ARRL Laboratory Test Result Report

Manufacturer: ICOM

Model: IC-775DSP

Serial #: 01179

QST "Product Review" January, 1996 page 67.

American Radio Relay League, Inc., Technical Department Laboratory, 225 Main St., Newington, CT 06111, (860) 594-0214. Internet: mtracy@arrl.org.

Price $7.50 for ARRL Members, $12.50 for non-Members, postpaid.

Test Record:

Test or Test Series	Test Engineer	Date
Test battery	Mike Gruber	8-1-95
Spectral purity graphs	Ed Hare	11-15-95

Table of Contents:
(Page numbers are omitted because the length of the report varies from unit to unit.)

Introduction:

This document summarizes the extensive battery of tests performed by the ARRL Laboratory for each unit that is featured in *QST* "Product Review." For all tests, there is a discussion of the test and test method used in ARRL Laboratory testing. For most tests, critical conditions are listed to enable other engineers to duplicate our methods. For some of the tests, a block diagram of the test setup is included. The ARRL Laboratory has a document, the *ARRL Laboratory Test Procedures Manual*, that explains our specific test methods in detail, with a test description similar to the one in this report, a block diagram showing the specific equipme nt currently in use for each test, along with all equipment settings and a specific step by step procedure used in the ARRL Laboratory. While this is not available as a regular ARRL publication, the ARRL Technical Department Secretary can supply a copy at a cost of $20.00 for ARRL Members, $25.00 for non-Members, postpaid.

Most of the tests used in ARRL product testing are derived from recognized standards and test methods. Other tests have been developed by the ARRL Lab. The ARRL Laboratory test equipment is calibrated annually, with traceability to National Institute of Standards and Technology (NIST). Most of the equipment is calibrated by a contracted calibration laboratory. Other equipment, especially the custom test fixtures, is calibrated by the ARRL Laboratory Engineers, using calibrated equipment and standard techniques.

The units being tested are operated as specified by the equipment manufacturer. The ARRL screen room has an ac supply that is regulated to 117 or 234 volts. If possible, the equipment under test is operated from the ac supply. Mobile and portable equipment is operated at the voltage specified by the manufacturer, at 13.8 volts if not specified, or from a fully charged internal battery. Equipment that can be operated from 13.8 volts (nominal) is also tested for function, output power and frequency accuracy at the minimum specified voltage, or 11.5 volts if not specified. Units are tested at room temperature and humidity as determined by the ARRL HVAC system. Also, units that are capable of mobile or portable operation are tested at their rated temperature range, or at -10 to +60 degrees Celsius in a commercial temperature chamber.

ARRL "Product Review" testing represents a sample of only one unit (although we sometimes obtain an extra sample or two for comparison purposes). This is not necessarily representative of all units of the same model number. It is not uncommon that some parameters will vary significantly from unit to unit. The ARRL Laboratory and Product Review editor work with manufacturers to resolve any deviation from specifications or other problems encountered in the review process. These problems are documented in the Product Review.

Units used in "Product Review" testing are purchased off the shelf from major distributors. We take all necessary steps to ensure that we do not use units that have been specially selected by the manufacturer. When the review is complete, the unit is offered for sale in an open mail bid, announced regularly in *QST* .

Related ARRL Publications and Products:

The *1998 ARRL Handbook for Radio Amateurs* has a chapter on test equipment and measurements. The book is available for $32.00 plus $6 shipping and handling. The *Handbook* is also now available in a convenient, easy to use CD-ROM format. In addition to the complete *Handbook* text and graphics, the CD-ROM includes a search engine, audio clips, zooming controls, bookmarks and clipboard support. The cost is $49.95 plus $4.00 shipping and handling. You can order both versions of the *Handbook* from our Web page, or contact the ARRL Publications Sales Department at 888-277-289 (toll free). It is also widely stocked by radio and electronic dealers and a few large bookstores.

The ARRL Technical Information Service has prepared an information package that discusses Product Review testing and the features of various types of equipment. Request the "What is the Best Rig To Buy" package from the ARRL Technical Department Secretary. The cost is $2.00 for ARRL Members, $4.00 for non-Members, postpaid.

Many *QST* "Product Reviews" have been reprinted in three ARRL publications: The *ARRL Radio Buyers Sourcebook* (order #3452) covers selected Product Reviews from 1970 to 1990. The cost is $15.00 plus $4.00 shipping and handling. The *ARRL Radio Buyers Sourcebook Volume II* (order #4211) contains reprints of all of the Product Reviews from 1991 and 1992. The cost is $15.00 plus $4.00 shipping and handling. The *VHF/UHF Radio Buyer's Sourcebook* (order #6184) contains nearly 100 reviews of transceivers, antennas, amplifiers and accessories for VHF and above. You can order these books from our Web page or contact the ARRL Publications Sales Department to order a copy.

QST is now available on CD ROM! The *1995 ARRL Periodicals CD ROM* (order #5579) and the *1996 ARRL Periodicals CD ROM* (order #6109) contain a complete copy of all articles from a year's worth of *QST,* the *National Contest Journal* and *QEX,* ARRL's experimenter's magazine. It is available for $19.95 plus $4.00 for shipping and handling. Contact the ARRL Publications Sales Department to order a copy.

Older issues of *QST* are also available: *QST View CD-ROMs* come in sets covering several years each **-** *QST View 1990-1994* (order #5749), *QST View 1985-1989* (order #5757), *QST View 1980-1984* (order #5765), *QSTView 1975-1979* (order #5773), *QSTView 1970-1974* (order #5781), *QSTView 1965-1969* (order #6451), *QSTView 1960-1964* (order #6443) and *QSTView 1950-1959* (order #6435). The price for each set is $39.95. Shipping and handling for all ARRL CD ROM products is $4.00 for the first one ordered, $1.00 for each additional set ordered at the same time.

Additional test result reports are available for:

Manufacturer	Model	Issue
Alpha Power	91ß	Sep 97
Amewritron	AL-800H	Sep 97
ICOM	IC-706	Mar 96
	IC-756	May 97
	IC-775DSP	Jan 96
	IC-821H	Mar 97
JRC	NRD-535	May 97
Kenwood	TS-570D	Jan 97
	TS-870S	Feb96
QRO	HF-2500DX	Sep 97
Ten-Tec	Centaur	Jun 97
	Omni VI +	Nov 97
Yaesu	FT-920	Oct 97
	FT-1000MP	Apr 96

The cost is $7.50 for ARRL Members, $12.50 for non-Members for each report, postpaid. ARRL Members can obtain any three reports for $20.00, postpaid.

Transmitter Output Power:

Test description: One of the first things an amateur wants to know about a transmitter or receiver is its RF output power. The ARRL Lab measures the CW output power for every band on which a transmitter can operate. The unit is tested across the across the entire amateur band and the worst-case number for each band is reported. The equipment is also tested on one or more bands for any other mode of operation for which the transmitter is capable. Typically, the most popular band of operation for each mode is selected. Thus, on an HF transmitter, the SSB tests are done on 75 meters for lower sideband, 20 meters for upper sideband, and AM tests are done on 75 meters, FM tests are done on 10 meters, etc. This test also compares the accuracy of the unit's internal output-power metering against the ARRL Laboratory's calibrated test equipment.

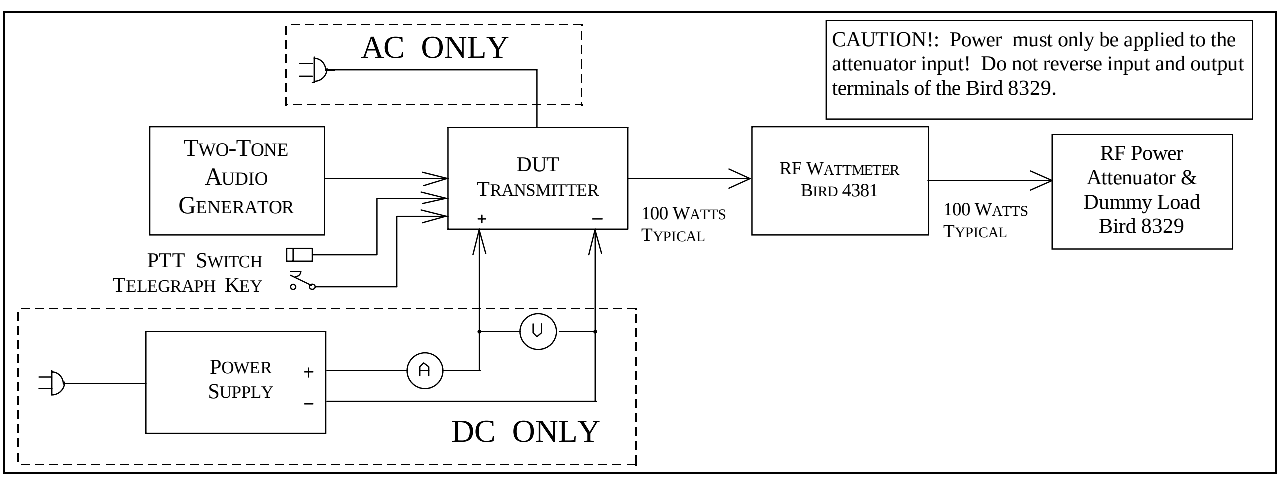
The purpose of the Transmitter Output-Power Test is to measure the DC current consumption at the manufacturer's specified DC-supply voltage, if applicable, and the RF output power of the unit under test across each band in each of its available modes. A two-tone audio input, at a level within the manufacturer's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

Many transmitters are derated from maximum output power on the full-carrier, double-sideband (AM)and FM modes. In most cases, a 100-watt CW/SSB transmitter may be rated at 25 watts carrier power on AM. The radio may actually deliver 100 watts PEP in AM or FM but is not specified to deliver that power level for any period of time. In these cases, the published test-result table will list the AM or FM power as being "as specified."

In almost all cases, the linearity of a transmitter decreases as output power increases. A transmitter rated at 100 watts PEP on single sideband may actually be able to deliver more power, but as the power is increased beyond the rated RF output power, adjacent channel splatter (IMD) usually increases dramatically. If the ARRL Lab determines that a transmitter is capable of delivering its rated PEP SSB output, the test-result table lists the power as being "as specified."

Key Test Conditions:
Termination: 50 ohms resistive, or as specified by the manufacturer.

Block Diagram:



Transmitter Output Power Test Results:

Frequency	Mode	Unit Minimum Power	Measured Minimum Power	Unit Maximum Power	Measured Maximum Power	Notes
1.8 MHz	CW	N/A	<1W	N/A	204W	
3.5 MHz	CW	N/A	<1W	N/A	200W	
3.5 MHz	AM	N/A	1.0W	N/A	47.3W	
7.0 MHz	CW	N/A	<1	N/A	200W	
10.1 MHz	CW	N/A	<1	N/A	200W	
14.0 MHz	CW		<1	220W	201W	
14.0 MHz	USB		<1	210W	201W	
14.0 MHz	CW	N/A	<1	N/A	N/A	1
14.0 MHz	CW	N/A	<1	N/A	N/A	2
14.0 MHz	CW	N/A	N/A	N/A	N/A	3
18.0 MHz	CW	N/A	<1	N/A	201W	
21 MHz	CW	N/A	<1	N/A	201W	
24 MHz	CW	N/A	<1	N/A	201W	
28.0 MHz	CW	N/A	<1	N/A	200W	
28.0 MHz	FM	N/A	1.2W	220W	199W	

Notes:
1. Temperature chamber test at -10 degrees Celsius.
2. Temperature chamber test at +60 degrees Celsius.
3. Output power test at 11.5 volts dc power supply (if applicable).

Temperature chamber tests and 11.5 volt tests are performed only for portable and mobile equipment.

Transverter Jack Output Power Test:

Test Description: This test measures the output power from the transverter jack (if applicable). This is usually somewhere near 0 dBm. The transverter-jack power usually varies from band to band. The 28-MHz band is the most common band for transverter operation. Most transverter outputs are between -10 dBm and + 10 dBm.

Test Results:

Frequency	Output	Notes
20 M	-10.2 dBm	1,2
15 M	-12.2 dBm	1,2
10 M	-12.1 dBm	1,2

Notes:
1. -10 dBm nominal = 100 uW.
2. Output was observed to be roughly the same on all bands.

Current Consumption Test: (DC-powered units only)

Test Description: Current consumption can be a important to the success of mobile and portable operation. While it is most important for QRP rigs, the ARRL Lab tests the current consumption of all equipment that can be operated from a battery or 12-14 vdc source. The equipment is tested in transmit at maximum output power. On receive, it is tested at maximum volume, with no input signal, using the receiver's broadband noise. Any display lights are turned on to maximum brightness, if applicable.

Transmit Current Consumption:

Voltage	Current	Output Power	Notes
N/A	N/A	N/A	1

Receive Current Consumption:

Voltage	Current	Lights?	Notes
N/A	N/A	N/A	1

Notes:
1. This test is not performed on ac-main powered equipment.

Transmit Frequency Range Test:

Test Description: Many transmitters can transmit outside the amateur bands, either intentionally, to accommodate MARS operation, for example, or unintentionally as the result of the design and internal software. The ARRL Lab tests the transmit frequency range inside the screen room. 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. The key test conditions are to test it at rated power, using nominal supply voltages. Frequencies are as indicated on the transmitter frequency indicator or display. Most modern synthesized transmitters are capable of operation outside the ham bands. However, spectral purity is not always legal outside the hams bands, so caution must be used.

Test Results:

Frequency	Low-Frequency Limit	High-Frequency Limit	Notes
160 M	1.800.00 MHz	1.999.99 MHz	
80 M	3.400.00 MHz	4.099.99 MHz	
40 M	6.900.00 MHz	7.499.99 MHz	
30 M	9.900.00 MHz	10.499.99 MHz	
20 M	13.900.00 MHz	14.499.99 MHz	
17 M	17.900.00 MHz	18.499.99 MHz	
15 M	20.900.00 MHz	21.499.99 MHz	
12 M	24.400.00 MHz	25.099.99 MHz	
10 M	28.000.00 MHz	29.999.99 MHz	

Notes:

CW Transmit Frequency Accuracy Test:

Test Description: Most modern amateur equipment is surprisingly accurate in frequency. It is not uncommon to find equipment operating within a few Hz of the frequency indicated on the frequency display. However, some units, notably "analog" units, not using a phase-lock loop in the VFO design, can be off by a considerable amount. This test measures the output frequency. Unit is operated into a 50-ohm resistive load at nominal temperature and supply voltage. Frequency is also measured at minimum output power, low supply voltage (12 volt units only) and over the operating temperature range (mobile and portable units only).

Test Results:

Unit Frequency	Supply Voltage	Temperature	Measured Frequency Full Output Power	Measured Frequency Minimum Output Power	Notes
14.000.00 MHz	N/A	25 C	14.000.00 MHz	14.000.00 MHz	1,2

Notes:
1. Temperature specified as 25 C is nominal room temperature.
2. Non-portable equipment is not tested in the temperature chamber.

Transmit Frequency Offset Test:

Test Description: This test measures the difference between the CW receive and transmit frequencies. The receive CW audio pitch will be equal to the transmit offset frequency.

Test Results:

Default Offset	Minimum Offset	Maximum Offset	Notes
600 Hz	300 Hz	900 Hz	

Notes:

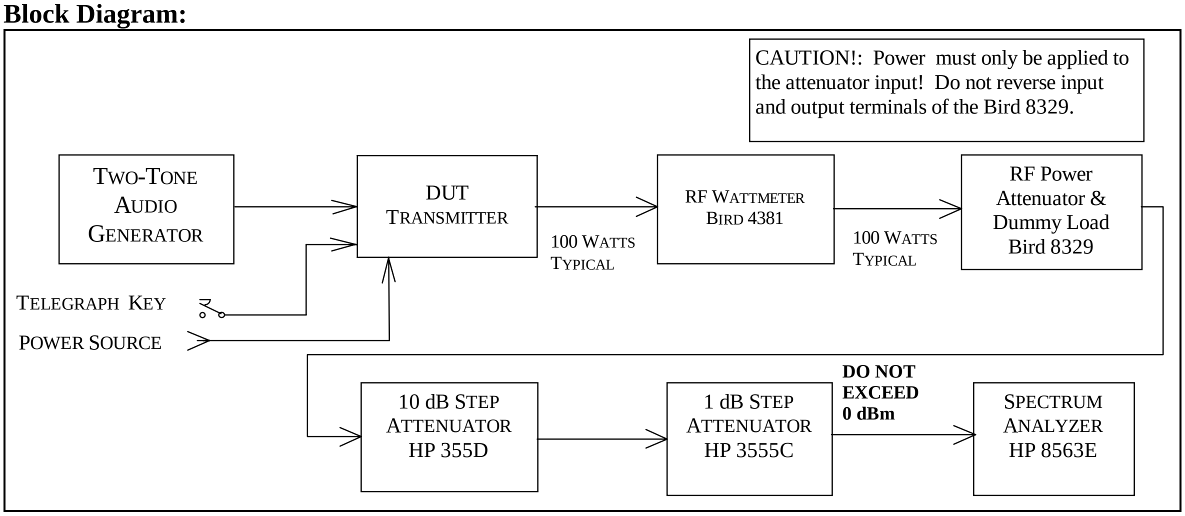
Spectral Purity Test:

Test Description: All transmitters emit some signals outside their assigned frequency or frequency range. These signals are known as spurious emissions or "spurs." Part 97 of the FCC rules and regulations specify the amount of spurious emissions that can be emitted by a transmitter operating in the Amateur Radio Service. The ARRL Laboratory uses a spectrum analyzer to measure the spurious emission on each band on which a transmitter can operate. The transmitter is tested across the band and the worst-case spectral purity on each band is captured from the spectrum analyzer and stored on disk. Spectral purity is reported in dBc, meaning dB relative to the transmitted carrier.

The graphs and tables indicate the relative level of any spurious emissions from the transmitter. The lower that level, expressed in dB relative to the output carrier, the better the transmitter is. So a transmitter whose spurious emissions are -60 dBc (dB relative to the carrier) is a spectrally cleaner than is one whose spurious emissions are -30 dBc. FCC Part 97 regulations governing spectral purity are contained in 97.307 of the FCC rules. Information about all amateur rules and regulations is found in the *ARRL FCC Rule Book.* Additional information about the decibel is found in the *ARRL Handbook.*

Key Test Conditions:
Unit is operated at nominal supply voltage and temperature.
Output power is adjusted to full power on each amateur band.
A second measurement is taken at minimum power to ensure that the spectral output is still legal at low power.
The level to the spectrum analyzer is - 10 dBm maximum.
The resolution bandwidth of the spectrum analyzer is 10 kHz on HF, 100 kHz on VHF, MHz on UHF.

Block Diagram:

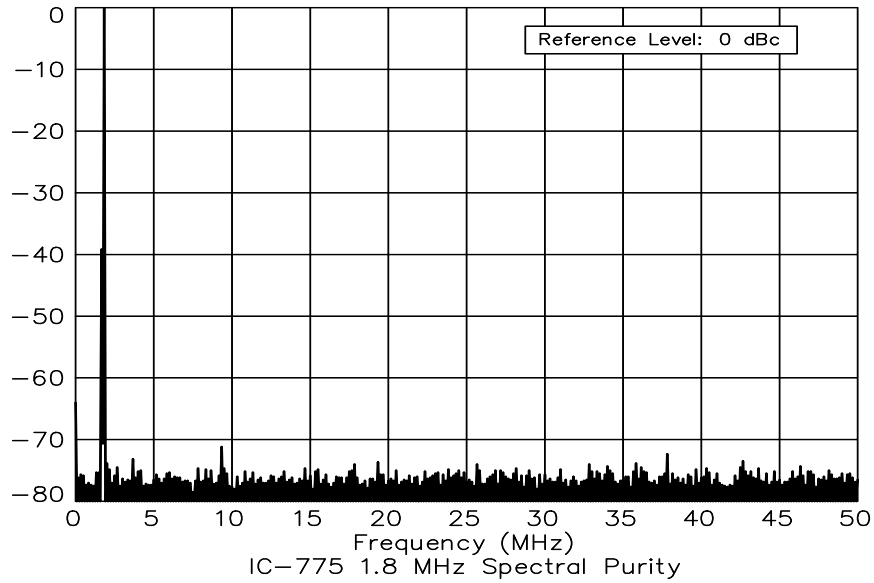


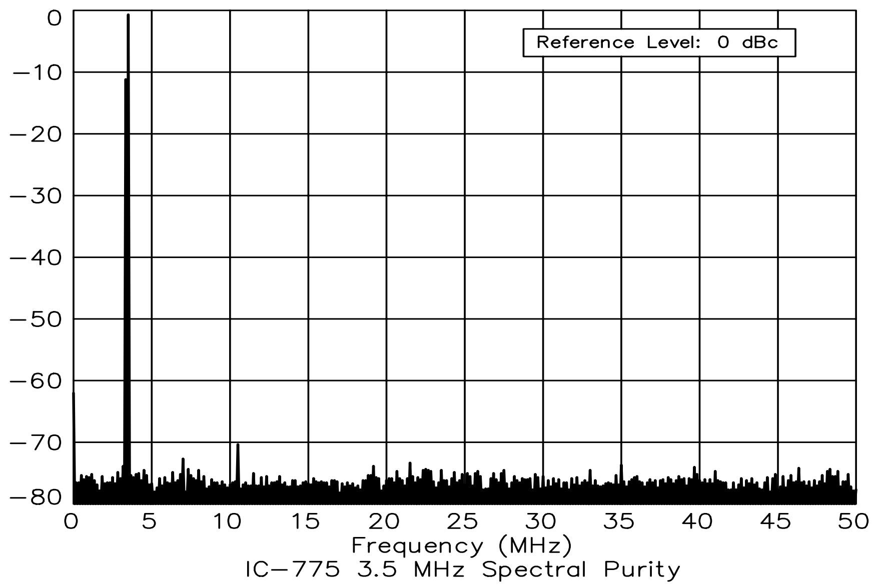
Test Results - summary:

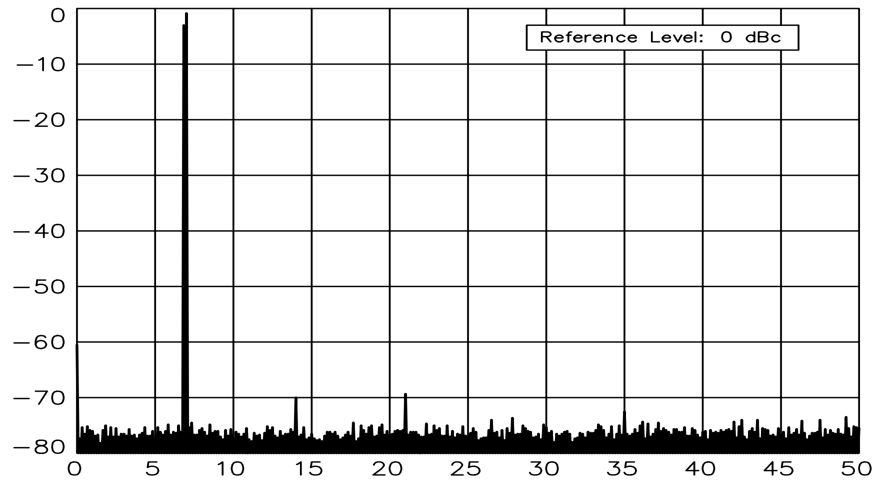
Frequency	Spurs (dB)	Notes
1.8 MHz	<-60 dBc	1
3.5 MHz		
7.0 MHz		
10.1 MHz		
14.0 MHz		
18.0 MHz		
21.0 MHz		
24.0 MHz		
28.0 MHz		

Notes:
1. Spectral purity was better than - 60 dBc on all bands. This is an exceptionally clean transmitter.

Transmit Spectral Purity Graphs:

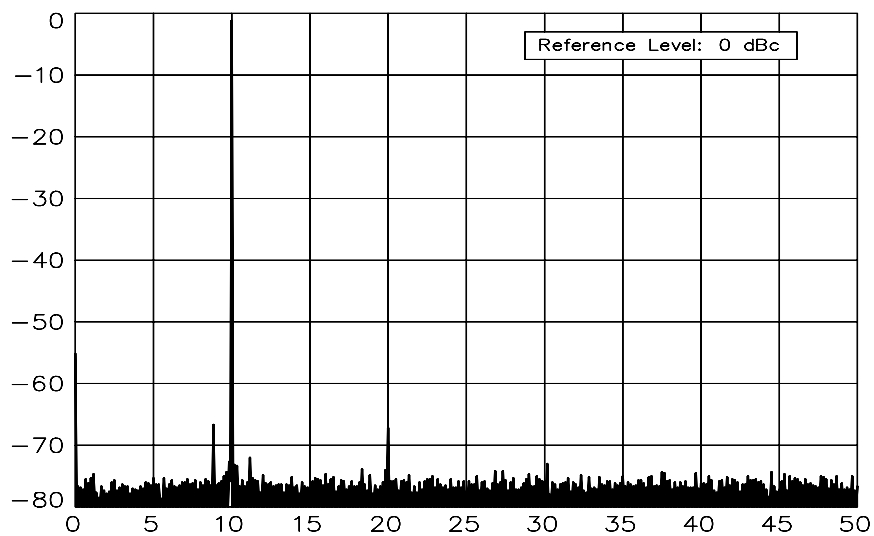




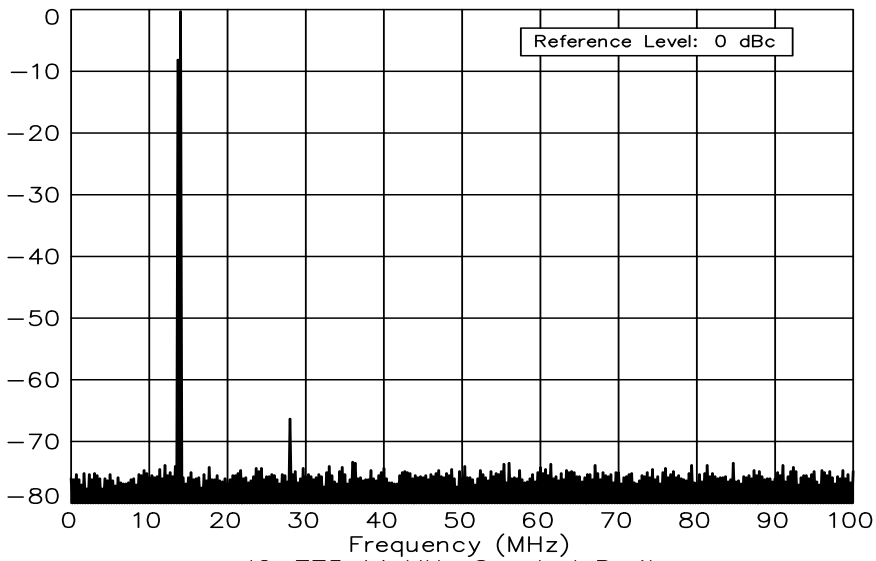


IC−775 7.0 MHz Spectral Purity

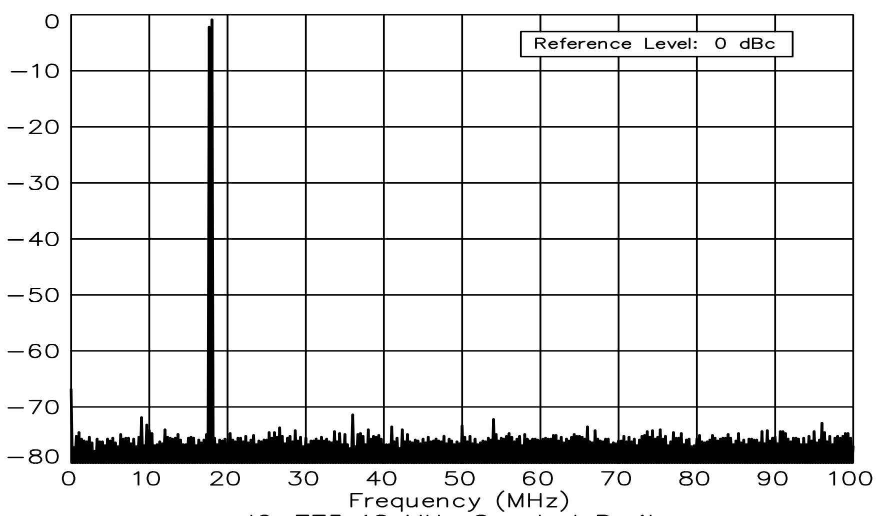
Transmit Spectral Purity Graphs:



IC−775 10.1 MHz Spectral Purity

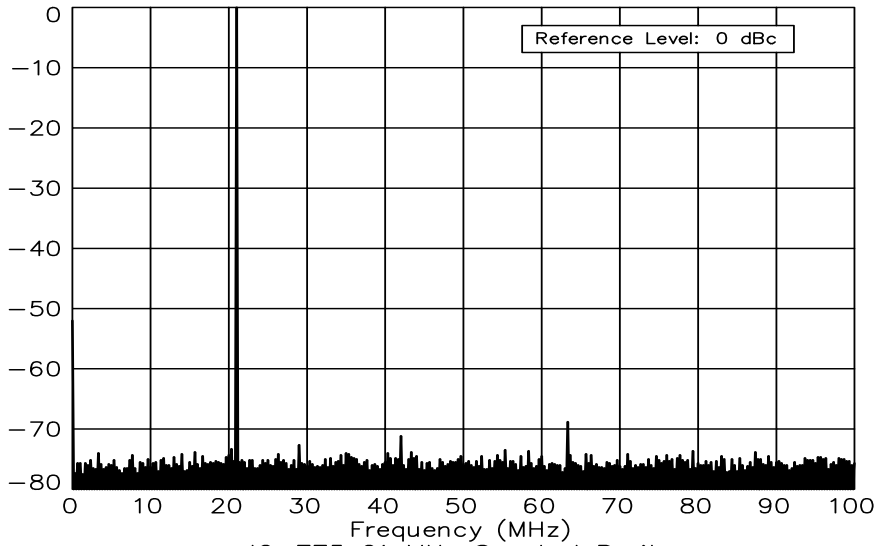


IC−775 14 MHz Spectral Purity

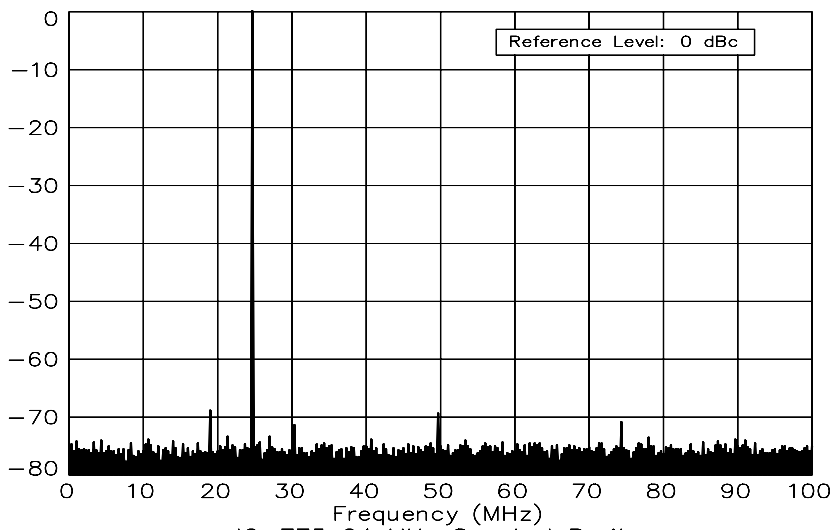


IC−775 18 MHz Spectral Purity

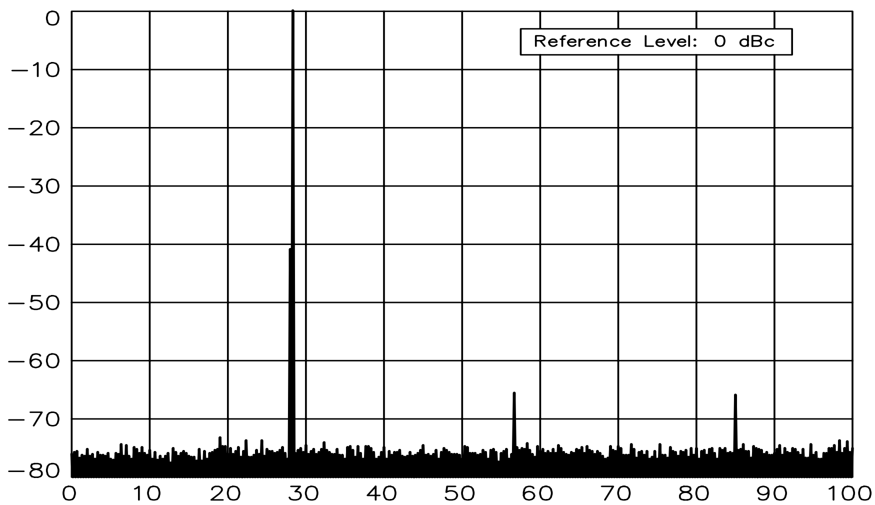
Transmit Spectral Purity Graphs:



IC−775 21 MHz Spectral Purity



IC−775 24 MHz Spectral Purity



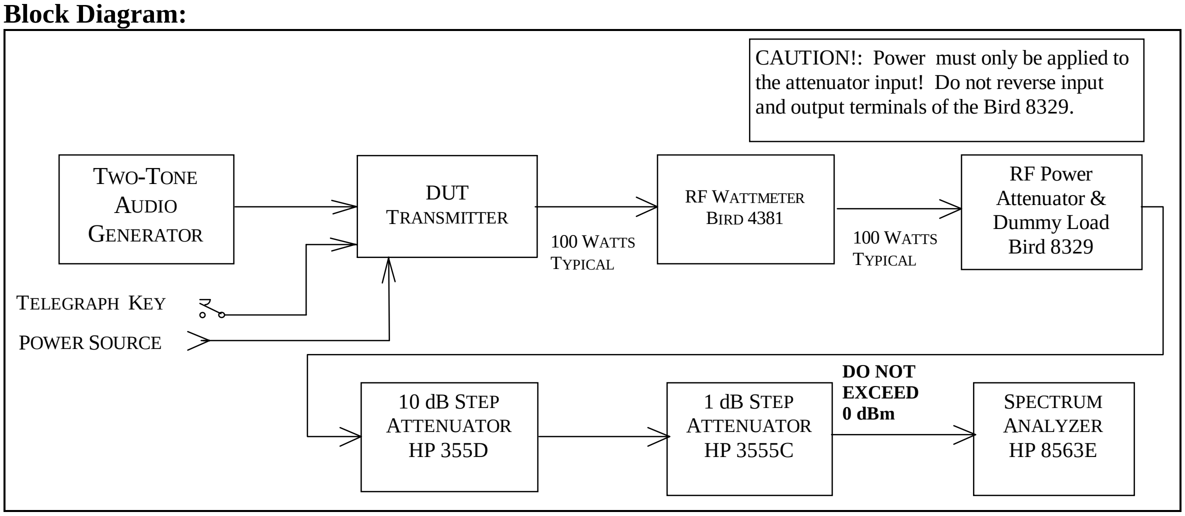
IC−775 28 MHz Spectral Purity

Transmit Two-Tone IMD Test:

Test Description: Investigating the sidebands from a modulated transmitter requires a narrow-band spectrum analysis. In this test, a two-tone test signal is used to modulate the transmitter. The display shows the two test tones plus some of the IMD products produced by the SSB transmitter. In the ARRL Lab, a two-tone test signal with frequencies of 700 and 1900 Hz is used to modulate the transmitter. These frequencies were selected to be within the audio passband of the typical transmitter, resulting in a meaningful display of transmitter IMD. The intermodulation products appear on the spectral plot above and below the two tones. The lower the intermodulation products, the better the transmitter. In general, it is the products that are farthest removed from the two tones (typically > 3 kHz away) that cause the most problems. These can cause splatter up and down the band from strong signals.

Key Test Conditions:
Transmitter operated at rated output power.
Audio tones and drive level adjusted for best performance.
Audio tones 700 and 1900 Hz.
Both audio tones adjusted for equal RF output.
Level to spectrum analyzer, - 10 dBm nominal, -10 dBm maximum
Resolution bandwidth, 10 Hz

Block Diagram:

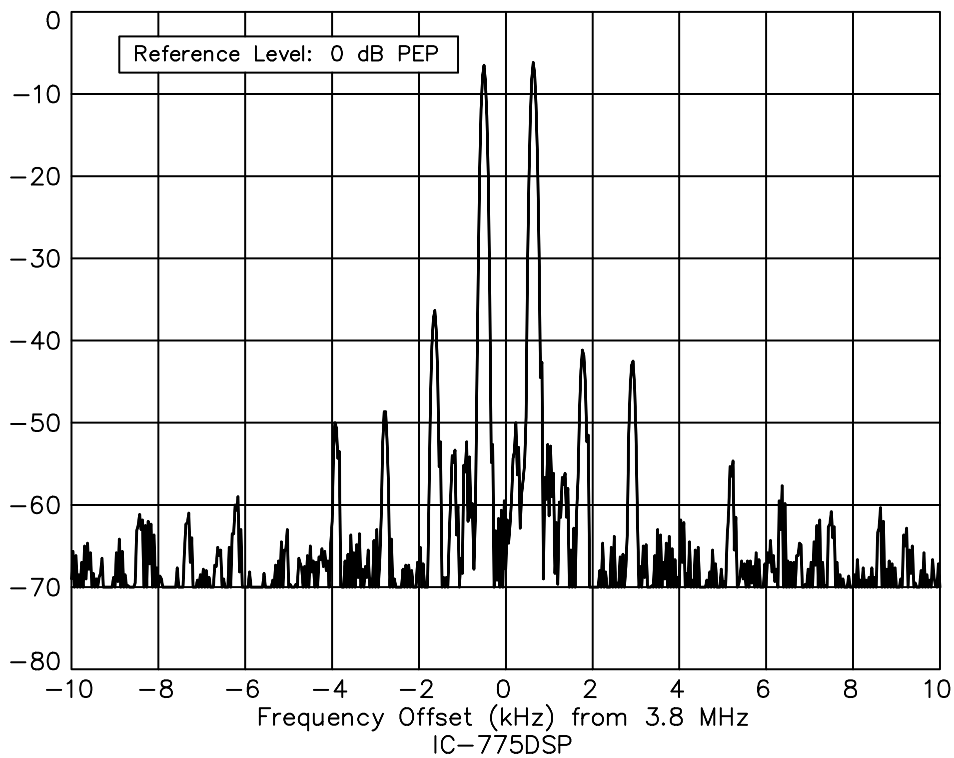


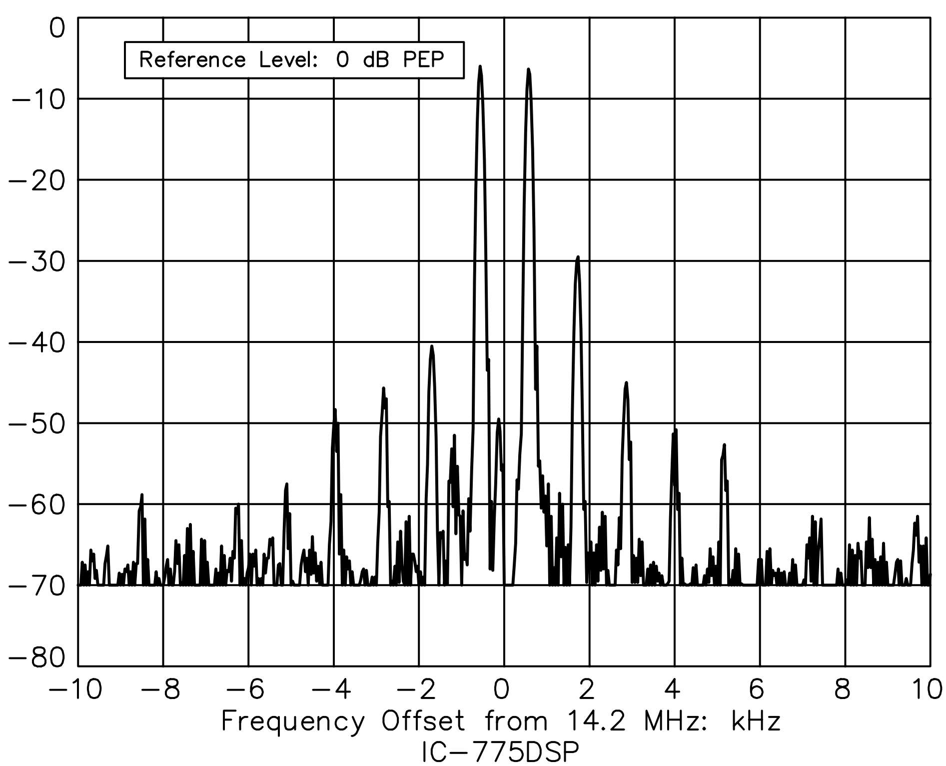
Test Result Summary:

Frequency	Worst-case 3rd-order	Worst-case 5th-order	Notes
3.9 MHz	- 36 dB	- 42 dB	
14.2 MHz	- 30 dB	- 41 dB	

Notes:

Transmit Two-Tone IMD Graphs:





SSB Carrier and Unwanted Sideband Suppression Test:

Test Description: The purpose of the SSB Carrier and opposite-sideband Suppression test is to determine the level of carrier and unwanted sideband suppression 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. The level to the spectrum analyzer is - 10 dBm nominal. The measurement bandwidth is 100 Hz. The greater the amount of suppression, the better the transmitter. For example, opposite sideband suppression of 60 dB is better than suppression of 50 dB.

Test Results:

Frequency	Carrier Suppression	Opposite Sideband Suppression	Notes
14.2 MHz USB	< 50 dB below PEP	< 60 dB below PEP	
14.2 MHz LSB	< 50 dB below PEP	< 60 dB below PEP	

CW Keying Waveform Test:

Test Description: The purpose of the CW Keying Waveform Test is to determine the rise and fall times for the 10% to the 90% point of the device under test's RF output envelope in the CW mode. The on and off delay times from key contact to RF output are also measured. If the transmitter under test has several CW modes, (i.e. VOX, QSK) these measurements is made at rated output power for each mode. A picture of the oscilloscope screen is taken of the results with the QSK off, and in the VOX mode showing the first dit, and any other test conditions that result in a waveshape that is significantly different from the others (more than 10% difference, spikes, etc.). The first and second dits are shown in all modes.

If the risetime or falltime become too short, the transmitter will generate key clicks. Most click-free transmitters have a rise and fall time between 1 ms and 5 ms. The absolute value of the on delay and off delay are not critical, but it is important that they be approximately the same so that CW weighting will not be affected.

Some transmitters used in the VOX mode exhibit a first dit that is shorter than subsequent dits. Other transmitters can show significant shortening of all dits when used in the QSK mode. The latter will cause keying to sound choppy.

The first dit foreshortening is expressed as a "weighting" number. In perfect keying, the weighting is 50%, meaning that the carrier is ON for 50% of the time.

Key Test Conditions:
The transmitter is operated at room temperature at rated output power into a 50-ohm resistive load. The power supply voltage is nominal. Attenuators are adjusted to obtain 3 volts RMS to the oscilloscope.

Test Result Summary:

Frequency	Mode	First Dit Risetime	First Dit Falltime	Subsequent Dits Risetime	Subsequent Dits Falltime	On Delay	Off Delay	Weight %	First Dit Weight %
14.02 MHz	QSK	0.6 ms	1.6 ms	1.8 ms	1.8 ms	9.0 ms	3.0 ms	25%	25%
14.02 MHz	VOX	0.6 ms	1.6 ms	1.2 ms	1.6 ms	8.4 ms	3.0 ms	25%	12.7%

Captions (Figures on next page):
All Figures are 10 ms/division.
Figure 1. This shows the first and second dits in the VOX mode. Note that the first dit is significantly foreshortened.
Figure 2. This shows the subsequent dits in the VOX mode.
Figure 3. This shows the first and seconds dits in the QSK mode. The first dit is a bit sharper than the following dits, but this will probably not be noticable in normal operation.

CW Keying Waveforms:

Figure 1

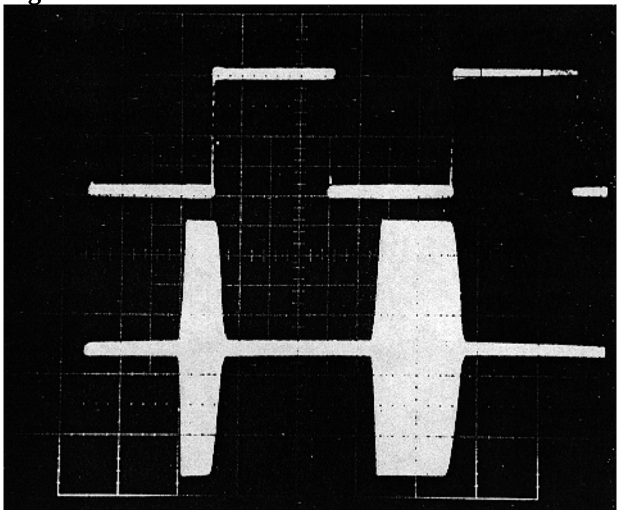


Figure 2

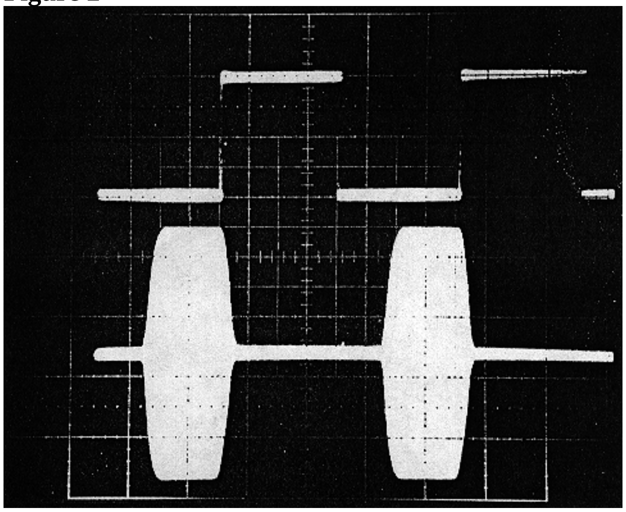
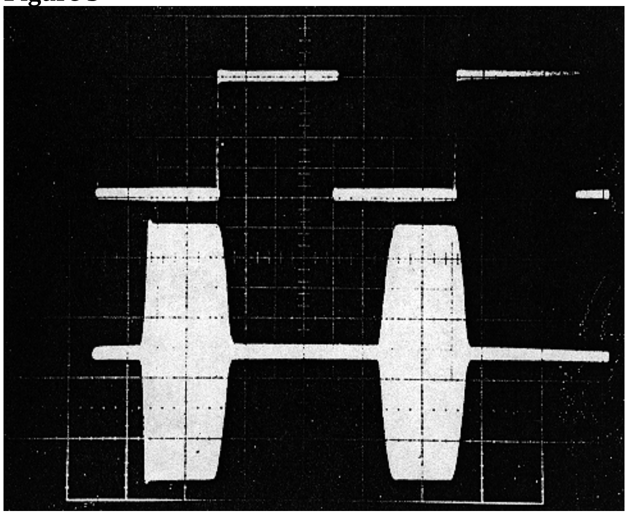


Figure 3



Transmit Keyer Speed Test:

Test Description: This test measures the speed of the internal keyer on transmitters so equipped. The keyer is tests at minimum, midrange and maximum speeds and the time from dit to dit is measured using an oscilloscope and used to calculate the speed using the "Paris" method of code speed calculation. (In the Paris method, the word "Paris" is used as the standard word to calculate words per minute.)

Test Results:

Min WPM	Max WPM	Mid WPM	Notes
8.3	85.7	34.2	

Notes:

Sidetone Pitch Test:

Test Description: This test measures the sidetone pitch, including the range of adjustment. In many transceivers, the sidetone pitch tracks the CW offset, so setting the received CW tone to be equal to the sidetone is possible for zero beating.

Test Results:

Default Pitch	Minimum Pitch	Maximum Pitch	Notes
600 Hz	300 Hz	900 Hz	1

Notes:
1. As programmed from the front-panel menu. This is identical to the offset.

Transmit/Receive Turnaround Test:

Test Description: The purpose of the Transmit/Receive turnaround test is to measure the delay required to switch from the transmit to the receive mode of a transceiver.

Test Results:

Frequency	Conditions	T/R Delay	Notes
14.2 MHz	50% audio	18 ms	1

Notes:
1. T/R delay less than or equal to 35 ms is suitable for use on AMTOR.

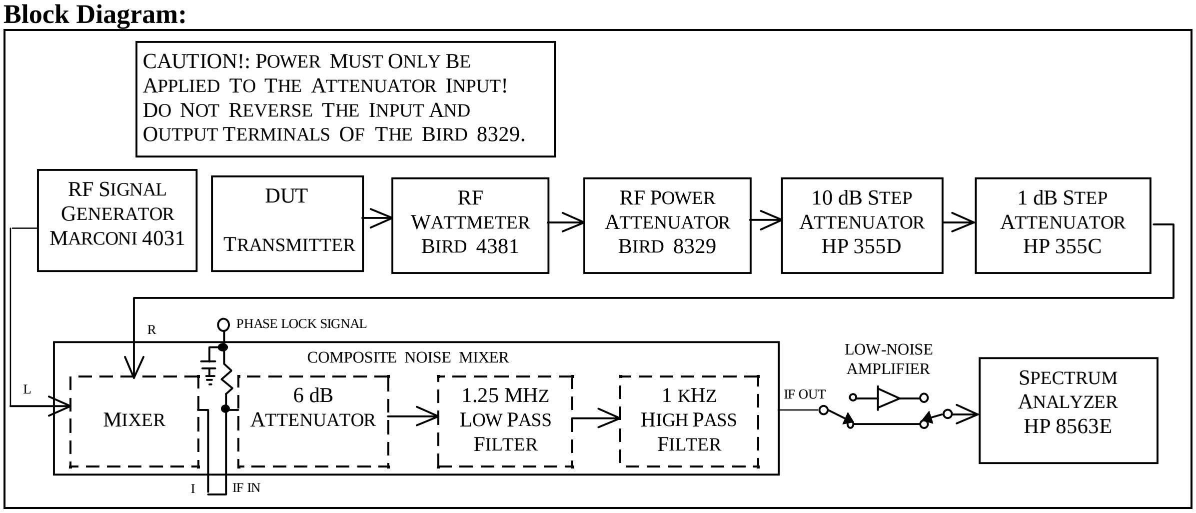
Transmit Composite Noise Test:

Test Description: The purpose of the Composite-Noise Test is to observe and measure the phase and amplitude noise, as well as any spurious signals generated by the device under test 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. This measurement is accomplished by converting the output of the transmitter down to a frequency about 10 or 20 Hz above baseband. A mixer and a signal generator used as a local oscillator are used to perform this conversion. Filters remove the 0 Hz component as well as the unwanted heterodyne components. The remaining noise and spurious signals are then observed on the spectrum analyzer.

The lower the noise as seen on the plot, the better the transmitter.

Key Test Conditions:
Transmitter operated at rated output power into a 50-ohm resistive load.
Transmitter operated at room temperature.
Frequencies from 2 to 22 kHz from the carrier are measured.
Ten sweeps are averaged on the spectrum analyzer to reduce noise.

Block Diagram:

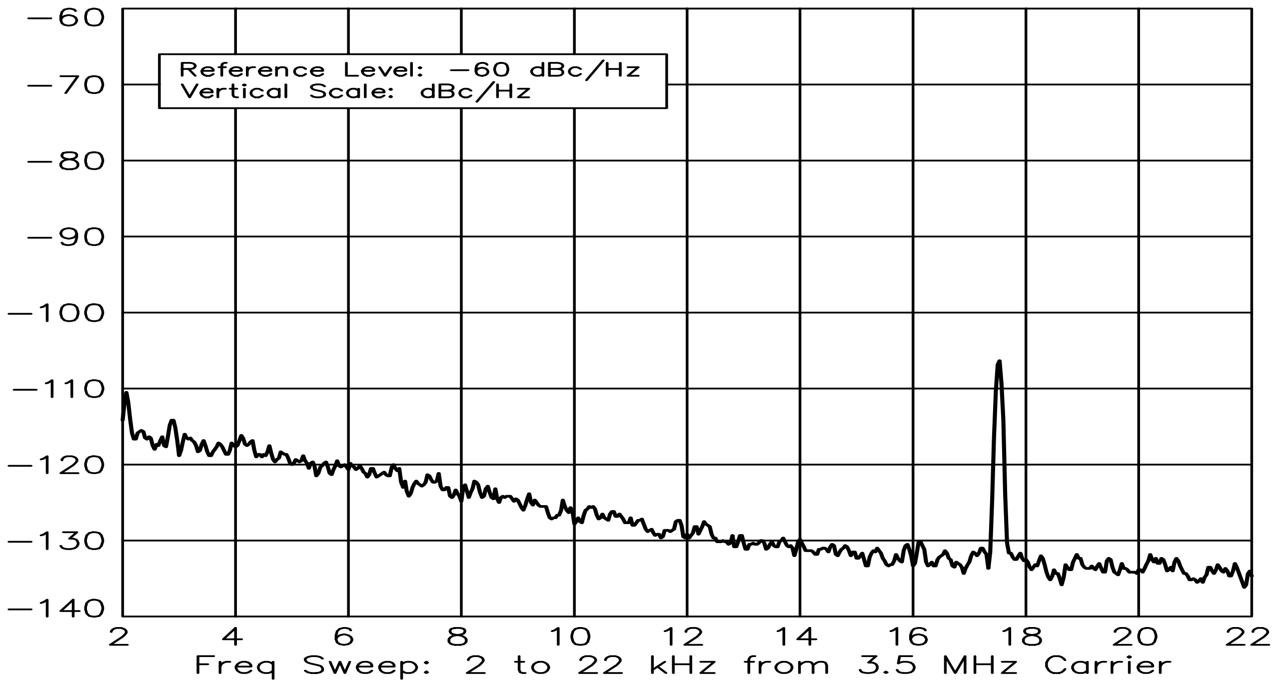


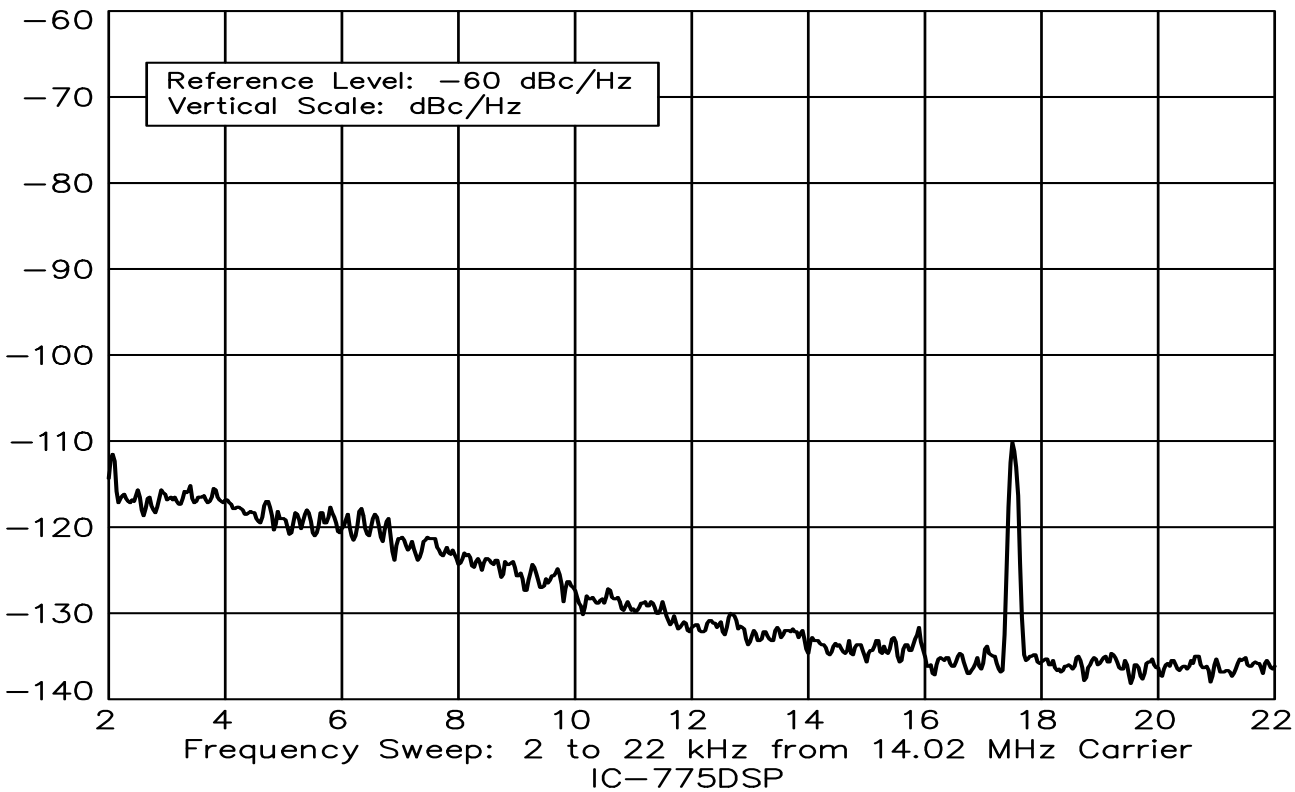
Test Result Summary:

Frequency	2 kHz offset (dBc/Hz)	22 kHz offset (dBc/Hz)	Notes
3.520 MHz	- 115 dBc/Hz	-135 d dBc/Hz	1
14.02 MHz	-115 dBc/Hz	-137 dBc/Hz	2

Notes:
1. The signal observed at 17.5 kHz is a close-in transmitter spur at -112 dBc (112 dB below the carrier).
2 The signal observed at 17.5 kHz is a close-in transmitter spur at -107 dBc (107 dB below the carrier).

Transmit Composite Noise Graphs:



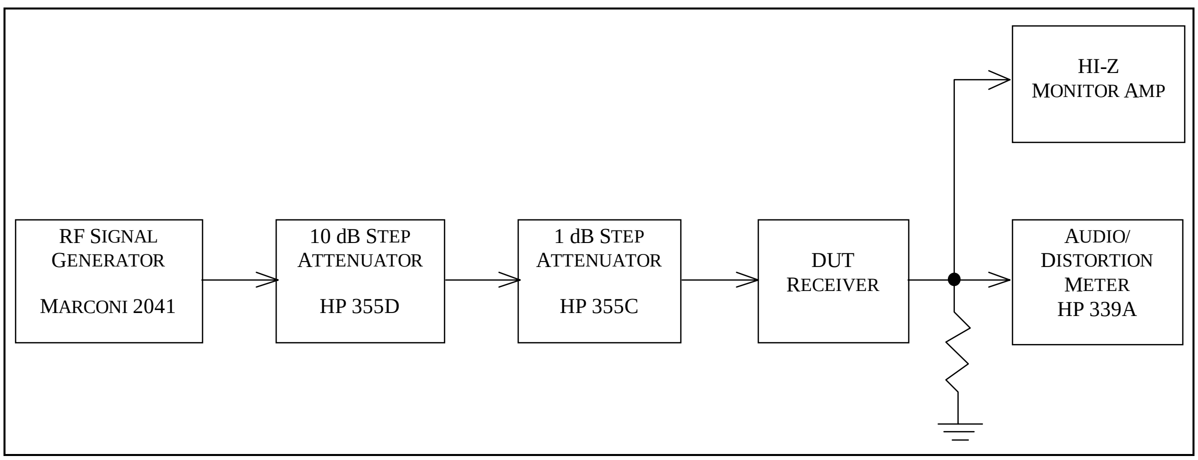

Reference Level: −60 dBc/Hz
Vertical Scale: dBc/Hz
−60
−70
−80
−90
−100
−110
−120
−130
−140
2
4
6
8
10
12
14
16
18
20
22
Frequency Sweep: 2 to 22 kHz from 14.02 MHz Carrier
IC−775DSP

Receiver Noise Floor (Minimum Discernible Signal) Test:

Test Description: The noise floor of a receiver is the level of input signal that gives a desired audio output level that is equal to the noise output level. This is sometimes called "minimum discernible signal " (MDS), although that term is actually a misnomer. A skilled operator can detect a signal up to 10 dB or so below the noise floor. Most modern receivers have a noise floor within a few dB of "perfect." A perfect receiver would hear only the noise of a resistor at room temperature. However, especially for HF receiving systems, the system noise is rarely determined by the receiver. In most cases, external noise is many dB higher than the receiver's internal noise. In this case, it is the external factors that determine the system noise performance. Making the receiver more sensitive will only allow it to hear more noise. It will also be more prone to overload. In many cases, especially in the lower HF bands, receiver performance can be improved by sacrificing unneded sensitivity by placing an attenuator in front of the receiver. The more negative the sensitivity number expressed in dBm, or the smaller the number expressed in voltage, the better the receiver.

Key Test Conditions:
50-ohm source impedance for generators.
Receiver audio output to be terminated with specified impedance.
Receiver is tested using 500 Hz bandwidth, or closest available bandwidth to 500 Hz.

Block Diagram:



Noise Floor Test Results:

Frequency	Preamplifier	dBm	Notes
1.02 MHz	Preamps OFF	-130.5	1,2
3.52 MHz	Preamps OFF	-138.7	
3.52 MHz	Preamps 1 ON	-142.9	
14.02 MHz	Preamps OFF	-137.7	
14.02 MHz	Preamp 1 ON	-143.2	
28.0 MHz	Preamps OFF	-136.5	
28.0 MHz	Preamp 1 ON	-141.1	
28.0 MHz	Preamp 2 ON	-144.9	

Notes:
1. Preamplifier 1 functions from 1.8 to 30 MHz
2. Preamplifier 2 functions from 21 to 30 MHz.

Receive Frequency Range:

Test Description: This test measures the tuning range of the receiver. The range expressed is the range over which the receiver can be tuned. Most receivers exhibit some degradation of sensitivity near the limits of their tuning range. In cases where this degradation renders the receiver unusable, we report both the actual and useful tuning range.

Test Results:

Minimum Frequency	Minimum Frequency MDS	Maximum Frequency	Maximum Frequency MDS	Notes
31 kHz	-109 dBm	29.995 MHz	-128.4 dBm	1

Notes:
1. Unit has useable sensitivity over entire range, but some receiver birdies were observed near the band edges.

Antenna-Port Isolation Test:

Test Description: Isolation between antenna ports can be important if multiple antennas are left hooked up to the transceiver. (This is especially imoortant to multi-transmitter stations, such as found in contest or Field Day operation.) This test measures the isolation between the antenna connectors on the unit under test. The test equipment ensures that all ports are terminated with 50 ohms for this test. The greater the number espressesed in dB, the better the performance.

Test Results:

Frequency	Ports	Isolation	Notes
14.02 MHz	ANT 1 / ANT 2	59.5 dB	

Notes:

AM Sensitivity Test:

Test Description: The purpose of the AM receive Sensitivity Test is to determine the level of an AM signal, 30% modulated at 1 kHz, that results in a tone 10 dB above the noise level (MDS) of the receiver. Two frequencies, 1.020 MHz and 3.800 MHz are used for this test. The more negative the number, expressed in dBm, or the smaller the number expressed in voltage, the better the sensitivity.

Test Results:

Frequency	Preamplifier	dBm	uV	Notes
1.02 MHz	OFF	-98.2	2.75	1
3.8 MHz	OFF	-106.6	1.05	
3.8 MHz	Preamp 1 ON	-111.8	0.575	

Notes:
1. Preamplifiers do not function below 1.8 MHz.

FM SINAD and Quieting Test:

Test Description: The purpose of the FM SINAD and Quieting Test is to determine the following at a test frequency of 29.000 MHz:

1) 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 the following:

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

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:

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

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. The approximation now becomes:

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

For the 25% level of distortion used in this test, the SINAD value can be calculated as follows:

$$SINAD = 20 \log (1/25\%) = 20 \log 4 = 12 \text{ dB}$$

2) The level of unmodulated input signal that produces 10 dB of quieting if specified by the manufacturer.

3) The level of unmodulated input signal that produces 20 dB of quieting if specified by the manufacturer.

The more negative the number, expressed in dBm, or the smaller the number, expressed as avoltage, the better the sensitivity.

Test Results:

Frequency	Preamplifier	dBm	uV	Notes
29.000 MHz	OFF	-111.3	0.609	1
29.000 MHz	Preamp 1 ON	-111.7	0.581	1
29.000 MHz	Preamp 2 ON	-117.2	0.309	1

Notes:
1. Level for 12 dB SINAD. The FM quieting test is performed only to test a manufacturer's specification.

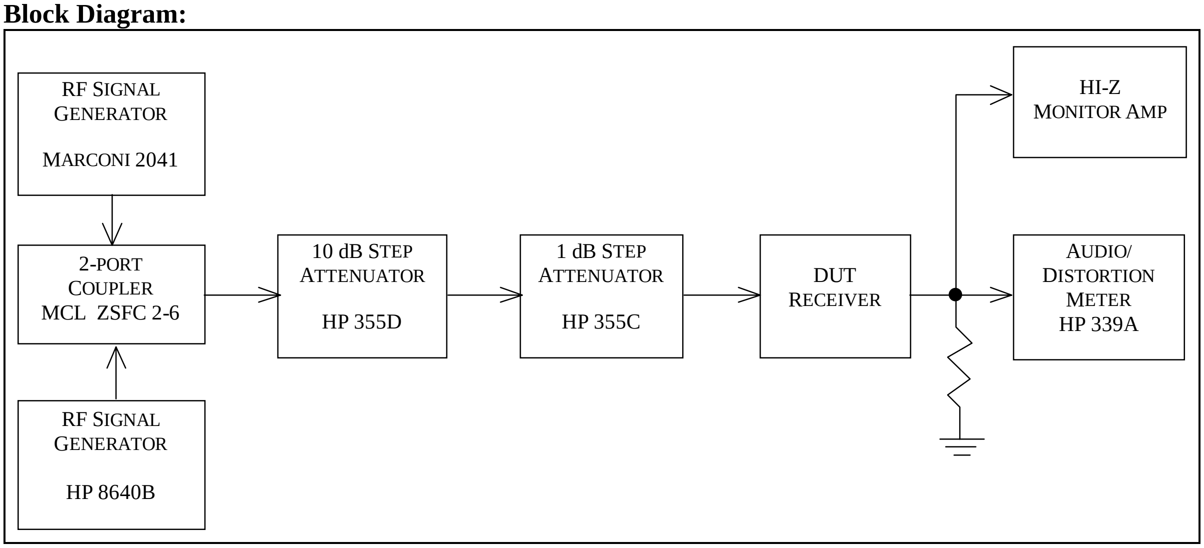
Blocking Dynamic Range Test:

Test Description: Dynamic range is a measurement that shows the difference between the weakest signal a receiver can hear (the noise floor) and the strongest signal outside its passband that a receiver can simultaneously accommodate. The latter is determined by measuring a specific amount of receiver degradation in the presence of a strong signal elsewhere in the band.

Blocking dynamic range (BDR) is the difference, in dB, between the noise floor and a off-channel signal that causes 1 dB of gain compression in the receiver. It indicates the signal level, above the noise floor, that begins to cause desensitization. BDR is calculated by subtracting the noise floor from the level of undesired signal that produces a 1-dB decrease in a weak desired signal. It is expressed in dB. The greater the dynamic range, expressed in dB, the better the receiver performance. It is usual for the dynamic range to vary with frequency spacing.

Key Test Conditions:
AGC is normally turned off; the receiver is operated in its linear region. Desired signal set to 10 dB below the 1-dB compression point, or 20 dB above the noise floor in receivers whose AGC cannot be disabled. The receiver bandwidth is set as close as possible to 500 Hz.

Block Diagram:



Test Result Summary:

Band	Preamp	Spacing	1 dB Comp point	BDR	Notes
1.02 MHz	OFF	20 kHz		140.5 dB	1
3.52 MHz	Preamp 1 ON	2 kHz	- 92 dBm	103.4 dB	
3.52 MHz	OFF	20 kHz	- 86 dBm	138.7 dB	
3.52 MHz	Preamp 1 ON	20 kHz	- 92 dBm	134.7 dB	
14.02 MHz	OFF	20 kHz		136.7 dB	
14.02 MHz	Preamp 1 ON	20 kHz		132.2 dB	
14.02 MHz	OFF	20 kHz		136.7 dB	
14.02 MHz	OFF	100 kHz		144.7 dB	
14.02 MHz	Preamp 1 ON	100 kHz		140.7 dB	
28.0 MHz	OFF	20 kHz		138.5 dB	
28.0 MHz	Preamp 1 ON	20 kHz		133.1 dB	
28.0 MHz	Preamp 2 ON	20 kHz		128.9 dB	

Notes:
1. 500 Hz receiver bandwidth for all tests.

Two-Tone 3rd-Order Dynamic Range Test:

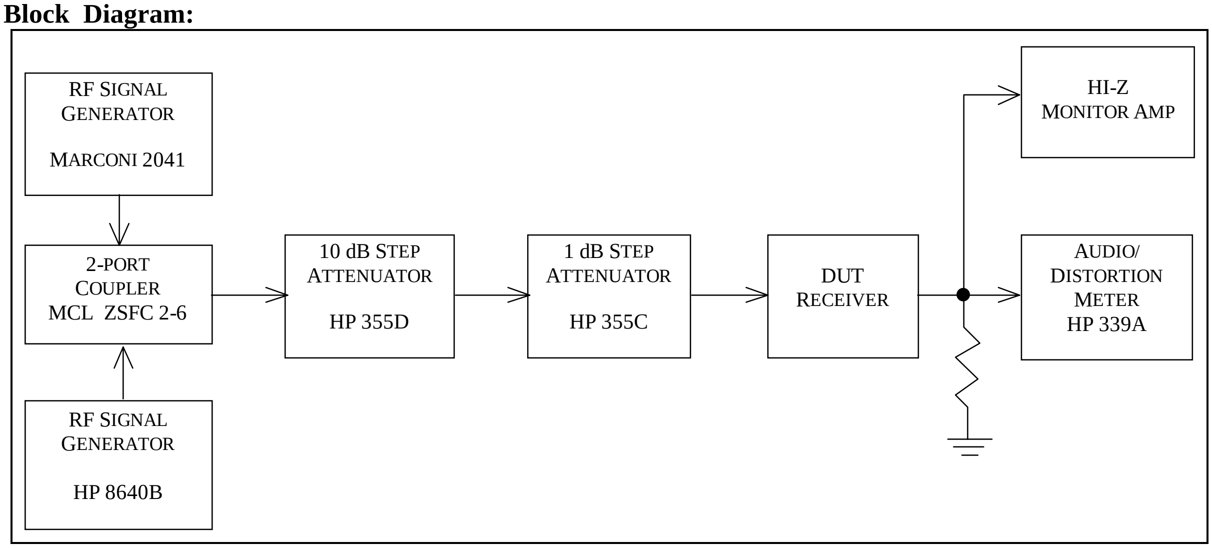
Test Description: Intermodulation distortion dynamic range (IMD DR) measures the impact of two-tone IMD on a receiver. IMD is the production of spurious responses resulting from the mixing of desired and undesired signals in a receiver. IMD occurs in any receiver when signals of sufficient magnitude are present. IMD DR is the difference, in dB, between the noise floor and the strength of two equal off-channel signals that produce a third-order product equal to the noise floor.

This test determines the range of signals that can be tolerated by the device under test 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 $(2f_2-f_1)$.

The greater the dynamic range, expressed in dB, or the higher the intercept point, the better the performance.

Key Test Conditions:
Sufficient attenuation and isolation must exist between the two signal generators. The two-port coupler must be terminated in a 20-dB return loss load. The receiver is set as close as possible to 500 Hz bandwidth.

Block Diagram:

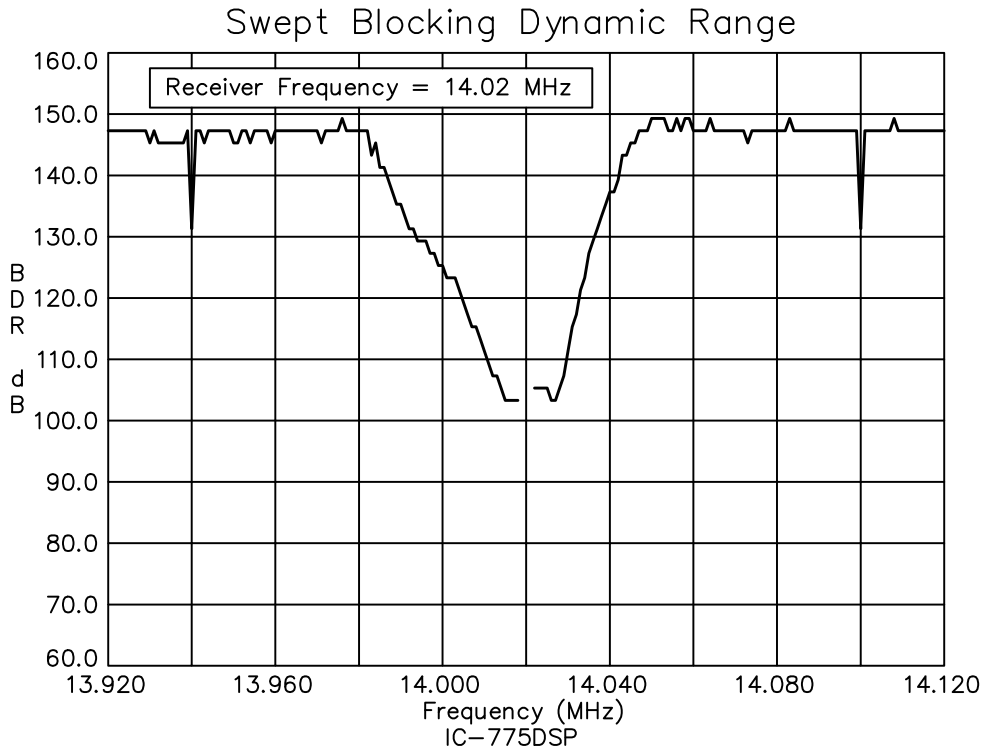


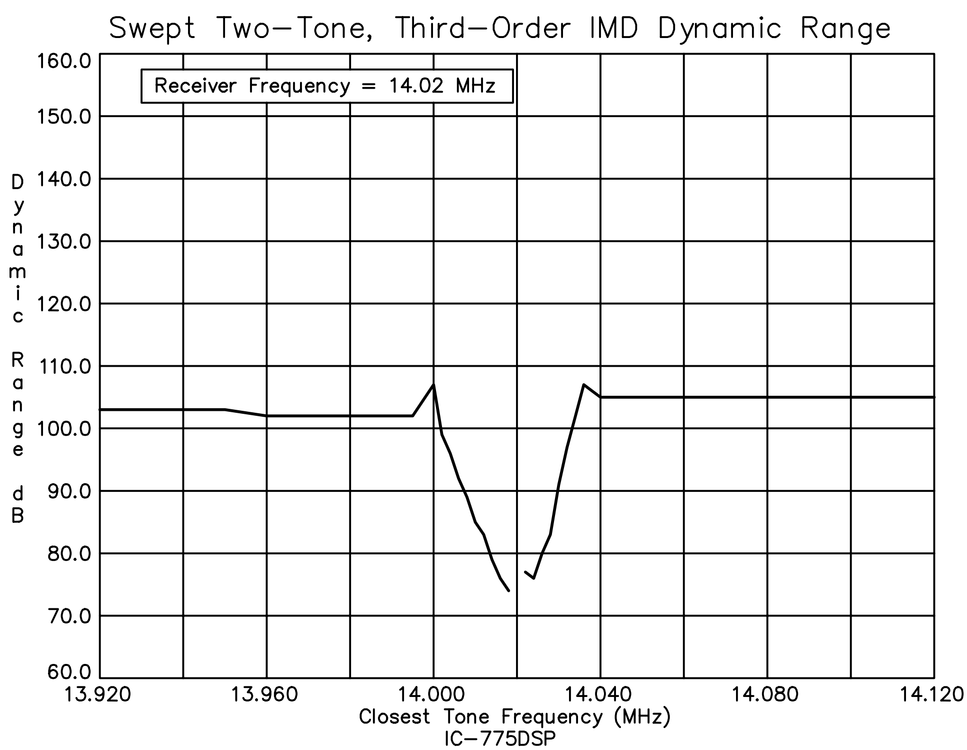
Two-Tone Receiver IMD Dynamic Range Test Result Summary:

Band	Preamp	Spacing	IMD DR	IP3	Notes
1.02 MHz	OFF	20 kHz	104.5 dB	+26.25 dBm	1
3.52 MHz	OFF	20 kHz	105.7 dB	+19.95 dBm	
3.52 MHz	Preamp 1 ON	20 kHz	103.9 dB	+12.95 dBm	
14.02 MHz	OFF	20 kHz	105.7 dB	+20.85 dBm	
14.02 MHz	Preamp 1 ON	20 kHz	103.2 dB	+11.6 dBm	
14.02 MHz	OFF	100 kHz	105.2 dB	+20.1 dBm	
14.02 MHz	Preamp 1 ON	100 kHz	101.2 dB	+8.6 dBm	
28.02 MHz	OFF	20 kHz	91.5 dB		2
28.02 MHz	Preamp 1 ON	20 kHz	87.1 dB		
28.02 MHz	Preamp 2 ON	20 kHz	84.9 dB		

Notes:
1. 500 Hz receiver bandwidth
2. IP3 not calculated for 28 MHz.

Dynamic Range Graphs:





Second-Order IMD Test:

Test Description: This test measures the amount of 2nd-order mixing that takes place in the receiver. Signals at 6 and 8 MHz are presented to the receiver and the resultant output at 14 MHz is measured.

Test Results:

Frequency	Preamplifier	Mode	Dynamic Range	IP2	Notes
14.02 MHz	OFF	CW	96.7 dB	+55.7 dBm	
14.02 MHz	Preamp 1 ON	CW	99.2 dB	+55.2 dBm	

Notes:

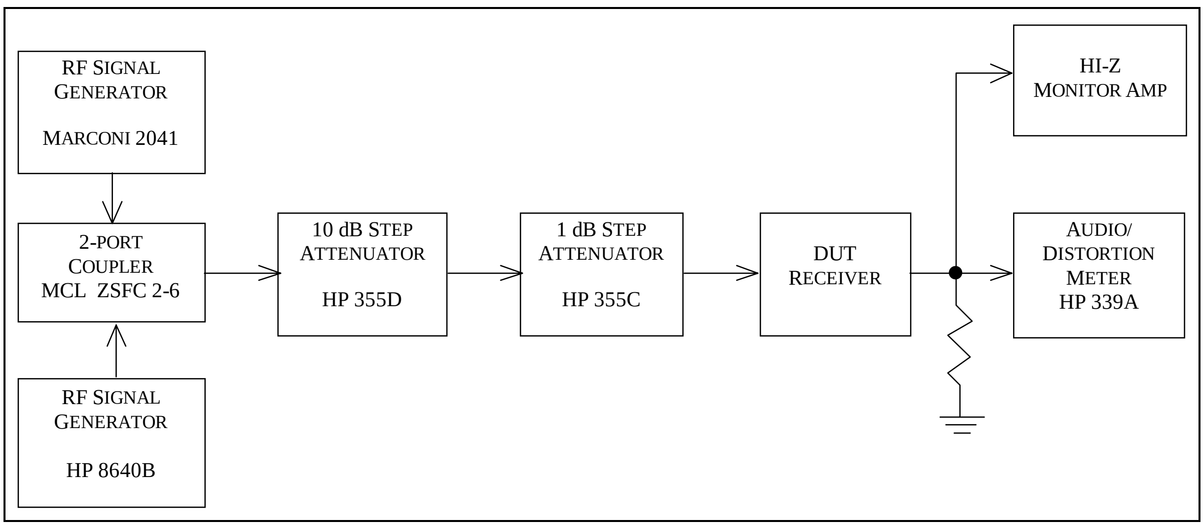
In-Band Receiver IMD Test:

Test Description: This test measures the intermodulation that occurs between two signals that are simultaneously present in the passband of a receiver. Two signals, at levels of 50 uV (nominally S9), spaced 100 Hz are used. The receiver AGC is set to FAST. The receiver is tuned so the two signals appear at 900 Hz and 1100 Hz in the receiver audio. The output of the receiver is viewed on a spectrum analyzer and the 3rd- and 5th order products are measured directly from the screen. The smaller the products as seen on the graph, the better the receiver. Generally, products that are less than 30 dB below the desired tones will not be cause objectionable receiver intermodulation distortion.

Key Test Conditions:

S9 or S9 + 40 dB signals
Receiver set to SSB normal mode, nominal 2 - 3 kHz bandwidth

Block Diagram:

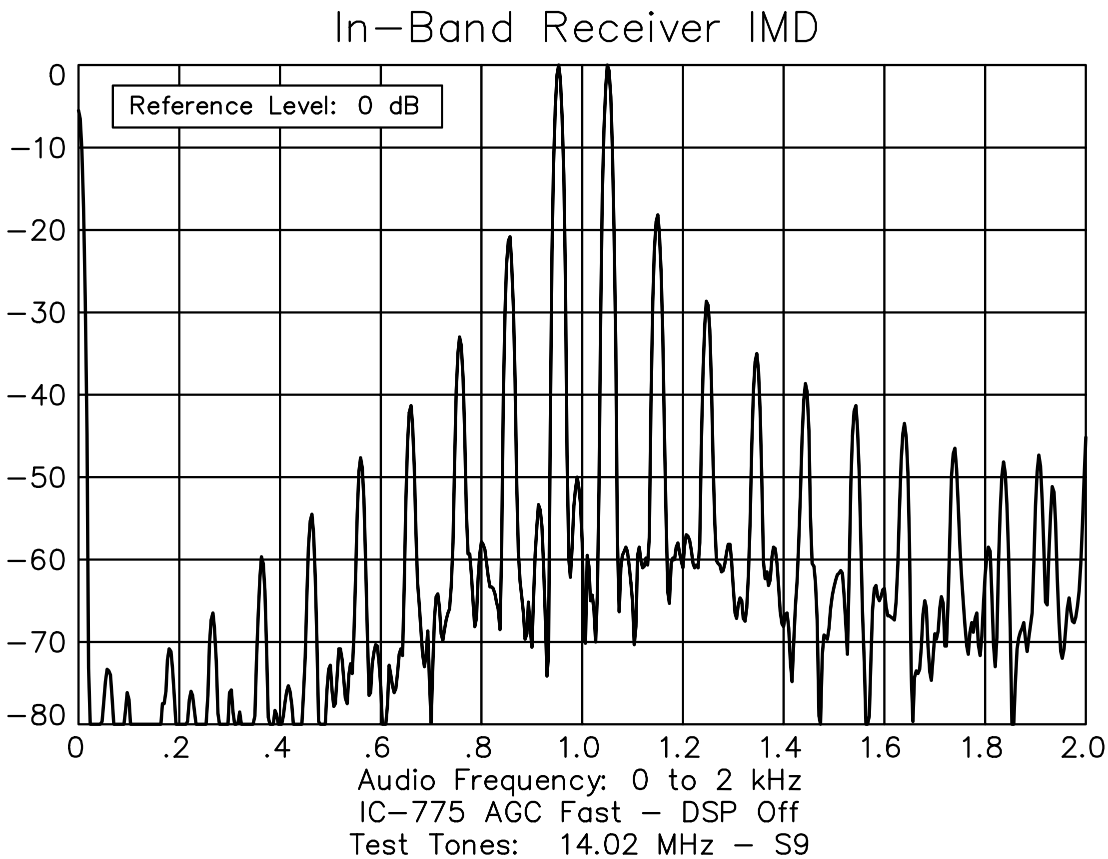


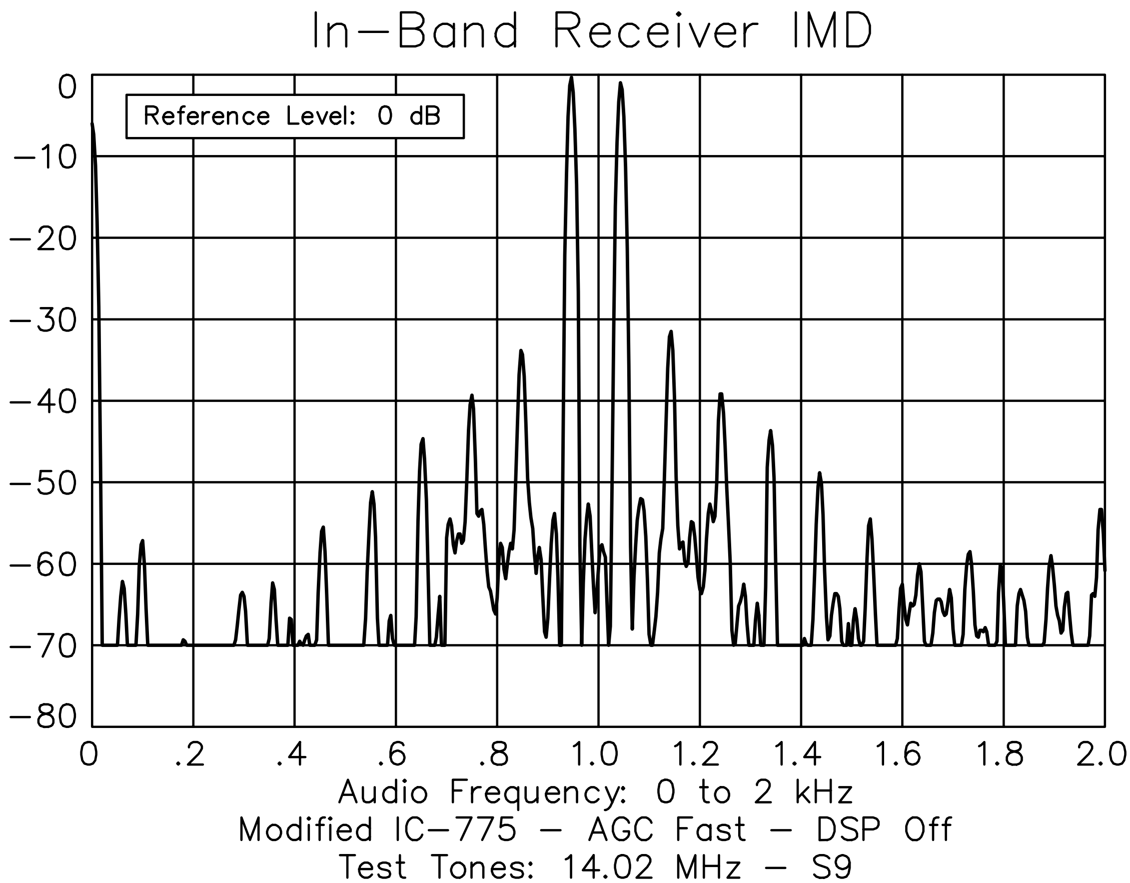
Test Result Summary:

Frequency	Preamplifier	AGC	3rd-order	5th-order	Notes
14.02 MHz	ON	FAST	-18 dB	-28 dB	1
14.02 MHz	ON	FAST	-32 dB	-38 dB	2

Notes:

1. "Stock" IC-775.
2. IC-775 with factory modification.


In—Band Receiver IMD
Reference Level: 0 dB
0
−10
−20
−30
−40
−50
−60
−70
−80
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Audio Frequency: 0 to 2 kHz
IC—775 AGC Fast — DSP Off
Test Tones: 14.02 MHz — S9


In—Band Receiver IMD
Reference Level: 0 dB
0
−10
−20
−30
−40
−50
−60
−70
−80
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Audio Frequency: 0 to 2 kHz
Modified IC—775 — AGC Fast — DSP Off
Test Tones: 14.02 MHz — S9

FM Adjacent Channel Selectivity Test:

Test Description: The purpose of the FM Adjacent Channel Selectivity Test is to measure the ability of the device under test 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.) The greater the number in dB, the better the recjection.

Test Results:

Frequency	Preamplifier	Frequency Spacing	Adjacent-channel rejection	Notes
29.0 MHz	OFF	20 kHz	88.8 dB	
29.0 MHz	ON	20 kHz	88.8 dB	

Notes:

FM Two-Tone 3rd-Order Dynamic Range Test:

Test Description: 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 device under testing the FM mode while producing no spurious responses greater than the 12-dB 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 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. Frequencies 10 MHz outside the amateur band are used to testthe wide-band dynamic range. The greater the dynamic range, the better the receiver performance.

Test Results:

Frequency	Preamplifier	Frequency Spacing	Dynamic Range	Notes
29.0 MHz	OFF	20 kHz	75.3 dB	
29.0 MHz	Preamp 1 ON	20 kHz	72.3 dB	
29.0 MHz	Preamp 2 ON	20 kHz	70.5 dB	

Notes:

Image Rejection Test:

Test Description: This test measures the amount of image rejection for superhetrodyne receivers by determining the level of signal input to the receiver at the first IF 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 AGC is turend OFF, if possible. The test is performed with the receiver tuned to 14.020 MHz for receviers that have 20-meter capability, or to a frequency 20 kHz up from the lower band edge for single-band receivers. The greater the inumber in dB, the better the image rejection.

Test Results:

Frequency	Preamplifier	Mode	Calculated Image Frequency	Image Rejection	Notes
14.250 MHz	OFF	CW	152.2712 MHz	124.7 dB	
14.250 MHz	Preamp 1 ON	CW	152.2712 MHz	126.5 dB	1
14.250 MHz	OFF	SSB	152.273 MHz	114.1 dB	1
14.250 MHz	Preamp 1 ON	SSB	152.273 MHz	114.6 dB	1

Notes:

1. Measurement was noise limited at level shown. This is not surprising; this is exceptionally good image rejection.

IF Rejection Test:

Test Description: This test measures the amount of first IF rejection for superhetrodyne receivers by determining the level of signal input to the receiver at the first IF 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 AGC is turend OFF, if possible. The test is performed with the receiver tuned to 14.020 MHz for receviers that have 20-meter capability, or to a frequency 20 kHz up from the lower band edge for single-band receivers. The greater the number in dB, the better the IF rejection.

Test Results:

Frequency	Preamplifier	Mode	IF Rejection	Notes
14.250 MHz	OFF	CW	124.9 dB	
14.250 MHz	Preamp 1 ON	CW	128.5 dB	1
14.250 MHz	OFF	SSB	116.1 dB	1
14.250 MHz	Preamp 1 ON	SSB	118.5 dB	1

Notes:
1. Measurement was noise limited at level shown. This is exceptionally good IF rejection.

Audio Output Power Test:

Test Description: This test measures the audio power delivered by the receiver. The manufacturer's specification for load and distortion are used. For units not specified, an 8-ohm load and 10% harmonic distortion are used.

Test Results:

Specified Distortion	Specified Load Impedance	Audio Output Power	Notes
10% T.H.D.	8 ohms	2.59 W	

Notes:

IF + Audio Frequency Response Test:

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

Test Results:

IF Filters	Center Frequency	Low Frequency	High Frequency	Difference (bandwidth)	Notes
500 Hz	529 Hz	360 Hz	836 Hz	476 Hz	
ON/2.4/2.7 kHz (CW Wide)	918 Hz	249 Hz	2639 Hz	2390 Hz	1
ON/2.4/2.7 kHz (USB Wide)	810 Hz	254 Hz	2671 Hz	2417 Hz	2
OFF/2.4/2.7 kHz (LSB Wide)	900 Hz	252 Hz	2628 Hz	2376 Hz	3
AM Wide (ON/OFF/OFF)	550 Hz	102 Hz	2580 Hz	2478 Hz	4.
AM Narrow (OFF/ON/OFF)	448 Hz	100 Hz	1290 Hz	1190 Hz	5

Notes:
1. This filter combination was selected to represent typical CW Wide filtering.
2. This filter combination was selected to represent typical USB Wide filtering.
3. This filter combination was selected to represent typical LSB Wide filtering.
4. This filter combination was selected to represent typical AM wide filtering.
5. This filter combination was selected to represent typical AM narrow filtering.

Squelch Sensitivity Test:

Test Description: The purpose of the Squelch Sensitivity Test is to determine the level of the input signal required to break squelch at the threshold and at the point of maximum squelch. This number is not usually critical. A result anywhere between 0.05 and 0.5 uV is usually useful. The maximum can range to infinity.

Test Results:

Frequency	Preamplifier	Mode	Minimum uV	Maximum uV	Notes
29.0 MHz	Preamp 1 ON	FM	0.339 uV	13600 uV	
29.0 MHz	Preamp 2 ON	FM	0.197 uV	4950 uV	
14.2 MHz	Preamp 1 ON	SSB	1.48 uV	17200 uV	

Notes:

S-Meter Test:

Test Description: The purpose of the S-Meter Test is to determine the level of RF input signal required to produce an S9 and S9+20 dB indication on the receiver S meter. This test is performed with the receiver in the CW mode at a frequency of 14.200 MHz. The IF filter is set to 500 Hz, nominal. A traditional S9 signal is a level of 50 uV (an old Collins receiver standard). The Collins standard S unit was 6 dB. This is , however, not a hard and fast rule, especially for LED or bar-graph type S meters.

Test Results:

Frequency	Preamplifier	S Units	uV	Notes
14.2 MHz	OFF	S9	52.5 uV	
14.2 MHz	Preamp 1 ON	S9	19.3 uV	
1.02 MHz	OFF	S9	162 uV	
28.02 MHz	OFF	S9	75 uV	
28.02 MHz	Preamp 1 ON	S9	24.8 uV	
28.02 MHz	Preamp 2 ON	S9	9.8 uV	

Notes:

Notch Filter Test:

Test Description: This test measures the notch filter depth at 1 kHz audio and the time required for auto-notch DSP filters to detect and notch a signal.

The more negative the notch depth number, the better the performance.

Test Results:

Frequency	Notch Depth	Notes
various	< - 40 dB	1

Notes:
1. DSP auto notch filter, one or two tones.

Audio Filter Test:

Test Description: The purpose of the Audio Filter Test is to measure the audio frequencies at which the receiver audio drops 6 dB from the peak signal response. The frequency-response bandwidth is then calculated by taking the difference between the lower and upper frequency. The signal-to-noise ratio, and/or amount of noise reduction in DSP denoise algorithms are also tested.

Test Results:

Filter Range	Center	Minimum	Maximum	Bandwidth	Notes
DSP disabled	1356 Hz	319 Hz	2566 Hz	2247 Hz	1
200-2700 Hz	1430 Hz	382 Hz	2491 Hz	2109 Hz	
300-2500 Hz	1419 Hz	451 Hz	2500 Hz	2049 Hz	
300-2200 Hz	1320 Hz	382 Hz	2310 Hz	1928 Hz	
400-1800 Hz	1530 Hz	511 Hz	1920 Hz	1409 Hz	

Notes:
1. All filters tested in USB mode at 14.2 MHz. IF filters On/.2.4/6.0 kHz.

Other Tests:

DSP Noise Reduction: Approximately 15 dB. Varies from 0 dB to 15 dB, depending on initial signal-to-noise ratio.

Temperature Chamber Test Description:

All equipment that would normally be used outdoors are subjected to a function, output power and frequency accuracy test over its specified temperature range. For those units not specified, the unit is operated at -10 and +60 degrees Celsius. These temperatures were chosen to represent typical specifications and typical outdoor use over most of the country.

Duty Cycle Test Description:

Most equipment does not specify a duty cycle. For this reason, most Product Review equipment is not subject to a specific duty cycle test. It is assumed that equipment without a duty-cycle specification is intended for conversational use on CW or SSB. The equipment sees considerable such use during the review process. If equipment does have a duty-cycle specification, such as "continuous," "continuous commercial" or a specific time parameter, the equipment is tested against that specification. If the unit does not pass, this will be treated as a defect that occurred during the review.