Test Procedures Manual

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Acknowledgement

This manual was not only created by ARRL Laboratory Test Engineers, its creation was the result of hard work and cooperation of several of the brightest minds in RF testing and design. The Lab is quite fortunate to have the outside assistance from these technical advisors, all who are on our Test-Review Board. RF technology is always changing and the ARRL Laboratory and its advisors are always investigating new and improved test methods. Readers of the ARRL Procedure Manual should have confidence using its instructions.

WB1GCM

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PURPOSE AND SCOPE

1.1 PURPOSE

The purpose of this manual is to ensure that all ARRL testing of HF transceivers, transmitters, and receivers will be conducted in a consistent and well-defined manner. The procedures used for this testing have been broken down into clear, step-by-step instructions. All testing should be "done by the book" in order to guarantee that all equipment is evaluated to the same standards.

This manual contains three major sections: Transmitter tests (Chapter 4), Receiver tests (Chapter 5) and Data Sheets (Chapter 6). The data sheets are arranged to allow test results to be recorded in the same order that measurements are taken.

1.2 SCOPE

This manual is designed to cover a wide range of amateur HF equipment. It is not intended to replace common sense or the expertise of an experienced test engineer. It is important, therefore, for the test engineer to be familiar with the Lab test equipment and the Device Under Test (DUT). The manufacturer's manual for the DUT should be completely read and understood before any testing is performed. At no time should any equipment be operated in a manner that is inconsistent with the manufacturer's recommended procedures or published limits. Failure to understand the unit under test could result in test error or, even worse, damage to the laboratory test equipment, or worst of all, damage to the test engineer.

II. LIST OF FIGURES

II. LIST OF REQUIRED TEST INSTRUMENTS

Instrument (or equivalent)	Manufacturer	Model	Qty.
Spectrum Analyzer	Agilent	N9020A	1
Digital Watt Meter	Telepost	LP-100	1
RF Signal Generator	IFR/Marconi	2041	2
Class A Wideband Amplifier	Synergy MW	SHL-2-12-01	2
Phase Noise Signal Analyzer	Rohde&Schwarz	FSUP 26	1
Spectrum Analyzer + Tracking Generator	Rigol	DSA815TG	1
Digital Storage Oscilloscope	Tektronix	MDO4104B-3	1
Signal Analyzer	HP	HP-3561-A	1
Two-Tone Audio Generator	ARRL	N/A	1
Power Attenuator	BIRD	8329, 2 KW Continuous	1
Keying-Test Generator	ARRL	N/A	1
Adjustable RF Attenuators	Tektronix	2701	1
Hybrid Combiner	Mini-Circuits	15542	Up to 3
Frequency Counter	HP	5351B	1
Voltmeter, Ammeter	Fluke	122	1
Test Receiver, Amplifier Exciter	Icom	IC-7100	1
Screen Room	Ray-Proof	S/N 4372	1
14.025 MHz Low-Noise Osc.	Wenzel	Custom, +15 dBm Ouput	1
Power Supply	Astron	RS-50M	1
Telegraph Key	Vibroplex	KC-122	1
Attenuator	Bird	8340-100 (10 dB)	1
Attenuator	Bird	50A-MFN-20 (20 dB)	1
Attenuator	Daven	T-1430Z (10, 1, 1/10 dB)	1
Test Speaker	ARRL	N/A	1
Wideband Noise Generator	Elecraft	N-gen	1
Distortion/Audio Meter	HP	339	1
Analog Watt Meter	Bird	43	1

IV. TRANSMITTER TESTS

4.0.1 As shown in the Table of Contents, there are 11 transmitter tests outlined in this chapter. They have been arranged to minimize the required number of hook-up changes and modifications. However, each hook-up is shown complete, with all changes from the previous test clearly indicated. A block diagram accompanies each hook-up and any changes from the previous test are shown within a dotted rectangle. This affords the flexibility to easily start anywhere within the test plan and to perform these tests in any desired order.

4.0.2 Before any transmitter testing is performed, it is essential for the test engineer to be completely familiar with the Device Under Test (DUT) and the test equipment that will be used. The transmitter output power must not exceed the limitations of any test equipment used or the manufacturer's specifications for the DUT – *including duty cycle or time*. The transmitter must be operated in a manner exactly as specified and be properly tuned. Any test in this manual that would cause a piece of equipment to be operated in a manner inconsistent with its manual must be accordingly modified as required by the test engineer.

4.0.2.1 Other considerations are as follows:

Spectrum Analyzer/Frequency Counter

The input to the spectrum analyzer or frequency counter should not exceed 0 dBm. Therefore, it is necessary to attenuate the output of transmitters or amplifiers down to this level. For example, if a particular transmitter is rated at 100 watts output, it will be necessary to use 50 dB of attenuation to obtain a level of 0 dBm (0 dBm = 1 mW).

RF Power Meter

The proper directional coupler must be selected for the expected power and frequency. If an analog meter is used, select the proper element for the appropriate frequency and power range.

The Telepost LP-100 Power Meter Modes are indicated as follows:

“w” : Average Forward Power (note small case “w”)
“W”: Forward Peak Envelope Power (note large case “W”)
“T”: Forward Peak Envelope Power used for two-tone measurements.

RF Power and Step Attenuators

RF power attenuators have an INPUT and an OUTPUT. Make sure that the RF source is connected to the INPUT of the power attenuator. Connecting RF power to the OUTPUT of the attenuator will result in damage to the attenuator or to the transceiver. The attenuators have a power rating, which must be observed. ***It is always best to be conservative, not to exceed +20 dBm into a step attenuator***.

4.1 OUTPUT POWER TEST

4.1.1 The purpose of the Transmitter Output Power Test is to measure the RF output power of the DUT across each band in each of its available modes.   A two-tone audio input, at a level within the manufacturer's microphone-input specifications, will be used for the SSB mode. No modulation will be used in the AM and FM modes. DC current consumption at the manufacturer's specified supply voltage is also measured, if applicable.

4.1.2 Test hook-up (See Fig. 4-1)

4.1.2.1 With all test equipment and DUT power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to Wattmeter INPUT	As Required to Type N	50-Ohm Coax
Wattmeter OUTPUT to RF Power Attenuator	Type N to Type N	50-Ohm Coax
Two-Tone Audio Generator to DUT Microphone INPUT	Banana or BNC to As Required	Coax
Telegraph Key to DUT KEY INPUT	As Required	As Required
AC power Only/AC Source to DUT Power Input	As Supplied with DUT	As Supplied with DUT
DC Power Only	As Required	As Required

1) Power supply to AC source.
2) Power supply OUT to voltmeter and ammeter.
3) Set power supply to specified voltage and connect to DUT.

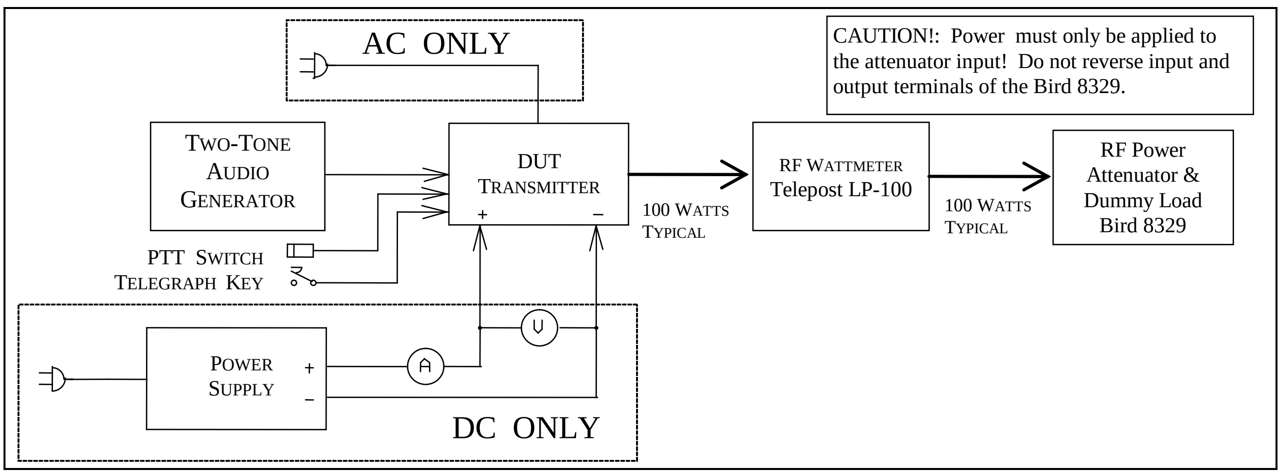

Fig. 4-1 Power Output Test Hook-Up
Please note some HF transceivers exhibit 200 Watts RF Output

4.1.3 Test Procedure

4.1.3.1 Turn the DUT and RF wattmeter power switches to ON and set the following controls:

Instrument	Control	Position
Two-Tone Audio Generator	TONE A	OFF
	TONE B	OFF
	HI-Z/LO-Z	As Required
	BALANCE	Center
	LEVEL	Full CCW
	Attenuator	–30 dB
RF Wattmeter	Mode Select Button	“W”
DUT	Mode	CW
	BAND Selector	Lowest Available
	XMIT/RCV	Receive
	DRIVE or RF LEVEL	Minimum

4.1.3.2 Allow all equipment at least 20 minutes warm-up time before proceeding to step 4.1.3.3

4.1.3.3 Tune the DUT per the operator's manual (Solid state transceivers require no tuning). Put the DUT in the CW transmit mode at *minimum* DRIVE/RF LEVEL.

> **NOTE**: The following three paragraphs, 4.1.3.4 , 4.1.3.5 and 4.1.3.6 apply only to transceivers with a DC power supply.   Skip these paragraphs if testing an ac-powered DUT, but make a note of the power consumed, using the Kill-A Watt AC Wattmeter on the data sheet.

4.1.3.4 Depress telegraph key. Observe that some minimum level of RF power is shown by the DUT Power Output Meter and Bird Wattmeter. Increase the RF DRIVE/LEVEL control if necessary. Record the power-supply ammeter and voltmeter values in 4.1.3.4 of the data sheet.

4.1.3.5 Increase RF DRIVE/LEVEL control to the maximum allowed by the manufacturer. Again, depress the telegraph key and record the power-supply meter readings in 4.1.3.5 of the data sheet. Decrease the RF DRIVE control to minimum. Release the telegraph key.

4.1.3.6 Increase the DUT AF gain control to maximum. (There should be no input signal.) Measure both current and voltage with the displays lights on default, maximum, or off, if applicable. Record measurements on the data sheet.

4.1.3.7 Depress the key and observe the DUT power output meter and wattmeter indications. Slowly tune the DUT to the upper band edge while observing these meters. Release the key and record the maximum value observed on the wattmeter in 4.1.3.7 of the data sheet.

4.1.3.8 Increase the DRIVE/RF LEVEL control to the maximum allowed. Depress the telegraph key. Slowly tune the DUT down to the lower band edge while observing both the DUT power output meter and wattmeter as in the previous step. Release the telegraph key and record the minimum wattmeter values observed in 4.1.3.8 of the data sheet. Return the DRIVE/RF LEVEL control to minimum.

4.1.3.9 Set the DUT for the lower edge of the 80-meter band and retune as necessary. Repeat steps 4.1.3.7 and 4.1.3.8. Record all values in 4.1.3.9 of the data sheet. Repeat this procedure for all the remaining bands. Record both the DUT power output meter and wattmeter indications for the 20-meter band. Note any significant deviations in the DUT meter indication observed between bands.

4.1.3.10 Return the transmitter to the lower edge of the 20-meter band and retune as necessary. Set the two-tone audio generator power switch to ON. Adjust for proper balance between both tones by setting the BALANCE control to the position so indicated. Adjust the generator LEVEL control for maximum specified ALC. Set the RF wattmeter to FWD PEP. Place the DUT in the USB mode and tune as required with the DUT mic gain control set about half-way. Adjust the audio generator for maximum audio as specified by the manufacturer's manual with the DUT mic gain control set about half-way.

4.1.3.11 Repeat steps 4.1.3.7 and 4.1.3.8 and using the PTT switch to key the transmitter. Verify similar power output performance with the DUT in the LSB mode. Note any significant deviation from the USB mode. Record DUT power output meter and wattmeter indications in 4.1.3.11 of the Data Sheets.

4.1.3.12 Set the RF Wattmeter to FWD CW and the two-tone generator power switch to OFF. Return the transmitter to the lower edge of the 80-meter band. Place the DUT in the AM mode. Repeat steps 4.1.3.7 and 4.1.3.8 using the PTT switch to key the transmitter. *Be sure not to exceed the maximum power output specified by the manufacturer for this mode*. Record DUT power output meter and wattmeter indications in 4.1.3.12 of the Data Sheets.

4.1.3.13 Return the transmitter to the lower edge of the 10-meter band. Place the DUT in the FM mode. Repeat steps 4.1.3.7 and 4.1.3.8 for this mode. *Be sure not to exceed the maximum power output specified by the manufacturer for this mode.*

NOTE: Proceed to the following step *only* if the DUT has a transverter output.

4.1.3.14 Put the DUT into the CW mode and activate the transverter function.. Set to the 15 meter band. Connect the HP-437 microwatt meter and any needed attenuation to the transverter output.   (Input to the microwatt meter must not exceed +20 dBm.) Repeat steps 4.1.3.7 and 4.1.3.8. Record on Data Sheet. Also observe and record any RF output that may appear at the normal antenna output.

4.2 TRANSMIT FREQUENCY RANGE TEST

4.2.1 The purpose of the Transmit Frequency Range Test is to determine the range of frequencies, including those outside amateur bands, for which the transmitter may be used.

4.2.2 Test Hook-up (See Fig. 4-2)

NOTE: No further hook-up changes are required if proceeding directly from the previous Power Output Test. This hook-up procedure, therefore, does not apply in this case and you may now proceed to step 4.2.3.1.

4.2.2.1 Connect the following with all power switches in the OFF position and the transceiver in the receive mode:

Connection	Connectors	Cable Type
DUT RF OUTPUT to Wattmeter INPUT	As Required to Type N	50-Ohm Coax
Wattmeter OUTPUT to RF Power Attenuator	Type N to Type N	50-Ohm Coax
Telegraph Key to DUT KEY INPUT	As Required	As Required
AC power Only/AC Source to DUT Power Input	As Supplied with DUT	As Supplied with DUT
DC Power Only	As Required	As Required

1) Power supply to AC source.
2) Power supply OUT to voltmeter and ammeter.
3) Set power supply to specified voltage and connect to DUT.

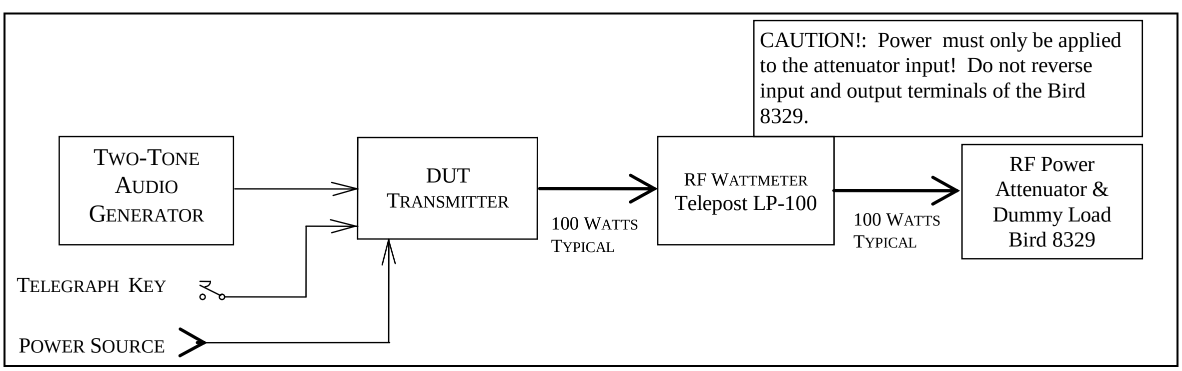

Fig. 4-2 — Transmit Frequency Range Test Hook-up

4.2.3 Test Procedure

4.2.3.1 Turn the DUT and RF wattmeter power switches to ON and set the following controls:

Instrument	Control	Position
RF Wattmeter	Mode Select	“w”
DUT	Mode	CW

Band Selector	Lowest available band
XMIT/RCV	RECEIVE
DRIVE/RF OUT	Minimum

4.2.3.2 Allow all equipment at least 20 minutes warm up time.

4.2.3.3 Tune the DUT per the operator's manual for the lowest available band. Return the DRIVE/RF OUTPUT control to minimum. (The DUT should still be in the CW mode.)

4.2.3.4 Tune down near the low end of the band. Depress the telegraph key. Observe some minimum RF indication on the wattmeter. Slowly tune down until the RF drops out or the manufacturer's specified limit is achieved. Release the key and record this frequency, as indicated by the DUT display in 4.1.3.4 of the data sheet.

4.2.3.5 Tune to the upper limit of the band. Again, depress the telegraph key and slowly tune up until the RF drops out. Release the key and record this frequency in 4.1.3.5 of the data sheet.

4.2.3.6 Repeat steps 4.1.3.3 to 4.1.3.5 for all remaining available bands on the DUT.

4.3 CW TRANSMIT-FREQUENCY ACCURACY TEST

4.3.1 The purpose of the CW Transmit-Frequency Accuracy Test is to measure and compare the actual output frequency of the DUT with its display adjusted for 14.020 MHz down to the least significant available digit.

4.3.2 TEST HOOK-UP (See Fig. 4-3)

NOTE: If proceeding directly from the previous Transmit Frequency Range Test, you need only modify the existing hook-up. Proceed to the steps indicated with a dotted line.

4.3.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to wattmeter INPUT	As Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attenuator INPUT	Type N to type N	50-Ohm coax
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Power Attenuator OUT to Step Attenuator INPUT	Type N to BNC	50-Ohm coax
Step Attenuator OUT to Frequency Counter IN	BNC to BNC	50-Ohm coax
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Telegraph key to DUT KEY INPUT	As Required	As Required
AC or DC power to DUT	As Required	As Required

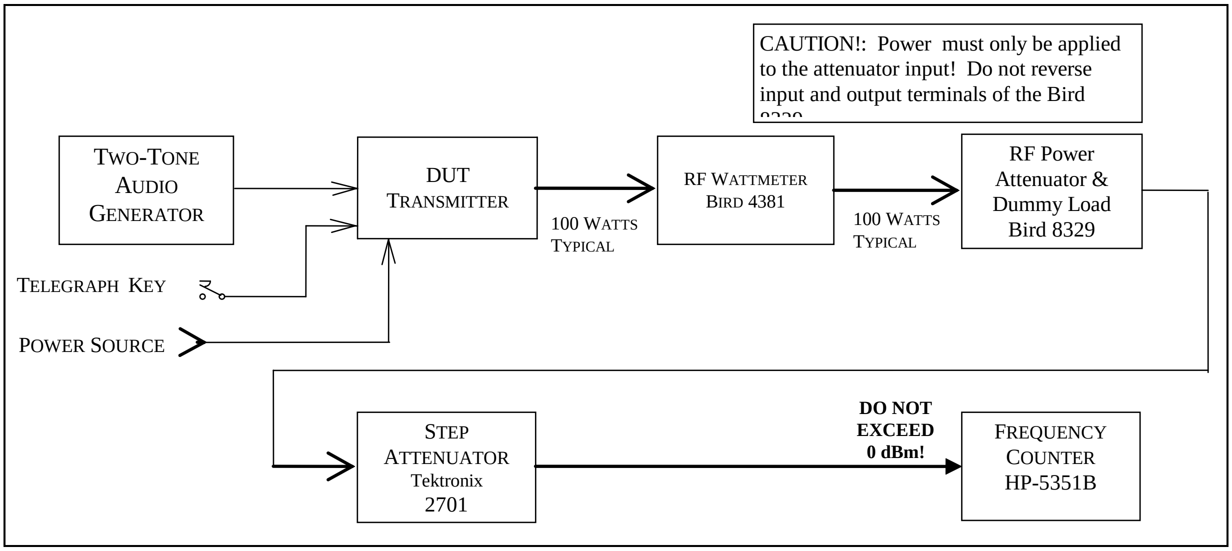


Fig. 4-3 — CW Transmit Accuracy Test Hook-up

4.3.3 Test Procedure

4.3.3.1 Turn the DUT, RF wattmeter and frequency counter power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.000 00 MHz
	XMIT/RCV	RECEIVE
	DRIVE/RF OUT	Minimum
RF Wattmeter	Mode Select	“w”
Step Attenuator	Attenuator	40 dB
Frequency Counter	50 Ohm	50 Ohm (Depress)

4.3.3.2 Key the transmitter. Observe the minimum output power on the RF wattmeter and unkey the transmitter. Set the step attenuator to provide –5 to 0 dBm input to the frequency counter.
Do not exceed the maximum input limitation to the Frequency Counter.

4.3.3.3 Check and readjust, if necessary, the DUT for 14.020 00 MHz as indicated by its display. Record this value if the DUT has a digital type display, or, as best as possible with an analog display.

4.3.3.4 Key the transmitter and note the frequency as indicated by both the DUT and the frequency counter. Place a check mark in 4.3.3.4 of the data sheet if there is any significant deviation from 14.020 00 MHz

4.3.3.5 Increase the step attenuator to 40 dB. Set the transmitter power to the maximum allowed. Key the transmitter and observe the RF output power as shown by the wattmeter. Set the attenuator to provide –5 to 0 dBm input to the counter.

4.3.3.6 Key the transmitter. Record the DUT and Frequency Counter indications in 4.3.3.6 of the Data Sheet. Unkey the transmitter.

4.3.3.7 Reduce the voltage to the minimum specified dc voltage (if using a DC supply; typically 11.7 V dc). Again key the transmitter and note the frequency displayed on the DUT and frequency counter. Place a check mark in 4.3.3.7 of the data sheet if there is any significant deviation from initial data.

4.4 SPECTRAL PURITY TEST

Setup of the spectrum analyzer is semi-automated using Keysight's Benchview software. Please see instructions on using it in the Appendix. **Instructions for manual setup are provided here.**

4.4.1 The purpose of the Spectral Purity Test is to determine and measure the content of any spurious emissions in the output of the transmitter. Full-power carriers will be examined and minimum power checked on all available bands.

4.4.2 Test hook-up (See Fig. 4-4)

NOTE: If proceeding from the previous Transmit Frequency Accuracy Test, skip to the steps indicated with a dotted line.

4.4.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to wattmeter INPUT	As Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to Step Attn INPUT	Type N to BNC	50-Ohm coax
Step Attn OUT to Spec Analyzer IN	BNC to BNC	50-Ohm coax
Telegraph key to DUT KEY INPUT	As Required	As Required
AC or DC power to DUT	As Required	As Required

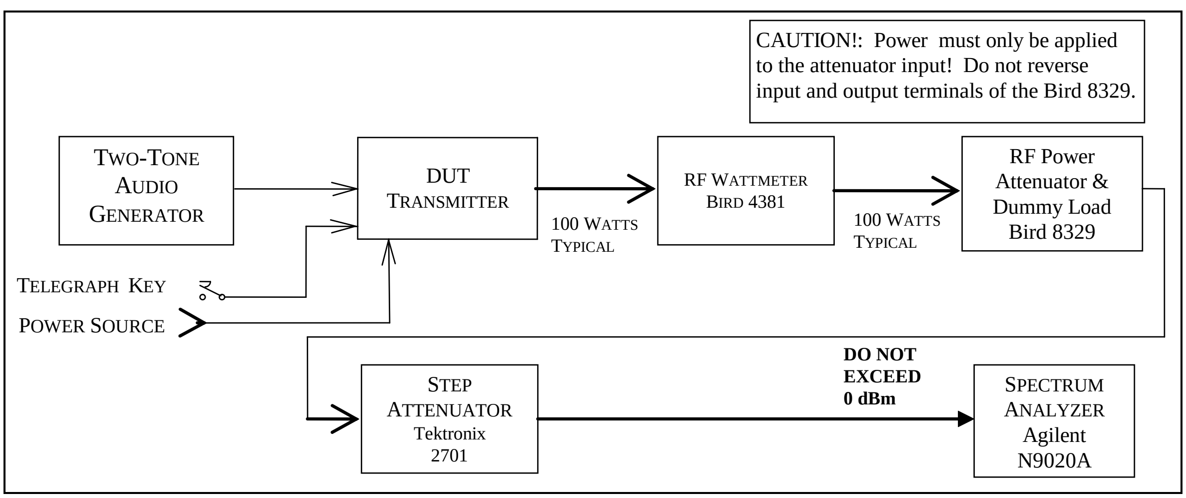


Fig. 4-4 — Spectral Purity Test Hook-up

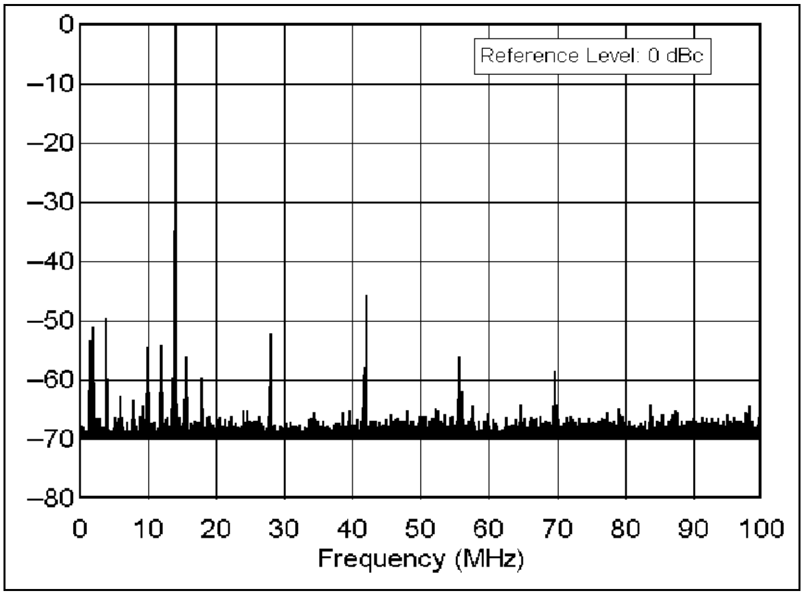


Fig. 4-4A — Example Spectral Purity Plot

4.4.3 Test Procedure

4.4.3.1 Turn the DUT, RF wattmeter and spectrum analyzer power switches to ON and set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	Lowest available
	XMIT/RCV	Receive
	DRIVE/RF LEVEL	Minimum
RF Wattmeter	Mode Select	“w”
Step Attn	Attenuator	40 dB
Spectrum Analyzer	START FREQ - STOP FREQ	0 – 50 MHz
	REF LEV (AMPLITUDE)	–10 dBm
	ATTEN (AMPLITUDE)	20 dB
	RES BW (BW)	10 kHz
	VIDEO BW (BW)	30 kHz
	THRESHOLD (DISPLAY)	–80 dBm
	SWP TIME (SWEEP)	AUTO

4.4.3.2 **NOTE**: If proceeding directly from the previous CW Transmit Frequency Accuracy Test, skip this paragraph.

Receiver hiss should be heard; adjust volume to desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.4.3.3.

4.4.3.3 Tune the DUT per the operator's manual at the low end of the band. Put the DUT in the CW transmit mode at maximum DRIVE/RF LEVEL.

4.4.3.4 Depress the telegraph key and observe the power output shown by the Bird wattmeter. Release the key and set the step attenuators for –10 dBm input to the spectrum analyzer. ***CAUTION: The input to the spectrum analyzer at no time should exceed 0 dBm. Damage to this instrument will occur at an input level of +30 dBm or greater.***[1]

[1] "Woe be unto he who breaks this thing." — Edward F. Hare, W1RFI

4.4.3.5 Key the transmitter. The largest pip to the right of 0 MHz should be the fundamental. (This may be verified by use of the PEAK SEARCH button. With the marker to be at the top of the pip, the indicated marker frequency should be very close to the transmitted frequency.)

4.4.3.6 Adjust the REF LEV control on the spectrum analyzer so that the peak of the fundamental pip is at the Log Ref (0 dB) line on top of the display graticule. (To optimize the display, the FREQ START-FREQ STOP may be set for 0-10 MHz and the RES BW may be set for 30 kHz on the 160-meter band.)

4.4.3.7 The spectrum analyzer is now calibrated. The smaller pips are harmonics or spurs. The level of each spur, in dB below the fundamental, can be read directly from the display graticule. Each horizontal division represents 5 MHz each in the case of a 0-50 MHz frequency range. The frequency range may be adjusted for the specific display being considered, or as deemed appropriate by the test engineer. Each vertical division represents 10 dB.

4.4.3.8 Turn on the crystal calibrator, if the DUT has one, and observe any spurious emissions created by the calibrator. Record in notes section of data sheet and turn off the calibrator.

4.4.3.9 Slowly tune up the band while observing the analyzer display. Retune as necessary if the transmitter is not a broadband type. Note the worst case observed. Record on data sheet.

4.4.3.10 Reduce the transmitter power output to minimum. Again, observe the analyzer display while tuning down to the lower band edge. Note the worst case observed and record on data sheet.

4.4.3.11 Repeat steps 4.4.3.9 and 4.4.3.11 for all remaining available bands on the DUT. The Frequency Range settings for each band are as follows:

1.8 MHz	0-50 MHz
14 MHz	0-100 MHz
28 MHz	0-200 MHz
50 MHz	0-500 MHz
144 MHz	0-1000 MHz
222 MHz	0-1000 MHz
432 MHz:	0-2000 MHz

4.4.3.12 Return the transmitter to the worst case on the worst band. With the all significant spurs visible on the screen, take a single sweep by depressing the SGL SWP button. (Typically, this will be the second or third harmonic, although it is possible for VHF parasitic to be present.) The START FREQ, STOP FREQ and RES BW may be varied as required. Record all information on data sheet and save the plot to an appropriately named file.

4.5 TWO-TONE TRANSMIT IMD TEST

4.5.1 The purpose of the Two-Tone Transmit Test is to measure the intermodulation-distortion (IMD) products present in the RF output of the DUT transmitter. The transmitter will be operated in the SSB mode at 3.900 MHz and

14.250 MHz initially and then on all other available bands subsequently. A two-tone audio input at frequencies of 700 and 1900 Hz, within the manufacturer's amplitude specifications, will be used.

4.5.2 Test hook-up (See Fig. 4-5)

NOTE: If proceeding in the test series, only the two-tone generator, shown within the dotted line, must be added to the previous Spectral Purity Test hook-up for the IMD Test.

4.5.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUT To Wattmeter IN	As Required To Type N	50-Ohm Coax
Wattmeter OUT To PWR Attn IN	Type N To Type N	50-Ohm Coax
PWR Attn OUT To Step Attn	Type N To BNC	50-Ohm Coax

Connection	Connectors	Cable Type
Step Attn OUT To Spectrum Analyzer IN	BNC To BNC	50 Ohm Coax
Two-Tone Generator OUT To DUT MIC IN	BNC To As Required	Coax
Power to DUT	As Required	As Required

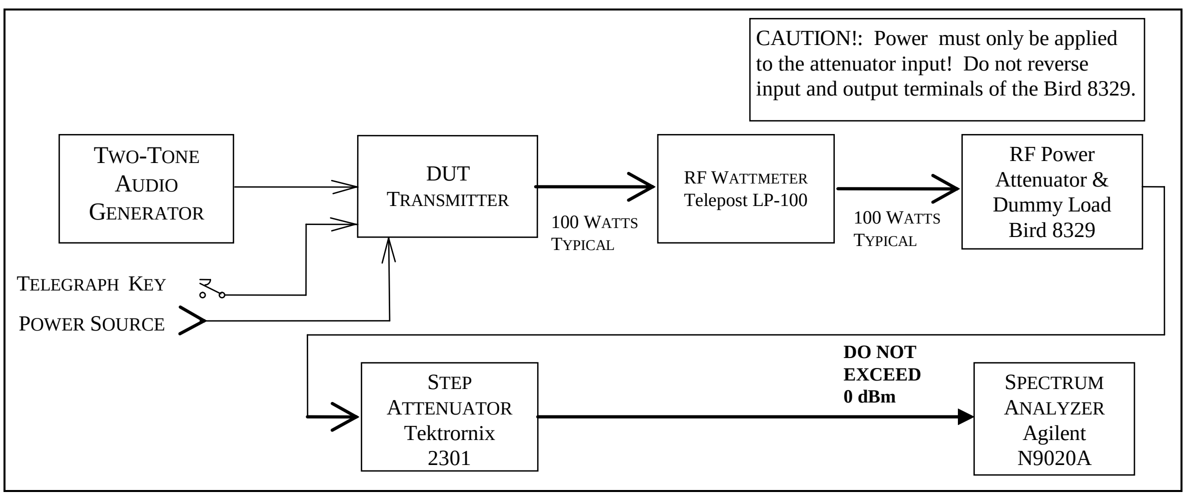


Fig. 4-5 — Two-Tone Transmit IMD Test Hook-up

4.5.3 Test Procedure

4.5.3.1 Turn on the DUT, RF wattmeter and spectrum analyzer and set the following controls:

Instrument	Control	Position
DUT	Mode	LSB
	Band Selector	80 Meters
	Frequency	3.900 00 MHz
	XMIT/RCV	RECEIVE
	DRIVE or RF LEVEL	Minimum
	Microphone	Minimum
Two-Tone Generator	TONE A (700 Hz)	OFF
	TONE B (1900 Hz)	OFF

	HI-Z/LO-Z	As Required
	BALANCE	Center
	LEVEL	Full CCW
	Attenuator	–30 dB
RF Wattmeter	Mode Select	"T"
Step Attn	Attenuator	–40 dB
Spectrum Analyzer (Menu in Parentheses)	CENTER FREQ (FREQUENCY)	3.89870 MHz
	SPAN (SPAN)	20 kHz
	REF LEV (AMPLITUDE)	–40 dBm
	ATTEN (AMPLITUDE)	20 dB
	RES BW (BW)	100 Hz
	VIDEO BW (BW)	10 kHz
	THRESHOLD (DISPLAY)	–110 dBm
	SWP TIME (SWEEP)	AUTO

4.5.3.2 **NOTE**: If proceeding from the previous tests, this paragraph may be skipped.

Receiver hiss should be heard; adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.5.3.3.

4.5.3.3 Tune the DUT per the operator's manual for the test frequency of 3.900 MHz. Turn on the two-tone generator and set both tone switches to ON. With the DUT in the LSB mode, set the generator LEVEL and ATTENUATOR controls for the maximum audio input as specified by the manufacturer. If the manufacturer does not list a specification for this figure, adjust the 2-tone generator's amplitude for maximum rated RF output of the transmitter with the transmitter's microphone gain near maximum. Observe the transmitter power as shown by the wattmeter. Ensure that the output power of the DUT is not greater than the manufacture's maximum power output rating. Unkey the transmitter and set the step attenuators for approximately -46 dBm input to the spectrum analyzer.

CAUTION: ***The input to the spectrum analyzer at no time should exceed 0 dBm.***

4.5.3.4 Place the DUT in the VOX mode and verify operation with the signal generator. Note on data sheet if VOX does not function correctly. Return the DUT to the PTT mode and key the transmitter. Set the BALANCE control on the generator for equal tone amplitude as shown on the display. Adjust the CENTER FREQ, if necessary, so that the display center is half-way between the two pips. The IMD-distortion products should now be visible.

4.5.3.5 Adjust the REF LEVEL control (and step attenuators, if necessary) for the peak of the two pips to be at –6 dB. The spectrum analyzer is now calibrated. The amplitude of each IMD distortion product may now be read in dB PEP (dB below the peak envelope power) directly from the display.

4.5.3.6 Manipulate, if necessary, the two-tone generator audio LEVEL and the transmitter audio gain and drive control to obtain the lowest possible IMD products. If this is done, the spectrum analyzer REF LEVEL control (and possibly the step attenuators) may need to be reset for tone pips of –6 dB.

4.5.3.7 Set the SWP TIME (in the SWEEP menu) for 6 seconds. Take a single sweep by depressing the SGL SWEEP button. Record all info on data sheet. Print and save to an appropriate file name.

4.5.3.8 Set and tune the transmitter for USB at a frequency of 14.250 MHz. Set the CENTER FREQ for 14.25130 MHz. and return the SWP TIME back to AUTO. Repeat paragraphs 4.5.3.3 to 4.5.3.7 for this frequency.

4.5.3.9 Repeat step 4.5.3.8 for the following frequencies (if applicable to the DUT): 1.850 MHz, 7.250 MHz, 10.120 MHz, 18.120 MHz, 21.250 MHz, 24.950 MHz, 28.350 MHz, 50.200 MHz, 144.200 MHz and

432.200 MHz.

4.6 SSB CARRIER AND UNWANTED SIDEBAND SUPPRESSION AT 14.250 MHz (No longer required in published data tables)

4.6.1 The purpose of the SSB Carrier and Unwanted-Sideband Suppression Test is to determine the level of suppression of the unwanted sideband and carrier relative to Peak Envelope Power (PEP). The transmitter output is observed on the spectrum analyzer and the unwanted components are compared to the desired sideband.

4.6.2 Test hook-up (See Fig. 4-6)

NOTE: No changes in hook-up are required if proceeding directly from the previous Two-Tone Transmit IMD Test, proceed now, in this case, to paragraph 4.6.3.

4.6.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUT To Wattmeter IN	As Required To Type N	50-Ohm Coax
Wattmeter OUT To PWR Attn IN	Type N To Type N	50-Ohm Coax
PWR Attn OUT To 10-dB Step IN	Type N To BNC	50-Ohm Coax
Step Attn OUT To Spec Analyzer IN	BNC To BNC	50-Ohm Coax
Two-Tone Generator OUT to DUT MIC IN	BNC to As Required	Coax

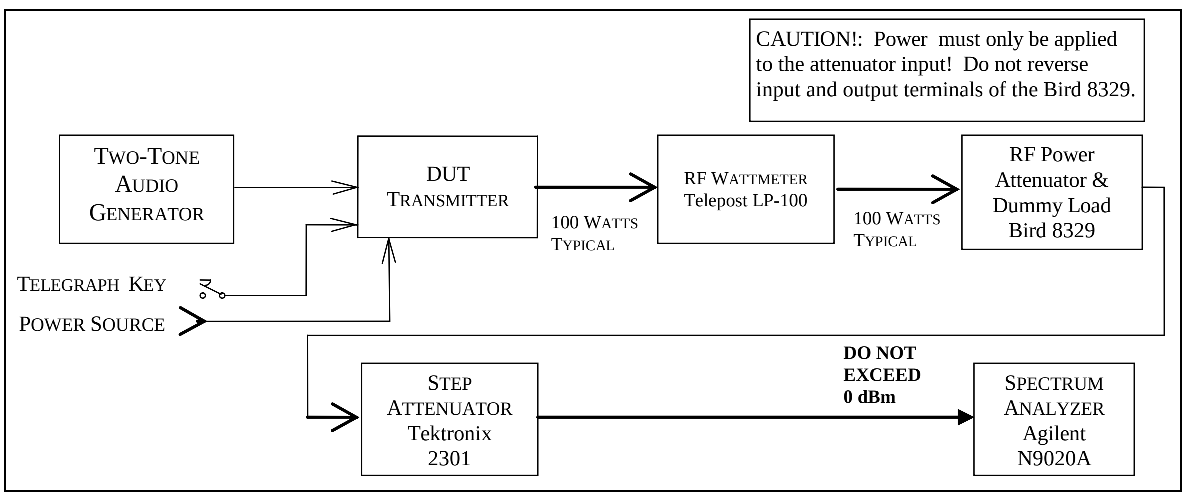


Fig. 4-6 — SSB Carrier and Unwanted Sideband Suppression Test Hook-up

4.6.3 Test Procedure

4.6.3.1 Turn the DUT, RF wattmeter and spectrum analyzer power switches to ON and set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.250 MHz
	XMIT/RCV	Receive
	DRIVE or RF LEVEL	Minimum

	Microphone	Minimum
Instrument	Control	Position
Two-Tone Generator	TONE A (700 Hz)	OFF
	TONE B (1900 Hz)	OFF
	HI-Z/LO-Z	As Required
	BALANCE	Center
	LEVEL	Full CCW
	Attenuator	–30 dB
RF Wattmeter	Mode Select	"w"
Step Attn	Attenuator	–40 dB
Spectrum Analyzer	CENTER FREQ (FREQUENCY)	14.25130 MHz
	SPAN (SPAN)	20 kHz
	REF LEV (AMPLITUDE)	–40 dBm
	ATTEN (AMPLITUDE)	20 dB
	RES BW (BW)	100 Hz
	VIDEO BW (BW)	10 kHz
	THRESHOLD (DISPLAY)	OFF
	SWP TIME (SWEEP)	AUTO

4.6.3.2 **NOTE**: If proceeding from the previous tests, this paragraph may be skipped.

Receiver hiss should be heard; adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.6.3.3.

4.6.3.3 Tune the DUT per the operator's manual for the test frequency of 14.250 MHz. Turn on the two-tone generator and set the TONE B switch to ON. With the DUT in the USB mode, adjust the MIC gain and set the generator LEVEL and ATTENUATOR controls for the maximum audio input as specified by the manufacturer. Observe the transmitter output power as shown by the wattmeter. Unkey the transmitter and set the step attenuators for -40 dBm input to the spectrum analyzer.

> *CAUTION: The input to the spectrum analyzer at no time should exceed +10 dBm. Damage to the instrument will occur at an input level of +30 dBm or greater.*

4.6.3.4 Key the transmitter. Adjust the DUT USB signal frequency to 14.2532 MHz on the spectrum analyzer display.

4.6.3.5 A tiny low level pip may appear 1900 Hz to the left of the USB signal at the center of the spectrum analyzer display. This is the suppressed carrier. Another pip, if visible 3800 Hz to the left of the USB (at 14.2494 MHz) is the unwanted Lower Sideband (LSB). This may be verified by keying the transmitter off and on again. All pips from the DUT will disappear. If necessary, adjust the CENTER FREQ control so that the USB pip is centered (or nearly centered) on the display graticule.

4.6.3.6 Adjust the REF LEV control (and step attenuators if required) so that the peak of the USB pip is at 0 dB. The spectrum analyzer is now calibrated. Press the SGL SWEEP button for a single trace. The amplitude of the unwanted sideband and carrier may now be read in dB below Peak Envelope Power (PEP) directly from the display.

4.6.3.7 Record the value of both the suppressed carrier and the unwanted sideband in 4.6.3.7 of the Data Sheet.

4.6.3.8 Set the transmitter mode switch for LSB. Return the SWP TIME to AUTO. Repeat paragraphs 4.6.3.4 to 4.6.3.7 for the lower sideband at 14.2494 MHz (the suppressed carrier and unwanted upper sideband now appear to the right of the lower sideband at 14.2513 and 14.2532 MHz, respectively). If the pip is lost when the mode is changed, it may also be necessary reset the CENTER FREQ control. Record results in 4.6.3.8 of the data sheet.

4.6.3.9 If the DUT also has any VHF or UHF outputs, set the DUT to approximately 200 kHz above the bottom of each band and repeat paragraphs 4.6.3.3 to 4.6.3.8, adjusting the spectrum analyzer center frequency as appropriate (Examples: for 6M, use a center frequency of 50.2013; the USB signal will appear at 50.2032 and the LSB signal at 50.1994; for 2M, use a center frequency of 144.2013; the USB signal will appear at 144.2032 and the LSB signal at 144.1994).

4.7 CW KEYING WAVEFORM TEST

4.7.1 The purpose of the CW Keying Waveform Test is to capture and store the first and second dit in a series of dits with the DUT in the VOX and QSK modes. The keying rate is 20 ms on and 20 ms off, a rate that corresponds to 60 WPM using the PARIS standard. A picture will also be taken of any other test conditions that result in any wave shape that is significantly different from the others (more than 10% difference, spikes, etc.).

4.7.2 Test hook-up (See Fig. 4-7)

> **NOTE**: If proceeding from the previous SSB Carrier and Unwanted Sideband Test, only the hook-up modifications indicated with a dotted line need to be implemented for this test.

4.7.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to wattmeter INPUT	AS Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to step Attn INPUT	Type N to BNC	50-Ohm coax
Step Attn OUT to CH1 Scope INPUT	BNC to BNC	50-Ohm coax
--	--	--
Key Test Gen OUT to Scope EXT TRIG IN	BNC to BNC	50-Ohm coax
Key Test Gen KEY OUT to DUT KEY IN	BNC to As Required	50-Ohm coax
XMTR Key Line to Scope CH2 INPUT	Probe clip to BNC	10X Probe
Scope GND to XMTR GND	As Required	As Required
--	--	--
Power to DUT	As Required	As Required

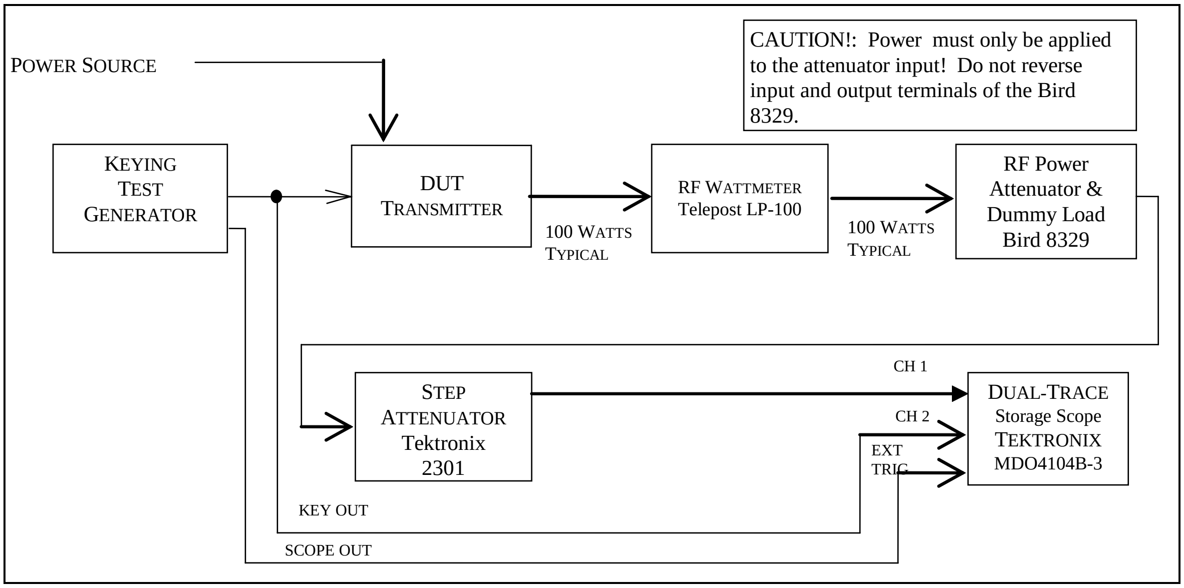


Fig. 4-7 — CW Keying Waveform Test Hook-up

4.7.3 Test Procedure

4.7.3.1 Turn the DUT, RF wattmeter and oscilloscope power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	XMIT/RCV	Receive
	Drive or RF Level	Maximum
	Keying Mode	VOX
RF Wattmeter	Mode Select	“w”
Step Attn	Attenuator	–40 dB
Keying Test Generator	OUTPUT	OFF
	RANGE	1-99 MS
	KEY DOWN	20
	KEY UP	20
Oscilloscope	CH1 VOLTS/DIV	500 mV
	CH1 Coupling	DC
	CH1 Position	As Needed
	CH2 VOLTS/DIV	1 V
	CH2 Coupling	DC
	CH2 Position	As Needed
	TIME/DIV	10 MS
	Trigger Coupling	DC
	Trigger Source	External
	Trigger Level	As Required

4.7.3.2 Set the keying test generator to ON. Allow all equipment at least 10 minutes warm-up time before proceeding.

4.7.3.3 Tune the DUT, if necessary, *exactly* per the operator's manual for the 14.250 MHz test frequency. Set for maximum power output.

4.7.3.4 Set the keying test generator OUTPUT to ON. Adjust the oscilloscope for a display trace similar to Fig. 4-7A. Note: If the keying generator pulse train shows capacitive shaping, this is due to the configuration of the DUT's keying input circuit and should be considered normal. Be sure that the RF-power level of the dit is approximately the same as the carrier level.

4.7.3.5 Capture the first dit and second dit in a string of dits by using the single-trigger mode of the oscilloscope. Turn the keying generator OFF then ON again to facilitate the string of dits. (NOTE: Some transmitters will lose or chop the first dit of a word).

4.7.3.7 Repeat steps 4.7.3.5 and 4.7.3.6 for QSK ON, and any other keying mode deemed appropriate by the Test Engineer. Also photograph the results of any mode of operation that results in a wave shape that is significantly different (>10% difference, spikes, etc.).

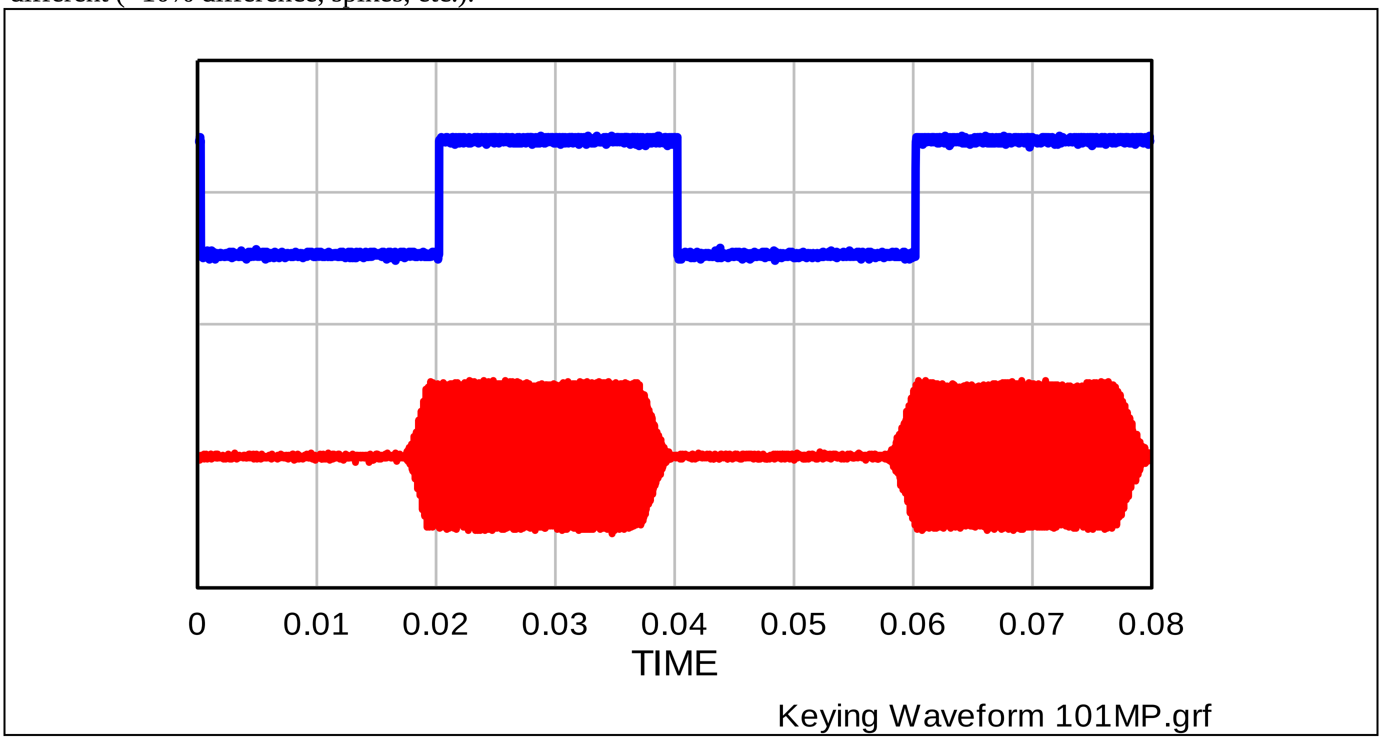


Fig. 4-7A — Oscilloscope Trace of RF Output Envelope

4.8 PTT TO SSB/FM RF OUTPUT TEST

4.8.1 The purpose of the PTT to SSB/FM RF Output Time Test is to determine the key time to RF output delay for the waveform 50% points in the SSB and FM modes. In the SSB mode, audio at a frequency of 700 Hz, and a level within the manufacturer's specified limits, will be applied to the DUT's mic input terminals. The FM mode is tested with an unmodulated carrier.

<u>4.8.2 Test hook-up (See Fig. 4-8)</u>

NOTE: If proceeding from the previous CW Keying Waveform Test, only the hook-up modifications indicated with a dotted line need to be implemented for this test.

4.8.2.1 With all power switches in the OFF position and the transmitter in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to Wattmeter INPUT	As Required to type N	50-Ohm coax

Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to 10-dB step INPUT	Type N to BNC	50-Ohm coax
Step Attn OUT to CH1 Scope IN	BNC to BNC	50-Ohm coax
Key Test Gen OUT to Scope EXT TRIG IN	BNC to BNC	50-Ohm coax
Two-Tone Gen OUT to DUT MIC INPUT	Banana to As Required	Coax

Key Test Gen Key OUT to DUT PTT IN	BNC to As Required	50-Ohm coax
XMTR PTT Key Line to Scope CH2 IN	BNC to BNC	10X Probe
Power to DUT	As Required	As Required
Scope GND to XMTR GND	As Required	As Required

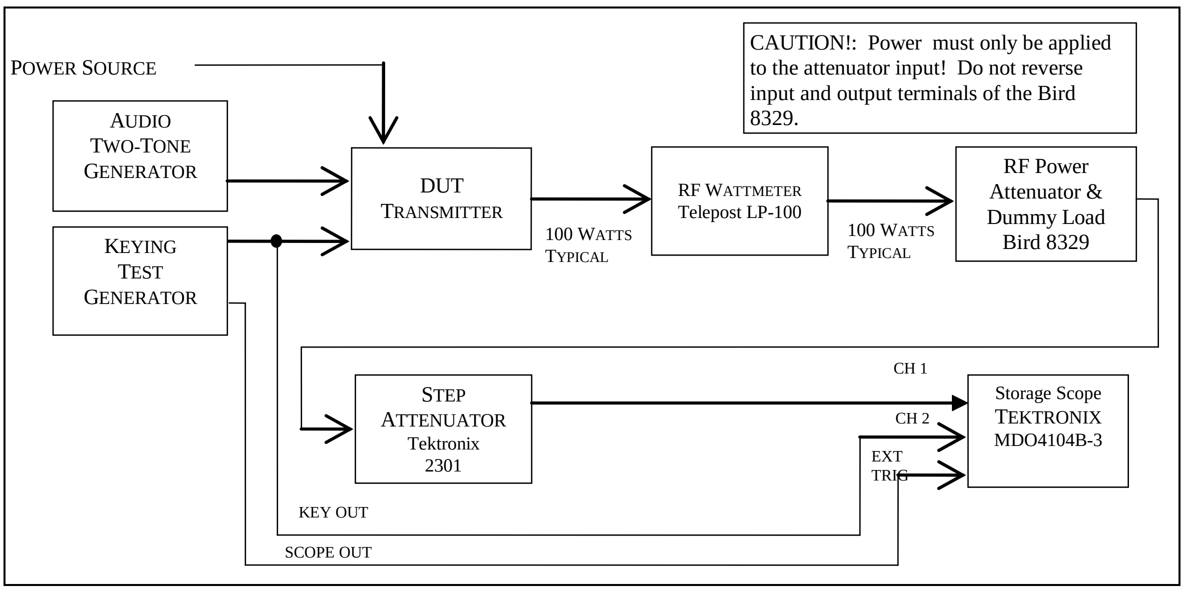


Fig. 4-8 — PTT SSB/FM RF Output Test Hook-up

4.8.3 Test procedure

4.8.3.1 Turn the DUT, RF wattmeter and oscilloscope power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.250 MHz
	XMIT/RCV	Receive
	DRIVE or RF LEVEL	Minimum
	VOX	Off
RF Wattmeter	Mode Select Button	“w”
Step Attn	Attenuator	–40 dB

Keying Test Generator	OUTPUT	OFF
	RANGE	1-99 MS
	KEY DOWN	20
	KEY UP	20
Two-Tone Generator	TONE A	ON
	TONE B	OFF
	HI-Z/LO-Z	As Required
	BALANCE	N/A
	LEVEL	Full CCW
	ATTENUATOR	–30 dB
Oscilloscope	CH1 VOLTS/DIV	500 mV
	CH1 Coupling	DC
	CH1 Position	As Needed
	CH2 VOLTS/DIV	1 V
	CH2 Coupling	DC
	CH2 Position	As Needed
	TIME/DIV	5 MS
	Trigger Mode	AUTO
	Trigger Coupling	DC
	Trigger Source	EXT
	Trigger Level	As Required

4.8.3.2 Set the Two-Tone and Keying Test Generator power switches to ON. Receiver hiss should be heard; adjust volume to desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.8.3.3

4.8.3.3 Tune the DUT transmitter, if necessary, *exactly* per the operator's manual for the 14.250 MHz test frequency. Adjust the two-tone generator OUTPUT level to the manufacturer's specified limit. Set the DUT for maximum rated power output.

4.8.3.4 Turn the keying test generator OUTPUT to ON. Adjust the oscilloscope for a display trace similar to Fig. 4-8A. It may be necessary to reduce the generator keying speed. Be sure that the RF power level of the Dit is approximately the same as the carrier level.

4.8.3.5 Measure the ON and OFF delay times between the 50% points of the keying pulse and the RF output pulse. Take a single sweep. Adjust the oscilloscope's sweep rate and horizontal position for optimum display results. It is often best to determine the on and off delay times from two different traces. The Trigger Level adjustment can be used to facilitate an easy transition between ON and off delay traces. Record both values in 4.8.3.5 of the data sheet. Turn off the two-tone and keying test generator outputs.

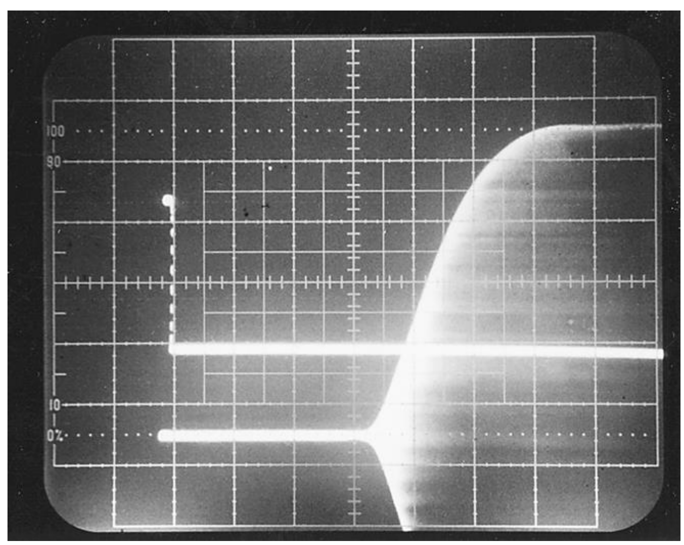


Fig. 4-8A — Oscilloscope Trace of RF Envelope

4.8.3.6 Place the DUT in the FM mode. Repeat paragraphs 4.8.3.3, 4.8.3.4 and 4.8.3.5 for this mode at a test frequency of 29.000 MHz . Record the results in 4.8.3.6 of the data sheet.

4.8.3.7 Repeat step 4.8.3.6 for test frequencies of 52.000 MHz, 146.000 MHz and 440.000 MHz, as appropriate.

4.9 TRANSMIT/RECEIVE TURN-AROUND TIME TEST
(Transceivers Only)

4.9.1 The purpose of the Transmit/Receive Turn-Around Time Test is to measure the time delay required for a transceiver to switch from transmit to the receive mode.

4.9.2 Test hook-up (See Fig. 4-9)

4.9.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to wattmeter INPUT	As Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to Step Attn INPUT	Type N to BNC	50-Ohm coax
Step Attn IN to Signal Gen RF OUT	BNC to Type N	50-Ohm coax
DUT Audio OUT to Scope CH2 INPUT	As Required	10X or 1X Probe
Key Gen Scope OUT to Scope EXT TRIG IN	BNC to BNC	50-Ohm coax
Key Test Gen Key OUT to PTT Key IN	BNC to As Req	50-Ohm coax
XMTR PTT Line to Scope CH1 INPUT	Probe clip to BNC	10X Probe

Connection	Connectors	Cable Type
Two-Tone Gen OUT to DUT MIC INPUT	Banana to As Required	Coax
Power to DUT	As Required	As Required
Scope GND to XMTR GND	As Required	As Required

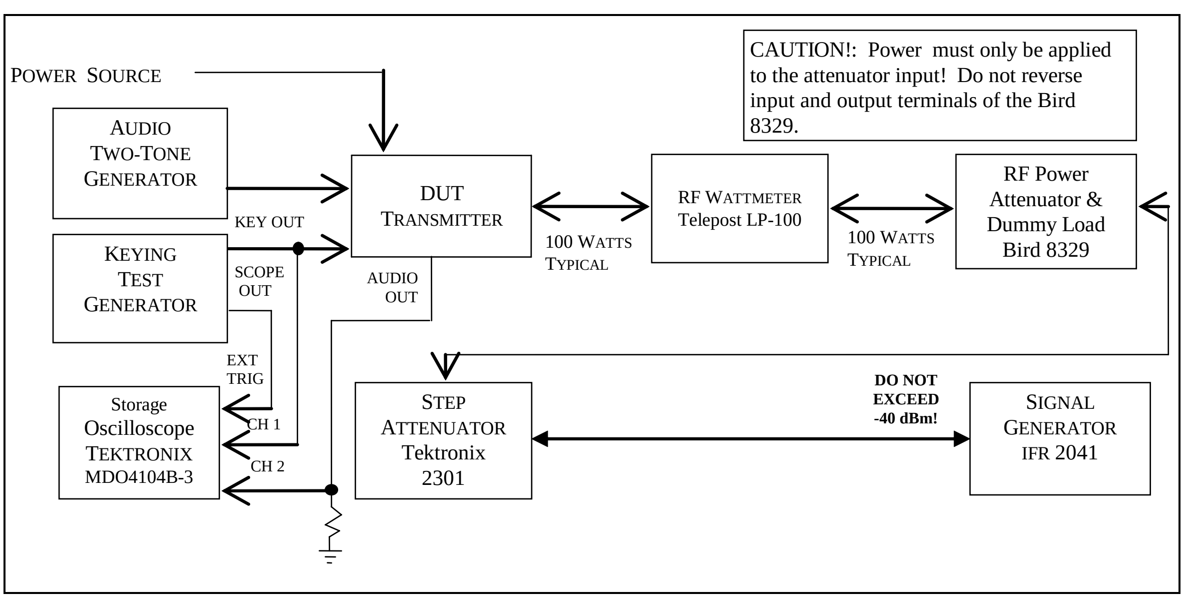


Fig. 4-9 — Transmit/Receive Turnaround Time Test Hook-up

4.9.3 Test procedure

4.9.3.1 Turn the DUT, RF wattmeter and oscilloscope power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Frequency	14.250 MHz
	XMIT/RCV	Receive
	AGC	ON (Fastest available)
	Squelch	OFF
RF Wattmeter	Mode Select	“w”
Step Attn	Attenuator	70 dB
Keying Test Generator	OUTPUT EN	OFF
	RANGE	1-99 ms
	KEY DOWN	50 ms
	KEY UP	50 ms
Oscilloscope	CH1 VOLTS/DIV	0.5 V
	CH1 Coupling	DC
	CH2 VOLTS/DIV	1 V
	CH2 Coupling	DC
	TIME/DIV	5 ms
	Trigger Coupling	DC
	Trigger Source	EXT
Two-Tone Generator	TONE A	ON
	TONE B	OFF
	HI-Z/LO-Z	As Required
	BALANCE	N/A
	LEVEL	FULL CCW
	ATTENUATOR	–30 dB
RF Generator	FREQUENCY TUNE	14.250 MHz
	OUT LEVEL	+10 dBm
	RF	ON
	AM	OFF
	FM	OFF

4.9.3.2 (If proceeding from the previous PTT to SSB RF Output Time Test, this paragraph may be skipped). _Set the Two-Tone and Keying Test Generator power switches to ON. Receiver hiss should be heard; adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.9.3.3.

> *CAUTION: Reverse power to the RF signal generator at no time should exceed -40 dBm (approx. 2 Vr_{ms}). Shut-down of the instrument may result.*

4.9.3.3 Reduce the step attenuators until the signal is heard and a deflection can be observed on the S meter. Tune the receiver for maximum S meter indication. Reduce the RF step attenuators until the receiver S meter indicates an S9 signal. If the DUT does not have an S Meter, then set for a 50 μV input to the DUT.

4.9.3.4 Tune the transmitter, if necessary, exactly per the operator's manual for the 14.250 MHz test frequency. Turn on the two-tone generator and set the A tone switch to ON. With the DUT in the USB mode, set the generator LEVEL and ATTENUATOR controls for the maximum audio input level as specified by the DUT manufacturer. specified by the manufacturer. Unkey the transmitter and turn the keying test generator 4.9.3.5 Key the transmitter and set for the maximum power as ON. Adjust the oscilloscope settings (including sweep rate) as required for an optimum display trace as shown in Fig. 4-9A. If the audio output is not visible at all on the oscilloscope it will be necessary to increase the keying test generator KEY-UP and KEY-DOWN time. Measure and record the time it takes to go from PTT key-up to 50% audio output. Set the keying test generator to OFF.

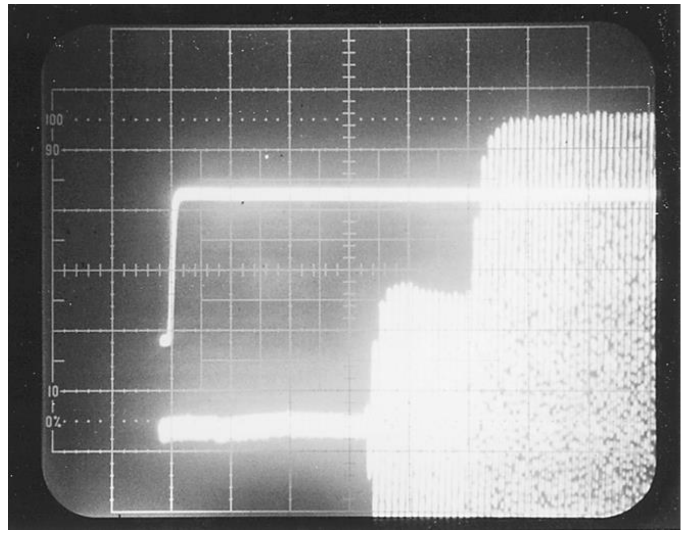


Fig. 4-9A — Oscilloscope Trace of RF Envelope

4.9.3.6 Repeat step 4.9.3.5 for other AGC options, if available, and a 20 dB decrease in signal strength. Check the appropriate box in 4.9.3.6 of the data sheet if no significant deviation is observed. Record the space provided any significant deviation.

4.9.3.7 AMTOR requires the transceiver audio to reach 50% of its full value in 35 ms or less. Determine the AMTOR suitability and record on the data sheet.

4.10 KEYER SPEED AND SIDETONE FREQUENCY TEST
(For units having an internal keyer.)

4.10.1 The purpose of this test is to measure the transmitter's internal keyer speed range and sidetone frequency range.

4.10.2 Test hook-up (See Fig. 4-10)

4.10.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type
DUT RF OUTPUT to wattmeter INPUT	As Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to Step Attn INPUT	BNC to Type N	50-Ohm coax
Step Attn Output to Scope CH 1 Input	BNC to BNC	50-Ohm Coax
XMTR Key Input to Keyer Paddles	As Required	Any
Power to DUT	As Required	As Required
DUT Audio Out to Scope CH 2 Input	1/8 inch mini* (typ) to BNC	50-Ohm Coax

NOTE: Many new transceivers have a stereo audio output. Be certain to use the correct adapters to avoid grounding the unused audio channel and terminate the unused audio output with the appropriate specified load (8 Ohms typical, consult DUT manual).

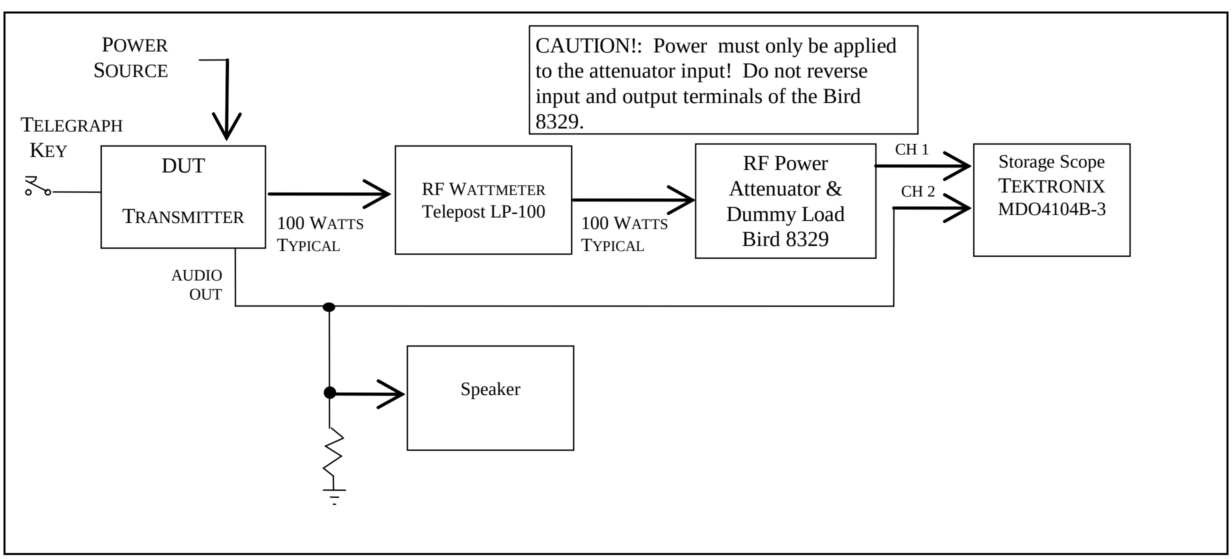


Fig. 4-10 — Keyer Speed and Sidetone Frequency Test Hook-up

4.10.3 Test procedure

4.10.3.1 Turn the DUT, RF wattmeter and oscilloscope power switches to ON. Set the following controls:

Instrument	Control	Position

DUT	Mode	USB
	Frequency	14.250 MHz
	XMIT/RCV	Receive
	AGC	N/A
	Squelch	OFF
RF Wattmeter	Push-button Mode Select	FWD PEP
	Element	As Required
	Forward Element Range	As Required
Step Attn	Attenuator	–40 dB
Oscilloscope	CH1 VOLTS/DIV	0.5 V
	CH1 Coupling	DC
	CH1 Position	As Needed
	CH2 VOLTS/DIV	1 V
	CH2 Coupling	DC
	CH2 Position	As Needed
	TIME/DIV	5 ms
	Trigger Coupling	DC
	Trigger Source	CH1
	Trigger Level	As Required

4.10.3.2 (If proceeding from the previous Turnaround Time Test, this paragraph may be skipped). Receiver hiss should be heard; adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 4.10.3.3.

4.10.3.3 Key the transmitter. Set the sidetone level for comfortable listening level. Adjust the step attenuators and oscilloscope controls for optimum display. Send a series of dits and then a series of dashes. Verify the dashes are three times longer in duration than the dits. Measure and record any significant deviation from the standard 3 to 1 ratio.

4.10.3.4 With keyer speed still set to minimum, send a series of dits and take a trace in the storage mode. Measure the time duration from the leading edge of a dit to the leading edge of the next dit. This duration is equivalent to two dits (one dit plus a dit space). Adjust the oscilloscope controls as required to obtain an optimum trace. Divide the measured time by (in ms) into 2400 to obtain the equivalent code speed (in WPM):

Code Speed in WPM = 1200 / Duration of Single Dit in ms   Record on Data Sheet.

4.10.3.5 Set keyer speed to maximum and repeat step 4.10.3.4.

4.10.3.6 Set keyer speed to center or the default position and repeat step 4.10.3.4.

4.10.3.7 Measure the initial default sidetone frequency with the storage scope . Reduce the sidetone for minimum frequency and measure again. Increase to maximum sidetone frequency and repeat. Record both all three frequencies on Data Sheet.

4.11 PHASE NOISE TEST

4.11.1 The purpose of the Phase Noise Test is to observe and measure the phase noise, as well as any spurious signals generated by the DUT transmitter. Since phase noise is the primary noise component in any well-designed transmitter, it can be assumed, therefore, that almost all the noise observed during this test is phase noise.

4.11.1.1 This measurement is accomplished with the use of a Rohde & Schwarz FSUP 26, which can measure phase noise on any frequency up to 26.5 GHz.

4.11.2 Test Hook-up (See Fig. 4-11).

4.11.2.1 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type*
DUT RF OUTPUT to wattmeter INPUT	As Required to type N	50-Ohm coax
Wattmeter OUTPUT to Power Attn INPUT	Type N to type N	50-Ohm coax
Power Attn OUT to Step Attn INPUT	Type N to BNC	50-Ohm coax
Step Attn OUT to R & S FSUP 26 INPUT	BNC to BNC	50-Ohm coax

NOTE: Composite noise setup is very sensitive to environment noise. It is very important to make certain this test is performed with the screen room door tightly closed and all other non-essential screen room test equipment is turned off. Use incandescent lighting only.

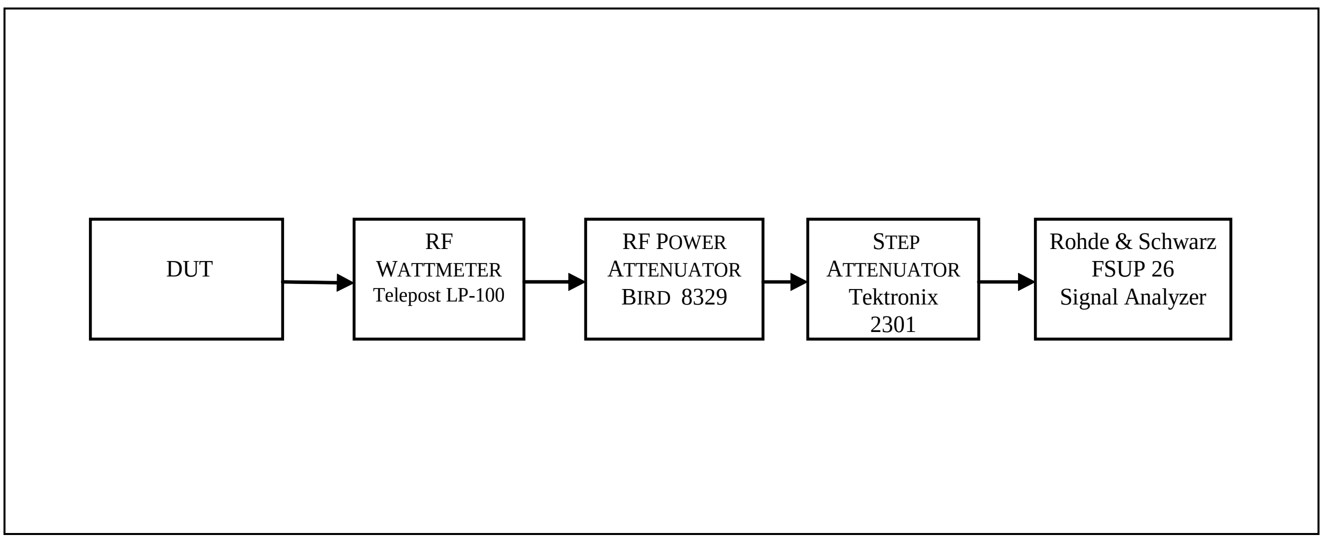


Fig. 4-11 — Phase Noise Test Hook-up

4.11.3 Test procedure

4.11.3.1 Turn the DUT, RF wattmeter, test system, spectrum analyzer power, and reference oscillator switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters

	Frequency Output Power	14.025 MHz 30-50 %
RF Wattmeter	Mode Select	“w”
Step Attn	Attenuator	As required for 0 dBm
FSUP 26	FREQUENCY	14.025 MHz

NOTE: Do not exceed 0 dBm at the input to the FSUP 26, or damage may occur!

4.11.3.2 Allow all equipment, including the test oscillator, at least 15 minutes warm-up time before proceeding. TURN OFF all non-essential test equipment and overhead fluorescent lights. Use the incandescent lighting.

4.11.3.3 Check the manufacturer’s specification of the transmitting duty cycle. If not stated, set the power output to 30 watts for a 100 watt maximum transmitter, or 50 watts for a 200 watt maximum transmitter. The test will take about a few minutes; do not exceed manufacturer’s duty cycle

4.11.3.4 The R & S FSUP 26 takes several minutes to boot up. The setup is automatic for the phase noise test, however, check to make sure the frequency of 14.025 MHz is selected for both the DUT and the FSUP 26. The range on the screen should be set to 100 Hz to 1 MHz. Select the proper parameter and make any necessary changes, if needed.

4.11.3.5 Key the transmitter, then press “measurement”. After a few minutes, there should be a complete trace across the display screen. Once complete, press, “stop”. Un-key the transmitter. Store the display trace on a flash drive. (ARRL Staff must save as “.wfm” file for publishing purposes, a “.bmp” file for manufacturers).

4.11.3.6 Repeat steps 4.11.3.4 through 4.11.3.5 with a test frequency of 50.020 MHz, 144.020, 432.020 MHz, if applicable.

V. RECEIVER TESTS: ***DISABLE THE TRANSMITTER, IF POSSIBLE.*** Or, minimize RF Output.

5.0.1 As shown in the Table of Contents, there many receiver tests outlined in this chapter. They have been arranged, just as in the previous transmitter tests, to minimize the required level and frequency of hook-up changes and modifications. Each hook-up, however, is shown complete with all changes from the previous test clearly indicated. A block diagram accompanies each hook-up and any changes from the previous test are shown within a dotted rectangle. This affords the flexibility to easily start anywhere and perform these tests in any desired order.

5.0.2 Before performing any receiver testing, it is essential for the test engineer to be completely familiar with the Device Under Test (DUT) and the test equipment that will be used. ***The RF output of a transceiver will damage the test equipment and therefore, it is essential never to accidentally key the transmitter while performing these tests!*** Completely disable the transmitter if at all possible and set all RF output and microphone controls to minimum, reduce drive, disconnect the telegraph key, microphone, etc. The receiver must be operated in a manner exactly as specified by the manufacturer. Any test that would cause equipment to be operated in a manner inconsistent with its operating manual must be modified accordingly.

5.0.2.1 Other considerations are as follows:

1) The RF Generator output must not exceed –14 dBm when using the Hybrid Combiner. This restriction is an effort to minimize intermodulation in the combiner and signal generators.

2) The level of input to the receiver should not exceed +10 dBm or the manufacturer's specification, whichever is less.

3) Read and understand all pertinent manuals before operating any laboratory instrument or the DUT receiver.

4) The testing should be conducted in a relatively RF free environment. If an RF source is in close proximity to the testing site, an RF screen room should be used.

5) If a preamp is available, each test must be performed with each level of the preamp and without the preamp.

6) If the audio output impedance is not 8 Ohms, select the appropriate load resistance.

NOTE: Special attention must be exercised to ensure the proper First IF (roofing filter) and DSP Filter selections are made prior to testing; typically, 500 Hz for each filter setting while in CW mode.

Also, please be mindful that some receiver tests require the AGC to be turned off.

5.1 NOISE FLOOR TEST

5.1.1 The purpose of the Noise Floor Test (also known as "Minimum Discernible Signal" or MDS) is to determine the level of signal input to the receiver that will produce an audio output where the power in the signal is equal to the power in the noise (S + N = N + 3 dB). The test is conducted with the receiver in the CW mode using the 500 Hz, or closest available IF filter (or audio filters where IF filters are not available. For receivers that have appropriate IF filters, all audio filtering is disabled.) Set the AGC to the OFF position if possible. The test is performed frequencies of 1.020 MHz, 3.520 MHz, 14.020 MHz, 50.020 MHz, 144.020 MHz and 432.020 MHz. For the expanded set of tests, this test is performed on all available amateur bands, 20 kHz above the lower band edge.

5.1.2 Test hook-up (See Fig. 5-1)

5.1.2.1 With all power switches in the OFF position, **the transmitter function disabled to the fullest extent possible** and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT AUDIO OUT to Dist/Audio Meter IN	As Required to BNC	50-Ohm Coax
8-Ohm Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

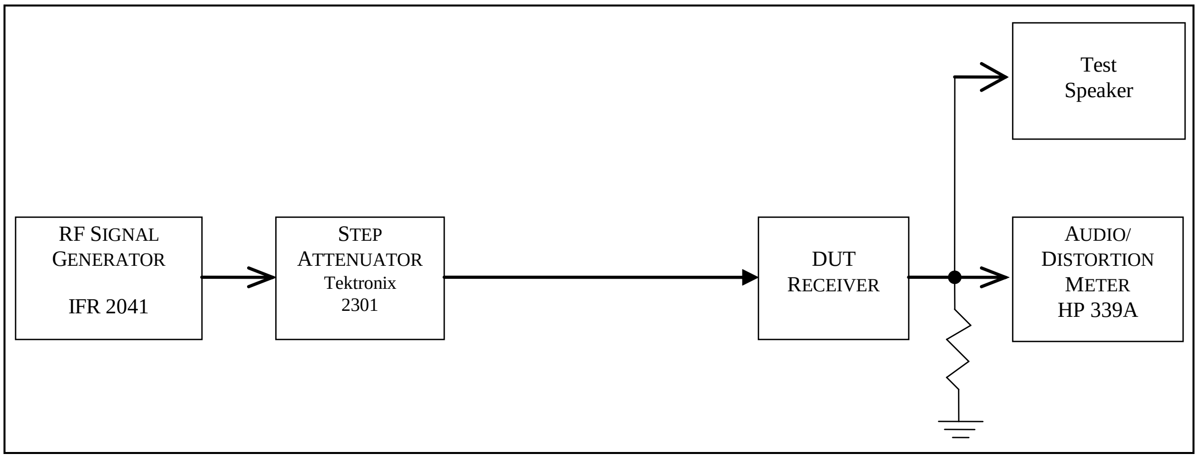


Figure 5-1 -- CW MDS Test Hook-up

5.1.3 Test Procedure

5.1.3.1 Turn the DUT and all test equipment power switches to ON. If the DUT does not cover 1.020 MHz, proceed directly to the second test frequency of 3.520 MHz. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	As Required for 1.020 MHz
	Frequency	1.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	OFF or ON
	Preamplifier	OFF
Step Attn	Attenuator	0 dB
RF Generator	CARRIER FREQ	1.020 MHz
	RF LEVEL	–110 dBm
	NOISE MODE (UTIL)	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)

METER RESPONSE NORM

5.1.3.2 Receiver hiss should be heard. Adjust the volume of the DUT to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.1.3.3.

5.1.3.3 Verify the RF Generator Output frequency has remained at 1.020 MHz. Reset if necessary.

5.1.3.4 Tune the receiver for 1.020 MHz. Adjust the INPUT RANGE and RELATIVE ADJUST controls as required to maintain approximately a mid-scale meter indication while carefully tuning the receiver for peak signal response. (Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver.)

5.1.3.5 Set the RF Generator RF switch to OFF. Decrease the Audio Meter INPUT RANGE until the meter indication is near mid-scale and the two lights above this control are out. Adjust the audio meter RELATIVE ADJUST control until the audio meter reads –6 dB on the upper scale. (Adjust the INPUT RANGE control one step in either direction if necessary.)

5.1.3.6 Set the RF Generator RF switch to ON. Rotate the generator OUTPUT LEVEL control to produce an audio meter reading of –3 dB. Ensure that the DUT is tuned for peak response.

5.1.3.7 Check to ensure that the Generator frequency is still at 1.020 MHz. Set the RF Generator RF to OFF. The audio meter should return to –6 dB. Turn the RF back on and the meter should again indicate –3 dB.

5.1.3.8 Determine the noise floor (MDS) of the receiver by computing the sum of the RF generator output in dBm and step attenuator. (NOTE: Be sure to include any additional attenuation you may have included in the line between the generator and the DUT.) Record on the Data Sheet.

Example: a) The RF generator is set for –128.6 dBm output.
b) The step attenuators are set for –10 dB.
c) The receiver MDS, therefore, is:

–128.6 – 10 = –138.6 dBm

5.1.3.9 Repeat steps 5.1.3.4 to 5.1.3.8 with DUT preamplifier set to ON.

5.1.3.10 Re-set the generator output level to –110 dBm. Repeat paragraphs 5.1.3.3 to 5.1.3.9 for a test frequency of 3.520 MHz.

5.1.3.11 Repeat step 5.1.3.10 for a test frequency of 14.020 MHz.

5.1.3.12 Repeat step 5.1.3.10 for test frequencies of 50.020 MHz, 144.020 MHz and 432.020 MHz, as applicable to the DUT.

5.1.3.13 Repeat step 5.1.3.10 for other amateur bands needed.

5.2 AM RECEIVE SENSITIVITY TEST

5.2.1 The purpose of the AM receive Sensitivity Test is to determine the level of an AM signal, 30% modulated at 1 kHz, that will produce a tone 10 dB above the noise level (MDS) of the DUT. Two frequencies, 1.020 MHz and 3.800 MHz are used for this test.

5.2.2 Test hook-up (See Fig. 5-2)

NOTE: If proceeding from the MDS Test, no hook-up changes are required. Proceed to step 5.2.3.

5.2.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to 10-dB Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio OUTPUT to Dist/Audio Meter INPUT	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

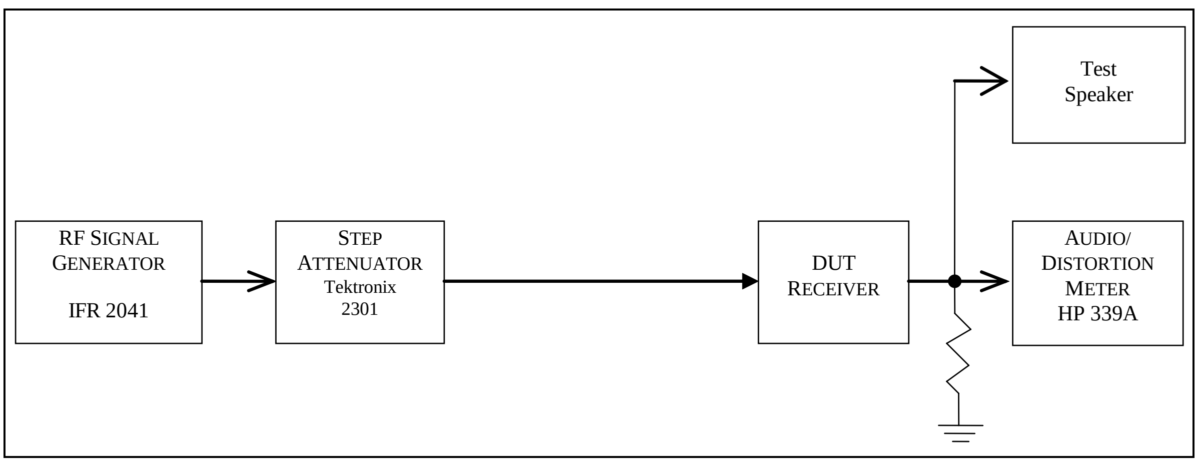


Fig. 5-2. AM Receive Sensitivity Test Hook-Up

5.2.3 Test Procedure

5.2.3.1 Turn the DUT and all test equipment power switches to ON. If the DUT does not cover 1.020 MHz, proceed directly to the second test frequency of 3.800 MHz. Set the following controls:

Instrument	Control	Position
DUT	Mode	AM
	Band Selector	As Required for 1.020 MHz
	Frequency	1.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	AM (Approx. 6 kHz)
	AGC	OFF
	Preamplifier	OFF

	DUT Audio Filter(s)	Disabled
10-dB Step Attn	Attenuator	0 dB
RF Generator	CARRIER FREQ	1.020 MHz
	RF LEVEL	–110 dBm
	CARR ON-OFF	ON
	AM	ON
	AM DEPTH	30%
	Modulation Frequency	1000 Hz
	FM	OFF
	NOISE MODE	LOW NOISE MODE
Audio/Distortion Meter	FUNCTION	DISTORTION
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.2.3.1 Adjust the signal generator output level for the following equivalent distortion level as required:

10 dB (S+N)/N = 31.6%

5.2.3.2 Determine the AM 10 dB sensitivity of the receiver by computing the sum of the output level of the RF generator, as read from the OUTPUT LEVEL switch and meter, and any additional attenuation in the line between the generator and the DUT. Record on the Data Sheet.

Example: a) The RF generator is set for –113 dBm output.
b) The step attenuators are set for 10 dB.
c) The receiver AM sensitivity is:
–113 - 10 = –123 dBm

5.2.3.3 Set the DUT preamplifier to ON and repeat steps 5.2.3.3 to 5.2.3.7.

5.2.3.4 Return the RF generator OUTPUT LEVEL control to –110 dBm and set for 3.800 MHz. Repeat paragraphs 5.2.3.1 to 5.2.3.3 for this test frequency, 29.0, 50.4, 144.14 and 432. 14 MHz, if applicable.

5.3 FM SINAD AND QUIETING TEST

5.3.1 The purpose of the FM SINAD and Quieting Test is to determine the 12 dB SINAD value.
SINAD is an acronym for "Signal plus Noise and Distortion" and is a measure of signal quality.
The exact expression for SINAD is:

$$\text{SINAD} = \frac{\text{Signal + Noise + Distortion}}{\text{Noise + Distortion}} \quad \text{(expressed in dB)}$$

If we consider distortion to be merely another form of noise, (distortion, like noise, is something unwanted added to the signal), we can further reduce the equation for SINAD to:

$$\text{SINAD} = \frac{\text{Signal + Noise}}{\text{Noise}} \quad \text{(expressed in dB)}$$

If we now consider a practical circuit in which the signal is much greater than the noise, the value of the SIGNAL + NOISE can be approximated by the level of the SIGNAL alone. The SINAD equation then becomes the signal to noise ratio and can be approximated by:

SINAD = Signal (expressed in dB)
Noise

For 25% level of distortion, SINAD can be calculated as: SINAD = 20 log (1/25%) = 20 log 4 = 12 dB

5.3.2 Test hook-up (See Fig. 5-3)

NOTE: If proceeding from the previous AM Receive Sensitivity Test, no hook-up changes are required. Proceed directly to step 5.3.3.

5.3.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT AUDIO OUTPUT to Dist/Audio Meter IN	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter INPUT	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

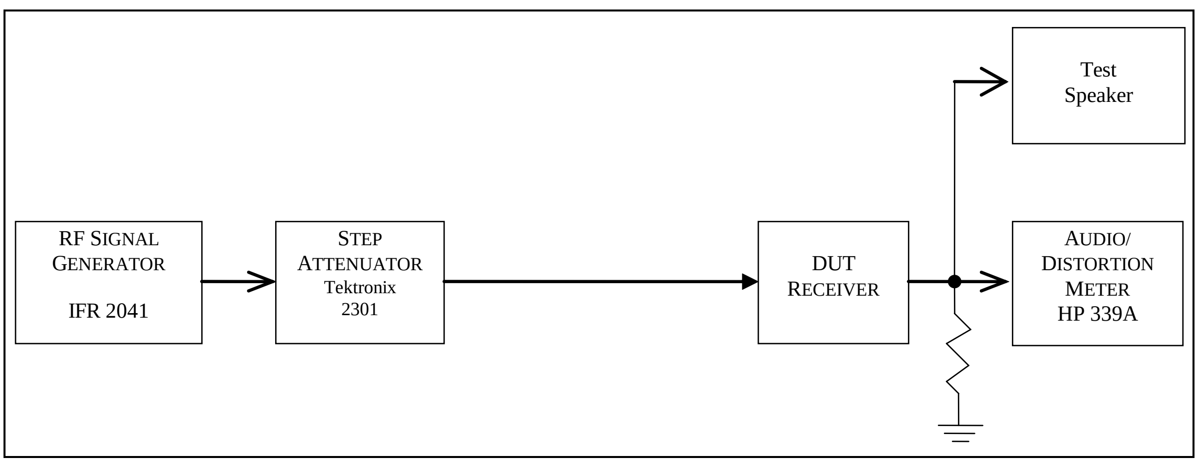


Fig. 5-3 FM SINAD and Quieting Test Hook-Up

5.3.3 Test Procedure

5.3.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	FM
	Frequency	29.000 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum

	RF Gain	Maximum
	IF Filters	FM (Aprx.15 kHz)
	AGC	OFF
	Preamplifier	OFF
Step Attn	Attenuator	0 dB
RF Generator	CARRIER FREQUENCY	29.000 MHz
	RF LEVEL	–110 dBm
	CARR ON-OFF	ON
	NOISE MODE	NORMAL[1]
	FM	On
	AM	Off
	FM DEVN	3 kHz
	Modulation Frequency	1000 HZ
Audio/Distortion Meter	FUNCTION	DISTORTION
	RELATIVE ADJUST	Any
	METER	–10/30
	FREQUENCY CONTROLS	1.0 X 1 kHz
	FILTERS	Low Pass On
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.3.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.3.3.3.

5.3.3.3 Turn the DUT's preamp on and tune the receiver for 29.000 MHz. Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver. Set the DUT volume control for a normal listening level, and carefully tune the receiver for minimum distortion. (This control should be set roughly between 1/4 and 3/4 of the maximum limit.)

5.3.3.4 Gradually increase the Signal Generator output until the Distortion Meter indicates 25% distortion. (The step Attenuator may also be used, if necessary, to help achieve the reading.)

5.3.3.5 Measure the level of the input signal to the DUT receiver and record in 5.3.3.5 of the Data sheet. Be sure to account for any attenuation in the line from the step attenuators or hybrid combiner.

Example: a) The RF generator is set for –112.4 dBm output
b) The step attenuator is set for 10 dB
c) The FM SINAD is:

<u>–112.4 - 10 = –122.4 dBm</u>

5.3.3.6 Repeat steps 5.3.3.3 to 5.3.3.5 with the DUT preamp off.

5.3.3.7 Reduce the Generator Output to –110 dBm. Repeat paragraphs 5.3.3.4 and 5.3.3.5 for any other applicable FM filters.

5.3.3.8 Repeat the above steps in FM Narrow Mode, if applicable.

NOTE: The following tests are only performed if quieting is specified by the manufacturer. Repeat these tests for all applicable bandwidths and preamp settings.

10 dB Quieting

5.3.3.8 Reduce the Generator Output to -110 dBm and reset the step attenuators if necessary to 0 dB. Set the Audio/Distortion meter to REL LEVEL and the RF Generator FM modulation button to OFF.

5.3.3.9 Set the Generator RF button to OFF. Adjust the INPUT RANGE and the RELATIVE ADJUST controls for a reading of -3 dB on the audio meter. Rotate the INPUT RANGE control 1 detent CCW. Gradually increase the output of the RF generator until the audio meter again indicates -3 dB (or a 10 dB decrease). The step attenuators may be used as necessary to help achieve this reading.

5.3.3.10 Set the RF button to OFF and the INPUT RANGE control 1 detent CW. The meter should return to -3 dB. Return the RF switch to ON and rotate the INPUT RANGE control 1 detent CCW. The meter should again indicate -3 dB. Record the input level to the DUT in 5.3.3.10 of the Data Sheet.

20 dB Quieting

5.3.3.11 Set the RF button to OFF. Adjust the INPUT RANGE and the RELATIVE ADJUST controls for a reading of -3 dB on the audio meter. Rotate the INPUT RANGE control 2 detents CCW. Gradually increase the output of the RF generator until the audio meter again indicates -3 dB (or a 20 dB decrease). The step attenuators may be used as necessary to help achieve this reading.

5.3.3.12 Set the RF button to OFF and the INPUT RANGE control 2 detent positions CW. The meter should return to -3 dB. Return the RF button to ON and rotate the INPUT RANGE control 2 detent positions CCW. The meter should again indicate -3 dB. Record the input level to the DUT in 5.3.3.12 of the Data Sheet.

5.3.3.13 Repeat paragraphs 5.3.3.3 to 5.3.3.7 for the following frequencies, as applicable to the DUT:

5.4 RECEIVE FREQUENCY RANGE TEST

5.4.1 The purpose of the Receive Frequency Range Test is to determine both the practical receive frequency range as well as the absolute maximum frequency range limits.

5.4.2 Test hook-up (See Fig. 5-4)

5.4.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter Input	As Required to BNC	50-Ohm Coax

Connection	Connectors	Cable Type
Test Speaker to Dist/Audio Meter Input	As Required	As Required

Power Source to DUT Power Input	As Required	As Required

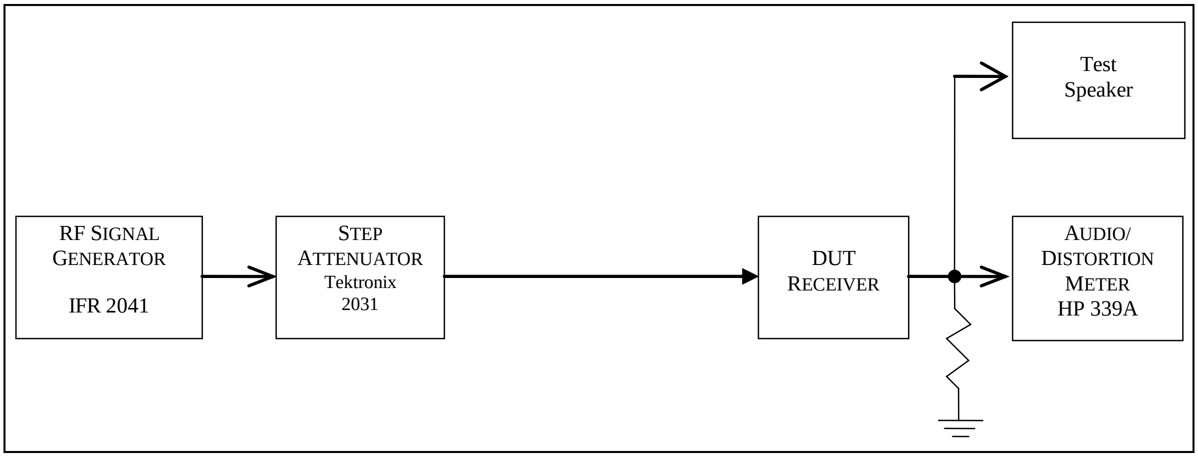


Fig. 5-4 — Receive Frequency Range Test Hook-up

5.4.3 Test Procedure

5.4.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	Lowest Available
	Frequency	Lowest Available
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	OFF
	Preamplifier	OFF
10 dB Step Attn	Attenuator	10 dB
RF Generator	CARRIER FREQ	Same as DUT
	RF LEVEL	–110 dBm
	CARR ON-OFF	OFF
	AM	Off
	FM	Off
	NOISE MODE	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.4.3.2 Receiver hiss should be heard. Adjust the volume of the DUT to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.4.3.3.

5.4.3.3 Tune the receiver for the minimum frequency possible. Verify useful sensitivity by performing an MDS test and record results in 5.4.3.2 of the Data Sheet. If useful sensitivity is not achieved, increase frequency and repeat until useful sensitivity is obtained. Perform an MDS test the DUT's specified limit if other than the lowest possible frequency.

NOTE: Useful sensitivity is somewhat ambiguous. In general terms, a receiver with less than about –100 dBm MDS sensitivity is probably marginal. Anything less than that is usually not practical for most applications.

5.4.3.4 Tune the receiver to the minimum frequency possible. Note and record any frequencies not being received by or not included in the tuning range of the DUT.

5.4.3.5 Repeat step 5.4.3.3 for the highest possible frequency. Reduce the as required for useful sensitivity and perform an MDS test at the maximum specified frequency.

NOTE: For amateur equipment, always check 824-849 and 869-894. These frequencies must be blockedt to be certificated for Part 15 and/or Part 90 FCC Rules. Equipment cannot be sold in the USA if cellular frequencies are not blocked.

5.4A RECEIVER PROCESSING DELAY TIME

5.4A.1 The purpose of this test is to determine the time delay from when a signal arrives at the antenna jack to when the same signal is heard out of the speaker. While not an issue with modern frequency conversion receivers, where delays zero with purely analog, or under 20 ms with DSP, SDR receivers can exhibit delays that are 100s of mil-seconds, an eternity for serious contesters, or for impossible for monitoring the transmitted signal off-air.

5.4A.2 Test hook-up (See Figure 5A1

5.4A.2.1 With all power switches in the OFF position, the DUT transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Test Transmitter to Bird Power Attenuator	PL-259 to N	50-Ohm Coax
Bird Power Attenuator to 0-10 dB Step Attenuator In	N to BNC	50-Ohm Coax
0-10 dB Step Att Out to CH B of Storage Scope	BNC T to BNC	50-Ohm Coax
0-10 dB Step Att Out to 0-120 dB Step Att In	BNC T to BNC	50-Ohm Coax
0-120 dB Step Att Out to DUT Antenna Jack	BNC to PL-259	50-Ohm Coax
DUT Speaker Output to CH A of Storage Scope	BNC to BNC	50-Ohm Coax
Power Source to DUT Power Input	As Required	As Required
Telegraph Key to Test Transmitter	As Required	As Required

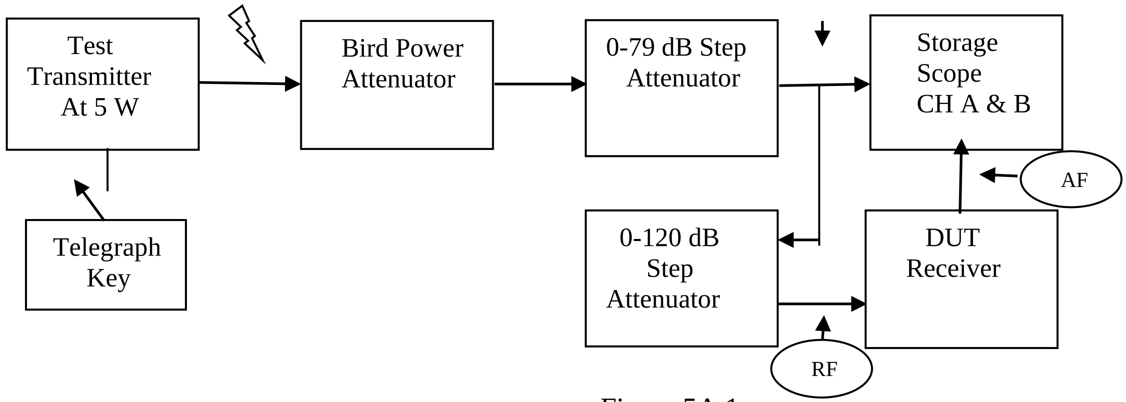


Figure 5A.1

5.4A.3 Test Procedure

5.4A.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	XMIT/RCV	RCV, (TX Disabled)
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	Fast
	Preamplifier	OFF
0-79 dB Step Attn	Attenuator	10 dB
0-120 dB Step Attn	Attenuator	30 dB
Test Transmitter	RF Power Output	Minimum Output
	Mode	CW
	Frequency	14.020 MHz
	Telegraph Key	Inserted
Dual channel Storage Scope	Ch A Voltage	500 mV/Div
	Ch B Voltage	1 V/Div
	Sweep Time	As Needed

5.4A.3.2 Key the Test Transmitter and tune in the transmitted signal with the DUT receiver. Note the RF envelope displayed on Channel B of the Storage Scope, adjust the voltage/division accordingly, filling about 2/3 of the top half of the screen.

5.4A.3.3 With the Test Transmitter keyed, adjust the 0-120 dB Step Attenuator so the DUT Receiver S Meter reads close to S9 (-73 dBm). note the speaker audio envelope displayed on Channel A of the Storage Scope. Adjust the voltage/division accordingly, as you did with Channel B, this time filling 2/3 of the bottom half of the screen.

5.4A.3.4 As you observe the Storage Scope Screen, key the transmitter slowly, Note the DUT Receiver Speaker Audio envelope lags behind the RF envelope. Press the key, then quickly pause the scanning of the Storage Scope.

5.4A.3.5 Measure the time delay between the two envelopes, record the figure onto the test data sheet.

5.5 FIRST IF AND IMAGE REJECTION TEST

5.5.1 The purpose of the first IF and Image Rejection Test is to determine the level of signal input to the receiver at the first IF and Image frequencies that will produce an audio output equal to the MDS level. The test is conducted with the receiver in the CW mode using the 500 Hz, or closest available, IF filters. Any audio filtering is disabled and the AGC is set to the OFF position if possible. The test is performed with the DUT tuned to 14.020 MHz.

5.5.2 Test hook-up (See Fig. 5-5)

5.5.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT AUDIO OUTPUT to Dist/Audio Meter IN	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter INPUT	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

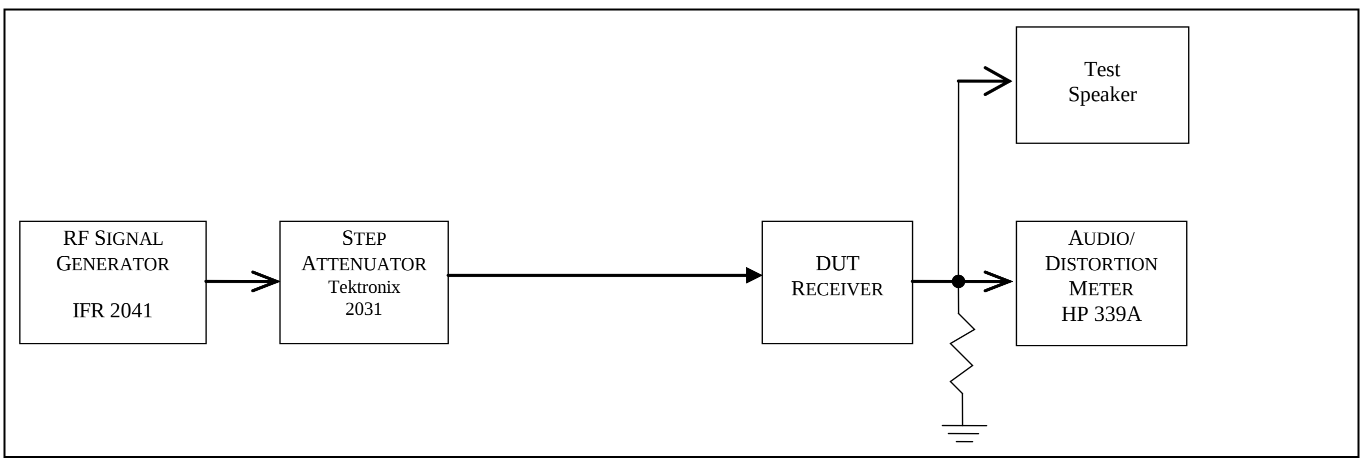


Fig. 5-5 — IFAnd Image Test Hook-up

5.5.3 Test Procedure

5.5.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	OFF
	Preamplifier	OFF
Step Attn	Attenuator	10 dB

RF Generator	CARRIER FREQ	DUT 1st IF
	RF LEVEL	–80 dBm
	CARR ON-OFF	ON
	AM	Off
	FM	Off
	NOISE MODE	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.5.3.2 Receiver hiss should be heard. Adjust the volume of the DUT to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.5.3.3.

5.5.3.3 Verify the RF Generator Output frequency has remained at the DUT 1st IF. Reset if necessary.

5.5.3.4 Tune the receiver for 14.020 MHz. Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver. Adjust the INPUT RANGE and RELATIVE ADJUST controls as required to maintain approximately a midscale meter indication while carefully tuning the Generator CARRIER FREQ control for peak signal response.

5.5.3.5 Set the RF Generator RF switch to OFF. Decrease the Audio Meter INPUT RANGE until the meter indication is near mid-scale and the two lights above this control are out. Adjust the audio meter RELATIVE ADJUST control until the audio meter reads –6 dB on the upper scale. (Adjust the INPUT RANGE control one step in either direction if necessary.)

5.5.3.6 Set the RF Generator RF switch to ON. Rotate the generator OUTPUT LEVEL control to produce an audio meter reading of –3 dB. Ensure that the Generator CARRIER FREQ control is tuned for peak response.

5.5.3.7 Set the RF Generator RF to OFF. The audio meter should return to –6 dB. Turn the RF back on and the meter should again indicate -3 dB.

5.5.3.8 Determine the IF level of the receiver by computing the sum of the RF generator output in dBm and the 10 dB step attenuator. (NOTE: Be sure to include any additional attenuation you may have included in the line between the generator and the DUT.) Find the difference in dB from the 20 Meter MDS (with preamp off) previously measured in the test battery. Record on the Data Sheet.

Example: a) The RF generator is set for –36.1 dBm output.
b) The step attenuators are set for –10 dB.
c) The receiver IF rejection level, therefore, is:
–36.1 - 10 = –46.1 dBm
d) If we measured the noise floor to be –138.6 dBm in the Noise Floor Test, then the IF rejection is:
–46.1 dBm - (–138.6 dBm) = 92.5 dB

5.5.3.9 Repeat steps 5.5.3.4 to 5.5.3.8 with DUT preamplifier set to ON.

5.5.3.10 Calculate the first IF image frequency as follows:

14.020 MHz +/- (2 X IF in MHz) = Image Frequency in MHz

Note there are two potential image frequencies if the 1st IF is less than 7.010 MHz Check *BOTH* frequencies for a response and record the appropriate one in 5.5.10 of the Data Sheet.

5.5.3.11 Tune the receiver for 14.020 MHz. Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver. Tune the Signal Generator to the other potential image frequency calculated in step 5.5.3.10. Compare the DUT response between the two input frequencies and set the Generator to the frequency that result in the greatest output response. Reduce the generator to provide an approximately the MDS level at the image frequency.

5.5.3.12 Adjust the INPUT RANGE and RELATIVE ADJUST controls as required maintaining approximately a mid-scale meter indication while carefully tuning the Generator CARRIER FREQ control for peak signal response. Increase the generator output level if necessary.

5.5.3.13 Set the RF Generator RF switch to OFF. Decrease the Audio Meter INPUT RANGE until the meter indication is near mid-scale and the two lights above this control are out. Adjust the audio meter RELATIVE ADJUST control until the audio meter reads –6 dB on the upper scale. (Adjust the INPUT RANGE control one step in either direction if necessary.)

5.5.3.14 Set the RF Generator RF switch to ON. Rotate the generator OUTPUT LEVEL control to produce an audio meter reading of –3 dB. Ensure that the Generator CARRIER FREQ control is tuned for peak response.

5.5.3.15 Set the RF Generator RF to OFF. The audio meter should return to -6 dB. Turn the RF back on and the meter should again indicate –3 dB. Record the Signal Generator output in 5.5.3.7 of the data Sheet and calculate the Image Rejection as follows:

Example: a) The RF generator is set for –59.6 dBm output.
b) The step attenuators are set for –10 dB.
c) The receiver image rejection level, therefore, is: –59.6 - 10 = –69.6 dBm
d) If we measured the noise floor to be -138.6 dBm in the previous Noise Floor Test, the image rejection is: –69.6 dBm - (–138.6 dBm) = 69.0 dB

5.5.3.16 Reset the generator output level to –80 dBm. Repeat steps 5.5.3.13 to 5.5.3.15 with the DUT preamplifier set to ON.

5.6 ANTENNA PORT ISOLATION TEST
(For Receivers with multiple antenna ports only)

5.6.1 The purpose of this test is to determine the level of isolation between antenna ports with receivers having multiple antenna ports. A comparison in MDS sensitivity is made between an unused and used antenna port. The test is conducted with the receiver in the CW mode using the 500 Hz, or closest available, IF filters. Any audio filtering is disabled and the AGC is set to the OFF position if possible. The test is performed with the DUT tuned to 14.020 MHz.

5.6.2 Test hook-up (See Fig. 5-6)

5.6.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to 10-dB Step Attn INPUT	BNC to BNC	50-Ohm Coax
10-dB Step Attn OUTPUT to DUT RF INPUT #1	BNC to As Required	50-Ohm Coax

DUT AUDIO OUT to Dist/Audio Meter IN	As Required to BNC	50-Ohm Coax
8-Ohm Load/HI-Z Amp Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

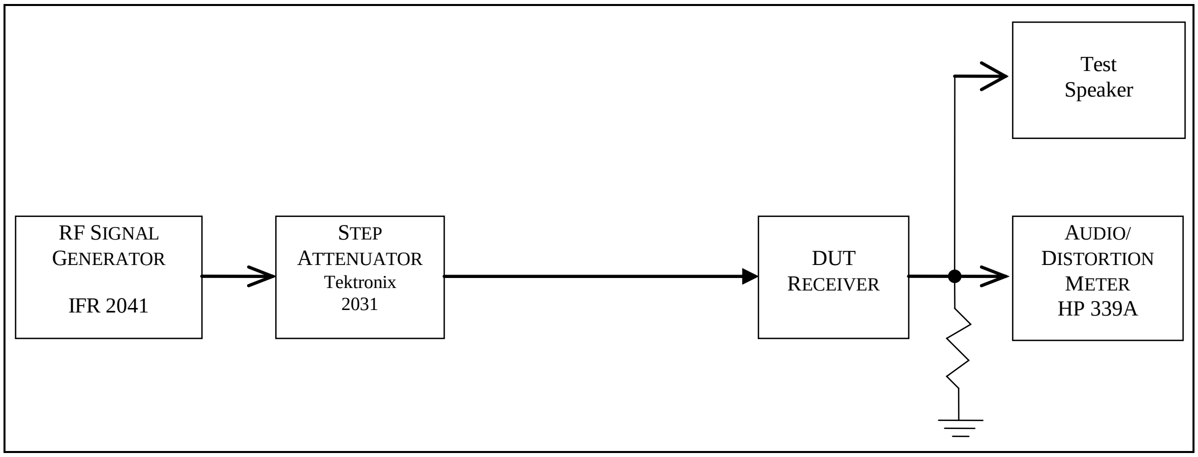


Fig. 5-6 Antenna Port Isolation Test Hook-Up

5.6.3 Test Procedure

5.6.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	IF Filters	500 Hz or Closest Available
	AGC	OFF
	Preamplifier	OFF
Step Attn	Attenuator	10 dB
RF Generator	CARRIER FREQ	14.020 MHz
	RF LEVEL	–80 dBm
	NOISE MODE	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.6.3.2 Receiver hiss should be heard. Adjust the volume of the DUT to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.6.3.3.

5.6.3.4 Tune the receiver for 14.020 MHz. Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver. Adjust the INPUT RANGE and RELATIVE ADJUST controls as required to maintain approximately a mid-scale meter indication while carefully tuning the Generator CARRIER FREQ control for peak signal response.

5.6.3.5 Set the RF Generator RF switch to OFF. Decrease the Audio Meter INPUT RANGE until the meter indication is near mid-scale and the two lights above this control are out. Adjust the audio meter RELATIVE ADJUST control until the audio meter reads –6 dB on the upper scale. (Adjust the INPUT RANGE control one step in either direction if necessary.)

5.6.3.6 Set the RF Generator RF switch to ON. Rotate the generator OUTPUT LEVEL control to produce an audio meter reading of –3 dB. Ensure that the Generator CARRIER FREQ control is tuned for peak response. Results should be similar to the previously measured 20 meter MDS measured in Test 5.1. Now remove the RF Input cable from RF Input #1 and connect it to RF Input #2. Increase the Generator RF LEV Control until the meter once again shows a 3 dB increase.

5.6.3.7 Set the RF Generator RF to OFF. The audio meter should return to –6 dB. Turn the RF back on and the meter should again indicate –3 dB.

5.6.3.8 Determine the Antenna Port Isolation by computing the difference between the two MDS measurements (in dBm). Record on the Data Sheet if deemed unsatisfactory by the test engineer.

5.6.3.9 Repeat steps 5.6.3.5 and 5.6.3.6 for preamp on and any other antenna port combinations deemed appropriate by the test engineer.

5.7 BLOCKING GAIN COMPRESSION DYNAMIC RANGE

5.7.1 The purpose of the Blocking Gain Compression Test is to determine the level of gain compression, or desensitization that occurs as a result of another signal on a nearby frequency. The blocking gain compression is the difference between the level of the noise floor and the level of undesired signal that produces a 1 dB decrease of audio in a weak desired signal. Frequencies of 3.520 MHz, 14.020 MHz, 50.020 MHz, 144.020 MHz and 432.020 MHz are used for this test as appropriate for the DUT. The test is performed with the desired signal level of 1 μV (–107 dBm) The calculation is as follows:

Blocking Gain Compression Dynamic Range = Blocking Level - Noise Floor (MDS level, expressed in dBm)

5.7.2 Test hook-up (See Fig. 5-7)

5.7.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 output to Hybrid Combiner input 1	BNC to BNC	50-Ohm Coax
Signal Gen 2 output to Hybrid Combiner input 2	BNC to BNC	50-Ohm Coax
Hybrid Combiner output to Step Attn. input	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio OUTPUT to Dist/Audio Meter input	As Required to BNC	50-Ohm Coax
DUT Audio Output to Signal Analyzer	BNC to BNC	50-Ohm Coax

Test Speaker Across Dist/Audio Meter INPUT	As Required	As Required

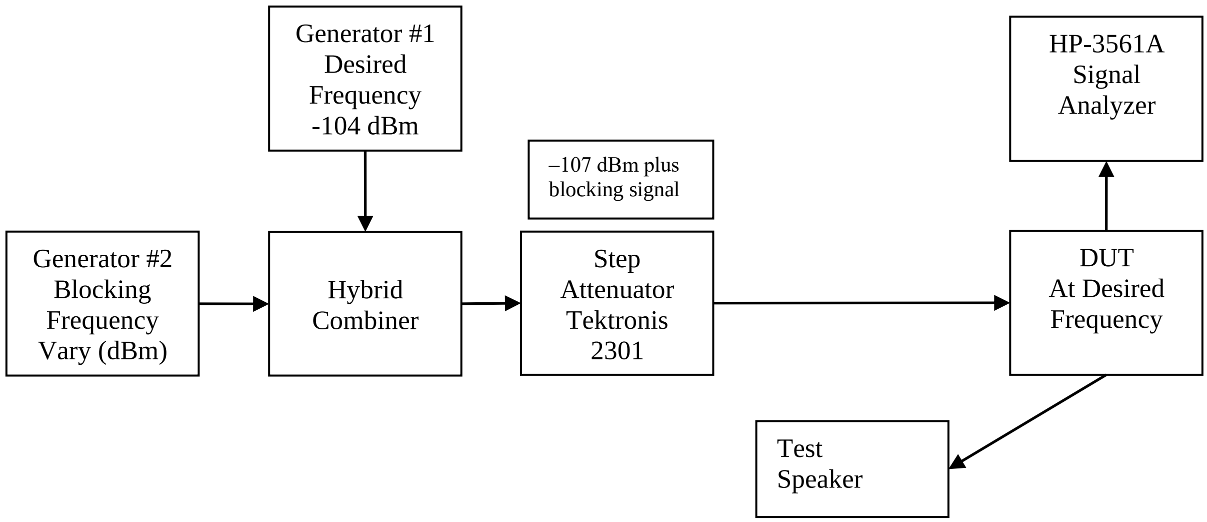


Fig. 5-7 — Blocking Dynamic Range Test Hook-up

5.7.3 Test Procedure

5.7.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Position	Control
DUT	Mode	CW
	Band Selector	3.520 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Closest Available to 500 Hz
	Any Audio Filtering	Disabled
	AGC	**OFF**
	VOLUME	Lowest Possible Setting
Step Attn	Attenuator	0 dB
RF Generator #1	CARRIER FREQ	3.520 MHz
	RF LEVEL	–104 dBm
	CARR ON-OFF	ON
	NOISE MODE (UTIL)	LOW NOISE
RF Generator #2	CARRIER FREQ	3.500 MHz
	RF LEVEL	–100 dBm
	CARR ON-OFF	ON
	NOISE MODE (UTIL)	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V

	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM
Signal Analyzer	CENTER FREQUENCY	600 Hz
	RANGE	10 dBv
	VERTICAL SCALE	-10 dBv
	SPAN	100 Hz
	PEAK TRACK	ON

5.7.3.2 Receiver hiss should be heard. Turn the volume level all the way down. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.7.3.3.

5.7.3.3 Verify generator #1 and generator #2 are still set for 3.520 MHz and 3.500 MHz, respectively. Set Generator #2 RF switch to OFF.

5.7.3.4 Tune the receiver for 3.520 MHz. Ensure Generator #1 RF Level is set to -107 dBm. Adjust receiver volume control, turning slowly until the desired signal is barely heard in the monitor speaker (high speaker levels will damage the Signal Analyzer!). Adjust the INPUT RANGE and REL ADJUST as required to maintain approximately a mid-scale meter indication while carefully tuning the receiver for peak signal response on the meter.

5.7.3.5 Check the Signal Analyzer for a pip and adjust the DUT volume level for a relative reading of -50 dBv on the scale. Make a note of the exact reading as displayed; ex: Y= -50.23 dB. Re-adjust the INPUT RANGE for a mid scale reading on the distortion meter. From this point on, the mid-scale reading on the distortion meter will be used for quick reference for adjustment of the volume control only. **NOTE:** Do not exceed 0 dBm into the HP-3561A Signal Analyzer or damage may result to its input circuits. Start each adjustment with the DUT volume down, turning it up slowly.

5.7.3.6 Determine the 1 dB reduction point (blocking level) by Switching Generator #2 to ON and increase the RF LEVEL to a point where a 1 dB decrease in audio is observed on the Signal Analyzer. Ex: Y= -50.23 dB with GEN #2 OFF and Y= -51.23 dB with GEN #2 ON and at the blocking level. An increase of noise level is likely, especially at 5 and 2 kHz spacing. Reduce the SPAN on the signal analyzer to 10, 5 or as low as 2 Hz, as needed, to separate the desired signal from the back round noise. (It may take several minutes for the Signal Analyzer to read the relative audio level, with the SPAN set to a narrow bandwidth, each time the blocking signal level is changed)

Record the value of the blocking level (Generator #2 level + 3 dB combiner *loss* = blocking level in dBm) in 5.7.3.5 of the Data Sheet. Be sure to account for the hybrid combiner *and* any step attenuator losses.

EX: (+5.6 dBm Blocking Signal) + (-3 dBm combiner loss)) = +2.6 dBm = Blocking Level

NOTE: Certain Software defined receivers may exhibit no blocking up to the point of digital to analog converter (ADC) overload. Do not exceed +10 dBm into DUT. In such a case, the blocking dynamic range is limited by the ADC clip level. BDR=MDS–(–ADC Clip Level); example, MDS = –130 dBm, ADC Clip Level = +2 dBm; –130 dBm – (+2dBm) = –132 dB. We report BDR = 132 dB.

5.7.3.7 Repeat the above steps for Generator #2 set to 3.540 MHz, then at 5 and 2 kHz above and below the desired frequency, then repeat steps with Generator #1 set to: 14.020, 50.020 and 432.020 MHz. Record on data sheet.

5.7.3.8 Repeat paragraphs 5.7.3.2 to 5.7.3.7 for 20 kHz spacing above and below the desired frequency with the DUT preamp ON. If the DUT has more than one preamp setting, test all settings and record on the data sheet.

Note: Strong blocking signals sometimes create false signals at the desired frequency. To check for this, turn off the desired signal from generator #1. If a signal is present, the Blocking Gain Compression Dynamic Range is noise limited at the blocking level at which the tone occurs.

5.7A RECIPROCAL MIXING DYNAMIC RANGE TEST

5.7A.1 The purpose of the Reciprocal Mixing Dynamic Range Test is to determine the level of noise generated the mixing of the First Local Oscillator's Phase Noise and a strong adjacent, steady signal. The resultant signal that is passed down the receiver chain causes an increase of background noise from this mixing. Often, this noise, reciprocal mixing, is the most limiting performance factor of a receiver. It must also be noted that some software defined receivers exhibit no reciprocal mixing up the point of ADC overload. A 14.025 MHz, ***very low noise*** Wenzel crystal controlled oscillator, with an output of +15 dBm is connected to the DUT RF input via a step attenuator. The receiver is tuned to a series of nearby frequencies, 2, 5 & 20 kHz above and 2, 5 & 20 kHz below the oscillator's frequency. The oscillator attenuation is then reduced to a point where the level of background noise is 3 dB above the noise floor of the DUT. Reciprocal Mixing Dynamic Range is calculated by use of the following equation:

Reciprocal Mixing Dynamic Range = (MDS) – (Crystal Oscillator Level at the DUT input). Example, MDS = –130 dBm. An adjacent signal at –32 dBm causes a 3 dB increase in background noise.
–130 dBm–(–32 dBm) = –98 dB; we report BDR = 98 dB.

5.7A.2 Test hook-up, See Figure 5.7A

5.7A.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Low Noise Osc OUTPUT to Step Attn INPUT	BNC to BNC	50 Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50 Ohm Coax
DUT AUDIO OUTPUT to Dist/Audio Meter INPUT	As Required to BNC	50 Ohm Coax
Test Speaker Across Dist/Audio Meter INPUT	As Required	As Required
Power Source to DUT Power Input	As Required	As Required
Power Source to Crystal Oscillator	As Required (12 V dc)	As Required

DUT

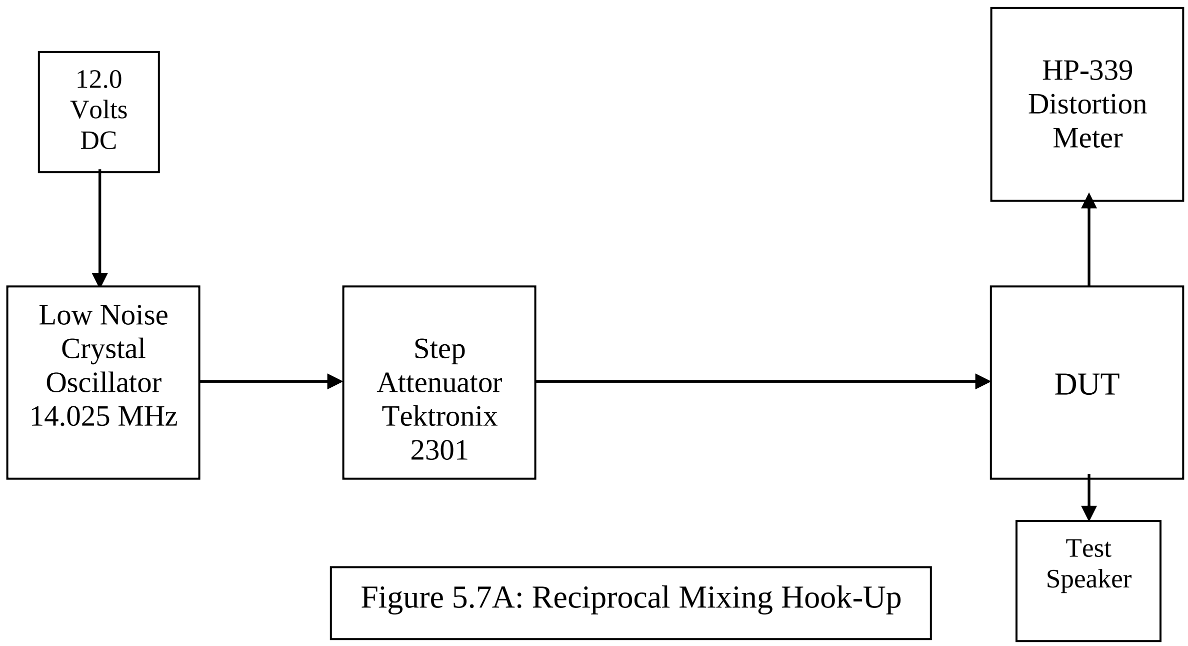


Figure 5.7A: Reciprocal Mixing Hook-Up

5.7A.3 Test Procedure

5.7A.3.1 Turn the DUT and Audio Distortion Meter power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Same as MDS Test (5.1)
Step Attn	Attenuator	–70 dB
Low Noise Oscillator	(DC Power) ON/OFF Switch	OFF
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.7A.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 6.5.3.3.

5.7A.3.3 Tune the receiver for 14.025 MHz. A signal that is only moderately strong should be heard in the speaker that is not quite strong enough to move the S-Meter. Decrease the Step Attenuator, one step at a time, until the signal is just heard in the receiver. Adjust the INPUT RANGE control as required to maintain approximately a midscale meter indication while carefully tuning the receiver for peak signal response. Tune the DUT receiver down 20 kHz from the point of peak response.

5.7A.3.4 Turn the Low Noise Oscillator switch to OFF. Set the meter REL ADJUST and INPUT RANGE controls for –6 dB. Turn the Low Noise Oscillator Switch to ON. Carefully decrease the Step Attenuators for a meter indication of –3 dB. Calculate the input to the DUT, in dBm, by subtracting the step attenuator settings from the +15 dBm output of the oscillator. Record on the Data Sheet.

5.7A.3.5 Continue to tune the DUT up to the following frequencies and repeat step 6.5.3.4. (NOTE: It is unnecessary to continue this procedure beyond the point that 3 dB of noise above MDS can no longer be achieved.)

14.005 MHz---Peak Response – 20 kHz
14.020 MHz---Peak Response – 5 kHz
14.023 MHz---Peak Response – 2 kHz
14.027 MHz---Peak Response + 2 kHz
14.030 MHz---Peak Response + 5 kHz
14.045 MHz---Peak Response + 20 kHz

5.7A.3.6 Calculate Reciprocal Mixing for each test frequency by using the equation shown in 5.7A1.

Record all results on the Data Sheet.

NOTE: Direct Conversion Receivers contain Analog to Digital Converters which may have little or no reciprocal mixing up to the point of ADC Clipping. Reciprocal Mixing should be reported as:
Reciprocal Mixing = > (MDS) – (threshold level of ADC Clipping)

EX: MDS = –126 dBm
ADC Clipping = +2 dBm
RM = –126 dBm – (+2 dBm) = –128 dB

We report “128 dB” and add the ADC Clip Level in a footnote.

5.8 TWO-TONE 2ND AND 3RD ORDER DYNAMIC RANGE TEST

5.8.1 The purpose of the Two-Tone Dynamic Range Test is to determine the range of signals that can be tolerated by the DUT while producing essentially no undesired spurious responses. To perform the 3rd Order test, two signals of equal amplitude and spaced 20 kHz apart, are injected into the input of the receiver. If we call these frequencies f_1 and f_2, the third-order products will appear at frequencies of $(2f_1 – f_2)$ and $(2f_2 – f_1)$. Similarly, the 2nd order test also requires two input signals of equal amplitude. The product, however, appears at a frequency of (f_1+f_2). The intercept points are calculated for each test point. This test is performed on 3.5 MHz, 14 MHz, 50 MHz, 144 MHz and 432 MHz as appropriate for the DUT.

5.8.2 Test hook-up (See Fig. 5-8)

NOTE: If proceeding from the previous Blocking Dynamic Range Test, no hook-up changes are required.

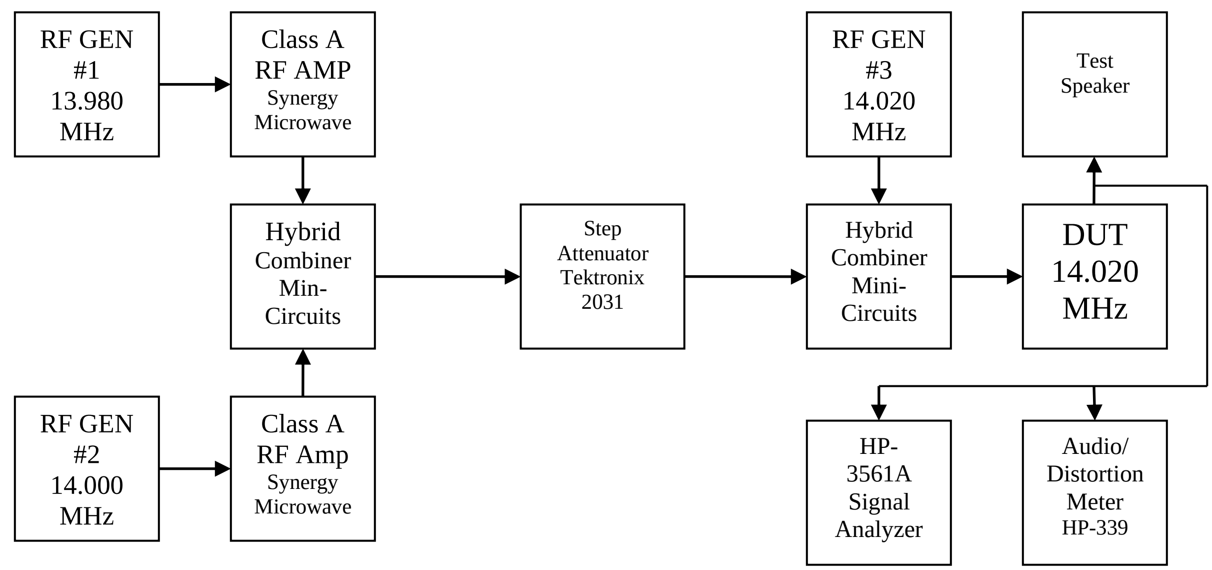


FIGURE 5.8. Second & Third order IMD Dynamic Range Hook-up

RF Generator 1: IFR 2041
RF Generator 2: IFR 2041
RF Generator 3: IFR 2041

5.8.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 output to input of Amp #1	BNC to BNC	50-Ohm Coax
Signal Gen 2 output to input of Amp #2	BNC to BNC	50-Ohm Coax
Amp #1 output to Hybrid Combiner input	BNC to BNC	50-Ohm Coax
Amp #2 output to Hybrid Combiner input	BNC to BNC	50-Ohm Coax
Hybrid Combiner output to Step Attn input	BNC to BNC	50-Ohm Coax
Step Attn output to Hybrid Combiner input	BNC to BNC	50-Ohm Coax

Signal Generator #3 to Hybrid Combiner input	BNC to BNC	50-Ohm Coax
Hybrid Combiner output to DUT RF input	BNC to as required	50-Ohm-Coax
DUT audio output to Dist/Audio Meter input	As Required to BNC	50-Ohm Coax
DUT to HP-3156A Signal Analyzer	BNC to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

5.8.3 Test Procedure

5.8.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Closest Available to 500 Hz
	DUT Audio Filter(s)	Disabled
	AGC	**ON**
Step Attn	Attenuator	70 dB
RF Generator #1	CARRIER FREQ	13.980MHz
	RF LEVEL	–18 dBm
	CARR ON-OFF	OFF
	NOISE MODE (UTIL)	LOW NOISE
RF Generator #2	CARRIER FREQ	14.000 MHz
	RF LEVEL	–18 dBm
	CARR ON-OFF	OFF
	NOISE MODE (UTIL)	LOW NOISE
RF Generator #3	CARRIER FREQ	14.020 MHz
	RF LEVEL	-97 dBm
	CARR ON-OFF	OFF
Signal Analyzer	CENTER FREQUENCY	600 Hz
	RANGE	10 dBv
	VERTICAL SCALE	-10 dBv
	SPAN	100 Hz
	PEAK TRACK	ON
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.8.3.2 Receiver hiss should be heard. Adjust the volume to the lowest possible setting. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.8.3.3.

5.8.3.3 Verify RF generators #1, #2 and #3 are still set for 13.980, 14.000 and 14.020 MHz, respectively. ALL CARR ON-OFF controls ***must*** be in the OFF position before proceeding to the next step.

IMPORTANT NOTE: Before proceeding, it is imperative to insure that both Class A RF amps have the same output of 3 dBm at the output of the Hybrid Combiner. Check the outputs buy hooking up a BCN to BNC cable from the combiner output to the HP-8563E spectrum analyzer, making sure the two signals are equal and at 3 dBm. Adjust the input level of each signal generator if needed.

5.8.3.4 Set Generator #3 to CARR OFF-ON to ON. Turn up the DUT volume so it is just heard in the Test Speaker. Tune the receiver for peak response at 14.020 MHz. Decrease the audio meter INPUT RANGE control until the meter indication is near mid scale. (The two lights just above the RANGE Control should go out.) Check to make sure the Generator 3 level is adjusted to –94 dBm, which is a –97 dBm (S5) level at the combiner output.

5.8.3.5 Look for a PIP on the Signal Analyzer. This is the **Desired Signal**. Center pip if needed. Adjust the DUT volume so it is close to –50 dB on the Signal Analyzer. Set the audio meter RELATIVE ADJUST control until meter reads –6 dB (upper scale). Adjust the INPUT RANGE switch as required to achieve this indication. From this point on, The audio meter is used as a handy reference for adjusting the DUT volume. Do NOT exceed 0 dBm at the input to the Signal Analyzer, or damage to its input circuits will result. Always start each measurement with the volume down.

5.8.3.6 Turn both the generators #1 & #2 CARR ON-OFF switches to ON. Slowly turn up the step attenuator until a second PIP appears on the Signal Analyzer. This is the **IMD Signal**. With peak tracking on, make both pips on the screen equal by adjusting the step attenuators. When both are equal, the IMD level is what the attenuators are set to. Example: Attenuators are set to 26 dB. The IMD level would be –26 dB. Record the IMD level on the data sheet.

5.8.3.7 Repeat steps 5.8.3.4 to 5.8.3.7, but with Generator #1 & 2 set for 14.010 & 14.015 MHz respectively (5 kHz spacing). Repeat steps having Generator 1 & 2 at 14.016 & 14-018 MHz respectively (2 kHz spacing). Repeat steps for 2, 5 & 20 kHz spacing above the desired frequency. Record on data sheet.

NOTE: Measurements at 5 and 2 kHz spacing may require reducing the bandwidth on the Signal Analyzer, especially when Generator #3 is set to the MDS level (plus 3 dB) . When doing so, it will be necessary to put both pips on the scope as close together as possible before reducing the bandwidth. This is accomplished by adjust either Generator #1 or Generator #2 by small fractions of a Hertz. Slowly adjust one of the generators while watching the IMD signal, placing the IMD pip close to the desired signal pip. The SPAN may now be adjusted to a smaller bandwidth. (50 or 25 Hz works well).

5.8.3.8 Repeat the above IMD measurements, but with Generator #3 set to the MDS plus 3 dB. This results with an MDS level at the combiner output. If the MDS is –126 dBm, set the generator to –123 dBm. At this point, the receiver should detect the desired signal at the MDS level. To verify this, Generator 3 can be turned off and on and the relative audio level should change by 3 dB, as per the MDS (Noise Floor) test.

5.8.3.9 Repeat steps 5.8.3.4 and 5.8.3.7 for preamp for 20 kHz spacing above and below the desired signal. Repeat if preamp has more than one setting. Return preamp to off.

5.8.3.10 Repeat IMD tests for the required frequencies and spacing shown on the data sheet.

5.8.3.11 Calculate the Two- Tone, Third Order IMD Dynamic Range for each data point.

3rd Order DR = MDS – IMD Level.

Example:
MDS = –126 dBm
IMD level = –26 dBm

3rd Order IMD DR = (–126 dBm) – (–26 dBm) = 100 dB.

Calculate for each data point.

5.8.3.12 Calculate the 3rd Oder Intercept Point (IP3) for each data point using the following formulas:

IP3 is no longer a useful figure regarding the performance of SDR receivers. It is no longer published.

IP3 at MDS : (1.5)(IMD DR in dB) + (MDS in dB)

Example: IMD DR = 100 dB, MDS = –26 dBm

IP3 (at MDS) = (1.5)(100 dB) + (–126 dBm) = 24 dB

IP3 at S5: $\dfrac{\text{3 X (S5 IMD level) – (S5 Reference)}}{2}$

Example: IMD level = –15 dBm, S5 reference = –97 dBm

IP3 at S5 = $\dfrac{\text{3 X (–15 dBm) – (–97 dBm)}}{2}$ = 26 dB

Record all IP3 data points on data sheet.

Important Notice About Software Defined Receivers and 3 IMD DR:

It was discovered in the ARRL Laboratory that *some* software defined receivers only have mediocre Third Order Two-tone IMD Dynamic Range in a laboratory environment. When hooked to an antenna, the same receiver has improved dynamic range; sometimes the improvement is very significant. The discovery was made by inserting a fourth signal generator at the antenna jack. This fourth signal generator is tuned away from the desired signal and the IMD signal generators, but is adjusted in frequency to the opposite end of the Amateur Band of which the receiver is tuned, perhaps some 300 kHz away. This signal represents “band energy”, or activity. The level of the fourth generator is adjusted for –20 to –30 dBm and acts as the cumulative band energy. The IMD levels are then measured as above using this fourth generator and the improved 3 IMDDR is calculated. This dynamic range improves with the presence of strong signals, which is desirable.[2]

5.8.3.13 Combine the desired signal (Gen3) with a 4th Generator, adjust the 4th Generator to –20 dBm and determine the improvement of the dynamic range. Record this figure on the Data Sheet as, “Up to XXX dB”.

[2]See February, 2010 QST, page 52 for a further explanation.

Second Order Two Tone IMD Test: (Still used)

Gen 1 = 6.000 MHz, Gen 2 =8.020 MHz, DUT = 14.020 MHz, same procedure as above.

Second Order Intercept = 2 X (S 5 IMD level) – (S 5 level)
Example IMD level = –10 dBm

2^{Nd} Order Intercept Point, S 5 level = 2(–10 dBm) – (–97 dBm) = +77 dBm

Record IP2 data point on data sheet.

5.8.3.13 The results of this method should show close correlation with the intercept points determined by the MDS test. If not, the test engineer determines (from the MDS and dynamic range data) which method provides the more accurate result.

5.9 FM ADJACENT-CHANNEL SELECTIVITY TEST

5.9.1 The purpose of the FM Adjacent Channel Selectivity Test is to measure the ability of the DUT receiver to reject interference from individual undesired signals while receiving various levels of desired signal. The desired carrier signal will be at 29.000 MHz, modulated at 1000 Hz, and the offending signal will be located at adjacent nearby frequencies with 400 Hz modulation. (NOTE: The SINAD Test in 5.3 must be performed before this test can be completed.)

5.9.2 Test hook-up (See Fig. 5-9)

5.9.2.1 With all power switches in the OFF position and the transmitter disabled, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 Output to Hybrid Combiner Input 1	BNC to BNC	50-Ohm Coax
Signal Gen 2 Output to Hybrid Combiner Input 2	BNC to BNC	50-Ohm Coax
Hybrid Combiner output to Step Attn input	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter input	As Required to BNC	50-Ohm Coax

Connection	Connectors	Cable Type
Test Speaker Across Dist/Audio Meter IN	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

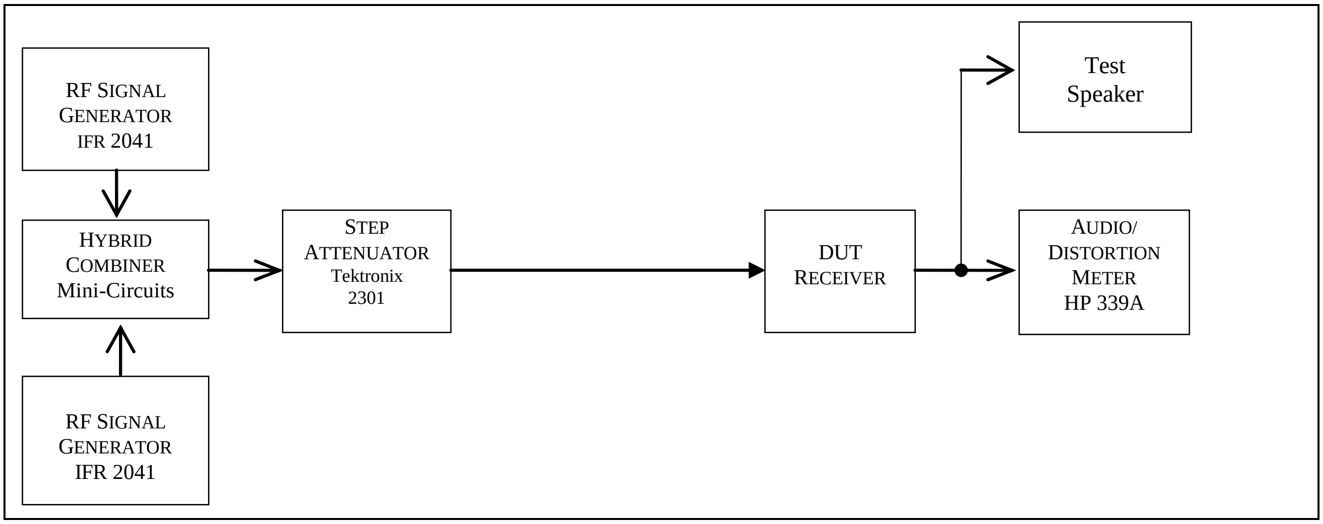


Fig. 5-9 — FM Adjacent Channel Selectivity Test Hook-up

5.9.3 Test Procedure

5.9.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	FM
	Band Selector	10 Meters
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	15 kHz for FM
	Any Audio Filtering	Disabled
	Preamp	On
Step Attn	Attenuator	0 dB
RF Generator #1	CARRIER FREQ	29.000 MHz
	RF LEVEL	–110 dBm
	NOISE MODE (UTIL)	NORMAL
	CARR ON-OFF	ON
	AM	OFF
	FM	ON
	FM DEVN	3 kHz (Utility, Normal)
	Modulation Frequency	1000 Hz
RF Generator #2	CARRIER FREQ	28.980 MHz
	RF LEVEL	–110 dBm
	NOISE MODE (UTIL)	NORMAL
	CARR ON-OFF	OFF
	AM	OFF
	FM	ON
	FM DEVN	3 kHz
	Modulation Frequency	400 Hz (Utility, Normal)

Instrument	Control	Position
Audio/Distortion Meter	FUNCTION	DIST
	DIST RANGE	30 %
	FREQUENCY	1.0 X 1K
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V

INPUT/GND SELECT	DIS (Center)
METER RESPONSE	NORM

5.9.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.9.3.3.

5.9.3.3 Tune the receiver for 29.000 MHz. Increase the #1 generator RF LEVEL, if necessary, until the signal is just heard in the receiver. Set the DUT volume control for a normal listening level, and carefully tune the receiver for minimum distortion. This control should be set for approximately 1/4 to 3/4 of the maximum.

5.9.3.4 Set the #1 signal generator level to produce a 12 dB SINAD response in the DUT. The generator output should be 3 dB greater than the level previously recorded in 5.3.3.5 of the Data Sheet during the initial SINAD test. (The 3 dB accounts for the attenuator loss.) The meter should now indicate 25% distortion. Change the DISTORTION RANGE to 100. Set the #2 signal generator RF switch to ON. Increase the output level of this generator until the distortion meter indicates 50% distortion or 6 dB SINAD. Note the generator and attenuator settings. Calculate the input signal level to the DUT and record in 5.9.3.4 of the Data Sheet.

5.9.3.5 Return generator and attenuator levels to their initial settings. Set the #2 generator to 29.020 MHz and set its RF switch to OFF. Repeat step 5.9.3.4.

5.9.3.6 Repeat paragraphs 5.9.3.4 and 5.9.3.5 for the following bands as applicable to the DUT: 52 MHz, 146 MHz and 440 MHz.

5.9.3.7 Calculate the adjacent channel rejection of the DUT for each test point by subtracting the 12 dB SINAD level in dBm from the 6 dB SINAD level in dBm measured in steps 5.9.3.4 and 5.9.3.5. Record in 5.9.3.9 of the Data Sheet.

Example: The 12 dB SINAD value measured in 5.3.3.6./5.3.3.7 = –113
The 6 dB SINAD level measured per this test = –68 dBm

Adjacent channel rejection = 6 dB SINAD – 12 dB SINAD = (–68 dBm) – (–113 dBm) = 45 dB

NOTE: The following step need only be performed if proceeding to the FM Two-Tone 3rd-Order Dynamic-Range Test (5.10). The results will be used to determine phase noise limiting during this test.

5.9.3.8 Return generator and attenuator levels to their initial settings and turn the #2 Generator RF LEVEL and FM switches to OFF. Repeat step 5.9.3.4 with the #2 generator still set for 29.020 MHz and with the FM switch still set to OFF. Calculate the equivalent phase noise limit using the same equations as in step 5.9.3.6. This limit figure represents the FM 2-tone, 3rd-order dynamic range of an unmodulated signal.

5.9.3.9 Repeat step 5.9.3.8 for the following bands as applicable to the DUT: 52 MHz, 146 MHz and 440 MHz.5.8.3.11 Calculate the Dynamic Range by subtracting the MDS noise floor from the IMD figure.

Example: Both RF generators are set at –14 dBm
The RF attenuators are set for –24 dB
The hybrid combiner loss is –3 dB
The receiver noise floor MDS is –135 dBm

IMD LEVEL = (–14 dBm) - 24 dB - 6 dB = –44 dBm
IMD Dynamic Range = IMD LEVEL - NOISE FLOOR = –44 dBm - (–135 dBm) = 91 dB

5.10 FM TWO-TONE 3rd ORDER DYNAMIC RANGE TEST

5.10.1 The purpose of the FM Two-Tone 3rd Order Dynamic Range Test is to determine the range of signals that can be tolerated by the DUT in the FM mode while producing no spurious responses greater than the SINAD level. To perform this test, two signals, f_1 and f_2, of equal amplitude and spaced 20 kHz apart, are injected into the input of the receiver. The signal located 40 kHz from the distortion product being measured is modulated at 1,000 Hz with a deviation of 3 kHz. The DUT receiver is tuned to the Third Order IMD frequencies as determined by $(2f_1-f_2)$ and $(2f_2-f_1)$. The input signals are then raised simultaneously by equal amounts until 25% distortion, or the 12 dB SINAD point, is obtained.

5.10.2 Test hook-up (See Fig. 5-10)

5.10.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 output to Hybrid Combiner input 1	BNC to BNC	50-Ohm Coax
Signal Gen 2 output to Hybrid Combiner input 2	BNC to BNC	50-Ohm Coax
Hybrid Combiner output to Step Attn input	BNC to BNC	50-Ohm Coax
Step Attn output to DUT RF input	BNC to As Required	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter input	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

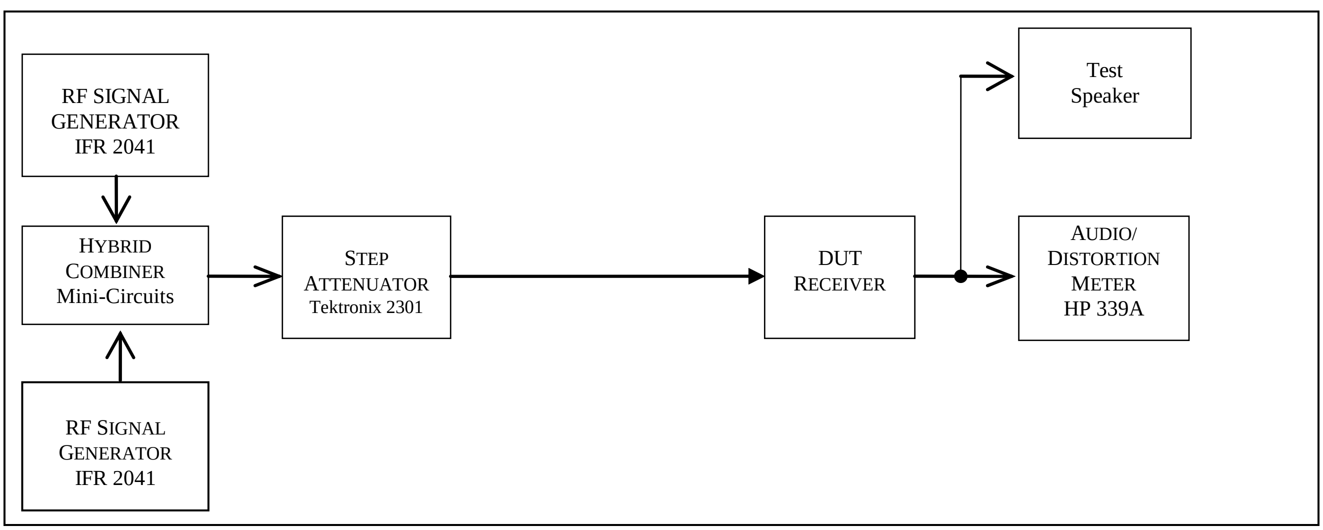


Fig. 5-10 — FM Two-Tone, 3rd Order Dynamic Range Test Hook-up

5.10.3 Test Procedure

5.10.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	FM
	Band Selector	10 Meters
	XMIT/RCV	RCV

	DRIVE or RF LEVEL	Minimum
	IF Filters	Narrowest Available
	DUT Audio Filter(s)	Disabled
	AGC	OFF
	Preamp	ON
Step Attn	Attenuator	70 dB
RF Generator #1	CARRIER FREQUENCY	29.000 MHz
	RF LEVEL	–14 dBm
	CARR ON-OFF	ON
	NOISE MODE[1]	NORMAL[1]
	FM	On
	AM	Off
	FM DEVN	3 kHz
	Modulation Frequency	1000 Hz
RF Generator #2	CARRIER FREQUENCY	29.020 MHz
	RF LEVEL	–14 dBm
	CARR ON-OFF	ON
	NOISE MODE[2]	NORMAL[1]
	FM	On
	AM	Off
	FM DEVN	3 kHz
	Modulation Frequency	1000 Hz
Audio/Distortion Meter	FUNCTION	DIST
	RELATIVE ADJUST	Any
	FILTERS	All OFF (Out)
	DISTORTION RANGE	30%/-10 dB
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM
	FREQUENCY	1.0 x 1 kHz
	OSCILLATOR	Any

5.10.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.10.3.3.

5.10.3.3 Verify RF generators #1 and #2 are still set for 29.000 and 29.020 MHz, respectively. Both CARR ON-OFF controls must be in the ON position before proceeding to the next step. Set generator #1 FM switch to OFF.

5.10.3.4 Tune the receiver for the lower IMD frequency of 28.980 MHz. Decrease the attenuation of the step attenuators until the signal is just heard in the receiver. Decrease the audio meter INPUT RANGE control until the two lights just above the range switch go out. Tune the DUT for minimum distortion on the meter.

5.10.3.5 Decrease the attenuator controls until the distortion meter indicates 25% distortion. Note all attenuator settings and record receiver signal input level in 5.10.3.5 of the Data Sheet.

5.10.3.6 Set #2 generator FM switch to OFF and the #1 generator FM switch to ON. Tune the DUT to the upper IMD frequency of 29.040 MHz and repeat paragraphs 5.10.3.3 to 5.10.3.5.

5.10.3.7 Calculate and record the 3rd order dynamic range in dBm for each IMD product as follows:

---

[2] NOTE: 3 kHz deviation is not possible at a frequency of 29 MHz unless the signal generator is in the Normal Noise Mode. Depress UTILITIES menu button for this setting.

DYNAMIC RANGE = (IMD LEVEL) – (12 dB SINAD)

Example: Both RF generators are set at –14 dBm
The hybrid combiner loss is –3 dB
The attenuators are set for –24 dB
The 12 dB SINAD is –122.3 dBm

The IMD level = (–14 dBm) – 3 dB – 27 dB – (122.3 dBm) = 78.3 dB

Note: An FM 2-tone, 3rd-order dynamic range that is noise-limited will appear to be better than it actually is due to the additional signal necessary to overcome the increased noise. If the calculated FM 2-tone, 3rd-order dynamic range is greater than the phase noise limit determined by the adjacent channel selectivity test, then the actual dynamic range is the phase noise limit figure and the measurement is noise-limited.

5.10.3.8 Repeat paragraphs 5.10.3.3 to 5.10.3.7 for the following frequency bands as applicable to the DUT: 52 MHz, 146 MHz and 440 MHz. Also perform this test at a spacing of 10 MHz on these bands.

5.11 AUDIO POWER OUTPUT TEST

5.11.1 The purpose of the Audio Power Output Test is to measure the audio output voltage developed by the DUT at 1,000 Hz. The manufacturer's specified load and distortion is used for this test. If unspecified, the power is measured with an 8 Ohm load at 10% distortion. The audio power is then calculated by the equation:

$$P_{audio} = \frac{V^2}{8\Omega}$$

5.11.2 Test hook-up (See Fig. 5-8)

NOTE: 1) If proceeding from the previous FM Two-Tone 3rd Order Dynamic Range Test, only the hook-up changes shown with a dotted line are required.

2) Do not use headphone audio output for this test. It will not develop full power.

5.11.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen Output to Step Attn Input	BNC to BNC	50-Ohm Coax
Step Attn Output to DUT RF Input	BNC to As Required	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter Input	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

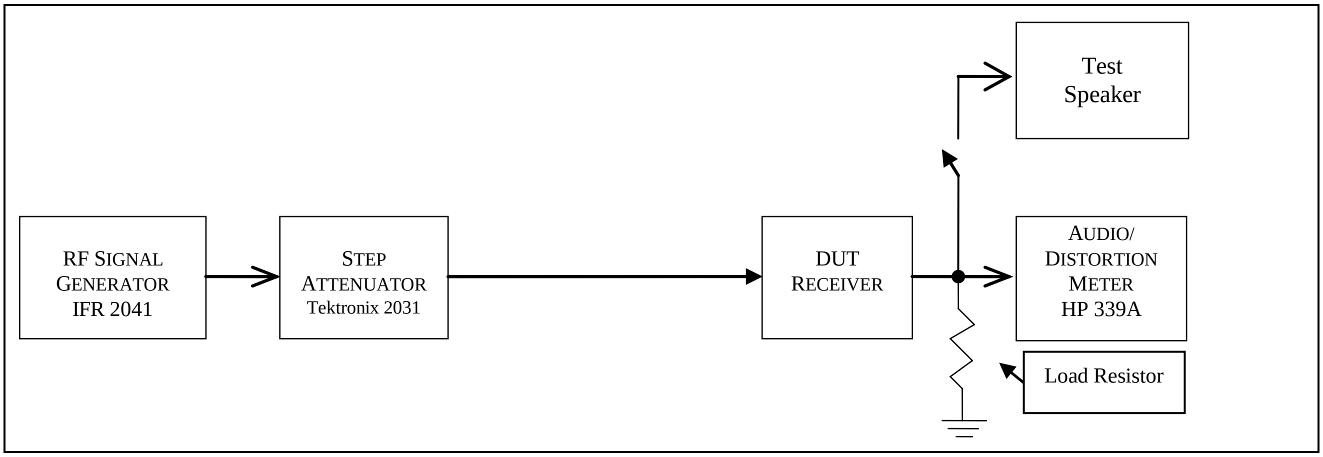


Fig. 5-11 — Audio Power Output Test Hook-up

5.11.3 Test Procedure

5.11.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	AGC	Enabled
	Band Selector	20 Meters
	Frequency Tune	14.200 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Widest Available
	Any Audio Filter	Disabled
Step Attn	Attenuator	0 dB
RF Generator	FREQUENCY TUNE	14.200 MHz
	OUT LEVEL	–80 dBm
	RF	ON
	AM	OFF
	FM	OFF
Audio/Distortion Meter	FUNCTION	DIST
	RELATIVE ADJUST	Any
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	DISTORTION RANGE	30%
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM
	FREQUENCY	1.0 X 1 kHz

5.11.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.8.3.3.

5.11.3.3 Select the appropriate speaker load resistor which matches the DUT audio output impedance.

511.3.4 Increase the generator OUTPUT LEVEL control, if necessary, until the signal is just heard in the receiver.

5.11.3.5 Tune the DUT for peak response on the receiver S meter. Increase the OUTPUT LEVEL control for an S9 signal.

5.11.3.6 Tune the DUT for approximately 1 kHz audio output. Carefully adjust the DUT tuning control so that both lights above the FREQUENCY control should are out. **Disconnect the Test Speaker to eliminate the extra audio output load.** The DUT audio output should only have the load resistor and the Audio/Distortion Meter across it.

5.11.3.7 Slowly increase the DUT audio gain until the meter indicates the manufacturer's specified distortion. If unspecified, increase the audio gain for a distortion of 10%. (If the distortion is under 10% at maximum volume, be sure to note the maximum distortion level on the Data Sheet.)[3]

5.11.3.8 Change the Meter FUNCTION control to INP LEVEL. Adjust the INPUT RANGE as necessary (over range lights should be out.) Read the audio output voltage on the correct scale of the Distortion/Audio meter and record on the Data Sheet.

5.11.3.9 Calculate the audio power using the following equation:

$P_{audio} = V^2/8$ Also, record THD% with 1 V_{rms} Audio Level.

If the manufacturer's specified load used for this test was other than 8 ohms, be sure to substitute the correct load impedance when calculating power output. Record on the Data Sheet.

5.12 AUDIO AND IF FREQUENCY RESPONSE TEST

5.12.1 The purpose of the Audio and IF Frequency Response Test is to measure the audio frequencies at which the receiver audio output drops by 6 dB from the peak signal response. The frequency response is then calculated by taking the difference between the upper and lower frequency.

5.12.2 Test hook-up (See Fig. 5-12)

> **NOTE**: If proceeding from the previous Audio Power Output Test, only the hook-up changes shown in the diagram are required. Proceed to step 5.12.3.

5.12.2.1 With all power switches in the OFF position and the transmitter function disabled to the fullest extent possible, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to 10 dB Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT AUDIO OUTPUT to Dist/Audio Meter INPUT	As Required to BNC	50-Ohm Coax
Oscilloscope Input Across Dist/Audio Meter	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

[3] If the manufacturer specifies audio power output at other than 10% THD, or other than an 8Ω load, test to specified conditions.

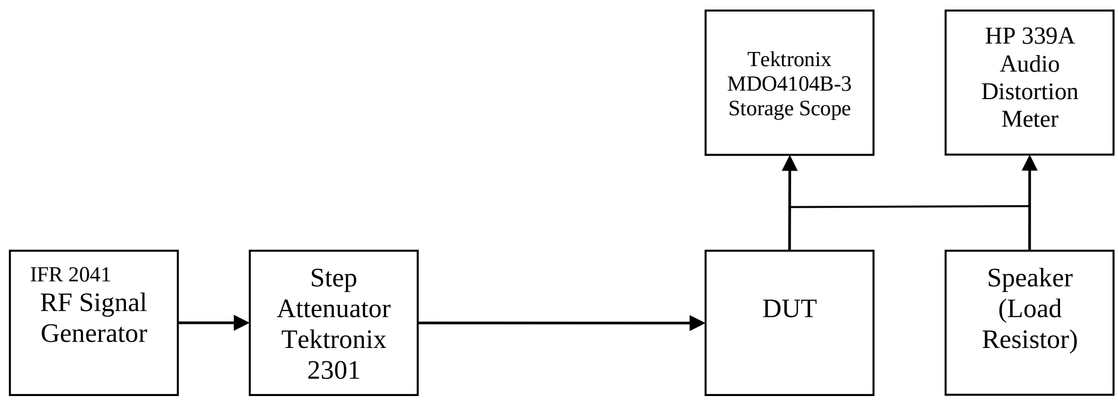


Figure 5-12: Audio and IF Frequency Response Test Hook-up

5.12.3 Test Procedure

5.12.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.200 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Widest Normal SSB
	AGC	OFF
Step Attn	Attenuator	0 dB
RF Generator	FREQUENCY	14.200 MHz
	OUTPUT LEVEL	–110 dBm
	RF	ON
	AM	OFF
	FM	OFF
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.12.3.2 Set the DUT, Signal Generator and Audio Distortion Meter and Frequency Counter power switches to ON. Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.12.3.3.

5.12.3.3 Set the RF generator to 14.200 MHz. Tune the DUT receiver to the Generator frequency. Rotate the generator OUTPUT LEVEL control to a point where the S meter on the DUT just before it starts to move. Turn off the AGC.

5.12.3.4 Adjust the INPUT RANGE control as required to maintain approximately a mid-scale meter indication while carefully tuning the Generator for peak signal response on the meter.

NOTE: Set the Generator to 20 dB above the MDS level if the AGC cannot be disabled.

5.12.3.6 Record the IF filter bandwidth in 5.12.3.6 of the data sheet. Set the RELATIVE ADJUST for a –1 dB indication on the meter. Tune the Generator downward in frequency until the meter indicates –7 dB. Adjust the oscilloscope for amplitude and frequency to show several sine waves. Using the *measure* function on the oscilloscope, the frequency of the waveform is displayed. Record Frequency indication in 5.12.3.6 of the Data Sheet. Return the Generator output to its initial level and the DUT to the peak response frequency. The meter should again indicate –1 dB.

5.12.3.7 Tune the Generator upward in frequency until the meter indicates –7 dB. Adjust the oscilloscope for amplitude and frequency to show several sine waves. Using the *measure* function on the oscilloscope, the frequency of the waveform is displayed. Record the Frequency indication in 5.12.3.7 of the Data Sheet. Return the Generator output to its initial level and the DUT to the peak response frequency. The meter should again indicate –1 dB. Subtract the lower –6 dB Frequency indication from the upper and record this difference in the space provided.

5.12.3.8 Tune the generator for peak response and repeat paragraphs 5.12.3.6 to 5.12.3.7 for all remaining DSP, SSB and CW IF filters and IF filter combinations.

AM Audio Frequency Response

5.12.3.9 Connect the output of the HP-8116A Function Generator to the EXT MOD INPUT of the RF Generator. Adjust the generators to provide an S8 to S9 signal with 80% modulation at approximately 1000 Hz.

5.12.3.10 Tune the DUT for peak audio response as indicated by the Audio Meter. Increase the modulation frequency until approximately a 6 dB drop is observed. Again, tune the DUT for peak audio response. Record the IF filter bandwidth in 5.12.3.10 of the data sheet. Record the modulation frequency that produces peak meter response in 5.12.3.10 of the Data Sheet.

5.12.3.11 Adjust the modulation frequency for peak response. Set the RELATIVE ADJUST for a –1 dB indication on the meter. Reduce the modulation frequency until the meter indicates –7 dB. Record the modulation frequency in 5.12.3.10 of the Data Sheet. Return the modulation to its initial frequency and the meter should again indicate –1 dB.

5.12.3.12 Increase the modulation frequency until the meter indicates –7 dB. Record the modulation frequency in 5.12.3.10 of the Data Sheet. Return the modulation to its initial frequency. The meter should again indicate –1 dB. Subtract the lower –6 dB frequency indication from the upper and record this difference in the space provided. The actual AM Filter Bandwidth is equal to twice the this difference

5.12.3.13 Repeat paragraphs 5.12.3.10 to 5.12.3.12 for all remaining AM filters.

5.13 SQUELCH SENSITIVITY TEST

5.13.1 The purpose of the Squelch Sensitivity Test is to determine the level of the input signal required to break the squelch at the threshold point . This test is performed for both FM and SSB.

5.13.2 Test hook-up (See Fig. 5-13)

> **NOTE**: If proceeding from the previous Audio & IF Frequency Response Test, no hook-up changes except removal of the oscilloscope is required. Proceed to step 5.13.3.

5.13.2.1 With all power switches in the OFF position and the transmitter disabled, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to 10-dB Step Attn INPUT	BNC to BNC	50-Ohm Coax
Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio OUTPUT to Dist/Audio Meter IN	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

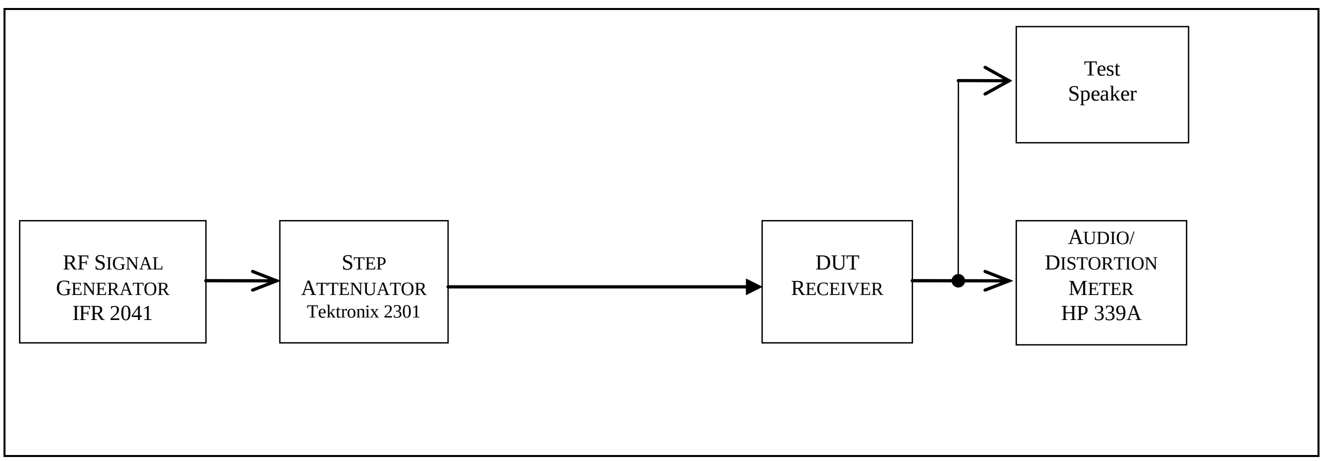


Fig. 5-13 — FM Squelch Sensitivity Test Hook-up

5.13.3 Test Procedure

5.13.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	FM
	Band Selector	10 Meters
	Frequency	29.000 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Suitable for FM
	AGC	OFF
	Preamp	ON
	Any Audio Filter	Disabled

10-dB Step Attn	Attenuator	0 dB
RF Generator	FREQUENCY TUNE	29.000 MHz
	OUT LEVEL	–110 dBm
	AM	OFF
	FM	INT
	DEVIATION	3 kHz
	MODULATION FREQ	1000 Hz
	RF	ON
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.13.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.13.3.3.

5.13.3.3 Increase the Generator OUTPUT LEVEL control, if necessary, until the signal is just heard in the receiver. Adjust the INPUT RANGE control as required to maintain approximately a mid-scale meter indication while carefully tuning the receiver for minimum distortion (FM) or peak signal response (SSB) as appropriate.

5.13.3.4 Set the RF Generator RF switch to OFF. Carefully adjust the squelch control on the DUT to just past the threshold point, closing the receiver. Set the RF switch back to ON. *Slowly* increase the Generator output to a level that holds the receiver open continuously without dropping out. (Use the step attenuator controls as necessary to obtain the threshold point.) Note the attenuator settings and generator output. Calculate the level of the input signal to the DUT and record on the Data Sheet. Return the step attenuators to their initial settings.

5.13.3.5 Repeat paragraphs 5.13.3.3 to 5.13.3.4 for the following frequency bands, as appropriate to the DUT: 52 MHz, 146 MHz and 440 MHz.

5.13.3.7 Return the attenuator controls to their initial settings. Set the generator for 14.200 and the FM switch to OFF. Set the DUT for USB at 14.200 MHz. Repeat paragraphs 5.13.3.4 through 5.13.3.4, if squelch is available for USB, EXCEPT this time, set the Generator OUTPUT LEVEL to a point where the squelch opens momentarily and closes again. Calculate the level of the input signal and record on the Data Sheet.
(**Note: AGC may have to be enabled**)

5.14 S METER TEST

5.14.1 The purpose of the S Meter Test is to determine the level of RF input signal required to produce an S9 indication on the receiver S Meter. This test is performed with the DUT in the CW mode at frequencies of 1.020, 14.020, 52.020, 146.020 and 440.020 MHz as appropriate for the DUT. An S9+20 dB signal is also used to check for significant S Meter deviation. The IF filter is set for the closest bandwidth to 500 Hz.

5.14.2 Test hook-up (See Fig. 5-14)

> **NOTE**: If proceeding from the previous Squelch Sensitivity Test, no hook-up changes are required. Proceed to step 5.14.3.

5.14.2.1 With all power switches in the OFF position and the transmitter disabled, connect the following:

Connection	Connectors	Cable Type
Signal Gen OUTPUT to Step Attn INPUT	BNC to BNC	50-Ohm Coax

Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter Input	As Required to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

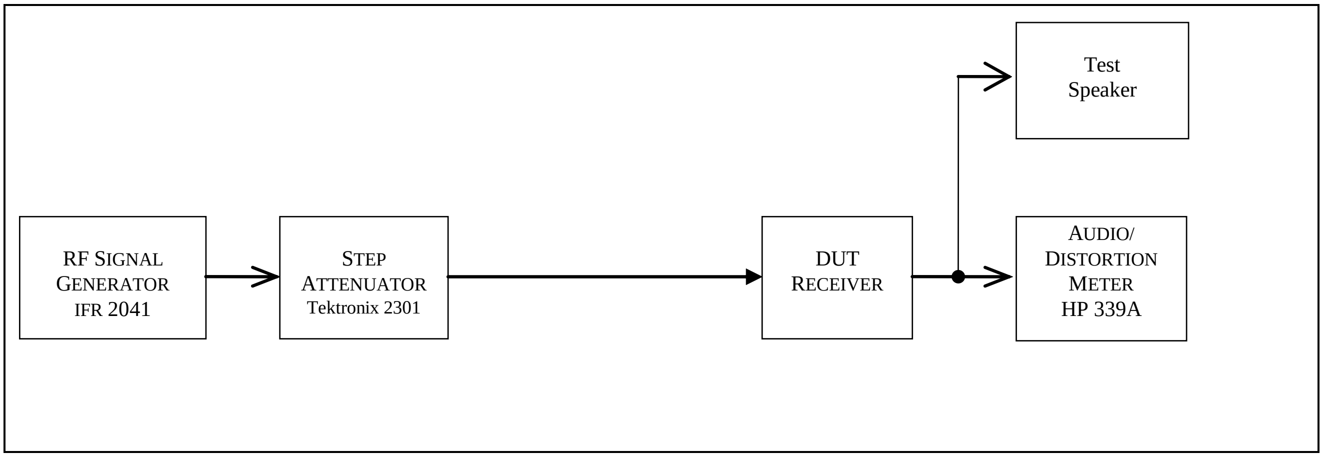


Fig. 5-14 — S-meter Test Hook-up

5.14.3 Test Procedure

5.14.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	SSB
	Band Selector	20 Meters
	Frequency	14.200 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	Closest to 500 Hz
	AGC	ON
	Preamp	OFF
Step Attn	Attenuator	0 dB
RF Generator	FREQUENCY TUNE	14.200 MHz
	OUT LEVEL	–100 dBm
	RF	ON
	AM	OFF
	FM	OFF
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All OFF (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.14.3.2 Receiver hiss should be heard. Adjust the volume to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.14.3.3.

5.14.3.3 Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver. Adjust the INPUT RANGE control as required to maintain approximately a mid-scale meter indication while carefully tuning the receiver for peak signal response.

5. 14.3.4 Increase the Generator OUTPUT LEVEL control for approximately an S9 indication. Adjust the DUT tuning control for maximum S Meter indication, then set the Generator output for an exact indication of S9. Rock the DUT tuning control back-and-forth to ensure the S Meter is still peaked on the signal. Note the Generator output and attenuator settings and record the input signal level in microvolts to the DUT in the 5.14.3.4 of the Data Sheet.

5.14.3.5 Increase the Generator output for an S9+20 dB S Meter indication. Check the appropriate box in 5.14.3.5 if an approximately 20 dB increase in generator output was required. If not, record levels and settings as in step 5.14.3.4.

5.14.3.6 Repeat steps 5.14.3.4 through 5.14.3.5 with DUT preamp on.

5.14.3.7 Return DUT preamp to off and repeat steps 5.14.3.3 to 5.14.3.6 for frequencies of 1.020, 52.020, 146.020 and 432.020 MHz.

5.15 IN-BAND IMD TEST

5.15.1 The purpose of the In-Band IMD Test is to measure the intermodulation-distortion (IMD) products present in the audio output of the receiver. *This test is typically performed on units that will undergo the expanded set of tests.* The receiver will be operated in the SSB mode at 14.200 MHz. Two input signals, spaced 200 Hz apart, are applied to the DUT and adjusted for equal output amplitude. (The audio tones are approximately 900 and 1100 Hz.) The input signals are adjusted for approximately a single tone n S-9 level and the audio output is observed on the Spectrum Analyzer. The tones are set for a 0 dB level for a single tone reference. (This is unlike the transmit two-tone test, where the -6 dB is used for a PEP reference level.) The AGC fast option is used for this test.

5.15.2 Test Hook-up (See FIGURE 5-15)

Note: If proceeding from the previous S-Meter Test, only the hook-up changes shown with a dotted line are required.

5.15.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and each Generator RF OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 Output to Hybrid Combiner Input 1	BNC to BNC	50-Ohm Coax
Signal Gen 2 Output to Hybrid Combiner Input 2	BNC to BNC	50-Ohm Coax
Hybrid Combiner Output to 10-dB Step Attn Input	BNC to BNC	50-Ohm Coax
10-dB Step Attn Output to 1-dB Step Attn IN	BNC to BNC	50-Ohm Coax
1-dB Step Attn Output to DUT RF Input	BNC to As Req.	50-Ohm Coax
8 Ohm Load / HI-Z Amp across DUT Audio Output	As Req.	As Required

DUT Audio Output to Audio Attn Pad Input	As Req. to BNC	50-Ohm Coax
Audio Attn Pad Output to Spectrum Analyzer Input	BNC to BNC	Coax
Power Source to DUT Power Input	As Req.	As Req.

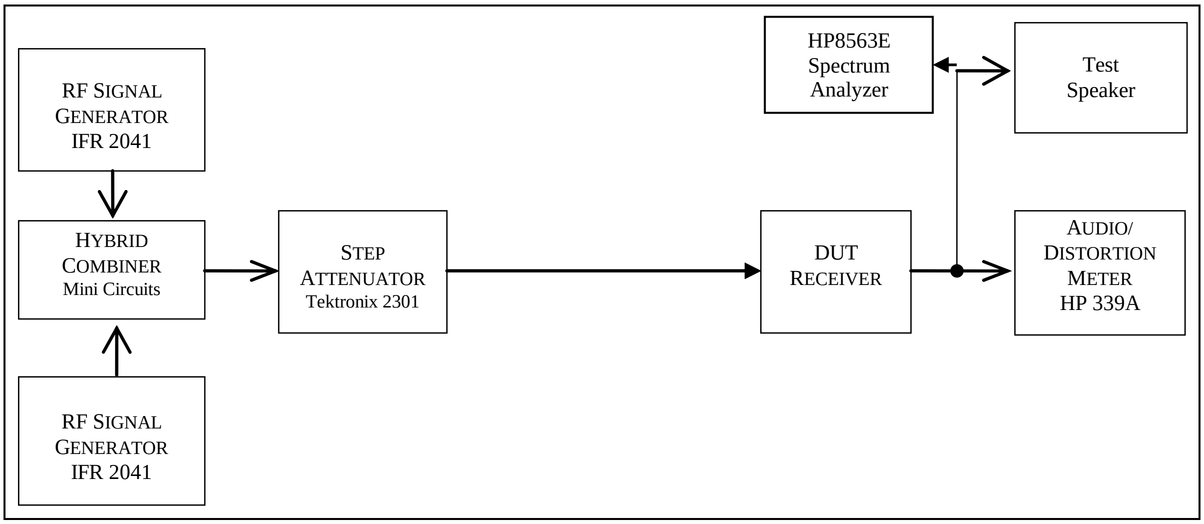


Figure 5-15 In-Band IMD Test Setup

5.15.3 Test Procedure

5.15.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.20000 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	SSB Widest Available
	Any Audio Filtering	Disabled
	AGC	Fastest Available
	AF Gain (Volume Control)	Minimum
Step Attn	Attenuator	0 dB
RF Generator #1	CARRIER FREQ	14.2009 MHz
	RF LEVEL	–63 dBm
	CARRIER ON-OFF	ON
	AM	OFF
	FM	OFF
	NOISE MODE (UTIL)	LOW NOISE
RF Generator #2	CARRIER FREQ	14.2011 MHz
	RF LEVEL	–63 dBm
	CARRIER ON-OFF	ON
	AM	OFF

	FM	OFF
	NOISE MODE (UTIL)	LOW NOISE

Instrument	Control	Position
Spectrum Analyzer	START FREQ - STOP FREQ	0 - 2 kHz
	REF LEV (AMPLITUDE)	–10 dBm
	ATTEN (AMPLITUDE)	20 dB
	RES (BW)	10 Hz
	VIDEO BW (BW)	10 kHz
	THRESHOLD (DISPLAY)	-80 dBm
	SWP TIME (SWEEP)	AUTO (1.3 s)

CAUTION: The input to the spectrum analyzer at no time should be greater than +10 dBm (0.707 Vrms). Damage to this instrument will occur at an input level of +30 dBm (7.07 Vrms) or greater. It is recommended to monitor the audio on the analyzer display at all times during this test - especially when increasing the AF Gain Control or decreasing the variable attenuators.[1]

5.15.3.2 Slowly increase the AF Gain control of the DUT. Receiver hiss should be heard. Adjust the volume to the desired level. Be careful not to exceed the -10 dBm reference limit on the analyzer display. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.15.3.3.

5.15.3.3 Tune the DUT for peak response as indicated by the receiver's S-Meter. Adjust #1 Generator RF LEVEL control, if necessary, for an S-9 indication. Set the #2 Generator RF switch to ON and set for the same output level as Generator #1. Both pips should now be clearly visible on the Spectrum analyzer display

5.15.3.4 Adjust the DUT Tuning control, if necessary, for the two tones to be centered on the spectrum analyzer display. The scan rate may be increased temporarily by adjusting the SWP TIME (SWEEP) control. (NOTE: Analyzer calibration is lost once the scan rate is increased beyond the point MEAS UNCAL appears on the screen.) Adjust the attenuators and DUT AF Gain control for an approximate indication of -10 dBm (top reference line) on the spectrum analyzer.

5.15.3.5 If necessary, slow the scan rate down to a point where the analyzer is again in calibration. Carefully adjust the #2 RF Generator RF LEVEL control for the second pip to be equal to the first pip. Adjust the DUT audio output so that both pips are now at the -10 dBm reference (top) line of the spectrum analyzer display. Re-adjust, if necessary, the #2 RF Generator RF LEVEL Control if the two tones are no longer equal in amplitude.

5.15.3.6 Take a single sweep by depressing the SGL SWEEP (SWEEP) button. Plot and save to an appropriately named file.

5.15.3.7 Repeat if desired for any other AGC options as deemed appropriate by the Test Engineer.

5.16 NOTCH FILTER TEST

5.16.1 The purpose of the Notch Filter Test is to determine the notch depth of any and all applicable receiver filters. Two 20–meter input signals, spaced 1200 Hz apart, are applied to the DUT and adjusted for equal output amplitudes. The receiver notch filter is then set to null the undesired upper audio tone. The lower audio tone is adjusted to provide a 0–dB reference on the spectrum analyzer display. The depth of the notch filter is then

[1] "Woe be unto he who breaks this thing." ---- Edward F. Hare, W1RFI

determined by comparing the difference in levels between the two tones. Similar tests are performed with receivers having DSP auto-notch capabilities. In addition, the time to notch, or notch attack time will also be measured for DSP units. Some receivers have an “Auto Notch” feature when in USB or LSB mode.

5.16.2 Test Hook-up (See FIGURE 5-16) Note: If proceeding from the previous In-Band IMD Test, only the hook-up changes shown with a dotted line are required.

5.16.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and each Generator RF OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen 1 Out to Hybrid Combiner IN 1	BNC to BNC	50-Ohm Coax
Signal Gen 2 Out to Hybrid Combiner In 2	BNC to BNC	50-Ohm Coax
Hybrid Combiner Output to Step Attn Input	BNC to BNC	50-Ohm Coax
Step Attn Output to DUT RF Input	BNC to As Req.	50-Ohm Coax
DUT Audio Output to Dist/Audio Meter IN	As Req. to BNC	50-Ohm Coax
Test Speaker Across Dist/Audio Meter Input	As Req.	As Req.
20 dB Audio Pad (Attn) Output to Signal Analyzer Input	BNC to BNC	Coax

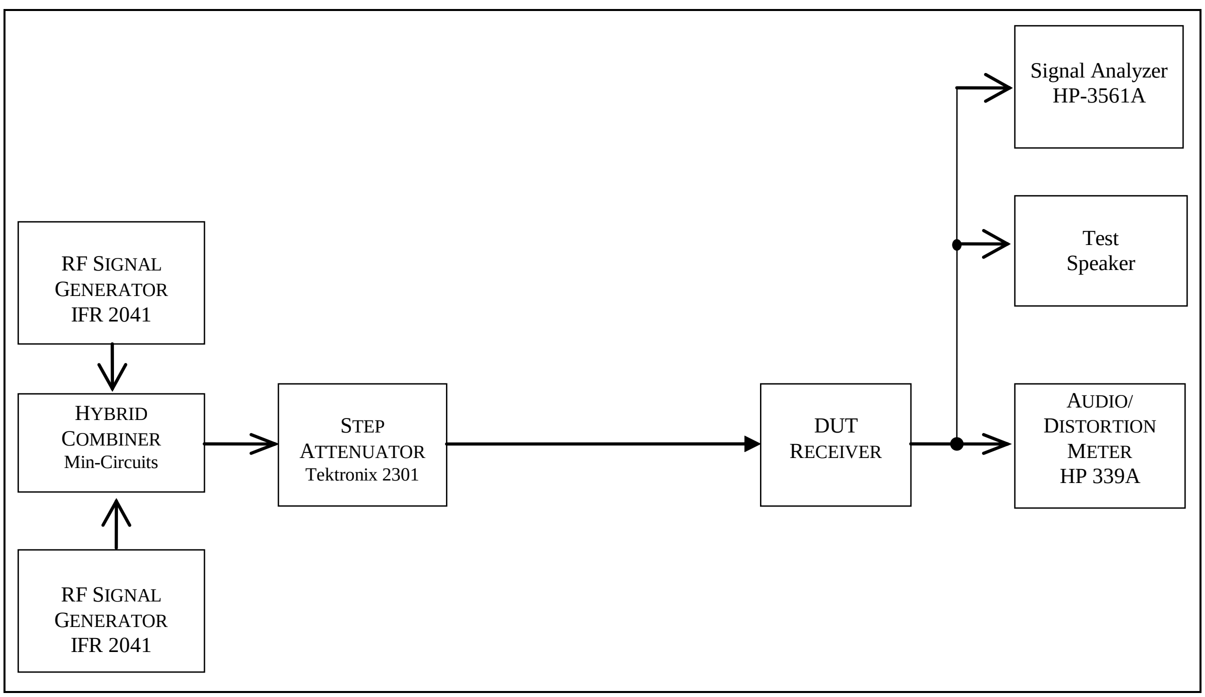


Figure 5-16 Notch Filter Test Hook-Up

5.16.3 Test Procedure

5.16.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB

	Band Selector	20 Meters
	Frequency	14.200 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	SSB Widest Available
	Any Audio Filtering	Disabled
	AGC	OFF (if available) or Fast
	Notch Filter	OFF
	AF Gain (Volume Control)	Minimum
Step Attn	Attenuator	0 dB
RF Generator #1	CARRIER FREQ	14.2000 MHz
	RF LEVEL	–80 dBm
	CARRIER ON-OFF	ON
	AM	OFF
	FM	OFF
	NOISE MODE (UTIL)	LOW NOISE
RF Generator #2	CARRIER FREQ	14.2012 MHz
	RF LEVEL	–80 dBm
	CARRIER ON-OFF	ON
	AM	OFF
	FM	OFF
	NOISE MODE (UTIL)	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM
Signal Analyzer	CENTER FREQUENCY	600 Hz
	RANGE	10 dBv
	VERTICAL SCALE	-10 dBv
	SPAN	100 Hz
	PEAK TRACK	ON

5.16.3.2 Slowly increase the AF Gain control of the DUT. Receiver hiss should be heard. Adjust the volume to the desired level. Be careful not to exceed the –10 dBm reference limit on the analyzer display. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.16.3.3.

5.16.3.3 Adjust the #1 Generator RF LEVEL control until the signal is just heard in the receiver. Adjust the INPUT RANGE and receiver controls as required to maintain approximately a mid-scale meter indication while carefully tuning the receiver for peak signal response on the audio level meter.

5.16.3.4 Set the #2 Generator RF switch to OFF. Peak the DUT tuning control for maximum response as indicated by the audio level meter.

5.16.3.5A If the DUT AGC is OFF, adjust the #1 RF generator for a level approximately 10 dB below the 1-dB compression point. Recheck the receiver tuning for peak response on the Distortion Meter. The audio output frequency should be approximately 500 to 1,000 Hz. If necessary, adjust the receiver tuning to bring the output audio into this range while maintaining a peak response on the meter as best as is possible.

5.16.3.5B If the DUT AGC is set to Fast, increase the #1 RF generator for approximately an S-9 indication on the DUT S-Meter. (The input signal to the DUT should be approximately 50 μV.) Recheck the receiver tuning for peak response on the Distortion Meter. The audio output frequency should be approximately 500 to 1,000 Hz. Adjust, if necessary, the receiver tuning to bring the output audio into this range while maintaining a peak response on the meter as best as is possible.

5.16.3.6 Adjust the Distortion Analyzer INPUT LEVEL and RELATIVE ADJUST Controls for a meter reading of –1 dB. Turn on the notch filter and observe any change in the meter indication. Adjust the notch filter for the minimum meter reading *change* between Notch Filter On and Off. Record the difference between the –1 dB reference and the meter reading in 5.16.3.6 of the Data Sheet. Return the notch filter adjustment to its upper or lower limit.

5.16.3.7 Observe the receiver's output audio on the spectrum analyzer. The scan rate may be increased temporarily by adjusting the SWP TIME (SWEEP) control. (NOTE: The analyzer will not be in calibration if the scan rate is increased beyond the point MEAS UNCAL appears on the display.) Adjust the attenuators and DUT AF Gain control for an indication of –10 dB on the spectrum analyzer.

5.16.3.8 Set the #2 RF Generator RF switch to ON. A second tone that is 1,200 Hz greater in pitch should be heard in the receiver output. Adjust the Signal Analyzer CENTER FREQ (FREQUENCY) Control for this second tone to appear right on the display vertical centerline. Adjust the #2 RF Generator RF LEVEL Control for the second pip to be equal to the first pip. (The first pip should now be visible just over two divisions to the left of the display centerline.)

5.16.3.9 If necessary, slow the scan rate down to a point where the analyzer is again in calibration. Adjust the signal analyzer input step attenuator for the two pips to be at the –10 dBm reference (top) line of the spectrum analyzer display. Re-adjust, if necessary, the #2 RF Generator RF LEVEL Control if the two tones are no longer equal in amplitude.

5.16.3.10 Set the #1 RF Generator RF switch to OFF. Adjust the notch filter for the best null of the remaining higher pitched tone. Both the ear and the spectrum analyzer display may be used to determine the point of best null. The scan rate may again be temporarily increased to facilitate this adjustment. Be sure to slow it down so that the display is once again calibrated before proceeding to the next step.

5.16.3.11 Set the #1 Signal Generator RF Switch to ON. Adjust, if necessary, the Step Attenuators and DUT AF GAIN Control for the #1 Generator tone for the -10 dBm reference on the display. The notched #2 Generator tone should now be on the vertical centerline. The notch depth may now be read directly on the display. A single sweep may now be taken to facilitate this measurement by depressing the SGL SWEEP Button. Record in 5.16.3.11 of the Data Sheet.

5.16.3.12 Repeat for all other available DSP, IF and AF notch filters and notch filter combinations. Also try the following combinations:

2 tones (S9 each), AGC on, manual notch	2 tones (S9 + S1), AGC on, manual notch
1 tone, AGC on, manual notch	1 tone, AGC off, manual notch
1 tone, AGC on, auto notch	1 tone, AGC off, auto notch

Note changes in tone level and noise level. Also note changes in S-meter for AGC on tests.

Auto-Notch Attack Time: Proceed only if DUT has DSP Auto-Notch Feature

5.16.3.13 With all power switches in the OFF position and the transceiver in the receive mode, connect the following:

Connection	Connectors	Cable Type

Signal Gen Output to 10-dB step INPUT	Type N to BNC	50-Ohm coax
10-dB step Attn OUT to 1-dB step IN	BNC to BNC	50-Ohm coax
1-dB step Attn IN to DUT RF Input	BNC to Type N	50-Ohm coax
Signal Gen Output to Scope CH1 INPUT	BNC clip to BNC	50-Ohm coax
DUT Audio Output to Scope CH2 INPUT	As Required to BNC	50-Ohm coax
DUT Audio Output to 8 Ohm Load	As Required to BNC	50-Ohm coax

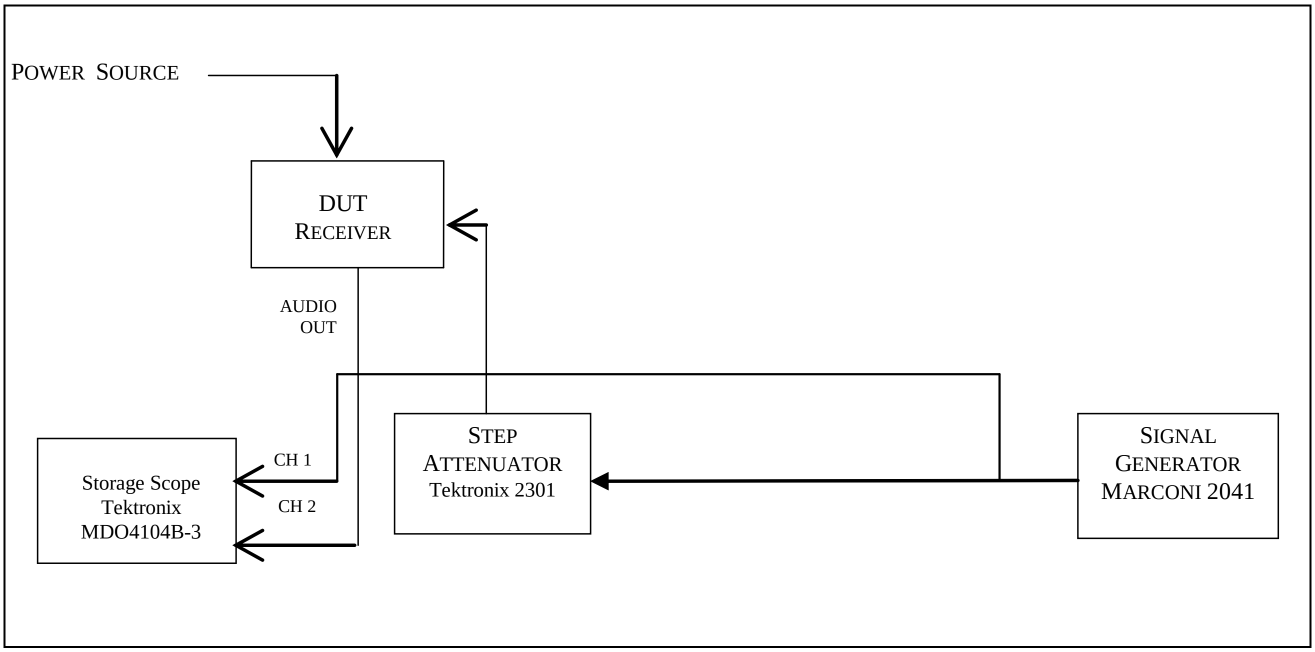


Fig. 5-16A — Notch Attack Time Test Hook-up

5.16.3.14 Turn the DUT and test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.200 MHz
	XMIT/RCV	Receive
	DRIVE or RF LEVEL	Minimum
	AGC	OFF

Instrument	Control	Position
RF Generator	FREQUENCY TUNE	14.200 MHz
	OUT LEVEL	–63 dBm
	RF	ON
	AM	OFF
	FM	OFF
Step Attn	Attenuator	0 dB

Oscilloscope	CH1 VOLTS/DIV	0.5 V
	CH1 Coupling	DC
	CH1 Position	As Needed
	CH2 VOLTS/DIV	1 V
	CH2 Coupling	DC
	CH2 Position	As Needed
	TIME/DIV	5 ms
	TRIG MODE	AUTO
	Trigger Coupling	DC
	Trigger Source	CH1
	Trigger Level	as required

5.16.3.15 Set the Signal Generator RF to ON. Tune the DUT for peak response. Set the DUT AF Gain control for comfortable listening level and adjust CH1 and CH2 VOLTS/DIV for suitable display similar to Figure 5.16B. Set the Signal Generator RF to OFF.

5.16.3.16 Place the oscilloscope into the single sweep storage mode and clear the display. Key the Signal Generator by pressing the RF to button to ON. Repeat and adjust the trigger level until a single sweep occurs every time the generator is keyed.

5.16.3.17 Measure the time delay for from the point the signal appears until it is notched by at least 50%. The oscilloscope sweep rate may be adjusted as required to facilitate this measurement. Make several sweeps and compare results. Record on data sheet.

5.17 DSP NOISE REDUCTION TEST

5.17.1 The purpose of this test is to determine the level of noise reduction possible with receivers equipped with DSP Noise Reduction. An uninterrupted un-modulated CW will be mixed with noise and fed to the DUT RF input. The audio output will be observed on a signal analyzer. Noise level comparisons will be made with the DSP Noise Reduction on and off..

5.17.2 Test Hook-up (See FIGURE 5.17)

Note: If proceeding from the previous test, only the hook-up changes shown with a dotted line are required.

5.17.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and each Generator RF OFF, connect the following:

Connection	Connectors	Cable Type
Signal Gen Output to Hybrid Combiner INPUT	BNC to BNC	50-Ohm Coax
Elecraft Noise Gen Output to 10-dB Step Attn Input	BNC to BNC	50-Ohm Coax
Step Attn Output to Hybrid Combiner Input	BNC to As Req.	50 Ohm Coax
Hybrid Combiner Output to DUT RF Input	BNC to As Req.	50 Ohm Coax

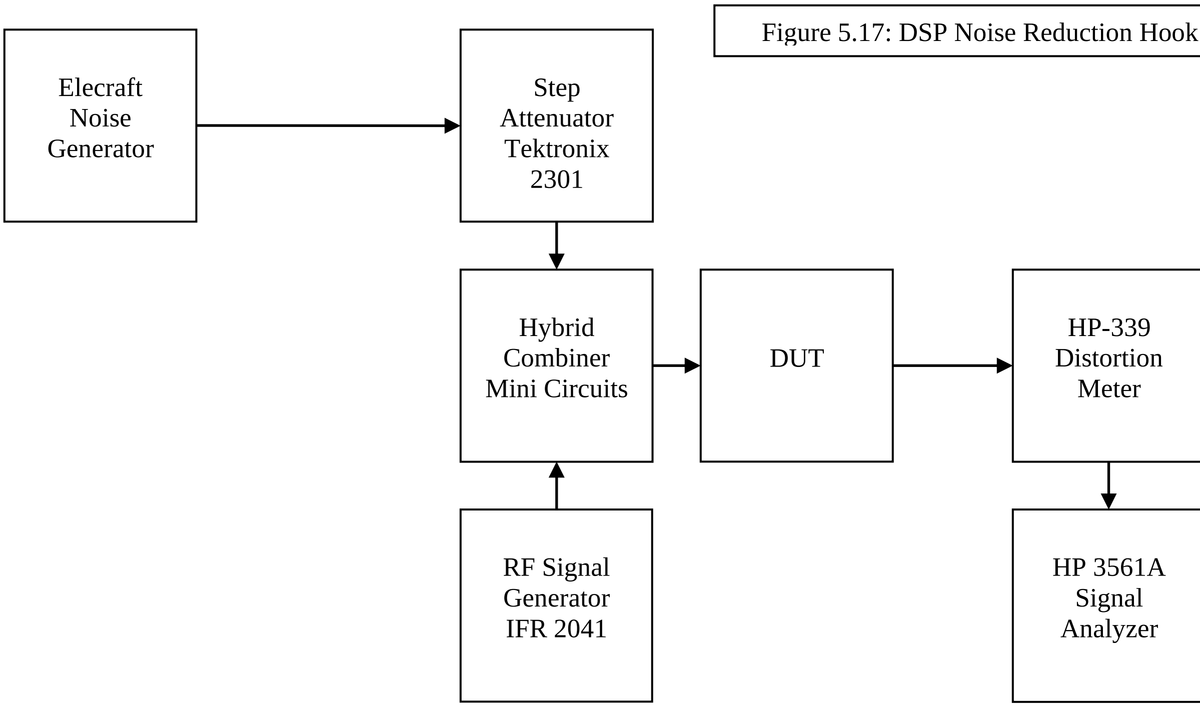


Figure 5.17: DSP Noise Reduction Hook-up

Connections	Cable Type	Connectors
Test Speaker Across DUT Audio OUT	As Req.	As Req.
Audio Output to Signal Analyzer Input	BNC to BNC	Coax
Power Source to DUT Power Input	As Req.	As Req.

5.17.3 Test Procedure

5.17.3.1 Turn the DUT and all test equipment power switches to ON. Set the following controls:

Instrument	Control	Position
DUT	Mode	USB
	Band Selector	20 Meters
	Frequency	14.200 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	SSB Widest Available
	Any Audio Filtering	Disabled
	AGC	OFF
	AF Gain (Volume Control)	Minimum
Step Attn	Attenuator	0 dB
	RF LEVEL	–63 dBm
	CARRIER ON-OFF	OFF

	AM	OFF
	FM	OFF
	NOISE MODE (UTIL)	LOW NOISE
Signal Analyzer	CENTER FREQUENCY	600 Hz
	RANGE	10 dBv
	VERTICAL SCALE	-10 dBv
	SPAN	100 Hz
	PEAK TRACK ON	

5.17.3.2 Slowly increase the AF Gain control of the DUT. Receiver hiss should be heard. Adjust the volume to the desired level. Be careful not to exceed the –10 dBm reference limit on the analyzer display. Allow all equipment at least 10 minutes warm-up time before proceeding to step 6.2.3.3.

5.17.3.3 Increase the Generator RF LEVEL control until the signal is just heard in the receiver. Adjust the INPUT RANGE and receiver controls as required to maintain approximately a midscale meter indication while carefully tuning the receiver for peak signal response on the Audio meter.

5.17.3.4 Increase the RF generator output for approximately an S-9 indication on the DUT S-Meter. (The input signal to the DUT should be approximately 50 μV.) Recheck the receiver tuning for peak response on the Distortion Meter. Turn on the Noise Source and adjust for approximately a 3 dB increase as indicated by the meter.

5.17.3.5 Adjust the Distortion Analyzer INPUT LEVEL and RELATIVE ADJUST Controls for a meter reading of –6 dB. Turn on the DSP Noise Reduction and observe any change in the meter indication. Adjust the Noise Reduction for best results as determined by ear and note the meter indication. Record the best case increase or decrease in 6.2.3.5 of the Data Sheet.

5.17.3.6 Vary the signal level, noise level and DSP Noise Reduction Level for the best case. Record results on data sheet.

5.17.3.7 Turn off the DSP Noise Reduction and Noise Source. Observe the receiver's output audio on the signal analyzer. Adjust the DUT AF Gain control for an indication of –10 dB (top line) on the signal analyzer.

5.17.3.8 Set the DSP Noise Reduction to ON. Observe any change in the tone as shown by the signal analyzer. Readjust, if necessary the decrease in the DUT AF Gain Control for the –10 dB reference on the signal analyzer. Turn on the Noise Source and adjust so that the noise floor is 20 dB below the single tone reference. Readjust the AF Gain control if necessary for the –10 dB reference.

5.18 Noise Figure & Equivalent Rectangular Bandwidth

This is an automated test procedure.

Hook-up:

Audio Output to HP3561 Input
Signal Generator set to 14.020 MHz
Set level to –107 dBm

Turn on HP-3551

CVI File, open, project
Up folder
FFT plot
ffplot.prg
load (green arrow)
Set Analyzer to one minute sweep
Single sweep

On the computer, pick points where the edges and the tops meet. Ex: 350 and 845 Hz.
Calculate EqivRBW button (502 HZ)

5.19 Noise Figure Calculation:

Theory:
Resistor noise is -174 dBm/Hz at room temperature
500 Hz is 27 dB away from 1 Hz
Thus, an ideal receiver's noise figure would be:
-174 dBm/Hz + 27 dB = -147 dBm

Noise Figure of the receiver = 147 dBm – dBm of MDS at 20M
Ex: MDS at 20 meters, preamp off = -129.5 dBm
NF = 147 – 129.5 dBm = 17.5 dB

Calculate the Noise Figure for Preamp off, P1 and P2 if available

VI. NON-STANDARD AND SPECIAL PURPOSE TESTS

Chapter 6 contains five non-standard and special purpose tests. These include tests for mobile radios, 9600 baud packet and obsolete tests dropped from the standard test list.

6.1 LOW VOLTAGE AND TEMPERATURE CHAMBER TEST

6.1.1 The purpose of the Low Voltage and Temperature Chamber Test is to determine the functionality of the mobile type DUT Transceivers at low voltage and its specified temperature limits. The temperatures and voltage used for this test are intended to simulate worst case mobile conditions within the manufacturer's specified limits. Three parameters are checked at each test point, receiver sensitivity, transmit frequency accuracy and RF power output.

6.1.2 Test hook-up (See Fig. 6-1)

6.1.2.1 With all test equipment and DUT power switches in the OFF position and the transceiver in the receive mode, set the DUT in the temperature chamber. Connect the following cables to the DUT and route them through the cable port to the specified termination at the opposite end:

Connection	Connectors	Cable Type
DUT RF OUTPUT to Wattmeter INPUT	As Required to Type N	50-Ohm Coax
Wattmeter OUTPUT to RF Power Attn	Type N to Type N	50-Ohm Coax
RF-Power Attenuator Output to Step Attenuator Input	BNC to BNC	50-Ohm Coax
Step Attenuator Output to Frequency Counter Input	BNC to BNC	50-Ohm Coax
Telegraph Key to DUT KEY INPUT	As Required	As Required
DUT AUDIO OUTPUT to Dist/Audio Meter Input	As Required	Double Banana
8-Ohm Load /HI-Z Amp Across Dist/Audio Meter Input	As Required	As Required
DC Power Only	As Required	As Required
1)	Variable DC Power supply to AC source.	
2)	Set power supply to specified voltage and connect to DUT.	

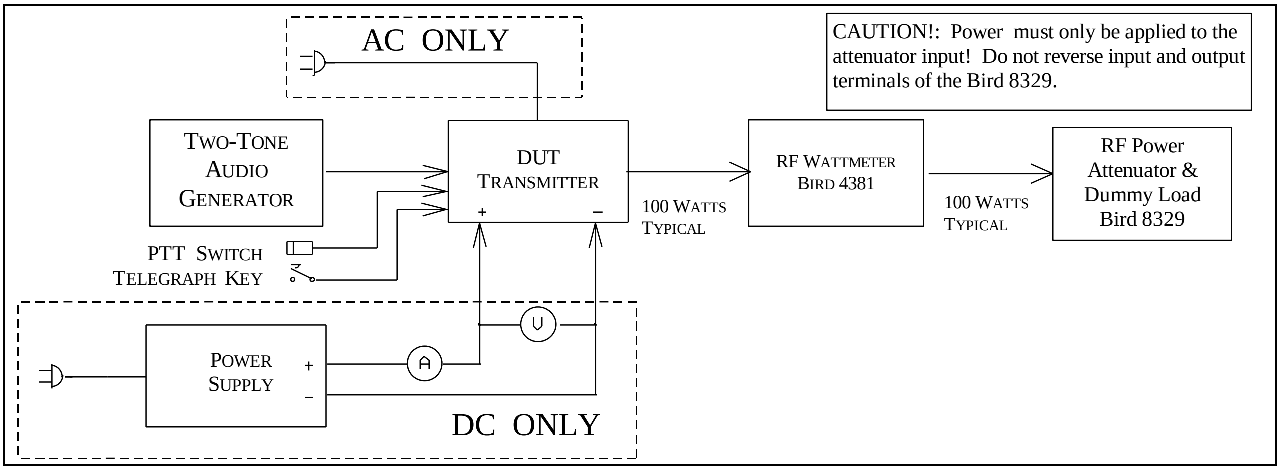


Fig. 6-1 — Chamber Test Hook-up

6.1.3 Test Procedure

6.1.3.1 Turn the DUT and RF wattmeter power switches to ON and set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	20 Meters
	Frequency	14.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	OFF
	Preamplifier	OFF
RF Generator	CARRIER FREQ	14.020 MHz
	RF LEVEL	–110 dBm
	CARR ON-OFF	ON
	AM	Off
	FM	Off
	NOISE MODE	LOW NOISE
RF Wattmeter	Push Button mode select	FWD CW
	Element	As Required
	Forward Element Range	As Required
Step Attn	Attenuator	10 dB
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

6.1.3.2 Receiver hiss should be heard; adjust volume to desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 6.1.3.3

6.1.3.3 Tune the DUT per the DUT operator's manual. Put the DUT in the CW mode Depress telegraph key. Observe that some minimum level of RF power is shown by the DUT Po Meter and Bird Wattmeter. Increase the RF DRIVE/LEVEL control if necessary to the maximum rated power.

6.1.3.4 Adjust the step attenuators for an indication on the Frequency Counter. Record both the power output and the frequency counter indication in 6.1.3.4 of the Data Sheet.

6.1.3.5 Remove the DUT RF Cable from the Power Wattmeter and connect to the Signal Generator Output. Perform an MDS Test and record results on Data Sheet.

6.1.3.5 Reduce the Power Supply voltage to 11.5 V dc. Repeat steps 6.1.3.4 and 6.1.3.5 at this reduced voltage. Return the power supply to voltage to initial setting.

6.1.3.6 Record initial chamber / ambient room temperature. Set chamber for minimum specified temperature. (NOTE: If temperature is not specified, use -10 C.) Once the chamber reaches minimum temperature, let DUT reach thermal equilibrium for at least 1 hour. Repeat steps 6.1.3.4 and 6.1.3.5. Temporarily open chamber and check functionality of several randomly selected main DUT controls.

6.1.3.7 Set chamber for maximum specified temperature. (NOTE: If temperature is not specified, use +60 C.) Once the chamber reaches maximum temperature, let DUT reach thermal equilibrium for at least 1 hour. Repeat the steps of 6.1.3.4 and 6.1.3.5. Temporarily open chamber and check functionality of several randomly selected main DUT controls.

6.1.3.8 Set chamber for initial recorded ambient temperature. Once the chamber reaches initial temperature, let DUT reach thermal equilibrium for at least 1 hour. Repeat steps 6.1.3.4 and 6.1.3.5. Open chamber and check functionality of several randomly selected main DUT controls.

6.1.3.9 Record on data sheet any significant problems or lack of functionality during any of the test points.

6.2 Power Meter Test

6.2.1 The purpose of the power meter test is to measure power output developed by a RF transmitter by the DUT. This measurement directly compared to the HP 432B power meter and the table provided in Appendix XX.X. This table takes into account losses of attenuators and coax cables between the DUT and the HP power meter. Measurements will be recorded on Data Sheet X.XX. Also included are measurements of SWR compared against a known 1:1 and 2:1 load.

Two special RG-8 cables must be used. The dB loss of each cable has been previously measured on the frequencies used during this test. They are labeled with green tags as "Coax 1" and "Coax 2".

An RF linear amplifier must be used along with a transceiver capable of more than 100 watts (105 -110 watts) at the frequencies used must also be located. Inspect the data sheets of each DUT to determine if 6 meters or higher frequencies are needed for your choice of transceiver and linear amplifier. Also, use a linear amplifier that runs off of the 220 volt power receptacle in the screen room.

6.2.2 Test hook-up (See FIG. 6-1)

6.2.2.1 With all test equipment and DUT power switches in the off position and the transmitter in the receive mode, connect the following:

Connection	Connectors	Cable Type
HF/VHF transceiver to Linear Amplifier	PL-259 to PL-259	50 Ohm Coax
Linear Amplifier to DUT	PL-259 to PL-259	50 Ohm Coax
DUT to Bird 8329 30 dB Attenuator	PL-259 to Type N	“Coax 1”
Bird 8329 to HP 20 dB Attenuator	Type N to Type N	“Coax 2”
HP 20 dB Attenuator to Bird 10 dB Attenuator (for high power test)	Direct Connection	
HP or Bird Attenuator to HP 432B Power Meter	Direct Connection	
DC Power supply to DUT	As Required	
Two-Tone Generator to Microphone Jack	As Required	
Telegraph Key	As Required	
Keying Generator to Transceiver Key Jack	As Required	50 Ohm Coax
Keying connection from Transceiver to Linear Amplifier		

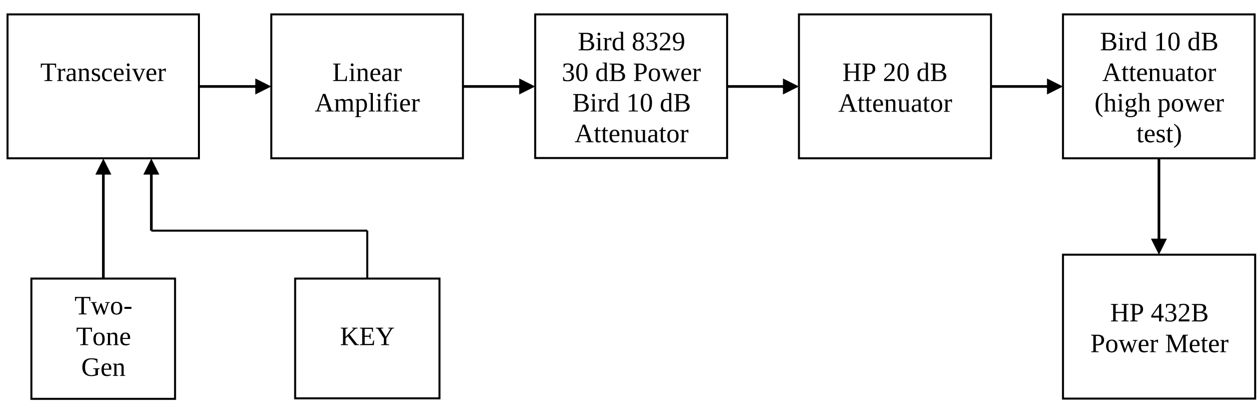


Figure 6.6: Power Meter Test Hook-up

6.2.3 Test Procedure

6.2.3.1 Turn on DUT, transceiver and power meter. Turn on DC supply for DUT. Leave the linear amplifier off until doing the high power tests.

6.2.3.2 Calibrate the HP 432B Power Meter. Make sure the frequency and calibration factor is correct for each individual test. Consult the power meter manual if needed.

Instrument	Control	Position
Transceiver	Power Output	Lowest Setting
	Frequency	1.995 MHz
	Antenna Port	As Required
	Mode	CW
	Mic Gain	Lowest Setting
Linear Amplifier	AC Power	Off
HP Power Meter	Frequency	.002 GHz
	Calibration Factor	See Table XX.X
	Zero	As Required
	dBm/mW	mW
DUT	RANGE	200 or "Mid"
	AVE/PEP	AVE.
	DC Power	ON
	HOLD	Mid Scale

6.2.3.3 Allow all equipment to warm up at least 10 minutes before proceeding to step 6.1.3.4

6.2.3.4 Tune the transceiver per the operator's manual. Put the transceiver in the CW transmit mode. Depress the telegraph key. Slowly turn up the power until a reading of XX.X mW is read on the power meter, equivalent to 100 watts at the DUT. If this reading cannot be attained, get to as close to XX.X as possible as possible. Note the difference, if any. Transmitting as long as necessary to get a steady reading on the HP power meter, at least 15 seconds. Let go of the telegraph key to turn off transmit mode.

6.2.3.5 Read DUT meter. Add or subtract power from this reading if an exact level could not be attained on the HP 432B power meter with step 6.1.3.4. Example:

HP 432B reads .925 mW but should read .930 mW. The DUT meter should be reading approximately 0.5 lower than it should be when applied 100 watts. Add a half of a watt for this example.
In reality, the difference should be multiplied by the percentage of power reaching the HP power meter, in this case, 0.5 watts X 0.930 = 0.465 watts. This may not make much difference on the 5 and 100 watt tests (especially with analog power meters), but does on the 1000 watt tests.

6.2.3.6 Remove telegraph key from the transceiver. Plug in Keying Generator. Adjust the keying generator for its highest speed. This gives the 50% duty cycle required. Turn generator on. Without adjusting the power output from the previous step, note the power reading on the DUT in the AVE and also in the PEP mode. (add any correction if necessary as in step 6.1.3.5). Record on Data Sheet.

6.2.3.7 Repeat the above steps for the 5 watt level tests. Set the DUT to the lowest power range. Please note the table for the HP432B at this level. Record results of the AVE and PEP and 50 % duty cycle power as in steps 6.1.3.4 through 6.1.3.6 in on Data Sheet.

6.2.3.8 Place transceiver on 14 MHz, Replace the keying generator with the telegraph key. Adjust power until the desired level is reached on the HP power meter for 100 watts at the DUT. Do not forget to adjust the HP power meter for the proper calibration factor and frequency. Zero before making all measurements. Record the AVE and PEP on the Data Sheet. Repeat for 5 watt measurements as in steps 6.1.3.4 through 3.1.3.6.

6.2.3.81 Repeat the above steps for 28, 50, 144, 222, & 432 MHz, if necessary.

6.2.3.9 Remove the telegraph key. Plug in the two-tone generator to the transceiver's microphone jack. Place the transceiver in the USB mode and turn on the VOX. Turn on the generator, both tones on. Turn up the mic gain on the transceiver and note the ALC. Adjust gain so the ALC is one quarter scale. Put the DUT to PEP. Note the power on the DUT and record it on the Data Sheet. Turn off tone generator.

****NOTE: Before the two-tone reading can be made, the two tones of the generator must be exactly even. Use the HP 8563E Spectrum Analyzer with the proper attenuators and step attenuators to match the tones evenly. Adjust the "Balance" control on the tone generator to match the tones on the analyzer. ****

6.2.3.10 Turn the AC power "on" on the Linear Amplifier. Place the amplifier in "standby" Allow to warm up at least 10 minutes. Set the Linear Amplifier and Transceiver for the 160 Meter band, the transceiver frequency adjusted to 1.995 MHz.

6.2.3.11 Place the 10 dB Bird Attenuator in series with the HP 20 dB attenuator. This is now a total of over 50 dB of attenuation for the input of the HP 432B power meter. Please note the set of tables for this extra attenuator for the 1000 watt measurements.

6.2.3.12 Set the transceiver for the lowest power output. <u>Set the DUT to the highest power range.</u> Place the telegraph key in the transceiver. Make sure the transceiver is in the CW mode. Place the Linear Amplifier in the "operate" position. Key the transmitter and slowly adjust the power output of the transceiver. Match the HP power meter to the table provided for 1000 watts at the DUT. Record the AVE and PEP power read by the DUT on the Data Sheet. Let go of the key ! Repeat the above steps for 50 % duty cycle, two-tone (14 MHz only) for 14 and 28 Mhz. (At this time, we do not have linear amplifiers for VHF and UHF testing.) Is it getting hot in there or what ?

Note: Keep an eye on the Linear Amplifier and Transceivers heat dissipation. Let them cool down if necessary.

<u>SWR TEST</u>

For this test, only the transceiver is used. Make certain the Linear Amplifier AC power is "off". The test is preformed at the 100 watt level. Only the 30 dB Bird 8329 Attenuator is needed and used as a 1:1 load. Two 50 ohm precision carbon resistors in parallel will be used as a 2:1 load. "Coax 1" cable is used between the DUT and the 1:1 load. The 2:1 is connected directly to the DUT via its 6 inch long coax cable. Care must be used to keep the 2:1 load away from on top of or near conductive surfaces.

6.2.3.13 With the linear amplifier AC power off, set the power meter to "MID" or the 200 watt range. Connect the DUT antenna connector to the 1:1 load. Set the frequency of the transceiver to 1.995 Mhz. Set the power output of the transceiver to the lowest output setting. Place the transceiver in CW transmit mode and depress the key. Adjust the power output while watching the DUT. Adjust the transceiver for 100 watts on the DUT. Read the SWR and record on the Data Sheet. Release the key ! Repeat for 14, 28, 50 MHz, if necessary.

There are two kinds of SWR measuring meters, cross needle and single needle. Cross needle meters are read directly, single meters employ a "SET" knob and a forward/ reflected switch. If using a single needle SWR meter, rotate the set knob to full scale in the "forward" position while transmitting. Keep transmitting and switch to "reflected" to read the SWR.

6.2.3.14 Plug in the 2:1 load to the DUT antenna connector to the 2:1 load. Repeat step 6.2.3.13 and record on the data sheet.

Section 6.3 through 6.6, classified.

6.7 HF LINEAR AMPLIFIER TEST

6.7.1 The purpose of the Linear Amplifier Test is to determine if the amplifier meets the manufacturer's power output specification, meets FCC Part 97 regarding Spurious Emissions and measure and record the level of Intermodulation Distortion.

It is very important for the test engineer to be familiar with the Lab test equipment and the Device Under Test (DUT). The manufacturer's manual should be completely read and understood before any testing is performed. At no time should any equipment be operated in a manner that is inconsistent with the manufacturer's recommended procedures or published limits. Failure to understand the DUT could result in test error, damage to the equipment and worse, damage to the test engineer.

6.7.2 List of Equipment:

Instrument	Manufacturer	Model	Quantity
Spectrum Analyzer	HP	8563E	1
In-Line RF Wattmeter	Bird	4381	1
In-Line RF Wattmeter	Bird	43	2
Power Attenuator	Bird	8329	1
RF Step Attenuator	HP	355C	1
RF Step Attenuator	HP	355D	1
Fixed RF Attenuator	Bird	8340-100	1
Fixed RF Attenuator	Bird	8340-200	1
Signal Generator	Any	Any	2
Driver Amplifier	ARRL	N/A	2
150W Power Amplifier	CCI	EB63	2
14 MHz Power Combiner	ARRL	NA	1
Inter-Connecting Cables	NA	As Required	As Required

6.7A LINEAR AMPLIFIER OPERATION TEST

6.7A.1 The purpose of the Linear Amplifier Operation Test is to determine the ability of the amplifier to produce its full rated output power in each applicable Amateur Band without exceeding any of the manufacturer's specified limits. The input drive power, the input reflected power, the output forward and reflected power and the spurious emissions are measured at each test point. Measurements are made at the edges of the bands and one or more mid-band points. The spectral display on each band is saved to disc. Additionally, the Linear Amplifier will be tested with an input signal of 27 MHz to ensure the amplifier does not function on the Citizen's Band.

6.7A.2 Test Hook-Up (See FIGURE 6.7A)

Diagram here:

6.7A.3 With all power switches in the OFF position and the signal generator outputs disabled, connect the following:

CONNECTION	CONNECTORS	CABLE TYPE
Signal Generator Out to Driver #1 In	Type N to BNC	RG-58
Driver #1 Out to Linear Amp #1 In	BNC to BNC	RG-58
Linear Amp #1 Out to	BNC to BNC	RG-58

Filter #1 In

Filter #1 Out to Bird 43 Wattmeter In	BNC to PL-259	RG-58
Bird 43 Wattmeter Out to DUT In	PL-259 to As Required	RG-58
DUT Out to Bird 4381 Wattmeter In	As required to type N	RG-8
Bird 4381 Wattmeter Out to Power Attenuator In	Type N to type N	RG-8
Power Attenuator Out to 20 dB Attenuator In	Type N to type N	RG-58
20 dB Attenuator Out to 10 dB Step Attenuator In	Type N to BNC	RG-58
10 dB Step Attenuator Out to 1 dB Step Attenuator In	BNC to BNC	RG-58
1 dB Step Attenuator Out to Spectrum Analyzer In	BNC to BNC	RG-58

6.7A.4 Set the following controls in the order shown

INSTRUMENT	CONTROL	POSITION
DUT	Operate/Standby	Standby
DUT	Power On/Off	On
DUT	TUNE	Pre-set for 160 m
DUT	Load	Pre-set for 160 m
DUT	CW/SSB	CW
Bird 4381	Power On/Off	ON
Bird 4381	Function	FWD CW
Bird 4381	Forward Element	As Required
Bird 43	Element	As Required
Bird 43	Element Direction	Forward
10 dB Step Attn	Attenuator	>20 dB
1 dB Step Attn	Attenuator	Any
Signal Generator	Modulation	Off
Signal Generator	Frequency	1.800 MHz
Signal Generator	Carrier Off/On	Off
Signal Generator	RF Level	< -40dBm
**Spectrum Analyzer	Reference Level	-10dBm
Spectrum Analyzer	Input Attenuation	20 dB
Spectrum Analyzer	Threshold	-80 dBm
Spectrum Analyzer	Resolution Bandwidth	10 kHz
Spectrum Analyzer	Video Bandwidth	30 kHz
Spectrum Analyzer	Range MHz	0 to 50 MHz
Spectrum Analyzer	Sweep Time	Auto

**** NOTE:** The spectrum analyzer is automatically set to these values when using the LabWindows/CVI software.

6.7A.5 Allow the equipment to warm up for at least 10 minutes before proceeding to the next step.

6.7A.6 Check to make sure all power switches are on, including the filament switch if the DUT has one.

6.7A.7 If the DUT is if the vacuum tube type, the tuning of the amplifier must be performed in a manner consistent with all DUT and vacuum tube limits. Be sure not to exceed the maximum plate current, grid current and DUT power output limits while performing the following steps. If the amplifier is of the solid state type, be sure not to exceed the final PA maximum operating temperature and duty cycle limit.

NOTE: Some of the tuning steps may be omitted when the DUT is of the solid state type. Usually, there are no tuning adjustments, such as Plate and Load. Follow the procedure for adjusting the amplifier's drive level for the rated output.

6.7A.8 Switch the DUT to the Operate mode and enable the carrier on the generator. Increase the generator level until a moderate amount of RF is produced but the DUT (consult the operator's manual for the recommended drive level for tune-up). Tune the DUT per the manufacturer's instructions, for the maximum power output <u>without exceeding the maximum rated power output</u>.
Be sure to adjust the generator as necessary if the rated output is exceeded.

6.7A.9 Measure and record on the data sheet the following items:

MEASUREMENT	INSTRUMENT
Forward Power	Bird 43
Reflected Power	Bird 43
Plate Voltage	DUT Meter
Plate Current	DUT Meter
Grid Current	DUT Meter
Output Power	Bird 4381

6.7A.9.1 Adjust the step attenuators to provide approximately -10 dBm input to the spectrum analyzer (the fundamental should be just at the top of the frequency sweep display).

NOTE: *At no time should the input to the spectrum analyzer exceed 0 dBm. Damage to the instrument will occur at +10 dBm or greater !*

6.7A.9.2 If using the LabWindows/CVI software, click on the READ ANALYZER button to acquire data from the analyzer and display it on the screen. The level of the harmonics and/or spurs, in dB below the fundamental, can be read on the analyzer using the delta function. Note worst case harmonic and spur and record it on the data sheet. Disable the carrier on the signal generator.

6.7A.9.3 Set the generator frequency to the next value on the data sheet and re-tune the DUT as necessary. Repeat step 6.7A.9 for this test frequency. Again, repeat this step incrementing the generator's frequency each time, until the upper limit of the Amateur Band is reached.

6.7A.9.4 Repeat the above steps for each of the available Amateur Bands for each frequency on the data sheet. For 10 to 20 MHz, set the spectrum analyzer for a frequency range of 0 to 100 MHz. For 20 to 30 MHz, set the spectrum analyzer for a frequency range of 0 to 200 MHz.

6.7B LINEAR AMPLIFIER IMD TEST

6.7A.1 The purpose of the Linear Amplifier IMD Test is to measure and record the IMD products generated within the DUT when subjected to two simultaneous input signals. This test is performed by generating two RF signals (at 14.020 and 14.0212 MHz), amplifying them to an appropriate drive level, combining the amplified signals and feeding them to the DUT input. The DUT output IMD products are then displayed on the spectrum analyzer.

6.7B.2 Test Hook-Up (See Figure 6.7B)

Diagram here:

6.7B.3 With all power switches in the off position and both signal generator carriers disabled, connect the following:

CONNECTION	CONNECTORS	CABLE TYPE
Signal Generator #1 Out to Driver #1 In	Type N to BNC	RG-58
Signal Generator #2 Out to Driver #2 In	Type N to BNC	RG-58
Driver #1 Out to Linear Amp #1 In	BNC to BNC	RG-58
Driver #2 Out to Linear Amp #2 In	BNC to BNC	RG-58
Linear Amp #1 Out to Filter #1 In	BNC to BNC	RG-58
Linear Amp #2 Out to Filter #2 In	BNC to BNC	RG-58
Filter #1 Out to Bird 43 #1 In	BNC to PL-259	RG-58
Filter #2 Out to Bird 43 #2 In	BNC to PL-259	RG-58
Bird 43 #1 Out to Power Combiner #1 In	PL-259 to As Required	RG-58
Bird 43 #1 Out to Power Combiner #2 In	PL-259 to As Required	RG-58
Combiner 50 Ohm Out to 100 Watt Dummy Load	BNC to SO-239	RG-58
Combiner RF Out to DUT RF In	BNC to As Required	RG-58
DUT RF Out to Bird 4381 In	As Required to Type N	RG-8
Bird 4381 Out to Power Attenuator In	Type N to Type N	RG-8
Power Attenuator Out to 20 dB Attenuator In	Type N to Type N	RG-58
20 dB Attenuator Out to 10 dB Step Attn In	Type N to BNC	RG-58
10 dB Step Attn Out to 1 dB Step Attn In	BNC to BNC	RG-58
1 dB Step Attn Out to Spectrum Analyzer In	BNC to Type N	RG-58

6.7B.4 Set the following controls in the order shown

INSTRUMENT	CONTROL	POSITION
DUT	Operate/Standby	Standby
DUT	Power On/Off	On
DUT	TUNE	Pre-set for 20 m
DUT	LOAD	Pre-set for 20 m
DUT	CW/SSB	CW
Bird 4381	Power On/Off	On
Bird 4381	Function	FWD CW
Bird 4381	Forward Element	As Required
Bird 43	Element	As required
Bird 43	Element Direction	Forward
10 dB Step Attn	Attenuator	> 40 dB
1 dB Step Attn	Attenuator	Any
Generator #1	Modulation	Off
Generator #1	Frequency	14.020 MHz
Generator #1	Carrier On/Off	Off
Generator #1	RF Level	-40dBm
Generator #2	Modulation	Off
Generator #2	Frequency	14.0212 MHz
Generator #2	Carrier On/Off	Off
Generator #2	RF Level	-40 dBm
**Spectrum Analyzer	Input Attenuation	20 dB
Spectrum Analyzer	Reference Level	-40 dBm
Spectrum Analyzer	Threshold	-110 dBm
Spectrum Analyzer	Resolution Bandwidth	100 Hz
Spectrum Analyzer	Video bandwidth	10 kHz
Spectrum Analyzer	Center Frequency	14.0206 MHz
Spectrum Analyzer	Span	20 kHz
Spectrum Analyzer	Sweep Time	Auto

** NOTE: The spectrum Analyzer is automatically configured to these values when using the LabWindows/CVI software.

6.7B.5 Allow all equipment to warm up for at least 10 minutes before proceeding to the next step.

6.7B.6 Enable the carrier on Signal Generator #1. Proceed with DUT tuning adjustments as described in the Operation Test. When the DUT tuning is complete, disable the carrier on Signal Generator #1 and reduce its level back to -40 dBm.

6.7B.7 Enable the carrier on both signal generators. Simultaneously, the RF level of both generators slowly until the DUT is operating at about 50% of its rated power output.

6.7B.8 Observe the spectrum analyzer display and adjust the signal generator levels for equal power of the two signals on the spectral display. (Be sure to monitor the DUT's Grid and Plate Current if DUT is a Tube type to keep them within the manufacturer's limits.)

6.7B.9 Adjust the impedance matching controls on the test fixture for minimum SWR (Note that the dummy load matching network shouldn't have to be readjusted after the initial adjustment unless a fixture change has been made).

6.7B.10 It the DUT is not yet at full rated power at this point, slowly increase the signal generator levels simultaneously to bring the power up to the rated full power output. Adjust the step attenuators to adjust the signal peaks to 6 dB below the reference level on the spectrum analyzer.

6.7B.11 Readjust the fixture impedance matching controls if needed and trigger the spectrum analyzer sweep to obtain a static trace. Disable the signal generator carriers to remove the drive to the DUT. *Is it getting hot in there or what ?*

6.7B.12 If using the LabWindows/CVI software, click on the READ ANALYZER button to acquire data from the analyzer and display it on the computer screen. The level of the IMD products, in dB below the PEP level can be directly read off the displayed data. Save the results to a file.

6.7B.13 Record the 3rd and 5th IMD product levels on the data sheet.

About the Linear Amplifier IMD Test Fixture

To test for intermodulation distortion (IMD) in power amplifiers, two closely spaced RF signals are necessary. Since a single transmitter would introduce its own IMD into the test setup; two transmitters are used instead, with their outputs combined in a power combiner. An inexpensive hybrid combiner may be constructed using RG-8 and RG-11 coax for a particular design frequency. Slight amounts of reactance at the load port and output port can cause degraded isolation between the input ports, so impedance matching networks are used to adjust these ports for a pure resistive load.

For convenience sake, the entire test setup is mounted in a 6-foot tall equipment rack, mounted on wheels for a limited degree of portability.

In place of two amateur transceivers or transmitters, signal generators and appropriate amplification may also be used. This allows better control of the power levels as well as improved frequency accuracy and stability. This is the approach taken in the ARRL Lab.

Figure 6.7B provides an overview of the test fixture and interconnections used in the test setup. The two signal generators used must be capable of an output up to about +10dBm. Drivers 1 & 2 are an ARRL design. The schematic of the drivers appears in figure 6.7BA. The linear amplifiers are Communications Concepts model EB63. The filters are 20 meter band pass units made by Ed Wetherhold, W3NQN and were described in the May and June 1998 issues of QST. A copy of this article appears in Appendix B. Similar filters may be substituted. The power combiner is a coaxial hybrid ring adapted from a design for 2 meters and 440 MHz that appeared in the 1998 Central States VHF Conference Proceedings. A copy of this paper also appears in Appendix B.

The RF Sampling Unit is also an ARRL design. The schematic for this circuit appears in Appendix B. The Directional Coupler is a Tandem Match Design. The circuit of the Tandem Match appeared in January, 1987 QST (also in Appendix B). The PI network used to tune out the stray reactance of the dummy load consists of a 0.432 micro Henry coil and two variable capacitors with a nominal value of 104 Pico farads. The T network used to match the input impedance of the amplifiers under test consists of a 1.07 micro Henry coil and two variable capacitors with a nominal value of 70 Pico farads.

LINEAR AMPLIFIER PRODUCT REVIEW DATA SHEET

Manufacturer:__________ Model:_____________ Serial #:_______________

Date:________________ Test Engineer:_____________________________

		DRIVE	DUT		Bird		
Band (M)	Frequency (MHz)	PFWD (W)	PREF (W)	Po (W)	Po (W)	SP/PUR (dBc)	NOTES
160	1.801						
	1.900						
	1.999						
80	3.501						
	3.750						
	3.999						
40	7.001						
	7.299						
20	14.001						
	14.175						
	14.349						
17	18.069						
	18.167						
15	21.001						
	21.250						
	21.449						
12	24.891						
	24.989						
10	28.001						
	28.400						
	29.000						
	29.699						
6	50.001						
	50.400						
	51.000						
	52.000						
	53.000						
	53.999						

Worst Case Spectral Purity: ______________________________________

Two-Tone IMD, 20 Meters: 3rd:____ 5th____ 7th: ____ 9th: ____ dBc

Test Engineer's Notes:

VII. DATA SHEETS/ PRODUCT REVIEW TEST MANUAL

Manufacturer:__________ Model:_________ Serial #:_____________

Date:__________________ Test Engineer:_______________________

4.0 TRANSMITTER TESTS

4.1 OUTPUT-POWER TEST **NOTE:___________________**

4.1.3.4 DC Power Supply Only/ Minimum Output Power:
Voltmeter Reading: ______V Ammeter Reading: _______A

4.1.3.5 DC Power Supply Only/ Maximum Output Power:
Voltmeter Reading: ______V Ammeter Reading: _______A

4.1.3.6 Receive Current:
Maximum volume; no signal; lights default: ______mA

Maximum volume; no signal; lights off: _______mA
maximum lights: _______mA

4.1.3.7 to 4.1.3.9; 4.1.3.11 to 4.1.3.13

Band	Mode	DUT Min	Bird Min	DUT Max	Bird Max	Spurs/ Notes
160	CW	________	________	________	________	_____________
80	CW	________	________	________	________	_____________
	AM	________	________	________	________	_____________
60	SSB	________	________	________	________	_____________
40	CW	________	________	________	________	_____________
30	CW	________	________	________	________	_____________
20	CW	________	________	________	________	_____________
	SSB	________	________	________	________	_____________
17	CW	________	________	________	________	_____________
15	CW	________	________	________	________	_____________
12	CW	________	________	________	________	_____________
10	CW	________	________	________	________	_____________
	FM	________	________	________	________	_____________
6	CW	________	________	________	________	_____________

	SSB	________	________	________	________	_____________
	FM	________	________	________	________	_____________
	AM	________	________	________	________	_____________
2	CW	________	________	________	________	_____________
	SSB	________	________	________	________	_____________
	FM	________	________	________	________	_____________
	AM	________	________	________	________	_____________
440	CW	________	________	________	________	_____________
	SSB	________	________	________	________	_____________
	FM	________	________	________	________	_____________
	AM	________	________	________	________	_____________

Maximum Power Output at Minimum Specified Voltage, 14.020 MHz____

4.1.3.14 Transverter Output

Band	µWattmeter Max
20	________
15	________
10	________

4.2 TRANSMIT FREQUENCY RANGE TEST

	Band	Low Frequency Limit	High Frequency Limit
4.2.3.4/ 4.2.3.5	160	__________________MHz	__________________MHz
4.2.3.6	80	__________________MHz	__________________MHz
	60	__________________MHz	__________________MHz
	40	__________________MHz	__________________MHz
	30	__________________MHz	__________________MHz
	20	__________________MHz	__________________MHz
	17	__________________MHz	__________________MHz
	15	__________________MHz	__________________MHz
	12	__________________MHz	__________________MHz
	10	__________________MHz	__________________MHz
	6	__________________MHz	__________________MHz
	2	__________________MHz	__________________MHz
	440	__________________MHz	__________________MHz

All frequencies as measured on transmitter dial read-out.

4.3 CW TRANSMIT-FREQUENCY ACCURACY TEST

Note: See 6.1 Low-Voltage and Temperature Chamber Test for units designed for mobile and/or portable use.

4.3.3.3 20M Unkeyed DUT Frequency: __________________MHz

4.3.3.5/ 20M Max Power Out/ Counter Display: __________________MHz

4.3.3.6

4.3.3.4/ No significant display variation due to change in DC input
4.3.3.7 power (12V min) or Power Output ( ).

4.3.3.8 6M Unkeyed DUT Frequency: ___________________MHz
Max Power Out/ Counter Display: ___________________MHz

No significant display variation due to change in DC input power or Power Output ( ).

2M Unkeyed DUT Frequency: ___________________MHz
Max Power Out/ Counter Display: ___________________MHz

No significant display variation due to change in DC input power or Power Output ( ).

440MHz Unkeyed DUT Frequency: ___________________MHz
Max Power Out/ Counter Display: ___________________MHz

No significant display variation due to change in DC input power or Power Output ( ).

4.4 SPECTRAL PURITY TEST

	Band	Spur @ Max Power	Note	Spur Check @ Min Power	Note
4.4.3.9/ 4.4.3.10	160	______dBc	______	______dBc	______
4.4.3.11	80	______dBc	______	______dBc	______
	60	______dBc	______	______dBc	______
	40	______dBc	______	______dBc	______
	30	______dBc	______	______dBc	______
	20	______dBc	______	______dBc	______
	17	______dBc	______	______dBc	______
	15	______dBc	______	______dBc	______
	12	______dBc	______	______dBc	______
	10	______dBc	______	______dBc	______
	6	______dBc	______	______dBc	______
	2	______dBc	______	______dBc	______
	440	______dBc	______	______dBc	______

*NOTE: 5W minimum power.

4.4.3.12 PLOT - WORST CASE/ SPECTRAL PURITY TAKEN ( )

DUT FREQUENCY _________MHz SPUR LEVEL _________dBc

4.4.3.13 DUT Meets FCC Specifications: ______YES ______NO

4.5 TWO-TONE TRANSMIT IMD TEST

100W PEP
ac Volt.

4.5.3.7 3.900 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______

4.5.3.8 14.250 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______

4.5.3.9 1.850 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
5.330 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
7.250 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
10.120 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
18.120 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
21.250 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
24.950 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
28.350 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
50.200 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
144.200 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______
432.200 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/) ______

Half-Power 14.250 MHz - TWO-TONE TRANSMIT IMD $3^{rd}/5^{th}$ (/)

4.6 SSB CARRIER AND UNWANTED SIDEBAND SUPPRESSION TEST

4.6.3.7 20M Level Of Suppressed Carrier/USB Mode: ______dB Below PEP
20M Level Of Unwanted Sideband/USB Mode: ______dB Below PEP

4.6.3.8 20M Level Of Suppressed Carrier/LSB Mode: ______dB Below PEP
20M Level Of Unwanted Sideband/LSB Mode: ______dB Below PEP

4.6.3.9 6M Level Of Suppressed Carrier/USB Mode: ______dB Below PEP
6M Level Of Unwanted Sideband/USB Mode: ______dB Below PEP

6M Level Of Suppressed Carrier/LSB Mode: ______dB Below PEP
6M Level Of Unwanted Sideband/LSB Mode: ______dB Below PEP

2M Level Of Suppressed Carrier/USB Mode: ______dB Below PEP
2M Level Of Unwanted Sideband/USB Mode: ______dB Below PEP

2M Level Of Suppressed Carrier/LSB Mode: ______dB Below PEP
2M Level Of Unwanted Sideband/LSB Mode: ______dB Below PEP

440 Level Of Suppressed Carrier/USB Mode: ______dB Below PEP
440 Level Of Unwanted Sideband/USB Mode: ______dB Below PEP

440 Level Of Suppressed Carrier/LSB Mode: ______dB Below PEP
440 Level Of Unwanted Sideband/LSB Mode: ______dB Below PEP

4.7 CW KEYING WAVEFORM TEST

4.7.3.6 CW KEYING / QSK OFF ( )
CW KEYING / QSK ON ( )
CW KEYING – QSK & HALF POWER - SPIKE? ( )

4.7.3.7 Keying sidebands plots saved ( )

4.8 PTT TO SSB/FM RF OUTPUT TEST

4.8.3.5
20M SSB 50% Delay ON Time: ______ms

4.8.3.6
10M FM 50% Delay ON Time: ______ms

4.8.3.7
6M FM 50% Delay ON Time: ______ms
2M FM 50% Delay ON Time: ______ms
440 FM 50% Delay ON Time: ______ms

4.9 TRANSMIT/ RECEIVE TURNAROUND TIME TEST

4.9.3.5 S9 Signal * /AGC Slow/PTT Key-Up To 50% Audio Output
Time: _______ms

4.9.3.6 S9 Signal * /AGC Fast/PTT Key-Up To 50% Audio Output
Time: _______ms

S9 -20 dB /AGC Slow/PTT Key-Up To 50% Audio Output
Time: _______ms

No significant variation due to change in AGC or a 20 dB decrease in input signal ( ).

S9 Signal * /AGC Fast/CW Mode/Key-Up to 50% Audio Output
Time: _______ms

MDS + 10dB Signal/AGC Fast/CW Mode/Key-Up to 50% Audio Output
Time: _______ms

4.9.3.7 DUT Suitable For AMTOR: ______YES ______NO

*NOTE: If an S meter is not available, use standard 50 μV input signal.

4.10 KEYER SPEED AND SIDETONE

4.10.3.3 DOT to DASH ratio near 1:3 ( ).

4.10.3.4 Default keyer speed dit to dit time: ________ ms
Code Speed (WPM): _______

4.10.3.5 Minimum keyer speed dit to dit time: ________ ms
Code Speed (WPM): _______

4.10.3.6 Maximum keyer speed dit to dit time: ________ ms
Code Speed (WPM): _______

4.10.3.7 Default sidetone: __________ Hz
Minimum sidetone: __________ Hz
Maximum sidetone: __________ Hz

4.10.3.7 Iambic Keyer Mode "A" or "B": _________
(Mode B completes extra element from the opposite paddle)

4.11 PHASE NOISE TEST

4.11.3.13 Plot taken - Phase Noise at _____________ MHz ( )
Noise level at 100 Hz offset from carrier: ______ dBc/Hz
Noise level at 3 kHz offset from carrier: ______ dBc/Hz

4.11.3.14 Plot taken - Phase Noise at _____________ MHz ( )
Noise level at 100 Hz offset from carrier: ______ dBc/Hz
Noise level at 3 kHz offset from carrier: ______ dBc/Hz

Plot taken - Phase Noise at ____________ MHz ( )
Noise level at 100 Hz offset from carrier: ______ dBc/Hz
Noise level at 3 kHz offset from carrier: ______ dBc/Hz

Plot taken - Phase Noise at ____________ MHz ( )
Noise level at 100 Hz offset from carrier: ______ dBc/Hz
Noise level at 3 kHz offset from carrier: ______ dBc/Hz

5.0 RECEIVER TESTS

5.1 CW MINIMUM DISCERNIBLE SIGNAL (MDS) TEST

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB

IF FILTERS: __________Hz

5.1.3.8/
5.1.3.9 Can AGC be set to OFF?: ________

1.020 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: __________dBm
Preamp Two, MDS: __________dBm

5.1.3.10
3.520 MHz Preamp Off, MDS: __________dBm S5 Reference: __________dBm
Preamp One, MDS: __________dBm S5 Reference: __________dBm
Preamp Two, MDS: __________dBm S5 Reference: __________dBm

5.1.3.11
14.020 MHz Preamp Off, MDS: __________dBm S5 Reference: __________dBm
Preamp One, MDS: __________dBm S5 Reference: __________dBm
Preamp Two, MDS: __________dBm S5 Reference: __________dBm

5.1.3.12
50.020 MHz Preamp Off, MDS: __________dBm S5 Reference: __________dBm
Preamp One, MDS: __________dBm S5 Reference: __________dBm
Preamp Two, MDS: __________dBm S5 Reference: __________dBm

144.020 MHz Preamp Off, MDS: _________dBm S5 Reference: __________dBm
Preamp One, MDS: _________dBm S5 Reference: __________dBm
Preamp Two, MDS: _________dBm S5 Reference: __________dBm

430.020 MHz Preamp Off, MDS: _________dBm S5 Reference: __________dBm
Preamp One, MDS: _________dBm S5 Reference: __________dBm

Preamp Two, MDS: __________dBm S5 Reference: ___________dBm

5.1.3.13 Expanded Tests

1.820 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

7.020 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

10.120 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

18.088 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

21.020 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

24.910 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

28.020 MHz Preamp Off, MDS: ___________dBm
Preamp One, MDS: ___________dBm
Preamp Two, MDS: ___________dBm

5.2 AM RECEIVE SENSITIVITY TEST

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB

IF FILTER ___________kHz

5.2.3.7/5.2.3.8

1.020 MHz Preamp off, 10 dB (S+N)/N: _________µV
Preamp one, 10 dB (S+N)/N: _________µV
Preamp two, 10 dB (S+N)/N: _________µV

5.2.3.9

3.800 MHz Preamp off, 10 dB (S+N)/N: _________µV
Preamp one, 10 dB (S+N)/N: _________µV
Preamp two, 10 dB (S+N)/N: _________µV

5.2.3.10

53.000 MHz Preamp off, 10 dB (S+N)/N: ________μV
Preamp one, 10 dB (S+N)/N: ________μV
Preamp two, 10 dB (S+N)/N: ________μV

120.000 MHz Preamp off, 10 dB (S+N)/N: ________μV
(AIR) Preamp one, 10 dB (S+N)/N: ________μV
Preamp two, 10 dB (S+N)/N: ________μV

146.000 MHz Preamp off, 10 dB (S+N)/N: ________μV
Preamp one, 10 dB (S+N)/N: ________μV
Preamp two, 10 dB (S+N)/N: ________μV

440.000 MHz Preamp off, 10 dB (S+N)/N: ________μV
Preamp one, 10 dB (S+N)/N: ________μV
Preamp two, 10 dB (S+N)/N: ________μV

5.3 <u>FM 12 dB SINAD TEST</u>

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB
IF Filters: ________kHz (Normal/Narrow)

5.3.3.5/5.3.3.6

29.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
(Normal/	Preamp one, 12 dB SINAD:	________µV	________dBm
Narrow)	Preamp two, 12 dB SINAD:	________µV	________dBm

5.3.3.13

52.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp two, 12 dB SINAD:	________µV	________dBm
100.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
(Wide)	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
146.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp two, 12 dB SINAD:	________µV	________dBm
162.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp two, 12 dB SINAD:	________µV	________dBm
223.500 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp two, 12 dB SINAD:	________µV	________dBm
440.000 MHz	Preamp off, 12 dB SINAD:	________µV	________dBm
	Preamp one, 12 dB SINAD:	________µV	________dBm
	Preamp two, 12 dB SINAD:	________µV	________dBm

Spectral Sensitivity: Panadapter________________________ dBm
Waterfall ________________________ dBm
Other ________________________ dBm

5.4 RECEIVE FREQUENCY RANGE TEST

	Band	Low Frequency Limit	High Frequency Limit
5.4.3.4/ 5.4.3.5	160	____________________MHz	____________________MHz
5.4.3.6	80	____________________MHz	____________________MHz
	60	____________________MHz	____________________MHz
	40	____________________MHz	____________________MHz
	30	____________________MHz	____________________MHz
	20	____________________MHz	____________________MHz
	17	____________________MHz	____________________MHz
	15	____________________MHz	____________________MHz
	12	____________________MHz	____________________MHz
	10	____________________MHz	____________________MHz
	6	____________________MHz	____________________MHz
	2	____________________MHz	____________________MHz
	440	____________________MHz	____________________MHz
	Other	____________________MHz	____________________MHz
	Other	____________________MHz	____________________MHz
	Other	____________________MHz	____________________MHz
	Other	____________________MHz	____________________MHz
	Other	____________________MHz	____________________MHz
	General Coverage	____________________MHz	____________________MHz

All frequencies as measured on transmitter dial read-out.

5.5 FIRST IF AND IMAGE REJECTION TEST

Specified First Intermediate Frequency _______ MHz

IF or Calculated Image Frequency	MDS Level in dBm	IF or Image Suppression in dB

5.6 ANTENNA PORT ISOLATION TEST

Number of antenna ports: ________

Level of signal on opposite port for MDS on desired port

Desired Port: _____ Opposite Port: _____ Signal level: ________ dBm
Desired Port: _____ Opposite Port: _____ Signal level: ________ dBm
Desired Port: _____ Opposite Port: _____ Signal level: ________ dBm
Desired Port: _____ Opposite Port: _____ Signal level: ________ dBm
Desired Port: _____ Opposite Port: _____ Signal level: ________ dBm

5.7 BLOCKING DYNAMIC RANGE TEST

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB
On-Frequency Signal: -110 dBm

IF FILTERS __________Hz

5.7.3.7

3.520 MHz Block level, Preamp off, lower (3.500 MHz): __________dBm
Block level, Preamp off, lower (3.515 MHz): __________dBm
Block level, Preamp off, lower (3.518 MHz): __________dBm
Block level, Preamp off, upper (3.522 MHz): __________dBm
Block level, Preamp off, upper (3.525 MHz): __________dBm
Block level, Preamp off, upper (3.540 MHz): __________dBm
Block level, Preamp one, lower (3.500 MHz): __________dBm
Block level, Preamp one, upper (3.540 MHz): __________dBm
Block level, Preamp two, lower (3.500 MHz): __________dBm
Block level, Preamp two, upper (3.540 MHz): __________dBm

5.7.3.9

14.020 MHz Block level, Preamp off, lower (14.000 MHz): __________dBm
Block level, Preamp off, lower (14.015 MHz): __________dBm
Block level, Preamp off, lower (14.018 MHz): __________dBm
Block level, Preamp off, upper (14.022 MHz): __________dBm
Block level, Preamp off, upper (14.025 MHz): __________dBm
Block level, Preamp off, upper (14.040 MHz): __________dBm
Block level, Preamp one, lower (14.000 MHz): __________dBm
Block level, Preamp one, upper (14.040 MHz): __________dBm
Block level, Preamp two, lower (14.000 MHz): __________dBm
Block level, Preamp two, upper (14.040 MHz): __________dBm

50.020 MHz Block level, Preamp off, lower (50.000 MHz): ___________dBm
Block level, Preamp off, lower (50.015 MHz): ___________dBm
Block level, Preamp off, lower (50.018 MHz): ___________dBm
Block level, Preamp off, upper (50.022 MHz): ___________dBm
Block level, Preamp off, upper (50.025 MHz): ___________dBm
Block level, Preamp off, upper (50.040 MHz): ___________dBm
Block level, Preamp one, lower (50.000 MHz): ___________dBm
Block level, Preamp one, upper (50.040 MHz): ___________dBm
Block level, Preamp two, lower (50.000 MHz): ___________dBm
Block level, Preamp two, upper (50.040 MHz): ___________dBm

144.020 MHz Block level, Preamp off, lower (144.000 MHz): ___________dBm
Block level, Preamp off, lower (144.015 MHz): ___________dBm
Block level, Preamp off, lower (144.018 MHz): ___________dBm
Block level, Preamp off, upper (144.022 MHz): ___________dBm
Block level, Preamp off, upper (144.025 MHz): ___________dBm
Block level, Preamp off, upper (144.040 MHz): ___________dBm
Block level, Preamp one, lower (144.000 MHz): ___________dBm
Block level, Preamp one, upper (144.040 MHz): ___________dBm
Block level, Preamp two, lower (144.000 MHz): ___________dBm
Block level, Preamp two, upper (144.040 MHz): ___________dBm

430.020 MHz Block level, Preamp off, lower (430.000 MHz): ___________dBm
Block level, Preamp off, lower (430.015 MHz): ___________dBm
Block level, Preamp off, lower (430.018 MHz): ___________dBm
Block level, Preamp off, upper (430.022 MHz): ___________dBm
Block level, Preamp off, upper (430.025 MHz): ___________dBm
Block level, Preamp off, upper (430.040 MHz): ___________dBm
Block level, Preamp one, lower (430.000 MHz): ___________dBm
Block level, Preamp one, upper (430.040 MHz): ___________dBm
Block level, Preamp two, lower (430.000 MHz): ___________dBm

Block level, Preamp two, upper (430.040 MHz): ___________dBm

5.7A.1

Reciprocal Mixing

Level for 3 dB increase in background noise

14.005 MHz:_________________ dBm	Reciprocal Mixing _____dBc
14.020 MHz:_________________ dBm	Reciprocal Mixing _____dBc
14.023 MHz:_________________ dBm	Reciprocal Mixing _____dBc
14.027 MHz:_________________ dBm	Reciprocal Mixing _____dBc
14.030 MHz:_________________ dBm	Reciprocal Mixing _____dBc
14.045 MHz:_________________ dBm	Reciprocal Mixing _____dBc

5.8 TWO-TONE 3rd ORDER DYNAMIC RANGE TEST

5.8.3.6/5.8.3.7/5.8.3.8

3.480/3.500 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
3.510/3.515 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
3.516/3.518 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
3.522/3.524 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
3.525/3.530 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
3.540/3.560 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm

3.480/3.500 MHz Preamp One, IMD level: ________dBm
S5: ________dBm
3.540/3.560 MHz Preamp One, IMD level: ________dBm
S5: ________dBm

3.480/3.500 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm
3.540/3.560 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm

5.8.3.11

13.980/14.000 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
14.010/14.015 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
14.016/14.018 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
14.022/14.024 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
14.025/14.030 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
14.040/14.060 MHz Preamp Off, IMD level: ________dBm

S5: _________dBm
0 dBm: _________dBm

13.980/14.000 MHz Preamp One, IMD level: _________dBm
S5: _________dBm
14.040/14.060 MHz Preamp One, IMD level: _________dBm
S5: _________dBm

13.980/14.000 MHz Preamp Two, IMD level: _________dBm
S5: _________dBm
14.040/14.060 MHz Preamp Two, IMD level: _________dBm
S5: _________dBm

49.980/50.000 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
50.010/50.015 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
50.016/50.018 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
50.022/50.024 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
50.025/50.030 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
50.040/50.060 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm

49.980/50.000 MHz Preamp One, IMD level: _________dBm
S5: _________dBm
50.040/50.060 MHz Preamp One, IMD level: _________dBm
S5: _________dBm

49.980/50.000 MHz Preamp Two, IMD level: _________dBm
S5: _________dBm
50.040/50.060 MHz Preamp Two, IMD level: _________dBm
S5: _________dBm

143.980/144.000 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm
144.010/144.015 MHz Preamp Off, IMD level: _________dBm
S5: _________dBm
0 dBm: _________dBm

144.016/144.018 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm

144.022/144.024 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
144.025/144.030 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
144.040/144.060 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm

143.980/144.000 MHz Preamp One, IMD level: ________dBm
S5: ________dBm
144.040/144.060 MHz Preamp One, IMD level: ________dBm
S5: ________dBm

143.980/144.000 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm
144.040/144.060 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm

429.980/430.000 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
430.010/430.015 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
430.016/430.018 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
430.022/430.024 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
430.025/430.030 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm
430.040/430.060 MHz Preamp Off, IMD level: ________dBm
S5: ________dBm
0 dBm: ________dBm

429.980/430.000 MHz Preamp One, IMD level: ________dBm
S5: ________dBm
430.040/430.060 MHz Preamp One, IMD level: ________dBm
S5: ________dBm

429.980/430.000 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm
430.040/430.060 MHz Preamp Two, IMD level: ________dBm
S5: ________dBm

5.8.3.13 **TWO-TONE 2nd ORDER DYNAMIC RANGE**

(14.020 MHZ) RF Generator frequencies: 6.000/8.020 MHz

Preamp off, Second-Order IMD Level: ___x___dBm (MDS)
Level: _______dBm (S5)
Intercept point: ___x___dBm

Preamp one, Second-Order IMD Level: ___x___dBm (MDS)
Level: _______dBm (S5)
Intercept point: ___x___dBm

Preamp two, Second-Order IMD Level: ___x___dBm (MDS)
Level: _______dBm (S5)
Intercept point: ___x___dBm

(50.020 MHz) RF Generator Frequencies 29 MHz/21.020 MHz

For S5 Preamp off______ dBm
Preamp 1 ______ dBm
Preamp 2 ______ dBm

(144.020 MHz) RF Generator Frequencies 94 MHz/50.020 MHz

For S5 Preamp off______ dBm
Preamp 1 ______ dBm
Preamp 2 ______ dBm

(432.020 MHz) RF Generator Frequencies 300 MHz/132.020 MHz)

For S5 Preamp off______ dBm
Preamp 1 ______ dBm
Preamp 2 ______ dBm

Other:
____
____
____
____
____
____
____
____
____
____
____
____
____

5.9 **FM ADJACENT-CHANNEL SELECTIVITY TEST FM WIDE**

NOTE: 6 dB SINAD IS EQUAL TO 50% DISTORTION.

DUT Preamp: On
IF FILTERS __________kHz

5.9.3.4 29.000 MHz/28.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.5 29.000 MHz/29.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.6 52.000 MHz/51.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

52.000 MHz/52.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

146.000 MHz/145.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

146.000 MHz/146.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

440.000 MHz/439.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

440.000 MHz/440.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.8 Phase noise limit
Phase Noise Limit Level at 28.980 MHz: __________dBm
Phase Noise Limit Level at 29.020 MHz: __________dBm

5.9.3.9
Phase Noise Limit Level at 51.980 MHz: __________dBm
Phase Noise Limit Level at 52.020 MHz: __________dBm
Phase Noise Limit Level at 145.980 MHz: __________dBm
Phase Noise Limit Level at 146.020 MHz: __________dBm
Phase Noise Limit Level at 439.980 MHz: __________dBm
Phase Noise Limit Level at 440.020 MHz: __________dBm

5.6.3.7 Adjacent Channel Rejection

#1 Gen	#2 Gen		#1 Gen	#2 Gen	
29.000	28.980	_______dB	29.000	29.020	_______dB
52.000	51.980	_______dB	52.000	52.020	_______dB
146.000	145.980	_______dB	146.000	146.020	_______dB
440.000	439.980	_______dB	440.000	440.020	_______dB

5.9 FM ADJACENT-CHANNEL SELECTIVITY TEST FM Narrow

NOTE: 6 dB SINAD IS EQUAL TO 50% DISTORTION.

DUT Preamp: On

IF FILTERS __________kHz

5.9.3.4 29.000 MHz/28.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.5 29.000 MHz/29.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.6 52.000 MHz/51.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

52.000 MHz/52.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

146.000 MHz/145.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

146.000 MHz/146.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

440.000 MHz/439.980 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

440.000 MHz/440.020 MHz
Adjacent Channel Level for 6 dB SINAD: ________dBm

5.9.3.8 Phase noise limit

Phase Noise Limit Level at 28.980 MHz: __________dBm
Phase Noise Limit Level at 29.020 MHz: __________dBm

5.9.3.9

Phase Noise Limit Level at 51.980 MHz: __________dBm
Phase Noise Limit Level at 52.020 MHz: __________dBm
Phase Noise Limit Level at 145.980 MHz: __________dBm
Phase Noise Limit Level at 146.020 MHz: __________dBm
Phase Noise Limit Level at 439.980 MHz: __________dBm
Phase Noise Limit Level at 440.020 MHz: __________dBm

5.6.3.7 Adjacent Channel Rejection

#1 Gen	#2 Gen		#1 Gen	#2 Gen	
29.000	28.980	_______dB	29.000	29.020	_______dB
52.000	51.980	_______dB	52.000	52.020	_______dB
146.000	145.980	_______dB	146.000	146.020	_______dB
440.000	439.980	_______dB	440.000	440.020	_______dB

5.10 FM TWO-TONE 3rd ORDER DYNAMIC RANGE TEST

NOTE: 25% DISTORTION IS EQUAL TO 12 dB SINAD

Standard (STD) Conditions: RF Gen #1 and #2 Output
Level: -17 dBm
DUT Preamp: On
IF FILTERS __________kHz

5.10.3.5

Generator frequencies: 28.960/28.980 MHz
Signal Level for 25% Distortion @ 29.000 MHz: __________dBm

5.10.3.6

Generator frequencies: 29.020/29.040 MHz
Signal Level for 25% Distortion @ 29.000 MHz: __________dBm
Generator frequencies: 39.000/49.000 MHz
Signal Level for 25% Distortion @ 29.000 MHz: __________dBm

5.10.3.8

Generator frequencies: 51.960/51.980 MHz
Signal Level for 25% Distortion @ 52.000 MHz: __________dBm
Generator frequencies: 52.020/52.040 MHz
Signal Level for 25% Distortion @ 52.000 MHz: __________dBm
Generator frequencies: 62.000/72.000 MHz
Signal Level for 25% Distortion @ 52.000 MHz: __________dBm

Generator frequencies: 145.960/145.980 MHz
Signal Level for 25% Distortion @ 146.000 MHz: __________dBm
Generator frequencies: 146.020/146.040 MHz
Signal Level for 25% Distortion @ 146.000 MHz: __________dBm
Generator frequencies: 156.000/166.000 MHz
Signal Level for 25% Distortion @ 146.000 MHz: __________dBm

Generator frequencies: 439.960/439.980 MHz
Signal Level for 25% Distortion @ 440.000 MHz: __________dBm
Generator frequencies: 440.020/440.040 MHz
Signal Level for 25% Distortion @ 440.000 MHz: __________dBm
Generator frequencies: 450.000/460.000 MHz
Signal Level for 25% Distortion @ 440.000 MHz: __________dBm

5.10.3.7 FM IMD DYNAMIC RANGE

#1 Gen	#2 Gen	DUT	DYNAMIC RANGE
28.960	28.980	29.000	________dB
29.020	29.040	29.000	________dB
51.960	51.980	52.000	________dB
52.020	52.040	52.000	________dB
62.000	72.000	52.000	________dB
145.960	145.980	146.000	________dB
146.030	146.040	146.000	________dB
156.000	166.000	146.000	________dB
439.960	439.980	440.000	________dB
440.020	440.040	440.000	________dB
450.000	460.000	440.000	________dB

5.11 AUDIO POWER OUTPUT TEST

5.11.3.6 Specified Distortion: ________% THD

Specified Load Impedance: ________Ohms

5.11.3.7 Audio Voltage: ________V

5.11.3.8 Audio Output Power: ________W

5.11.3.9 Audio voltage at minimum volume (no signal): _______mV
(Hiss level)

5.11.3.10 THD at one volt rms _______________%

5.12 AUDIO AND IF FREQUENCY RESPONSE TEST

5.12.3.6 IF Filters: __________Hz (CW Narrow)

Low Frequency: __________Hz

5.12.3.7 High Frequency: __________Hz Difference: ________Hz

5.12.3.8 IF Filters: __________Hz (USB Wide)

Low Frequency: __________Hz

High Frequency: __________Hz Difference: _________Hz

IF Filters: __________kHz (LSB Wide)

Low Frequency: __________Hz

High Frequency: __________Hz Difference: _________Hz

5.12.3.10 IF Filters: __________kHz (AM)

Low Frequency: __________Hz

High Frequency: __________Hz   Difference: _________Hz

5.13 SQUELCH SENSITIVITY TEST

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB
Preamp On
IF FILTERS __________Hz

5.13.3.5
FM
29.000 MHz Squelch Threshold Point: __________μV

5.13.3.6
52.000 MHz Squelch Threshold Point: __________μV

146.000 MHz Squelch Threshold Point: __________μV

440.000 MHz Squelch Threshold Point: __________μV

5.13.3.7
SSB
14.200 MHz Squelch Threshold Point: __________μV

5.14 S METER TEST

Standard (STD) Conditions: 10 dB Step Attn: 10 dB
1 dB Step Attn: 0 dB
IF FILTERS __________Hz

5.14.3.4/5.14.3.5
14.200 MHz Preamp Off, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

5.14.3.6
14.200 MHz Preamp One, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

14.200 MHz Preamp Two, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

5.14.3.7

1.020 MHz Preamp Off, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

1.020 MHz Preamp One, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

1.020 MHz Preamp Two, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

50.020 MHz Preamp Off, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

50.020 MHz Preamp One, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

50.020 MHz Preamp Two, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

144.020 MHz Preamp Off, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

144.020 MHz Preamp One, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

144.020 MHz Preamp Two, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

420.020 MHz Preamp Off, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

420.020 MHz Preamp One, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

420.020 MHz Preamp Two, S9 Indication: _______dBm _______μV
No significant deviation from expected level
at S9+20 dB( ).

5.15 IN-BAND IMD TEST

5.15.3.6 14.200 MHz, AGC Fast, S9 Signals, plot taken ( ).
14.200 MHz, AGC Fast, S9 Signals, plot taken ( ).
14.200 MHz, AGC Fast, S9+40/60 Signals, plot taken ( ).
14.200 MHz, AGC Fast, S9+40/60 Signals, plot taken ( ).

5.16 NOTCH FILTER TEST

5.16.3.6 Minimum Notch Depth: _______dB

5.16.3.11 Maximum Notch Depth: _______dB

5.16.3.17 Notch Attack Time: _______ms

Test options -
2 tones (S9 each), AGC on, manual notch
2 tones (S9 + S1), AGC on, manual notch
1 tone, AGC on, manual notch
1 tone, AGC off, manual notch
1 tone, AGC on, auto notch
1 tone, AGC off, auto notch

Note changes in tone level and noise level.
Also note changes in S-meter for AGC on tests.

6.0 OTHER TESTS

6.2 DSP NOISE REDUCTION TEST

6.2.3.5 S9 Signal, best case noise reduction: _______dB

6.2.3.6 Overall best case noise reduction: _______dB

6.2.3.7 Dimensions

Height _______ inches

Wiidth _______ inches

Depth _______ inches

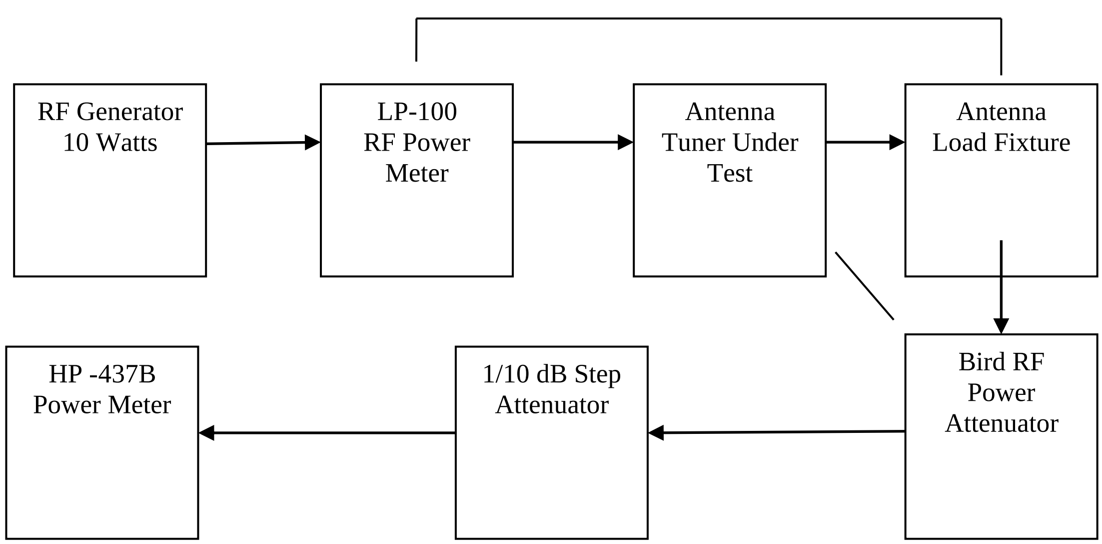
6.2.3.8 Weight

______________ lbs ozs (circle)

AUTOMATIC ANTENNA TUNER: ______________________________________
TYPE:____
CURRENT DRAW WHEN TUNING:_____________________________________
PEP RATING:__________ CLAIMED TUNING RANGE: ____________________

SWR	LOAD Ω	Measured Loads / Amateur Band	160m	80m	40m	20m	10m
9.26	5.4	Power Loss %					
		SWR					
7.35	6.8	Power Loss%					
		SWR					
3.85	13.0	Power Loss%					
		SWR					
1.95	25.6	Power Loss%					
		SWR					
1:02	50.9	Power Loss%					
		SWR					
2:02	100.8	Power Loss%					
		SWR					
4:02	200.9	Power Loss%					
		SWR					
8:02	400.9	Power Loss%					
		SWR					
16:04	802	Power Loss%					
		SWR					

1. Bypass ATU and Load Fixture for Calibration.
2. Set LP-100 to read 10.00 Watts, then adjust 1/10 dB step attenuator to read 1.0 mW on HP-437B power meter.
3. Insert ATU and Load Fixture and adjust the 1/10th dB step attenuator as noted.



ARRL Laboratory Power Supply Testing

Engineer ________________________
Date ___________________________
Make __________________________
Model _________________________
Serial Number ___________________

Lab Testing

Output Voltage, No Load _____________________V dc
Output Voltage , 20 Amp Load ________________V dc
Voltage Range _____________________________ V dc
Low Line Drop Out Voltage ___________________V ac
DC Variation During Dynamic Testing ___________ mV
Output Ripple __________________________ mV p-p

Manufacturer's Specifications

Power Requirement __________________________
Output Voltage ______________________________
Output Current ______________________________
Size (HWD)_________________________ Checked?_____
Weight ____________________________ Checked?_____
Output Ripple ________________________ mV p-p

DC Spectral Output Plot

0 – 100 MHz _____________________

DC Output under 20A Load

Vertical Scale, 50 mV/div
Horizontal Scale, 5 ms/div __________

Conducted Emission Levels

MHz	1A	20A
Outside Amateur Bands		
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
Inside Amateur Bands		
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Notes: ____
____

DATA SHEETS/ANTENNA ANALYZER

Manufacturer: _______________ Model: _______________ Serial#: _________________

Date: _______________ Test Engineer: ______________________

---

1) FREQUENCY RANGE TEST

1 MHz: ____________________ MHz ____________________ MHz
1.8 MHz: ____________________ MHz ____________________ MHz
3.5 MHz: ____________________ MHz ____________________ MHz
7 MHz: ____________________ MHz ____________________ MHz
14 MHz: ____________________ MHz ____________________ MHz
21 MHz: ____________________ MHz ____________________ MHz
28 MHz: ____________________ MHz ____________________ MHz
50 MHz: ____________________ MHz ____________________ MHz
144 MHz: ____________________ MHz ____________________ MHz
Other: ____________________ MHz ____________________ MHz
Other: ____________________ MHz ____________________ MHz

2A) WARM-UP DRIFT

14 MHz: ______________ MHz 15 Minutes: _________________ MHz

2B) TEMPERATURE DRIFT

Low Temp: ________________ °F High Temp: ____________________ °F

Initial Frequency (Room Temp), 14 MHz: __________________ MHz
Low Temp Drift Frequency: __________________ MHz
High Temp Drift Frequency: ___________________ MHz

---

3) OUTPUT POWER TEST

14 MHz: ____________ mW

---

4) CURRENT MEASUREMENT TEST

Measured Voltage: ______________V
Current: ______________ mA

---

5) SWR ACCURACY TEST

5 Ohm resistive load (10:1 SWR)	6.25 Ohm load (8:1 SWR)	12.5 Ohm load (4:1 SWR)
3.5 MHz: _________	___________	___________
14 MHz: _________	___________	___________
28 MHz: _________	___________	___________
50 MHz: _________	___________	___________
144 MHz: _________	___________	___________

25 Ohm load (2:1 SWR)	50 Ohm resistive load (1:1 SWR)	100 Ohm load (2:1 SWR)
3.5 MHz: _________	___________	___________
14 MHz: _________	___________	___________

28 MHz: ________	___________	___________
50 MHz: ________	___________	___________
144 MHz: ________	___________	___________

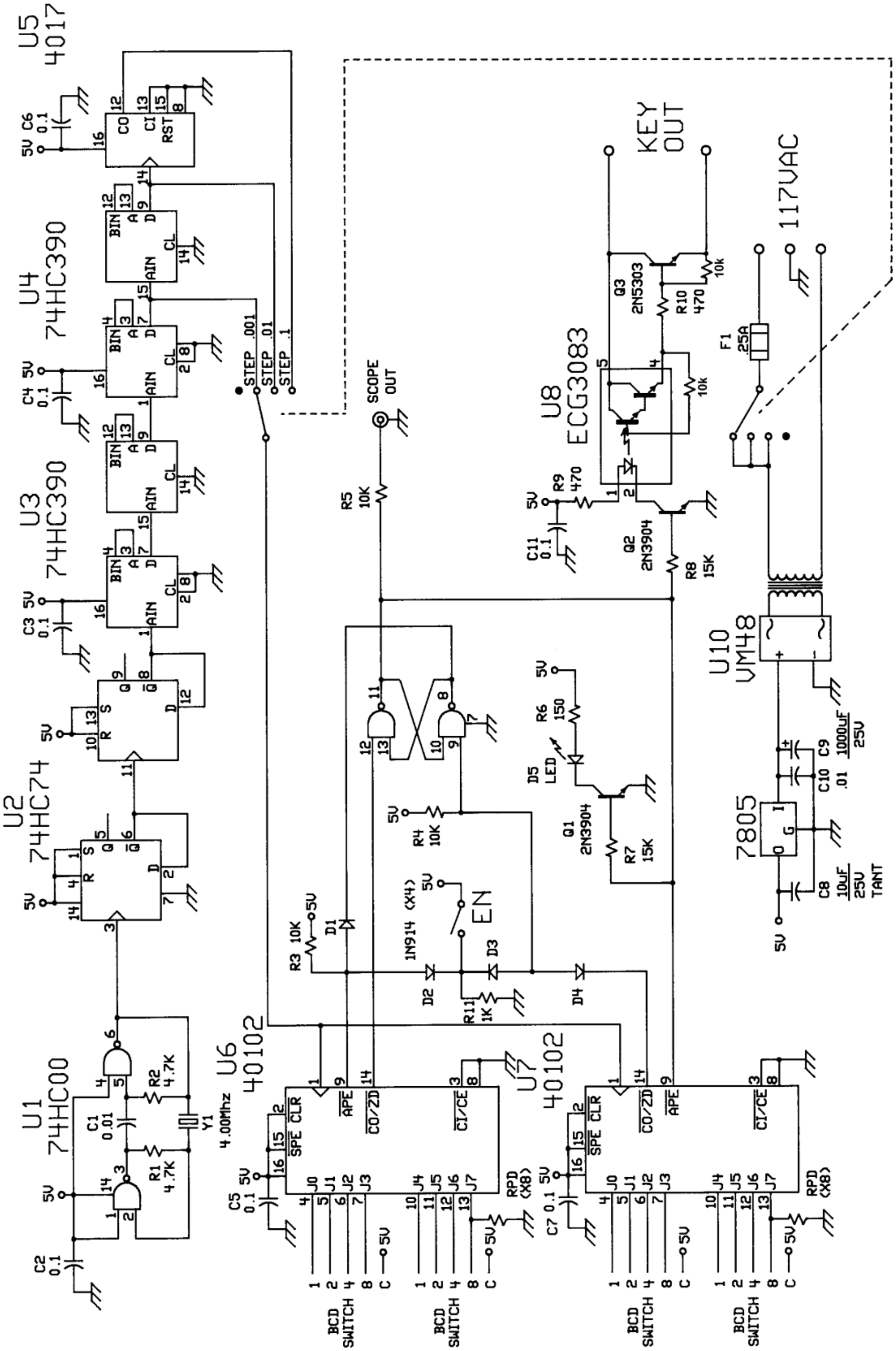
200 Ohm resistive load (4:1 SWR)	400 Ohm load (8:1 SWR)	1000 Ohm load (20:1 SWR)
3.5 MHz: ________	___________	___________
14 MHz: ________	___________	___________
28 MHz: ________	___________	___________
50 MHz: ________	___________	___________
144 MHz: ________	___________	___________

50-*j*50 Ohm reactive load (2.62:1)	50+*j*50 Ohm reactive load (2.62:1)
3.5 MHz: ________	___________
14 MHz: ________	___________
28 MHz: ________	___________

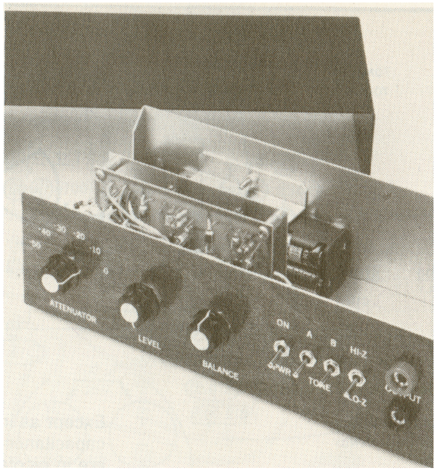
Appendix A

ARRL custom test circuits:

Keying
Generator


U1
74HC00
U2
74HC74
U3
74HC390
U4
74HC390
U5
4017
U6
40102
U7
40102
U8
ECG3083
U10
VM48
7805
4.00Mhz
STEP .001
STEP .01
STEP .1
SCOPE OUT
KEY OUT
117VAC
EN
1N914 (X4)
BCD SWITCH
BCD SWITCH
BCD SWITCH
BCD SWITCH
RPD (X8)
D5 LED
Q1 2N3904
Q2 2N3904
Q3 2N5303
F1 .25A
C9 1000uF 25V
C8 10uF 25V TANT

Two-Tone Audio Generator



Exterior view of the two-tone audio generator.

A TWO-TONE AUDIO GENERATOR

The audio frequency generator shown above makes a very convenient signal source for testing the linearity of a single-sideband transmitter. To be suitable for transmitter evaluation, a generator of this type must produce two non-harmonically related tones of equal amplitude. The level of harmonic and intermodulation distortion must be sufficiently low so as not to confuse the measurement. The frequencies used in this generator are 700 and 1900 Hz, both well inside the normal audio passband of an SSB transmitter. Spectral analysis and practical application with many different transmitters has shown this generator to meet all of the requirements mentioned above. While designed specifically for transmitter testing it is also useful any time a fixed-frequency, low-level audio tone is needed. Details on distortion measurement and the two-tone test can be found in Chapter 18.

Circuit Details

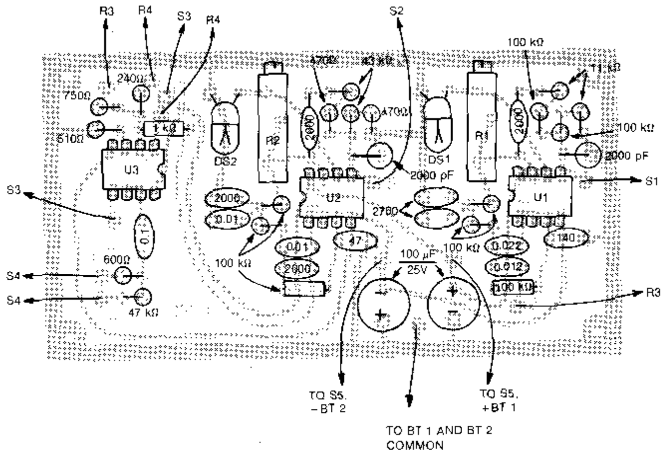
Each of the two tones is generated by a separate Wein bridge oscillator, U1B and U2B. The oscillators are followed by RC active low-pass filters, U1A and U2A. Because the filters require nonstandard capacitor values, provisions have been made on the circuit board for placing two capacitors in parallel in those cases where standard values cannot be used. The oscillator and filter capacitors should be polystyrene or Mylar film types if available. Two tones are combined at op amp U3A. This amplifier has a variable resistor, R4, in its feedback loop which serves as the output LEVEL control. While R4 varies both tones together, R3, the BALANCE control, allows the level of tone A to be changed without affecting the level of tone B. This is necessary because some transmitters do not have equal audio response at both frequencies. Following the summing amplifier is a step attenuator; S3 controls the output level in 10-dB steps. The use of two output level controls, R4 and S3, allows the output to cover a wide range and still be easy to set to a specific level.

The remaining op amp, U3B is connected as a voltage follower and serves to buffer the output while providing a high-impedance load for the step attenuator. Either high or low output impedance can be selected by S4. The values shown are suitable for most transmitters using either high- or low- impedance microphones.

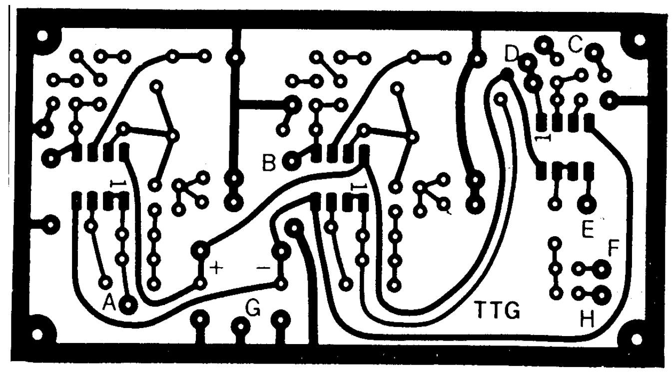
Construction and Adjustment

Component layout and wiring are not critical, and any type of construction can be used with good results. For those who wish to use a printed-circuit board, a parts placement guide is shown on the next page. Because the generator will normally be used near a transmitter, it should be enclosed in some type of metal case for shielding. Battery power was chosen to reduce the possibility of RF entering the unit through the ac line. With careful shielding and filtering, the builder should be able to use an ac power supply in place of the batteries.

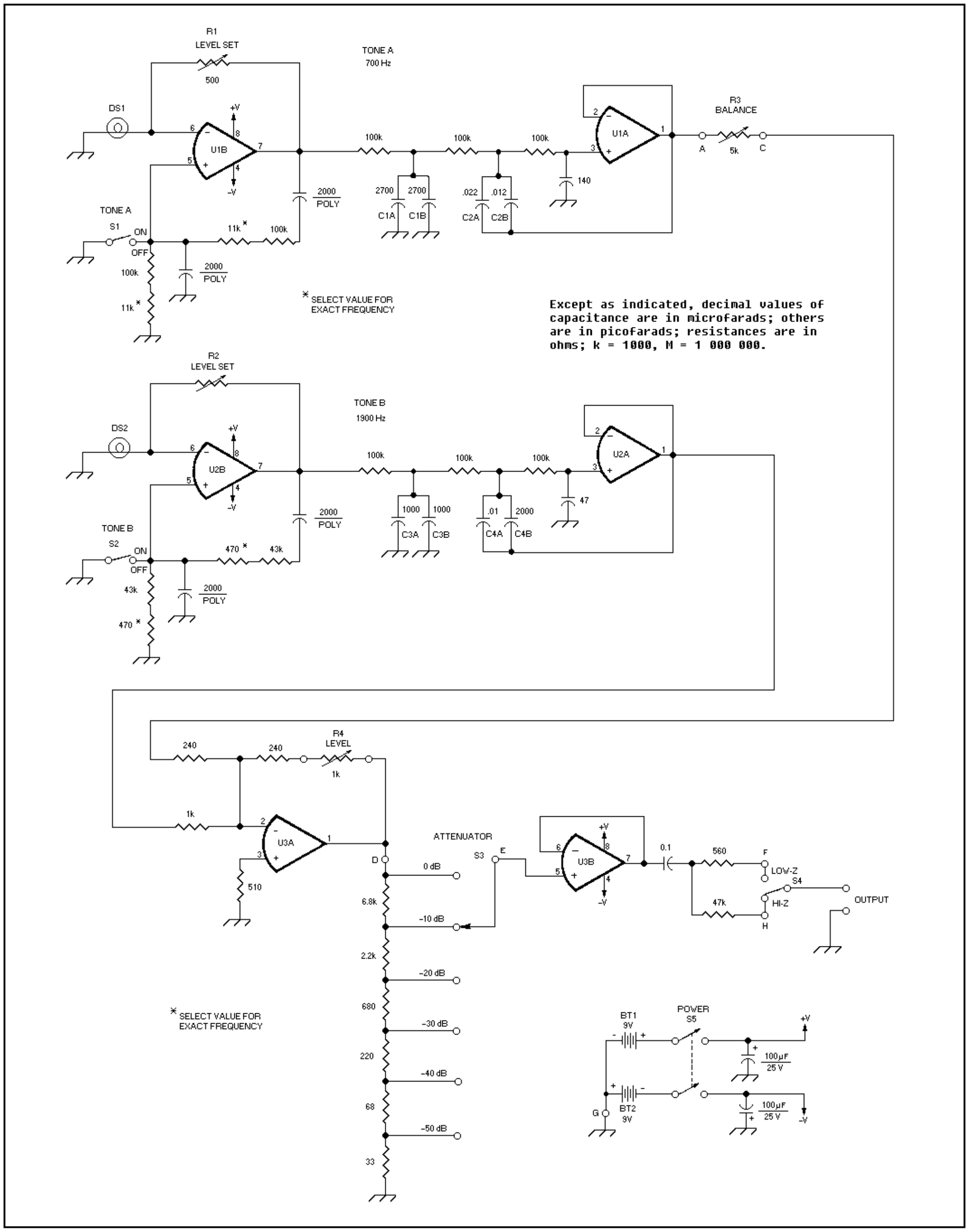
The only adjustment required before use is the setting of the oscillator feedback trimmers, R1 and R2. These should be set so that the output of each oscillator, measured at pin 7 of U1 and U2, is about 0.5 volt RMS. A VTVM or oscilloscope can be used for this measurement. If neither of these is available, the feedback should be adjusted to the minimum level that allows the oscillators to start reliably and stabilize quickly. When the oscillators are first turned on, they take a few seconds before they will have stable output amplitude. This is caused by the lamps, DS1 and DS2, used in the oscillator feedback circuit. This is normal and should cause no difficulty. The connection to the transmitter should be through a shielded cable.



Parts-placement diagram for the two-tone audio generator, shown from the component side of the board.



Printed-circuit board etching pattern, shown from the foil side of the board.



Schematic diagram of the two-tone audio generator. All resistors are 1/4-W carbon film.

BT1, BT2--9V Alkaline.
C1A, B--Total capacitance of 0.0054 µF, ±5%
C2A, B--Total capacitance of 0.034 µF, ±5%
C3A, B--Total capacitance of 0.002 µF, ±5%
C4A, B--Total capacitance of 0.012 µF, ±5%
DS1, DS2--12V, 25mA lamp.
R1, R2--500Ω, 10-turn trim potentiometer.
R3--500Ω, panel-mount potentiometer.
R4--1kΩ, panel-mount potentiometer.
S1, S2--SPST toggle switch.
S3--Single-pole, 6-position rotary switch.
S4--SPDT toggle switch.
S5--DPDT toggle switch.
U1, U2, U3--Dual JFET op amp, type LF353N
or TL082.