# SECTION 3.
# ALIGNMENT PROCEDURE

## 3.1 INTRODUCTION

This section provides a basic (paragraph 3.2) and an extended (paragraph 3.3) alignment procedure. The basic procedure, which should accompany any service work, requires only a calibrated oscilloscope. The extended procedure, which should be performed at nominal six-month intervals, requires the oscilloscope, module extenders, a calibrated digital voltmeter and other equipment as listed in Table 3-2. All adjustments not covered in this procedure should be performed on suitable module test fixtures only.

### 3.1.1 TEST EQUIPMENT REQUIRED

The basic procedure requires the test equipment listed in Table 3-1. The additional equipment required for the extended procedure is listed in Table 3-2.

Table 3-1. Basic Test Equipment Required

| Description | Model |
|---|---|
| *Oscilloscope<br>Test-Point Shorting Jumper<br>Nonmetallic Alignment Tool | Motorola R1004A |

*An R2001 is a suitable substitute.

Table 3-2. Extended Test Equipment Required

| Description | Model |
|---|---|
| *Oscilloscope | Motorola R1004A |
| *Digital Voltmeter | Motorola R1001A |
| *RF Signal Generator | Motorola R1201A |
| *Modulation Meter | Boonton 82AD |
| Audio Generator | Motorola S1067 |
| Receiver Test Cover | Motorola |
| Extender Card Set | Motorola |

*An R2001 is a suitable substitute for these separate equipments.

### 3.1.2 PREPARATION FOR ALIGNMENT

1. Perform all alignments at normal ambient temperature.
2. Remove the top cover of the unit to be aligned.
3. Turn on the unit to be aligned, allowing a warmup time of 15 minutes before starting alignment.

## 3.2 BASIC ALIGNMENT PROCEDURE

### 3.2.1 CRT INTENSITY BIAS

1. Select Scope DC display and Ext Horiz input mode on the System Analyzer. Set the Intensity control fully counter clockwise.

**CAUTION**

*Do not let a dot stay in one place on the CRT screen for more than 30 seconds because it will leave a permanent burn in the phosphor.*

2. Adjust the Intensity Bias potentiometer on the Scope Amplifier board (Figure 3-1) until a dot appears on the screen. You may have to use the Vertical and Horizontal position control (Vert, Horiz) on the front panel to bring the dot onto the screen. Then back off the Intensity Bias potentiometer until the dot just disappears.

### 3.2.2 CRT INTENSITY BALANCE

1. Select Scope DC display and a horizontal sweep rate of 1 mSec/Div on the System Analyzer. Set the horizontal timebase vernier to calibrate (Cal) and adjust the Intensity control for a barely visible horizontal line on the CRT.
2. Adjust the Intensity Balance potentiometer (Figure 3-1) for uniform intensity of the horizontal trace from left to right. The Balance potentiometer affects the intensity on the left side of the trace.

### 3.2.3 CRT ASTIGMATISM AND GEOMETRY

1. Select Monitor function and Gen/Mon Mtr display on the System Analyzer. Set the Intensity control for a medium-intense display.
2. While using the Focus control to maintain a focused display at the center of the CRT, adjust the Astigmatism and Geometry potentiometers (Figure 3-1) for the best focus at the outer edges of the CRT with minimum pincushion and barrel distortion of the display. The two adjustments are interactive; to get the best display, alternate repeated small adjustments between the two potentiometers.

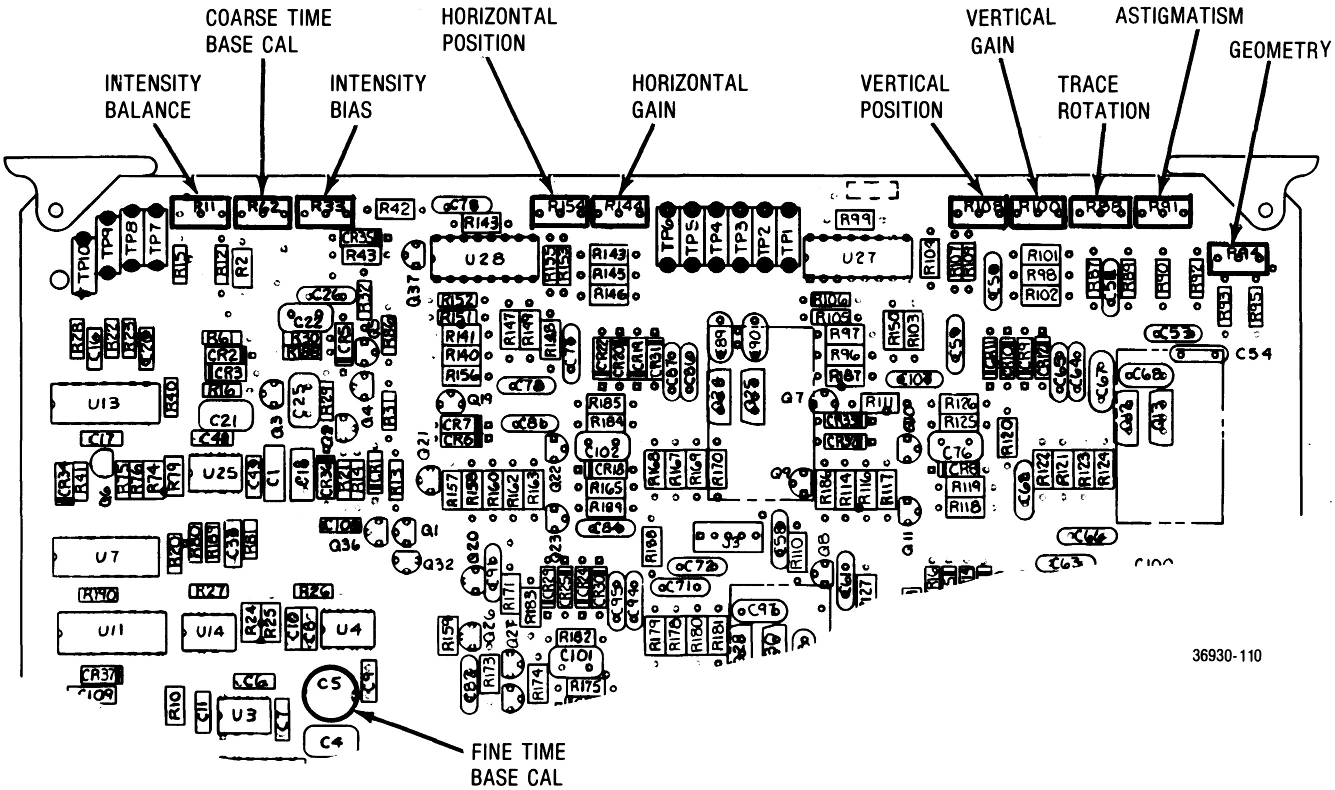


*Figure 3-1. Scope Amplifier Board (A2) - Alignment Points*

### 3.2.4 CRT VERTICAL CENTERING AND TRACE ROTATION

1. Select Gen/Mon Mtr display. Adjust the Intensity control for a comfortable viewing brightness.
2. With the Test-Point Shorting Jumper, connect TP1 of the Scope Amplifier board (Figure 3-1) to chassis ground.
3. Adjust the Trace Rotation potentiometer (Figure 3-1) to make the horizontal trace on the CRT perpendicular to the graticule center line.
4. Adjust the Vertical Position potentiometer (Figure 3-1) so that the horizontal trace on the CRT passes through the graticule center point.
5. Adjust the Trace Rotation potentiometer (Figure 3-1) to align the horizontal trace on the CRT behind the horizontal graticule line.
6. Remove the jumper from TP1.

### 3.2.5 CRT HORIZONTAL CENTERING

1. Select Gen/Mon Mtr display. Adjust the Intensity control for a comfortable viewing brightness.
2. With the Test-Point Shorting Jumper, connect TP6 of the Scope Amplifier board (Figure 3-1) to chassis ground.
3. Adjust the Horizontal Position potentiometer (Figure 3-1) so that the vertical trace on the CRT passes through the graticule center point.
4. Remove the jumper from TP6.

### 3.2.6 CRT HORIZONTAL GAIN

1. Connect the Mod Out port to the Ext Horiz port on the System Analyzer's front panel.
2. Select Generate FM function and Scope DC display. Set the Horiz control for external horizontal input (Ext). Turn the Code Synthesizer and the Ext Level control OFF, and the 1 KHz Level control up about half way.
3. Connect an oscilloscope with a calibrated vertical input to TP6 on the Scope Amplifier board (Figure 3-1).
4. Using the front panel's horizontal vernier control, adjust for a 3 Vp-p amplitude on the sinewave at TP6.
5. With 3 Vp-p at TP6, adjust the Horizontal Gain potentiometer (Figure 3-1) for a CRT horizontal trace of 6 cm. (Use the front panel controls to position the trace at a convenient place near the center of the CRT.)

### 3.2.7 CRT VERTICAL GAIN

1. Connect the Mod Out port to the vertical input port (Vert In) on the System Analyzer's front panel.
2. Select Generate FM function and Scope DC display. Set the Horiz control for a sweep rate of 1 mSec/Div and the horizontal vernier to Cal. Set the Vert control for an input sensitivity of 1V/Div and the vertical vernier to Cal.
3. Turn the Code Synthesizer and the Ext Level control OFF, and the 1 KHz Level control up about half way.
4. Connect an oscilloscope with a calibrated vertical input to TP1 on the Scope Amplifier board (Figure 3-1).
5. Using the 1 KHz Level control on the front panel, adjust for a 3 Vp-p amplitude on the sinewave at TP1.
6. With 3 Vp-p at TP1, adjust the Vertical Gain potentiometer (Figure 3-1) for a 6-cm p-p sinewave on the CRT. (Use the front panel's Horiz and Vert position controls to center the waveform on the CRT.)

### 3.2.8 VERTICAL INPUT GAIN

1. Select Generate FM function and Scope DC display. Set the Horiz control for a sweep rate of 1 mSec/Div and the horizontal vernier to Cal. Set the Vert control for an input sensitivity of 1V/Div, and the vertical vernier to Cal.
2. Connect an oscilloscope with a calibrated vertical input to the Mod Out port on the front panel.
3. Turn the Code Synthesizer and the Ext Level control OFF and adjust the 1 KHz Level control for a 6 Vp-p sinewave on the attached oscilloscope.
4. Disconnect the oscilloscope from the Mod Out port and connect the Mod Out port to the Vert input port.
5. Adjust the Input Vertical Gain potentiometer on the Front-Panel Interface board (Figure 3-2) for a 6-cm p-p sinewave on the CRT. (Use the front panel's Horiz and Vert position controls to center the waveform on the CRT.)

### 3.2.9 DVM ZERO

1. Select DVM display and DC mode.
2. Short the center conductor of the DVM input port (DVM In) to ground.
3. Adjust the Coarse DVM Zero and the Fine DVM Zero potentiometers on the Front-Panel Interface board (Figure 3-2) for a zero reading on the DVM display.

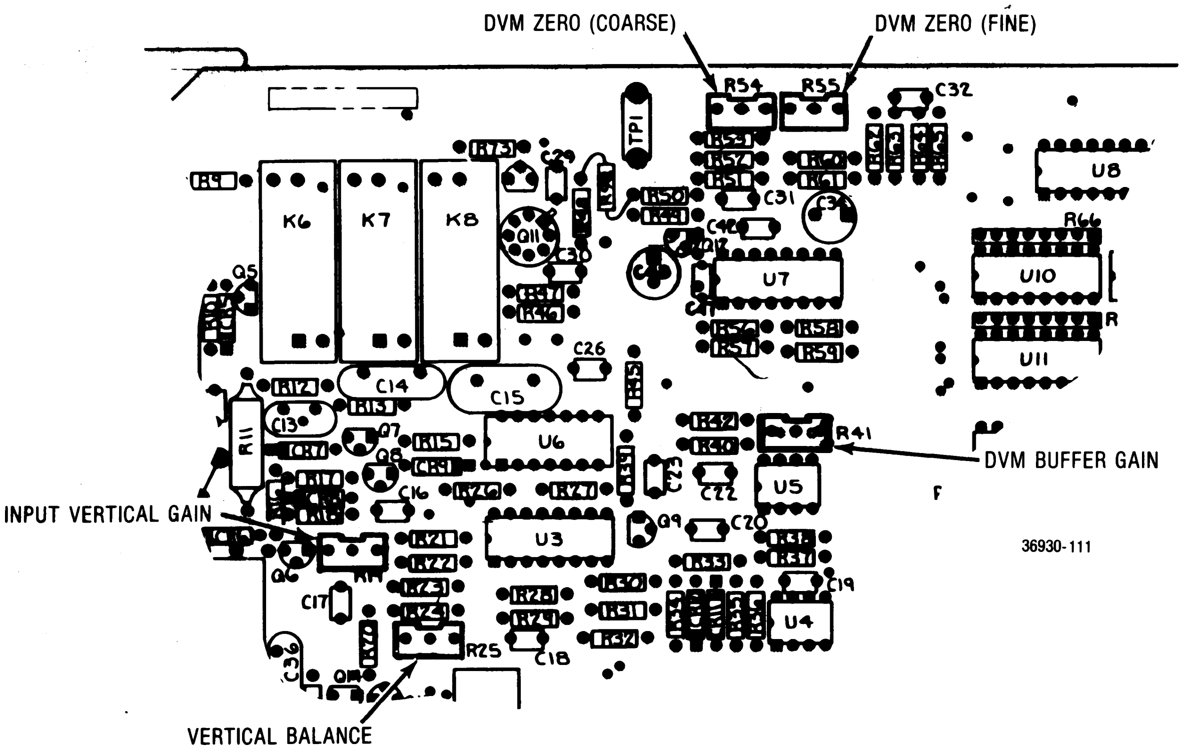


*Figure 3-2. Front-Panel Interface Board (A15) – Alignment Points*

### 3.2.10 CHARACTER GENERATOR

1. Select Monitor FM function and Gen/Mon Mtr display.
2. Adjust the Horizontal Character-Sweep-Width potentiometer on the Scope/DVM Control board (Figure 3-3) so that the right-hand edge of the CRT character display is approximately 4.2 graticule divisions to the right of the graticule center line.
3. Adjust the Vertical Character-Sweep-Width potentiometer on the Scope/DVM Control board (Figure 3-3) so that the bottom edge of the CRT display is approximately 3.3 graticule divisions below the graticule center line.

### 3.2.11 SPECTRUM ANALYZER CENTERING

1. Select Spect Analyzer display. Set the dispersion control (Dispr) on the front panel to 1 MHz (fully counter clockwise). Set the center frequency of the Analyzer to 10.0 MHz.
2. Connect the 10 MHz STD port on the rear panel to the RF In/Out port on the front panel. Set the RF step attenuator (Step) to obtain a convenient spectral display.
3. Adjust the Spectrum Analyzer Centering potentiometer on the Scope/DVM Control board (Figure 3-3) so that the spectral line on the CRT is centered about the center graticule line.

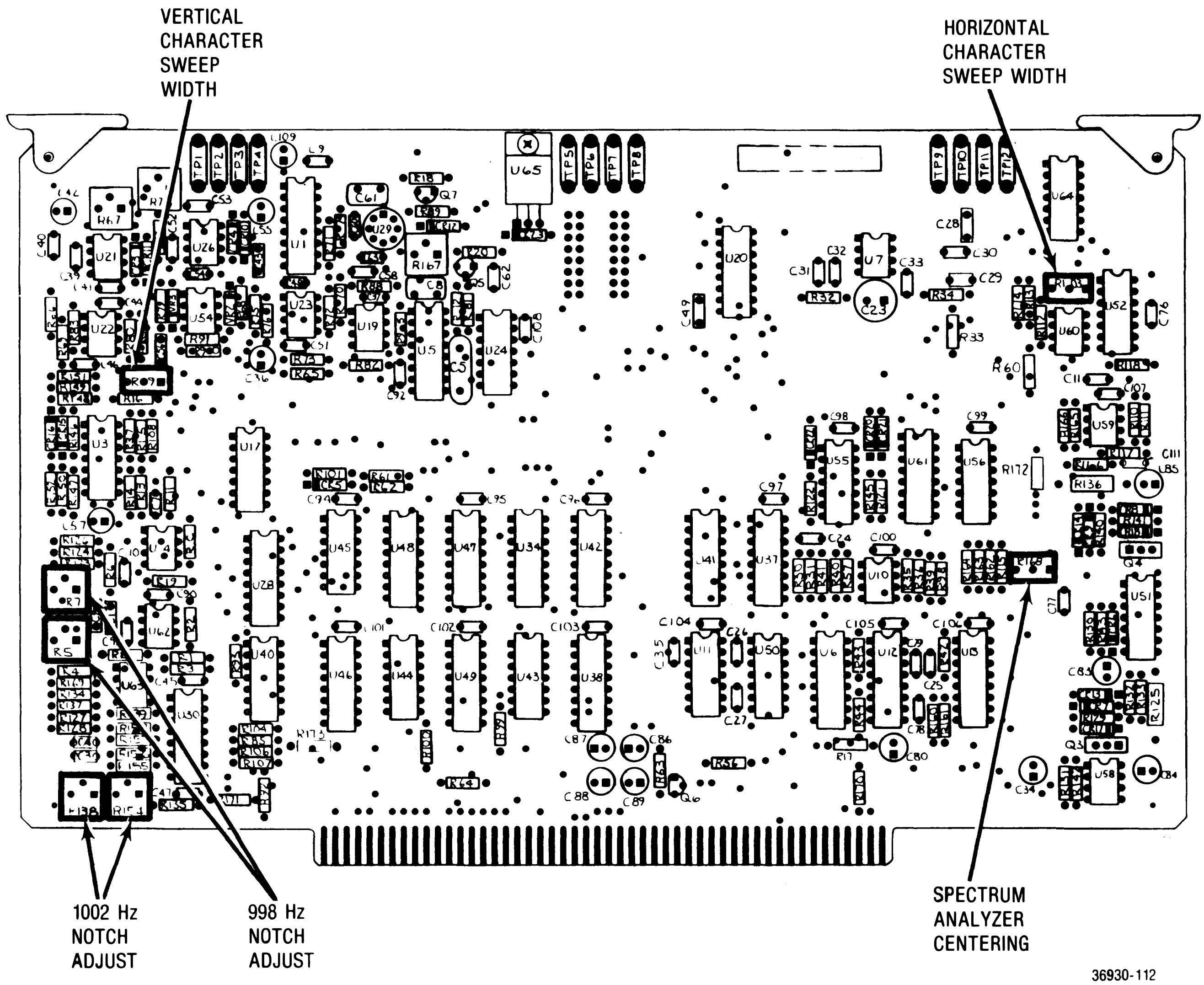


*Figure 3-3. Scope/DVM Control Board (A7) – Alignment Points*

### 3.2.12 HORIZONTAL TIMEBASE

1. Select Generate FM function and Signaling Sequence (Seq) display. Select A/B encode, and program Tone A for 20.0 Hz, and Tone B for 19,999.9 Hz.
2. Select Modulation display. Set the Oscilloscope controls for a vertical range of 2.5 kHz/Div, Auto Trigger, and a horizontal sweep rate of 10 mSec/Div. Set the horizontal and vertical vernier controls to Cal.
3. Set the Code Synthesizer for continuous (Cont) Tone A, and turn up the Code Synthesizer level control (Code Synth Lvl) to obtain a nearly full-scale sinusoidal waveform on the CRT. Turn the Ext Level and the 1 KHz Level controls OFF.
4. Adjust the Coarse Timebase Calibration potentiometer on the Scope Amplifier board (Figure 3-1) so that one cycle of the displayed waveform occurs in 5 cm along the horizontal axis. Use the Vert and Horiz position controls to center and move the waveform; this will measure the 5 cm in the middle of the screen and avoid nonlinearities near the edge of the CRT.
5. Set the Oscilloscope Horiz control for a sweep rate of 10 µSec/Div and select Tone B output on the Code Synthesizer.
6. Adjust the Fine Timebase Calibration capacitor on the Scope Amplifier board (Figure 3-1) so that one cycle of the displayed waveform occurs in 5 cm along the horizontal axis. As with coarse timebase calibration, use the Vert and Horiz position controls to center and move the waveform.

## 3.3 EXTENDED ALIGNMENT PROCEDURE

### 3.3.1 DVM

1. Remove the System Analyzer's top cover.
2. Connect the Analyzer to a primary power source, turn it on, and select the EXT DVM mode. Allow approximately 15 minutes warmup time before proceeding with alignment.
3. Select DVM/DIST display and DC Volts mode. Short the center conductor of the front panel's DVM input port (DVM In) to ground. Connect an external DVM between TP2 and TP9 on the Scope/DVM Control board (Figure 3-3).
4. Adjust the Coarse DVM Zero and the Fine DVM Zero potentiometers on the Front-Panel Interface board (Figure 3-2) until the external DVM reads 0 ± 0.5 mVdc.
5. Remove the short-circuit on the DVM input port and apply approximately 0.900 Vdc from an external power supply. The voltage between TP2 and TP9 of the Scope/DVM Control board should be within ± 1 mV of the voltage at the front panel's DVM input port. If the unit fails this test, adjust the DVM Buffer Gain on the Front-Panel Interface board (Figure 3-2) until the two voltages are equal.
6. Select Generate FM Narrowband mode and Gen/Mon Mtr display, and turn the MODULATION switch to OFF.
7. Short TP4 to TP9 on the Scope/DVM Control board (Figure 3-3).
8. Adjust the A/D Offset on the Processor Interface board (Figure 3-4) until the plus-peak-deviation

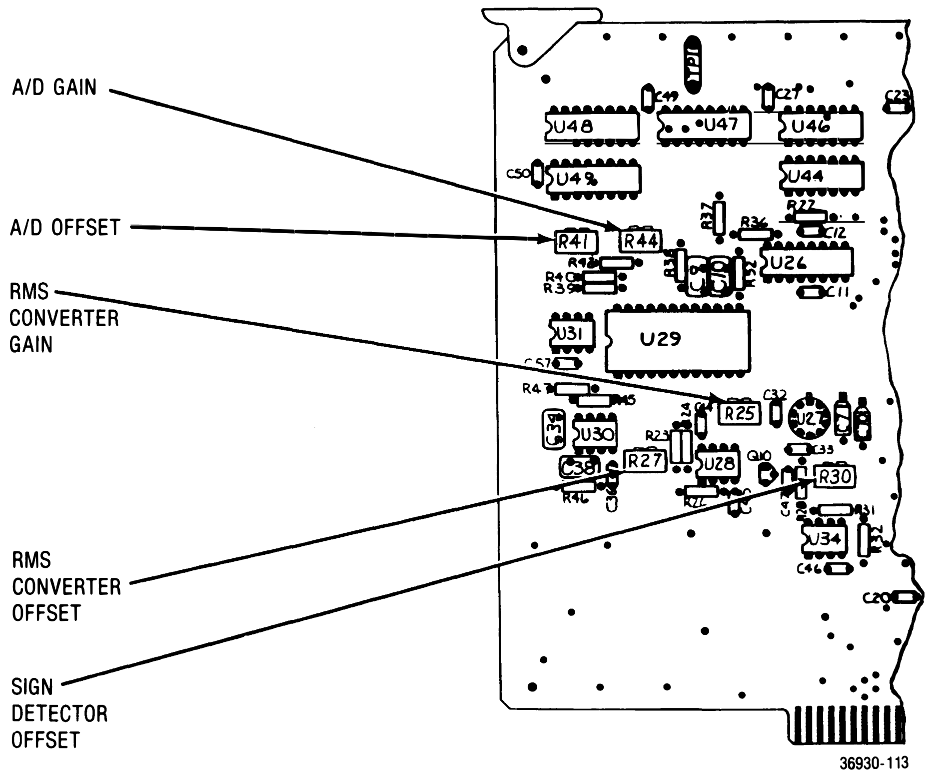


*Figure 3-4. Processor Interface Board (A11) – Alignment Points*

reading on the CRT is just toggling between 0.00 and 0.01 kHz. Then slightly turn the adjustment to maintain a constant 0.00 reading. Note that if the offset adjustment is turned past this point, the deviation reading is still 0.00, but the A/D converter is not aligned properly.

9. Remove the short-circuit between TP4 and TP9, and connect the positive lead of the external DVM to TP4 of the Scope/DVM Control board (Figure 3-3). Place the negative lead on the ground plane or TP9 of the Scope/DVM Control board.
10. Turn on the 1-kHz internal modulation and adjust the level until the voltage at TP4 reads 0.900V.
11. Adjust the A/D Gain (Figure 3-4) until the reading on the positive deviation peak is 4.50 kHz.
12. Select DVM DC mode.
13. With the center conductor of the front panel's DVM input port again shorted to ground, adjust the RMS-Converter Offset on the Processor Interface board (Figure 3-4) for a reading of 0.000V on the CRT DVM display.
14. Adjust the Sign Detector Offset (Figure 3-4) until the sign of the 0.000V reading is just flashing between plus and minus.
15. Remove the short and apply approximately 0.900V to the front panel's DVM input port.
16. While monitoring the input voltage on an external DVM, adjust the RMS-Converter Gain on the Processor Interface Board (Figure 3-4) until the CRT DVM reading equals the external voltage applied.

### 3.3.2 DISTORTION/SINAD ALIGNMENT

1. Select Generate function and Gen/Mon Mtr display. Using an audio generator with less than 0.1% distortion, apply a 900 mVrms, 1-kHz ± 2 Hz signal to the Vert/SINAD/DVM/Dist/Counter input port on the front panel.
2. Verify that the distortion reading on the CRT is ≤0.5%. If this test fails, align the notch filter.
3. Turn the System Analyzer OFF and extend the Scope/DVM Control board using the 100-pin extender card.
4. Turn the System Analyzer ON and select Generate FM function and Gen/Mon Mtr display.
5. Using the same low-distortion generator as in step 1, apply a 998 ± 0.2-Hz sinewave to the distortion input port (Dist In).
6. Alternately adjust the 998-Hz notch potentiometers on the Scope/DVM Control board (Figure 3-3) to null the distortion reading on the CRT. You should get a reading of less than 0.5%.
7. Change the audio generator's input frequency to 1002 ± 0.2 Hz.
8. Alternately adjust the 1002-Hz notch potentiometers on the Scope/DVM Control board (Figure 3-3) to again null the CRT distortion reading. You should again get a reading of less than 0.5%.
9. Turn the system's power OFF and put the Scope/DVM Control board back into the system chassis.

### 3.3.3 RECEIVER

#### 3.3.3.1 Linear IF

1. Perform the basic alignment procedure of paragraph 3.2.
2. Turn the System Analyzer OFF and remove the Receiver board. Remove the Receiver board cover, install the Receiver Test Cover on the board, and insert the Receiver board into the appropriate extender card. Place the Receiver and extender assembly in the Receiver board's edge connector.
3. Turn the Analyzer ON and select Monitor AM function and Distortion display. Set the monitor frequency to 250 MHz, the RF step attenuator (Step) to 0 dB, the IF bandwidth switch (BW) to Wide, and the Receiver audio filter to 300-Hz HPFL and 3-kHz LPFL.
4. Connect the external signal generator to the Antenna port on the front panel. Adjust the external generator for an output level of approximately −80 dBm and a calibrated, 30 percent AM, 1-kHz tone at 250 MHz.
5. Connect the Demod Out port to the distortion input port (Dist In) on the front panel.
6. Adjust C307 and C320 (marked on the Receiver Test Cover) for lowest distortion; adjust the signal strength of the generator as needed.
7. Select Narrowband FM mode.
8. Adjust the external generator for an output level of approximately −40 dBm and a calibrated, 3-kHz FM, 1-kHz tone.
9. Adjust C327, C328 and C320 (marked on the Receiver Test Cover) for lowest distortion.

#### 3.3.3.2 AM/AGC Calibration

1. Select Monitor AM function and Gen/Mon Mtr display. Set the monitor frequency to 250 MHz, the RF step attenuator to 0 dB, and the BW switch to Narrow.
2. Connect the external generator to the Antenna port on the front panel. Adjust the external generator for an output level of −50 dBm and a calibrated 40 percent AM at 250 MHz.
3. Adjust R359 (marked on the Receiver Test Cover) for a reading of 40% ± 5% on the CRT AM display.
4. Adjust R389 for over-load warning to just flash on the CRT.
5. Repeat steps 3 and 4 once.

#### 3.3.3.3 FM Calibration

1. Select Monitor FM function and Gen/Mon Mtr display. Set the monitor frequency to 250 MHz, the RF step attenuator to 0 dB, and the BW switch to Wide.
2. Connect the external signal generator to the Antenna port on the front panel. Adjust the external generator for a center frequency of 250 MHz at an output level of approximately −30 dBm and a calibrated 40-kHz FM.

3. Adjust R421 (marked on the Receiver Test Cover) for a reading of 40 kHz ± 2 kHz on the CRT FM display.

#### 3.3.3.4 Spectrum Analyzer

**NOTE**

Unless the factory alignment has been disturbed through repair, do not re-align the Spectrum Analyzer except for offset adjustment (R241B). Because all the adjustments interact, re-aligning the Spectrum Analyzer is difficult.

1. Select Monitor function and the Spect Analyzer display on the System Analyzer. Set the monitor frequency to 250 MHz, and the RF step attenuator to 40 dB.
2. Connect the external signal generator to the Antenna port on the front panel. Adjust the external generator for a center frequency of 250 MHz and a calibrated output level of −30 dBm with no modulation.
3. Adjust, in succession, C207, C208, C213 and C218 (marked on the Receiver Test Cover) to maximize the amplitude of the spectral line in the center of the CRT display.
4. Adjust R219, R226 and R229 (marked on the Receiver Test Cover) to obtain a uniform change in the spectral amplitude per 10-dB change of the RF step attenuator. R229 affects the level of the spectral component in the top quarter of the screen, R219 affects levels in the third quarter from the top, and R226 affects levels in the bottom quarter.
5. Adjust R241B for offset and R241A for gain, so that with the step attenuator at 0 dB, the peak of the spectral line lies on the 30-dB line of the CRT, and successive step increases of the input attenuator move the spectral amplitude downward on the CRT in 10-dB increments. The accuracy required for any one step-attenuator position is ±2 dB.
6. To obtain the best possible accuracy, you will generally need to repeat steps 4 and 5 multiple times.
7. For the Cellular Option, connect a calibrated signal of −40 dB at 850 MHz into the Antenna port on the front panel. Adjust R241B for a reading of −40 dBm ± 1 dB on the CRT signal-strength display.
8. Turn the power OFF and remove the Receiver board and extender card from the chassis. Remove the Test Cover from the Receiver board and replace the board cover. Put the board back into the system chassis.

### 3.3.4 RF SYNTHESIZER

1. Select Generate FM function and Gen/Mon Mtr display. Set the generate frequency to 100 MHz.
2. Connect the calibrated external modulation meter to the Antenna port on the front panel. Tune the external modulation meter to 100-MHz FM.
3. Turn on the Modulation 1 KHz Level switch and adjust for a reading of 20 kHz on the CRT generate-deviation display.
4. Adjust R13 through the hole in the RF Synthesizer cover. (First locate R13 by removing the RF Synthesizer cover.) The reading should be 20 kHz ± 1 kHz, as measured by the external modulation meter.

### 3.3.5 FREQUENCY STANDARD

1. Remove the timebase-calibration cover screw on the lower left side of the System Analyzer.
2. Allow the Analyzer to warm up for at least 20 minutes.
3. Select Monitor AM function and Gen/Mon Mtr display. Set the monitor frequency to one of the National Bureau of Standards radio stations (5, 10, 15, or 20 MHz), and use a suitable antenna for these frequencies.
4. Adjust the timebase for a reading of 0 Hz ± 1 Hz on the CRT monitor frequency-error display.

### 3.3.6 DUPLEX GENERATOR

1. Remove the bottom cover of the System Analyzer and the Duplex Generator cover.
2. Select Generate FM function and Duplex Gen display. Set the DUPLEX GEN switch to ON, the Duplex monitor frequency to 145 MHz, the offset frequency to 45 MHz, and the Image/Dplx switch to Low.
3. Adjust C68 on the Duplex Generator board (Figure 3-5) for 8 to 10V, as measured at TP 1.
4. Connect the calibrated external modulation meter to the DUPLEX GEN Output port on the front panel. Tune the external modulation meter to 100-MHz FM.
5. Turn on the Modulation 1 KHz Level switch and adjust for a reading of 20 kHz on the CRT generate-deviation display.
6. Adjust R64 on the Duplex Generator board (Figure 3-5) for a reading of 20 kHz ± 1 kHz, as measured by the external modulation meter.
7. Set the Duplex offset frequency to 0 Hz. Select Monitor FM function and Gen/Mon Mtr display.
8. Connect the DUPLEX GEN Output port to the Antenna port on the front panel.
9. Adjust C40 on the Duplex Generator board (Figure 3-5) for a reading of 0 Hz ± 50 Hz on the CRT monitor frequency-error display.

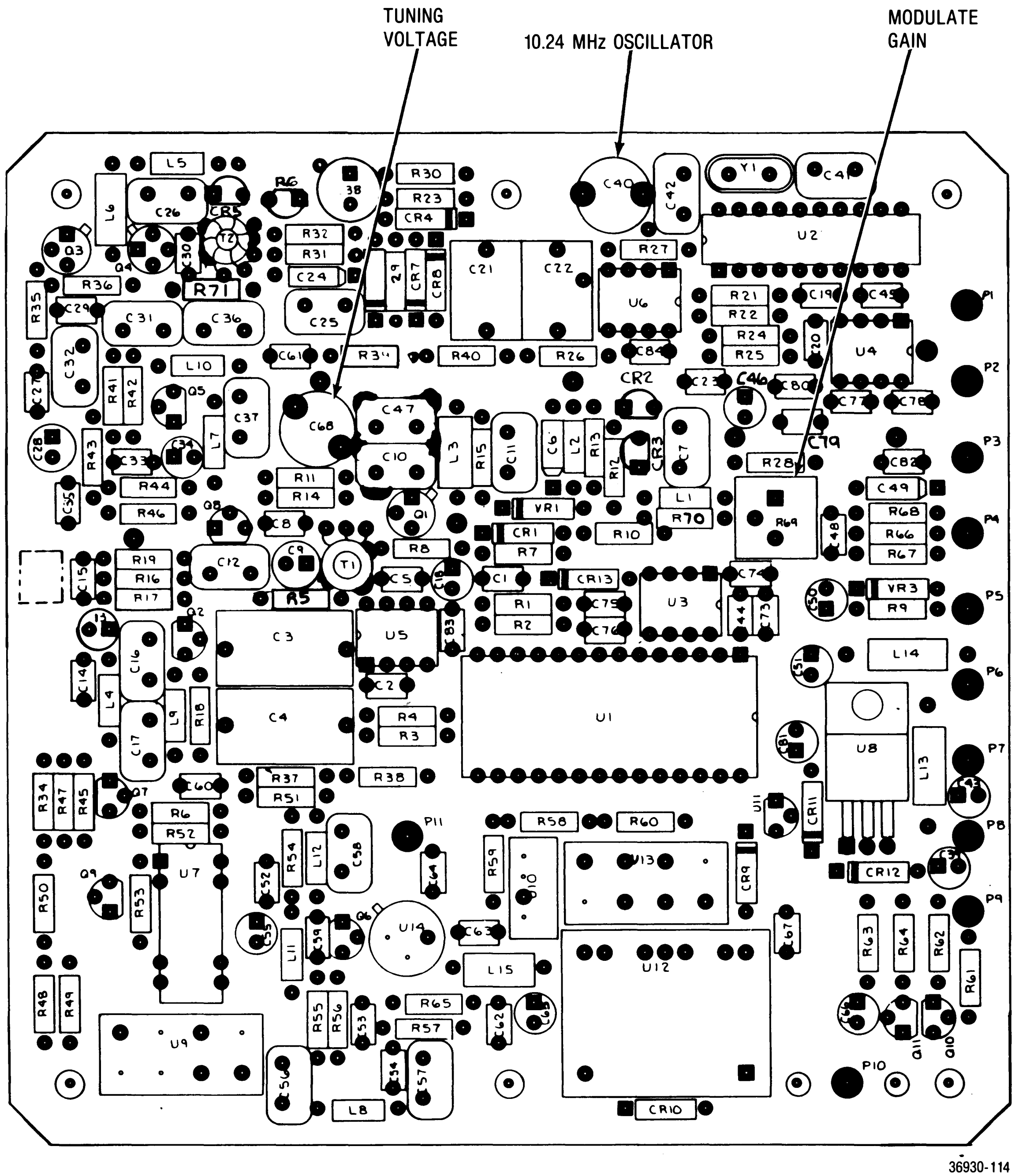


*Figure 3-5. Duplex Generator Board (A17A3) – Alignment Points*