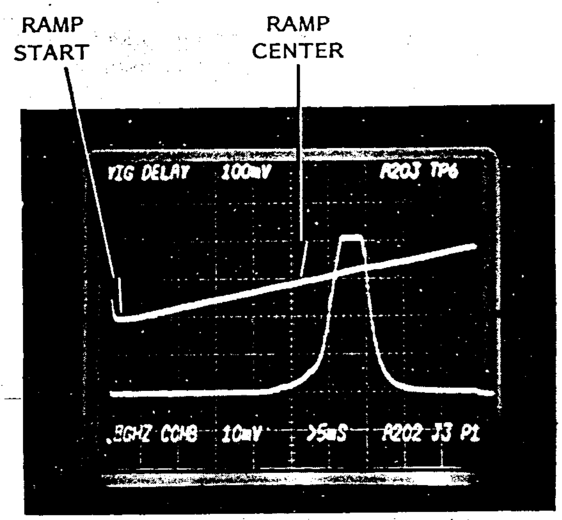


FIGURE 6-6
YIG DELAY CORRECTION 2

(5) Tune to 18 GHz (12.4 on 350D) and observe leading edge position with respect to DAC 2 "Ramp Center". This should be approximately one division to the left of "Ramp Center".

(6) If necessary, readjust A202R16 until the leading edge of the video pulse is the same distance to the right of "Ramp Center" at 1 GHz, as it is to the left of "Ramp Center" at 18 GHz (12.4 GHz on 350D).

g. Final Video Detector Gain Adjustment

NOTE: The procedure of paragraph 6-7b will not necessarily result in optimum performance. The following procedure sets the Video Detector gain to give maximum sensitivity without loss of instrument accuracy.

(1) Set stable source power level to -20 dBm, and frequency to 8 GHz (short term stability $\leqslant$ 1 kHz). Connect source to the Band III input. Observe frequency indication on counter.

(2) Reduce input power slowly while frequently pressing RESET button. At some power level, the counter will lose lock.

(3) Increase power slightly so counter will just achieve lock and display a frequency.

(4) Displayed frequency should be correct (no reduction in indicated frequency). Increase Video Detector gain (adjust A203R22), and repeat steps (2) and (3) until an erroneous count is obtained.

(5) Once an erroneous count is obtained, begin decreasing Video Detector gain and repeat steps (2) and (3) until frequency indication is either correct, or zero (no LOCK), as power level is varied and counter is reset.

U11 PRAM

h. Comb Leveling/Bias:

NOTE: The most important function of comb leveling is to insure that spurious mixing products (due to doubling of the comb frequency within the Mixer), do not cause erroneous readings. Thus this leveling procedure insures that maximum output due to these mixing products are below the lock threshold.

(1) Connect oscilloscope as follows:

Ch. A	A203TP6 (Video Detector output)
Ext. Trig.	A202P1 pin 12 (CONV. RESET)
Time Base	2 ms/div

(2) Ground A203TP1.

(3) Apply a 1.5 GHz signal at +7 dBm; observe the Video Detector signal.

(4) Slowly tune the frequency upward. At some frequencies, a spurious output corresponding to approximately one half the input frequency will be visible.

(5) As the frequency is varied from 1.5 to 18 GHz, adjust A202R69 so no spurious signal has an amplitude in excess of 290 mV. Refer to Figure 6-7 for a typical display. (Vary scope time base as necessary to keep the display on the screen.)

IMPORTANT: Do not attenuate comb lines more than absolutely necessary to maintain maximum spurious outputs of 290 mV. Comb line power relates directly to sensitivity.

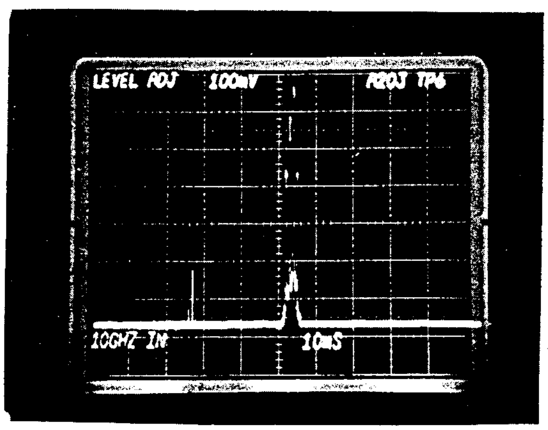


FIGURE 6-7
COMB FREQUENCY HARMONIC GENERATION

6-8. TIME BASE CALIBRATION

IMPORTANT

The precision of time base calibration directly affects overall counter accuracy. Reasons for recalibration, and procedures to be used, should be thoroughly understood before attempting any readjustment.

6-9. The fractional frequency error in the frequency indicated by the counter, is equal to the negative of the fractional frequency error of the Time Base Oscillator with respect to its true value. That is:

$$\frac{\Delta f_s}{f_s} = -\frac{\Delta f_t}{f_t}$$

where f_s is the true frequency of the measured signal, and f_t is the true frequency of the Time Base Oscillator. Thus the inaccuracy associated with a frequency measurement, is directly related to the quality of the Time Base Oscillator, and a measure of the precision with which it was originally adjusted.

6-10. TCXO CALIBRATION

6-11. The standard time base oscillator used in the counter is a temperature-compensated crystal oscillator: a TCXO (A116). The highest and lowest actual measured frequencies of this oscillator will differ by no more than 2 parts in 10^6 if the temperature is varied slowly from 0° to +50°C. Therefore, an indicated measurement will exhibit the same fluctuation even though the signal being measured is not changing. To center this fluctuation on the true value of the measured signal, each TCXO has imprinted on its side, the frequency to which it must be set at +25°C. The calibration procedure for this adjustment is described in Paragraphs 6-15 through 6-17.

6-12. At approximate room temperature (+25°C.), the slope of the frequency vs. temperature curve, is normally no worse than -1×10^{-7} parts per °C. Therefore, if the counter is used in an ordinary laboratory environment, the TCXO may be set as close to 10 000 000 Hz as desired. In this environment, a peak-to-peak temperature variation of 5°C. will result in a measured signal error due to oscillator temperature characteristics of no more than $\pm 2.5 \times 10^{-7}$ parts. Refer to Paragraphs 6-23 through 6-26 for a recommended adjustment procedure.

6-13. Another source of inaccuracy in the measured signal due to the Time Base Oscillator originates in the natural aging characteristic of the crystal. Aging refers to the long term, irreversible change in frequency, generally in the positive direction, which all quartz oscillators experience. The magnitude of this frequency fluctuation in the TCXO is specified to be less than 3×10^{-7} parts per month. This may be expected to improve in time to be no worse than 1×10^{-6} parts per year in continuous service.

6-14. Error due to aging adds directly to error due to temperature perturbations. Thus the frequency of recalibration is dependent upon the overall accuracy requirement of the counter and its environment. For example: If the counter is subjected to the full operating temperature range, and initially adjusted properly, then one month later, the inaccuracy over temperature could be expected to vary from $+1.3 \times 10^{-6}$ parts, to -0.7×10^{-6} parts.

6-15. TCXO CALIBRATION PROCEDURE

NOTICE

For both TCXO recalibration methods: Remove top cover of counter. Connect counter to reliable power source. Note ambient temperature.

6-16. METHOD 1:

a. Measure the frequency of the TCXO at the rear panel 10 MHz IN/OUT connector, with a second counter of known calibration accuracy.

b. Adjust the TCXO if necessary, by turning the calibration screw on the TCXO case until the measured frequency is the same as that shown on the TCXO calibration label.

6-17. METHOD 2:

a. Apply a 10 000 000 Hz signal from a frequency standard or other oscillator of suitable accuracy and stability to the Band I input of the counter. All RESOLUTION switches should be set to display all the digits including the 1 Hz digit.

b. Adjust the TCXO until the indicated reading on the counter is offset from 10 000 000 Hz by the negative of the frequency shown on the TCXO. For example: If the TCXO calibration label shows a frequency of 10 000 003 Hz, adjust the TCXO until the displayed reading shows 9 999 997 Hz.

6-18. OVEN STABILIZED OSCILLATOR CALIBRATION

6-19. If one of the Oven Stabilized Oscillator options is installed in the counter (see Section O), the effects of temperature perturbations and aging must still be considered, although the magnitude of these inaccuracies associated with each oscillator are greatly reduced.

6-20. Full benefit of the Oven Stabilized Oscillator characteristics can only be realized if the Oscillator is running continuously: that is, with the counter always connected to a source of AC power. Under these conditions, the perturbations in frequency will generally be in the positive direction for either an increase or decrease in temperature from +25°C. The aging characteristic is also generally in the positive direction.

6-21. The frequency of readjustment of the Oven Stabilized Oscillator is determined by the level of accuracy required. A method of adjusting the oscillator to an inaccuracy of less than 1×10^{-9} parts, relative to a standard, is given in Paragraphs 6-22 through 6-26.

6-22. OVEN STABILIZED OSCILLATOR TEST PROCEDURE

NOTE: This procedure is also usable with the TCXO under the conditions described in Paragraph 6-12.

6-23. TEST EQUIPMENT REQUIRED:

See Table 5-1.

6-24. Figure 6-8 shows the test set-up for determining the frequency of the Oven Stabilized Oscillator (A112). The frequency inaccuracy, relative to a standard, is determined by observing the drift of the oscilloscope pattern. The fractional frequency offset is computed from:

$$\frac{T_{\text{drift of zero crossing}}}{T_{\text{observation time of drift}}} = \frac{\Delta f}{f}$$

For example: If the pattern drifts at a rate of .01 microsecond every 10 seconds, the frequency is in error by 1 part in 10^9.

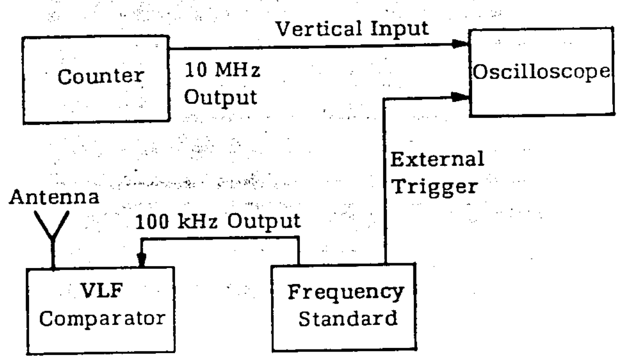


FIGURE 6-8
TIME BASE CALIBRATION

6-25. All frequency checks and adjustments should be made only after the Oven Stabilized Oscillator has been connected to its operating power supply for 24 hours. If the oscillator has been disconnected from its power source for more than 24 hours, it may require 72 hours of continuous operation to achieve the specified frequency aging rate (refer to paragraph 7-12).

6-26. TO MEASURE OSCILLATOR FREQUENCY:

a. Connect the counter's internal oscillator output signal from the 10 MHz IN/OUT connector (on the rear panel of the counter) to the vertical input of the oscilloscope.

b. Trigger oscilloscope externally with the frequency standard. The VLF Comparator is used to determine the absolute frequency of the standard.

c. Set oscilloscope sweep rate to 0.1 μ sec/cm and expand X10; this results in a sweep rate of .01 μ sec/cm.

d. Adjust oscilloscope vertical controls for maximum gain.

e. Determine the frequency difference (see para. 6-24).

f. Horizontal drift of oscilloscope display in μ sec/sec, is a measure of the difference between the frequency standard and the counter oscillator frequency. If the difference is excessive for the desired counter application, vary the TIME BASE ADJUST control on the rear panel of the counter until the pattern stops drifting. NOTE: For highest accuracy, the counter should be operated for 72 hours prior to adjustment.

6-27. LOCKBOX ADJUSTMENTS

No lockbox adjustments are required.

6-28. Instrument calibration is now complete.

SECTION 7

PERFORMANCE TESTS

7-1. GENERAL

7-2. The purpose of this section is to enable the user to verify that the counter meets specifications over the entire frequency range.

7-3. VARIABLE LINE VOLTAGE

7-4. During the performance tests the counter should be connected to the power source through a variable voltage device so that line voltage may be varied ± 10% from nominal (115 or 230 Vac) to assure proper operation of the counter under various supply conditions.

7-5. RECOMMENDED TEST EQUIPMENT

7-6. See Table 5-1 for recommended test equipment. Other equipment may be used provided that performance is equal to, or better than, that listed in the table.

7-7. PERFORMANCE TESTS

7-8. RANGE AND SENSITIVITY — BAND IA (20 Hz to 135 MHz)

a. Set controls as follows:

(1) SAMPLE RATE: Fully counter-clockwise.

(2) BAND SELECT: 20 Hz - 135 MHz range.

(3) TIME BASE switch: Set to INT.

b. Connect signal source output to Band I input via 50 ohm shunt feedthru resistor (to terminate source).

c. Set signal level to 25 mV rms (-19 dBm into 50 ohms).

d. Vary signal from 20 Hz to 135 MHz (changing signal source as required). Counter should display correct input frequency.

7-9. RANGE AND SENSITIVITY — BAND IB (10 MHz to 300 MHz)

a. Set controls as follows:

(1) SAMPLE RATE: Fully counter-clockwise.

(2) BAND SELECT: 10 MHz - 300 MHz range.

(3) TIME BASE switch: Set to INT.

b. Connect signal source output to Band I input.

c. Vary signal frequency from 10 MHz to 300 MHz at -20 dBm (22 mV rms) power level. Counter should display correct input frequency.

7-10. RANGE AND SENSITIVITY — BAND II (100 MHz to 850 MHz)

a. Set controls as follows:

(1) SAMPLE RATE: Fully counter-clockwise.

(2) BAND SELECT: 100 MHz - 850 MHz range.

(3) TIME BASE switch: Set to INT.

b. Connect signal source output to Band II input.

c. Vary signal frequency from 100 MHz to 150 MHz at -15 dBm (40 mV rms) power level. Counter should display correct input frequency.

d. Change level to -20 dBm (22 mV rms). Vary frequency from 150 MHz to 850 MHz. Counter should display correct frequency.

7-11. RANGE AND SENSITIVITY — BAND III (825 MHz to 18 GHz)

a. Set controls as follows:

(1) SAMPLE RATE: Fully counter-clockwise.

(2) BAND SELECT: 825 MHz - 18 GHz range.

(3) TIME BASE switch: Set to INT.

b. Connect leveled source output to Band III input.

c. Vary signal frequency from 825 MHz to 18 GHz at the following levels:

825 MHz - 1.1 GHz	-25 dBm (12 mV rms)
1.1 GHz - 12.4 GHz	-30 dBm (7 mV rms)
12.4 GHz - 18.0 GHz	-25 dBm (12 mV rms)

Counter should display correct input frequency.

7-12. YIG PRESET — BAND III

a. Connect microwave source to Band III input.

b. Program the YIG preset frequency as shown in Table 7-1. Verify that counter locks on the desired frequency but not on an undesired frequency.

YIG PRESET FREQUENCY	DESIRED LOCK FREQUENCY	UNDESIRED LOCK FREQUENCY
0.8 GHz	1.1 GHz	0.5 GHz
1.0	1.3	0.7
1.2	1.5	0.9
1.4	1.7	1.1
1.8	2.1	1.5
2.0	2.3	1.7
4.0	4.3	3.7
8.0	8.3	7.7
10.0	10.3	9.7

TABLE 7-1
YIG PRESET VERIFICATION

7-13. FREQUENCY PROGRAMMING

a. Adjust 10 - 300 MHz source for -10 dBm output.

b. Set counter to the 10 - 300 MHz range. Connect source output to the Band I input.

c. Tune source to within the capture range of the following MHz frequencies, and lock source to each frequency in turn: 10.0, 10.2, 10.4, 10.8, 11.0, 12, 14, 18, 20, 40, 80, 100, and 200 MHz.

7-14. LOCK-UP RANGE — BAND I

a. Set source and counter as in steps 7-13a and b. Set source to 280 MHz.

b. Program counter Auxiliary Display for 300 MHz and press LOCK button. Counter should lock within 1/2 second.

c. Press CLEAR button. Tune source to 30 MHz.

d. Repeat step b with 10 MHz programmed.

7-15. LOCK UP RANGE — BAND II

a. Set counter to 100 - 850 MHz range. Connect source to the Band II input.

b. Set source to 830 MHz at -10 dBm.

c. Program Aux Display for 850 MHz. Press LOCK button. Counter should lock within 1/2 second.

d. Press CLEAR button. Tune source to 120 MHz.

e. Repeat step c with 100 MHz programmed.

7-16. LOCK UP RANGE — BAND III

a. Set counter to 825 MHz - 18 GHz range. Connect source to the Band III input.

b. Set source to 850 MHz at -10 dBm.

c. Program Aux Display for 825 MHz. Press LOCK button. Counter should lock within 1/2 second without searching (SEARCH light should not flash).

d. Press CLEAR button. Tune source to 1050 MHz.

e. Repeat step c with 1070 MHz programmed.

7-17. TIME BASE AGING RATE
(For Options 03, 04, and 05 only)

a. Place counter in constant temperature environment.

b. Allow counter to warm up for 72 hours if the unit has been disconnected from AC power.

c. Connect 10 MHz rear panel output to input of VLF comparator. (If VLF comparator is not equipped to accept 10 MHz inputs, a divider must be provided.)

d. Determine average frequency over a six-hour interval.

NOTE: Time interval selected should be during periods of maximum stability of received VLF signal. Avoid periods near sunrise or sunset.

e. Determine average frequency over the same six-hour interval 24 hours later. Counter should remain plugged into the power line during this period to keep time base oven temperature constant.

f. The daily aging rate is the difference between the two readings. This should be within the specifications noted for the particular ovenized oscillator (Option 03, 04, or 05).