RPL-3, 4 TEST AND TUNE PROCEDURE

PURPOSE

The purpose of this test procedure is to provide the technician with a step-by-step procedure for testing, tuning, and otherwise readying for shipment, the RPL-3 and 4, and, in addition, to provide sufficient familiarity with the operational characteristics of this particular system so that basic troubleshooting methods can be inferred.

TEST EQUIPMENT

1. Volt-Ohm Meter (such as Simpson Model 260).
2. Digital Volt Meter (such as Data Precision 1750).
3. One-GHz Frequency Counter (such as Anadex CF700A).
4. Wattmeter (such as Bird Model 43), with one-watt slugs for each frequency range, and 25-watt slugs for each frequency range.
5. Spectrum Analyzer (Tektronix 7603 with 7L12 plug-in).
6. Audio Oscillator (such as Hewlett-Packard 204C).
7. Signal Generator (Hewlett-Packard 8640).
8. Distortion Measurement System (Sound Technology 1070A, Hewlett-Packard 339A).
9. Oscilloscope.
10. Bolometer (such as Hewlett-Packard 430C).
11. Appropriate Instruction Manual.

PROCEDURE

PRELIMINARY NOTE: If the system is to operate on 220 VAC, plug it into 110 VAC and measure DC voltage across the large filter capacitor. This reading should be approximately 10 volts. If it is 20 volts, the system is wired for 110 VAC.

A. TRANSMITTER SETUP

NOTE: Applying power to the RPL-3, 4 Transmitter will cause carrier radiation if the RF circuits are properly aligned. It is therefore required that a 50Ω termination, capable of dissipating 20 watts or more, be used to properly load the transmitter whenever the latter is powered up on the bench. When the emitted energy is being observed or used to test the transmitter-receiver system, this termination should be a 30-50 dB attenuator in order to protect the receiver and any test equipment receiving this radiation.

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NOTE: This procedure is written for the RPL-4 at 450-470 MHZ. For the RPL-3 at 148-174 MHZ, refer to appropriate prints for component designations.

1. Attach a digital volt meter on its 0-50 VDC range between pin 9 of the power supply card and ground, and press the front panel power switch. If this reading is in excess of 15 volts, turn the transmitter off immediately and adjust R111 fully CCW. If VDC is ≤15 volts, adjust R111 for +11.5 VDC. Switch front panel metering to VCC and adjust R110 so that the meter reading agrees with the actual power supply voltage.

2. The next step is to set up the VCXO. For each channel, insert the appropriate crystal in its holder. Attach the VOM to brown TP1 and observe that the voltage is approximately .75 volts. Set the slugs in L1 and L2 to their minimum insertion position, and turn the slug in L1 slowly in. The oscillator should turn on at some point, resulting in a jump of the voltage at TP1 by about 0.2 volts. This condition can also be verified by observing the output of the VCXO on the spectrum analyzer. Energy will be observed at the fundamental 4-5 MHz frequency and many of its harmonics.

   Continue to tune L1 and L2 for a maximum at TP1. Check the voltage at red TP2. This should be roughly 6 volts. Remove the crystal and make sure that the voltage at TP3 drops by several tenths of a volt. Reinstall the crystal. Repeat Step 2 for Channel 2, referring to VCXO drawings for parts designations. Test points are 4 (yellow) and 5 (green).

3. Connect the output of the multiplierdriver module to the wattmeter using either VCXO channel. Use a one-watt slug at the carrier frequency. That this module is receiving sufficient drive can be ascertained by measuring at least 3 VDC at brown TP1. Move the VOM on the 0-2.5 VDC scale to red TP2. Using an inductor probe, loosely couple a spectrum analyzer to toroid L4. A spike should be measurable at 12-14 MHz. Tune C4, C11, and C14 for maximum amplitude of this spike. (Each of these adjustments should yield two maxima, indicating that required capacitance values are within range of these capacitors. If this condition is not observed, the VCXO may be operating on the wrong frequency.) Now tune C4, C11, and C14 for a maximum of about 0.5

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volts at TP2.

With VOM at orange TP3, adjust C17 and C19 for a maximum of about 0.8 VDC. Move the VOM to yellow TP4 and tune C23 and C25 for a maximum of about 0.9 VDC. With VOM at green TP5, adjust C28 and C41 for a maximum of about 0.5 VDC.

Open C38 and C39 about halfway. There should now be an indication on the wattmeter. Tune C38 and C39 for a maximum reading. If no indication is observed, a spectrum analyzer connected to the output of the wattmeter-attenuator should disclose a spike at the carrier frequency. If not, troubleshooting of the multiplier module is in order (see manual text & prints). The final output of the module should be ≥100 mw, with all undesired emissions at least 40 dB lower than the desired signal. Make sure a brass shield is installed over L11, L12, C38 and C39 and soldered to the ground plane; retune C38 and C39 if necessary. Switch operation to the alternate channel, and ascertain that the results achieved in this section are not significantly degraded. If the multiplier is not sufficiently broadbanded to operate at both frequencies, some slight readjustment of C4, C11, and C14 may be required.

4. We now turn our attention to the RF power amplifier. Refer to manual section VII.A.4 for a circuit description and parts designations for tuning purposes. The required specifications are listed in TABLE I. All spurious emissions must be ≥60dB below carrier. The power amplifier is to be tuned to the above specifications (as measured with the amplifier's cover in place) with whatever fine give-and-take tuning as may be required, particularly in input and/or output stages. When tuning the output circuit, watch the final stage current draw carefully to avoid overheating the transistor. The multipler module may be responsible for some spurious emissions, particularly within 100 MHz of the carrier, as may be ascertained by fine tuning of this module, starting at its output circuit.

5. Once a satisfactory emission has been attained, the P.A. cover should be installed. Check front panel forward and reverse power metering for upper-mid and near-zero readings respectively. Then check the transmitter carrier frequency with the one-GHz counter, and vary L1 and L2, and L6 and L7, in turn, to produce the assigned carrier frequencies. If very large adjustments seem to

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be necessary, vary R60 or R15 as needed, increasing for higher frequency, to put the carrier frequency within range. Finally, check to see that the crystal ovens are operating. The voltage as measured at the upper pin of the oven should fluctuate. If it is fixed at zero or some positive voltage, the oven or its driver transistor is defective. This completes the initial transmitter setup.

B. RECEIVER SETUP

1. Apply AC power to the receiver, and adjust R101 on the power supply board for +11.5VDC at pin 6.

2. We begin by aligning the receiver's output section. Attach the balanced audio output connections on the receiver's rear barrier strip to the distortion analyzer input. (Since the latter has high input impedance, bridging the balanced connection with 600 Ω will properly load the receiver.) Inject a 10.7 MHz signal into the FM demodulator module. Use a level of 3000 µV and modulate 100% (see TABLE I) with a 700 Hz tone. Set the distortion analyzer on its "voltmeter" position, input level +10 dBm. Set audio level pot R26 about halfway and squelch pot R6 fully clockwise (disabled). If this setup yields no response on the meter, attach an oscilloscope to one side of the output; a sine wave should be visible at 700 Hz. If not, move the oscilloscope to pin 3 of the demodulator and/or inject a 700 Hz tone at 0.5 V p-p into the audio board at pin 2 to locate the fault. DISC-ALLIGN.

We first maximize the resulting output by alternately tuning the pink and blue slugs on the demodulator, and then adjust R26 for an output of +10 dBm. Then, adjust the blue slug carefully for minimum total harmonic distortion (THD) while correcting for level changes with R26. THD should be less than 0.5% at 700 Hz. Measure signal-to-noise ratio (SNR); this figure should be at least 62 dB. Measure the level necessary for 60 dB SNR and compare with TABLE III.

3. We now turn our attention to the receiver's RF and IF sections. If the receiver has a preselector (RPL-4, 450 MHz version), we will measure its insertion loss. If not, skip to section B5. First, set a reference on the spectrum analyzer with an unmodulated signal at the carrier frequency. Signal level should be around 500 µV, and should be adjusted until an increase in the RF

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analyzer's RF attentuation control causes a corresponding decrease in the magnitude of its vertical display; this insures that the vertical amplifier is not in saturation. (Absolute and relative level measurements on a spectrum analyzer should always be made with the "sweep rate" control in its "Spectrum" position (with Tektronix analyzers) or in the "msec", or frequency domain mode on the AIL.) Once this reference has been set, insert the preselector into the signal chain and measure the loss thus incurred. This figure should be less than 4 dB (see TABLE II), and will require tuning of the three tuning capacitors, C101, C102 and C103. If insertion loss is still greater than 4 dB, loosen the nut on the output connector and, with corresponding adjustment of C103, find the optimum position of this connector. Tighten the nut when this is complete, and retune. RF

We now measure the gain of the preamp. Leave the signal at the receiver input, and add the preamp to the signal chain. Measure the combined gain of the preselector/preamp combination. It should be at least +10 dB (see TABLE II). Since these receiver versions do not contain adjustable preamps, combined gain less than +10 dB may require troubleshooting or replacement of the preamp if the complete receiver does not meet sensitivity specifications.

4. We now adjust the receiver's local oscillator. One channel at a time must be selected on the front panel, and the appropriate crystal installed. The crystal frequency is given by

$$\frac{\text{Fc} \quad 30.000 \text{ MHZ}}{6} .$$

For channel 1, C103 tunes the frequency of the oscillator and C108 tunes its output tank. The adjustments which follow, C121, C126, C130, C133 and C134, are common to both channels. The output for each channel should be peaked at 5 milliwatts or more, (2 milliwatts for the RPL-3) and should be free of spurious responses within about 50 MHZ. 1ST OSC & MULT.

Inject one of these signals, together with the output of the preamp (or the signal generator at the appropriate carrier frequency, no modulation, level 500 μV) into the first converter or balanced mixer module. Observe the output of the latter on the spectrum

THE ALLIGNMENT PROCEDURE HAS A PROBLEM HERE. C 103 NEEDS TO BE TUNED SO THAT AN UNMODULATED CARRIER @ F1 FREQUENCY PRODUCES A 30.000,000 MHZ SIGNAL @ INPUT TO 30 MHZ TO 10.7MHZ CONVERTER.

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analyzer. Adjust signal level if necessary so that the amplifiers in these modules are not in saturation (i.e., variations in input level result in corresponding variations in output level). Tune all variable capacitors and/or coils for maximum output. Conversion gain should be at least +35 dB (see TABLE II). Remove the input carrier signal from the module, and verify that no oscillations appear on the analyzer screen. Reapply the signal, and verify that no unwanted radiation appears at any frequency. If these unwanted conditions are apparent on the 450 MHz version (20A2735), back off the slug in T1 until oscillations disappear. Retune the rest of the module for maximum gain.

BAL MIXER IF AMP

OSC PROB

Now insert this output into the 30-10.7 MHz converter, and observe the output of this module. (In the RPL-3, 150 MHz model, a mechanical 30 MHz bandpass filter intervenes. Its insertion loss should be less than 4 dB.) Set R13 about halfway and tune L1, T1, T2, and T3 for maximum output. C6 tunes the 40.7 MHz ocsillator's tank circuit and is very narrow in its adjustment. C8 sets the oscillator frequency, and can be adjusted to produce an output at exactly 10.7 MHz. (The L-C 10.7 MHz filter patches into this module, and can be bypassed with a jumper to localize difficulties.) Conversion gain should be in excess of +60 dB (avoid saturation). See TABLE II.

30-10.7 MHZ CONV

2ND OSC ADJ

XTAL FILTER

ADJUST C-2 & C-6 ON XTAL FILTER BOARD

5. We now inject this 10.7 MHz carrier into the FM demodulator. Modulate 100% at 700 Hz, 1000 μV level into the receiver input connector. Audio level out should be +10 dBm. Adjust R28 so that audio level out at 2 KHz modulating frequency is 3 dB below this level. Return audio to 700 Hz. Measure SNR; this figure should be at least 60 dB. Find the input signal level necessary for 60 dB SNR. This level should be less than 250 μV. Measure level necessary for 45 dB SNR. This is the measure of the sensitivity of the receiver, and should be less than 30 μV. Measure THD at 70, 700, 3000, 7000, 10,000, and 15,000 Hz modulating frequencies (the last only on RPL-4B, 15,000 Hz audio systems). This figure must be less than 1% at all frequencies, and should remain so for signal levels up to about 10,000 μV and down to roughly 10 μV where the noise level begins to take over.

Increase signal level to 10,000 μV and observe front panel "limiter", or signal-strength metering. If it is off scale, pad the circuit by attaching a resistor (560 Ω typical) between the

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input and ground of the meter so that the meter reads 8-10. Next, remove the signal entirely and observe the meter. Adjust R13 on the 30-10.7 MHz converter module so that the meter reads less than 2, and so that it begins to rise at 3 μV signal level. Now complete the portion of the test data sheet entitled "Receiver Meter Readings" by measuring SNR and observing the meter for the specified signal levels.

6. Set the receiver squelch with R6 on the audio board so that muting will occur when the signal level falls below that required for 45 dB SNR. Complete the squelch entry on the data sheet and glip R6. Secure covers on all subassemblies. This completes the receiver setup.

C. SYSTEM TUNING

1. Our task now is to mate the transmitter and receiver. Attach the output of the wattmeter-attenuator to the receiver input connector, and apply power to the transmitter.

   Complete the multi-driver section of the transmitter test point readings on the data sheet, and secure the cover to the module.

2. Insert a 700 HZ tone at -15 dBm into the line input on the side of the transmitter. Set the metering pots R66, R47, and R51 on audio board fully counterclockwise. With the front panel metering switch in "peak audio" position, increase the front panel "line" pot until limiting just occurs (the meter should read 7 to 8). Adjust R47 for a meter reading of +1½ dB. Turn "line" pot fully counterclockwise and zero the meter with R66.

   Make sure that channel 1 is selected on both transmitter and receiver, and turn the "line" pot up for a meter reading of 0 dB. Adjust R35 for +10 dBm out of the receiver.

   Now switch the modulating tone to 3000 Hz, and measure THD. (3000 Hz is typically the frequency at which highest THD is measured.) For each channel, final tuning of the VCXO is performed (with the tuning cover on) so that THD is $\leq$1.3% from 50 to 10,000 Hz (15,000 HZ for the RPL-4B) while the transmitter frequency is kept within .00025% of its assigned value with L1 and L2 (for channel 1). At the same time, adjust the receiver de-emphasis with R28 on the audio board and readjust it if necessary so that the audio response is + 1.5 dB relative to 700 Hz level from 50 to 10,000 HZ (15,000 HZ for the RPL-4B). The juggling of these adjustments can be tricky and should be done slowly and carefully. If this procedure requires very large adjustments of the tuning slugs, or if the VCXO will not oscillate at the assigned frequency, two solutions may be attempted. First, since the DC voltage at the junction of diodes CR1 and CR2 controls the frequency of the VCXO, this bias may be altered by changing the value of R15, perhaps to 1500 or 1800Ω. Second, since the tank circuit consisting of L1, C10, C11 and R16 determines the crystal oscillator frequency, C10 can be varied to alter the tuning range of L1. Values of 100 pf or so are typical. Otherwise, troubleshooting may be necessary.

When this procedure is complete, slight frequency adjustments may be performed with L2 without disturbing the THD and audio response performance. Drip a small amount of melted wax into L1 to seal it.

Repeat the last two paragraphs for channel 2, and readjust R28 in the receiver if necessary for the best balance for both channels.

3. Complete the "System Performance" section of the test data sheet. Measure the audio volts p-p at brown TP1 and yellow TP4 on the VCXO card with 100% modulation at 700 Hz, and the DC voltages at TP1, TP3, TP4 and TP5. Enter these values on the test data sheet. Secure the cover to the VCXO. Then enter the transmitter meter readings on the data sheet. Measure the SNR for 100% modulation, and enter this value on the data sheet. Minimum for this value is 60 dB. Set the meter acceleration with R51 on the transmitter audio board so that a step function input at the transmitter audio input produces a 1-dB overshoot of the program metering. Glip all pots. This completes the tuning of the system.

4. An additional method for locating receiver trouble spots is available. This consists of working backwards from the FM Demodulator in order to verify that each individual module does not add any significant degradation of performance to the system

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as a whole. Using TABLE III as a guide, inject the appropriate signal level and frequency into the input of each successive module until performance no longer meets typical specifications.

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			RPL-3, 4 TEST AND TUNE PROCEDURE		
			TOL: FRACT. ± 1/32, .XX ± .030, .XXX ± .010, ∠ ± 1/2°		
			DWN		SCALE: Page 9 of 12
			CHK		31A3147
			ENG LY	12-11-80	

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TABLE I

FREQUENCY BAND	DEVIATION FOR 100% MOD.	TX POWER OUTPUT	TX FINAL CURRENT
148-172 MHz	5 KHz	10-15 W	< 2 amps
450-470 MHz	5 KHz (10 KHz for RPL-4B)	10-15 W	< 2 amps

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TABLE II

MODULE	INPUT FREQUENCY	OUTPUT FREQUENCY	GAIN (CONVERSION) (TYPICAL VALUES)
Preselector (450 model)	Carrier	Carrier	-3.5 db
Preamp (450 model)	Carrier	Carrier	+14 dB
1st Converter (150 model)	Carrier + l.o. (30 MHz below carrier)	30 MHz	+35 dB
Balanced Mixer (450 model)	Carrier + l.o. (30 MHz below carrier)	30 MHz	+40 dB
30-10.7 Conv.	30 MHz	10.7 MHz	+60 dB

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TABLE III

POINT OF INJECTION	SIGNAL LEVEL	TYPICAL THD (700 Hz)	TYPICAL LEVEL NEEDED FOR 60 dB SNR
FM Demod	3000 µV	0.6%	1200-1400 µV
30-10.7 Conv.	500 µV	0.4%	130-150 µV
1st Conv.	500 µV	0.35%	300-400 µV
Preamp	500 µV	0.35%	100-200 µV
Preselector	500 µV	0.30%	150-250 µV

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