CHAPTER 4

TESTING TO SPECIFICATION

Contents

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PART 1 - GENERAL

INTRODUCTION

1. The following tests are designed to check that the complete equipment is operating correctly and that it meets the specified performance data.

TEST EQUIPMENT

2. The following test equipment is required:

(a) RF Signal General
(b) Two-tone Audio Generator
(c) Spectrum Analyser
(d) Frequency Counter
(e) Oscilloscope
(f) Audio Millivoltmeter (VTVM)
(g) Wattmeter
(h) 50 ohm Dummy Load
(j) Variable Stabilised d.c. Power Supply
(k) Crystals:
12,7015MHz
14,7015MHz
16,7015MHz
18,7015MHz

PART 2 - TRANSMITTER

INITIAL SETTING UP

3. Set up the equipment as follows:

(1) Remove the battery box.
(2) Set the front panel controls:

Mode Switch	-	OFF
GAIN Control	-	fully clockwise
CHANNEL Switch	-	see Note below
NET Control	-	centre position
LSB - USB Switch	-	LSB (A, B or C depending on crystal bank used)
BAND Switch	-	HP on appropriate band for crystal used

NOTE The set may be tested on any convenient frequency but a mid-band frequency of about 5MHz is recommended.

(3) Connect the 50 ohm dummy load, through the wattmeter, to the 50 ohm antenna socket.

(4) Arrange for pins 3 and 4 of either of the front panel sockets to be shortcircuited when necessary. This may be achieved with a simple on/off switch. When it is required that the pins are to be shorted, the phrase "switch to transmit" will be used. "Release the switch" will indicate that the pins are to be open-circuited.

(5) Connect 12,6V d.c. to the plug on the bottom of the set: positive to pin 2, negative to pin 1.

CW POWER MEASUREMENTS

4. Check CW power output as follows:

(1) Set the mode switch to BK CW.

(2) Switch to transmit and check that the meter pointer is between the two marks in the centre of the scale.

(3) Adjust the TUNE control for maximum reading on the wattmeter. Check that the power output is 12,5 ±1dB.

(4) Set the LSB - USB switch to USB. Adjust the TUNE control for maximum reading on the wattmeter and check that this reading is 12,5W ±1dB.

(5) Set the BAND switch to LP on the band in use, readjust the TUNE control for maximum reading and check that this reading is 5W ±1dB. Return the BAND switch to HP.

(6) Set the CHANNEL switch to each position for which a crystal is fitted in turn. At each position:

(i) Set the BAND switch to HP on the appropriate band.

(ii) Adjust the TUNE control for maximum reading on the wattmeter.

(iii) Check that this reading is 12,5W ±1dB.

(7) Release the switch. Return the CHANNEL and BAND switches to their original settings.

(8) Set the mode switch to CW and the BAND switch to TUNE on the appropriate band.

(9) Adjust the TUNE control for maximum reading on the wattmeter and check that this reading is 12,5W ±1dB. Return the mode switch to BK CW and the BAND switch to LP.

SSB POWER MEASUREMENTS

SSB P.E.P. Output/Intermodulation Products

5. Without altering the controls, check the power output as follows:

(1) Set the mode switch to SSB.

(2) Connect the oscilloscope across the dummy load.

(3) Connect the spectrum analyser via a suitable attenuator across the dummy load. (The voltage at the dummy load terminals is approximately 150V).

(4) Connect the two-tone generator to pins 1 and 3 (common) of one of the front panel sockets.

(5) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter. Release the switch.

(6) Set the BAND switch to HP.

(7) Set audio tones to 600Hz and 2kHz.

(8) Switch to transmit and adjust the amplitude of the two tones to obtain third order inter-modulation products of -20dB as displayed on the spectrum analyser.

(9) Adjust the oscilloscope vertical calibration until the two-tone envelope is between two vonvenient horizontal lines on the graticule. Note the amplitude in volts and call this V2

(10) Switch of the 2kHz tone and note the amplitude of the remaining signal on the oscilloscope. Call this V1

(11) Note the power output on the wattmeter and call this P1

(12) Release the switch

(13) Calculate the peak envelope power from the following formula:

$$P.E.P. = P1 \frac{V2^2}{V1}$$

P.E.P. to be 25W ±1dB for crystals with frequencies between 12,7015MHz and 18,7015MHz.

Carrier Suppression

6. With the same test set-up measure carrier suppression as follows:

(1) Disconnect the tone generator.

(2) Switch to transmit and locate the carrier on the spectrum analyser. (This will be 600Hz away from the single-tone waveform).

(3) Note the difference in dBs between the tone amplitude and the carrier amplitude. Call this difference dB1

(4) Release the switch.

(5) Calculate the carrier suppression:

Carr. Supp. = dB1 + dB2

where $dB2 = 20 \log_{10} \frac{V2}{V1}$ (see paragraph 5 above) or 6dB

To be 40dB minimum.

Unwanted Sideband Suppression

7. Continue with the same test set-up:

(1) Set the LSB-USB switch to LSB.

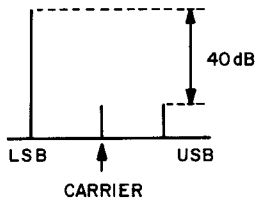
(2) Set the frequency of the tone generator in use to 1kHz.

(3) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter.

(4) Adjust the tone generator output to the position which gives a reading of 12W on the wattmeter.

(5) Locate both sideband signals on the spectrum analyser. (See sketch).

(6) Check the difference in amplitude (in dBs) between the LSB and USB signals. To be at least 40dB.



(7) Set the LSB-USB switch to USB and check the difference between the USB and LSB signals. To be at least 40dB.

(8) Release the switch and switch off both tones.

AM POWER MEASUREMENTS

8. Measure the AM PEP output with the test set-up unchanged:

(1) Set the BAND switch to HP.

(2) Set the mode switch to AM.

(3) Switch to transmit and adjust the TUNE control for maximum reading on the wattmeter. This should be 3W minimum.

(4) Remove all test equipment.

MEASUREMENT OF RADIATED HARMONICS AND SPURIOUS SIGNALS

9. This test should be carried out in an open field. The procedure is as follows:

(1) Remove the cover from the TR28 and locate the A bank crystals.
Fit crystals into the following positions:

Position	Crystal frequency
A1	12,7015MHz
A2	14,7015MHz
A3	16,7015MHz
A4	18,7015MHz

Refit the cover.

(2) Place the TR28, complete with battery box, on the ground.

(3) Connect the 3,6 metre whip antenna in a vertical position to the WHIP socket on the front of the TR28.

(4) Mount the 2,4 metre whip antenna on a non-conducting base, place 32 metres away from the TR28 and fit 12 x 3,5 metre bare copper wire radials spaced at 30^{o} under the antenna base. Bond the radials together at a point directly underneath the antenna and bond the spectrum analyser earth to these radials.

(5) Connect the spectrum analyser input socket to the 2,4 metre antenna by means of a coaxial cable (impedance to match spectrum analyser input impedance).

(6) Set the TR28 front panel controls as follows:

mode switch - CW
GAIN Control - fully clockwise
CHANNEL Switch - A1
NET Control - centre position
LSB-USB Switch - USB A
BAND Switch - 1,6 - 4 TUNE

(7) Set the CHANNEL and BAND switches to each position given in the table opposite and at each position:

(i) Adjust the TR28 TUNE control for maximum brightness of the neon lamp.

(ii) Set the spectrum analyser frequency control to the frequency given in the fourth column of the table.

(iii) Adjust the spectrum analyser attenuator control to bring the meter needle back to a previously chosen reference point. (See Note below)

NOTE The reference point should be established on the first measurement at 2MHz. All other measurements should be marked as dBs plus or minus relative to the reference point, in the 'Attenuator Setting' column of the table.

TR28 OUTPUT			SPECTRUM ANALYSER		Serial Number	Remarks
Band	Channel	Frequency	Frequency input setting	Attenuator setting		
1,6 - 4HP	1	2MHz	2MHz	Ref. point	1	In the Attenuator setting'
3,5 - 8HP	2	4MHz	4MHz		2	column tabulate the
3,5 - 8HP	3	6MHz	6MHz		3	difference in dBs between
3,5 - 8HP	4	8MHz	8MHz		4	the actual reading and
1,6 - 4HP	1	2MHz	4MHz		5	the reference reading
1,6 - 4HP	1	2MHz	6MHz		6	
3,5 - 8HP	2	4MHz	8MHz		7	
3,5 - 8HP	2	4MHz	12MHz		8	
3,5 - 8HP	3	6MHz	12MHz		9	
3,5 - 8HP	3	6MHz	18MHz		10	
3,5 - 8HP	4	8MHz	16MHz		11	
					12	
					13	
					14	

(8) On a sheet of graph paper (X axis - frequency, Y axis -dBs), plot a curve for measurements serial numbered 1 to 4. Extrapolate until the curve covers 2MHz to 18MHz.

(9) Measure the difference in dBs between the 2MHz reference point and the points on the graph for 12MHz, 16MHz and 28MHz. Add these differences to the "Attenuator Setting" column of the Table for serial numbers 12, 13 and 14.

(10) Compare the following measurements:

Serial No.		Serial No.
2	with	5
3	with	6
4	with	7
8	with	12
9	with	12
10	with	14
11	with	13

In all cases the right hand measurement must be at least 40dB below the left hand measurement.

(11) Set the TR28 CHANNEL switch to A1 and adjust the TUNE control for maximum brightness of the neon lamp.

(12) Slowly rotate the spectrum analyser frequency control from 2MHz to 18MHz and watch the meter. Any spurious signals encountered between these frequencies should be plotted on the graph. Each spurious signal must be at least 40dB below the point on the curve immediately above it.

(13) Set the TR28 CHANNEL switch to A2, A3 and A4 in turn. At each position, adjust the TUNE control for maximum brightness of the neon lamp and then carry out instruction (12) above.

(14) Remove all test equipment. Replace the test crystals with those to be used in normal operation.

NET CONTROL

10. Check the netting control range as follows:

(1) Set the FUNCTION switch to AM.

(2) Select the channel having the lowest frequency.

(3) Tune the TRANSCEIVER to this frequency. Switch the BAND switch to the corresponding frequency band - LP position.

(4) Transmit into a dummy load. Measure the transmitter frequency using the frequency counter. This should equal the crystal frequency - IF (10,7015MHz).
Adjust the netting control to obtain this frequency.

(5) Turn NET control fully clockwise.
The radiated frequency should increase by more than 100Hz.

(6) Turn NET control fully counter clockwise.
The radiated frequency should decrease by more than 100Hz.

PART 3 - RECEIVER

INITIAL SETTING UP

11. Set up the equipment for the receiver tests as follows:

(1) Remove the battery box.

(2) Set the front panel controls:

Mode switch	-	OFF
GAIN Control	-	fully clockwise
CHANNEL Switch	-	see Note under paragraph 3, instruction 2
Net Control	-	centre position
LSB-USB Switch	-	LSB
BAND Switch	-	HP on appropriate band for crystal used

(3) Connect 12,6V d.c. to the plug on the bottom of the set: positive to pin 2, negative to pin 1.

(4) Connect the VTVM and the oscilloscope to pins 2 and 3 (common) of one of the front panel sockets.

NOTE All sig. gen. levels e.m.f.

(5) Connect the r.f. signal generator to the 50 ohm antenna socket.
Signal generator settings:

frequency	-	crystal frequency minus 10,7025MHz
modulation	-	none
output	-	1µV e.m.f.

SENSITIVITY TESTS

12. Check the receiver sensitivity as follows:

(1) Set the mode switch to REC.

(2) Adjust signal generator frequency to give 1kHz output from RX.

(3) Adjust the TUNE CONTROL for maximum audio amplitude on the oscilloscope.

(4) Increase the signal generator output to 3µV.

(5) Check for a reading of between 320 and 520mV on the VTVM.

(6) Reset the signal generator frequency to crystal frequency minus 10,7005MHz.

(7) Set the LSB-USB switch to USB and adjust signal generator frequency to give 1kHz output from RX.

(8) Check for a sine wave on the oscilloscope and for a reading of 320 to 520mV on the VTVM.

(9) Reset the signal generator.

frequency - approximately crystal frequency minus 10,7015MHz

modulation - 30% at 1kHz

output - 30µV e.m.f.

(10) Set the mode Switch to AM.

(11) Check for a VTVM reading of 60mV minimum.

SIGNAL-TO-NOISE RATIO

13. With the same test set-up, check the signal-to-noise ratio as follows:

(1) Reset the signal generator:

frequency - crystal frequency minus 10,7005MHz

modulation - none

output - 1µV

(2) Set the mode switch to REC.

(3) Rotate the GAIN control anti-clockwise until a convenient reading (say 0dB) is shown on the VTVM. Call this dB4

(4) Interrupt the signal generator output and note the reading on the VTVM. Call this dB5

(5) Calculate the signal-to-noise ratio.

S/N ratio = dB4 - dB5

To be a minimum of 10dB

(6) Reconnect the signal generator and reset its frequency to crystal frequency minus 10,7025MHz.

(7) Set the LSB-USB switch to LSB and carry out (4), (5) and (6) above.

AGC OPERATION

AGC Threshold

14. Without altering the test set-up, check AGC as follows:

(1) Set the GAIN control fully clockwise and note the reading in dBs on the VTVM.

(2) Increase the signal generator output in 1dB steps and note that the VTVM reading also increases in 1dB steps.

(3) Continue increasing the signal generator output to the point where the increase in VTVM reading is less than 1dB. This point must be between 1µV and 3µV signal generator output.

AGC Range

15. Check AGC range as follows:

(1) Increase the signal generator output to 3µV and note the reading in dBs on the VTVM. Call this dB6

(2) Increase the signal generator output to 1mV and note the reading in dBs on the VTVM. Call this dB7

(3) Calculate the AGC range:

Range = dB7 - dB6

To be not greater than 3dB

SELECTIVITY TEST

16. With the same test set-up, check selectivity as follows:

(1) Reset the signal generator output to 1µV.

(2) Connect the counter across the VTVM terminals.

(3) Adjust the signal generator frequency for a reading of 1,000kHz on the counter.

(4) Rotate the GAIN control anti-clockwise for a reading of about 30mV on the VTVM. The receiver circuits should not now be subject to AGC control: check by increasing the signal generator output and noting that the VTVM reading rises by the same amount. If it does not, reduce the gain slightly and recheck. Maintain a counter reading of 1,000kHz by carefully adjusting the signal generator frequency. Call the final VTVM reading (in dBs) ..... R

(5) Increase the signal generator output by 6dB and decrease the frequency carefully until the VTVM reading falls to level R. The counter should now read approximately 300Hz. Note the exact reading and call this f1

(6) Increase the signal generator frequency to the point where the VTVM again reads level R. The counter should now read about 2,6kHz. Note the exact reading and call this f2

(7) Increase the signal generator output by 34dB.

(8) Increase the signal generator frequency to the point where the VTVM reading falls to level R. Note the counter reading and call this f3

(9) Decrease the signal generator frequency carefully, below f1, to the point where the VTVM again reads R. Note the counter reading and call this f4

(10) Check the following results obtain:

f1 = 100Hz - 500Hz.

f2 = f1 = 2kHz minimum

f3 = f4 = 5,5kHz maximum

(11) Set the LSB-USB switch to USB and carry out (3) to (10) for the upper side band circuits.

(12) Return the signal generator output to 3µV.

IMAGE REJECTION

17. The image frequency is crystal frequency plus 10,7015MHz. With the same test set-up, check for rejection of this frequency as follows:

(1) Set the signal generator output to 1µV and if necessary, re-adjust its frequency to give a reading of 1,000kHz on the counter. Note the signal generator output in dBs and call this dB8

(2) Adjust the TR28 GAIN control to give a convenient reference reading (say 0dB) on the VTVM.

(3) Reset the signal generator frequency to the image frequency.

(4) Increase the signal generator output to the point where the VTVM reading is at the previously chosen reference. If necessary, re-adjust both the signal generator frequency and output until the reference reading is obtained on the VTVM with a counter reading of 1,000kHz.

(5) Note the signal generator output in dBs and call this dB9

(6) Check image rejection:

Image Rejection = dB9 - dB8

To be not less than 75dB

IF REJECTION

19. Check i.f. rejection with the same test set-up:

(1) Reset the signal generator output to 1µV and its frequency to approximately crystal frequency minus 10,7MHz.

(2) Adjust the TR28 GAIN control for a convenient reference reading (say 0dB) on the VTVM. Re-adjust the signal generator frequency and the GAIN control until the reference reading on the VTVM is obtained for a 1,000kHz reading on the counter.

(3) Reset the signal generator frequency to 10,7015MHz.

(4) Increase the signal generator output until the previously chosen reference reading is obtained on the VTVM. Note the signal generator output in dBs and call this dB10

(5) Check IF rejection:
IF Rejection = dB10 - dB8
To be not less than 60dB

(6) Remove all test equipment.

BATTERY CHARGING CIRCUITS

19. Check the battery charging circuits as follows:

(1) Connect the 120 ohm resistor across pins 2 and 4 of the plug on the bottom of the set.

(2) Connect the multimeter (25V d.c. range) across the resistor: red lead to pin 2, black lead to pin 4.

(3) Set the mode switch to SSB.

(4) Connect 12V d.c. to pins 7 (positive) and 6 (negative).

(5) Set the mode switch to REC and OFF in turn. At each position check that the multimeter reads approximately 14V d.c.

(6) Remove all test equipment.