ARRL Laboratory
Expanded Test-Result Report
ICOM IC-756 Pro

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Model: IC-756 Pro Serial #: 01313
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Contents:

Introduction

This document summarizes the tests performed by the ARRL Laboratory for each unit that is featured in *QST* "Product Review." The ARRL Laboratory has a separate document, the *ARRL Laboratory Test Procedures Manual,* that explains our specific test methods in detail including a complete test description, a block diagram showing the specific equipment currently in use for each test, all equipment settings and the specific step by step procedure used. While this is not available as a regular ARRL publication, it can be downloaded from our Member's Only web page. The ARRL Technical Department Secretary can also mail out 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 test equipment is calibrated annually, with traceability to National Institute of Standards and Technology (NIST) standards.

The units being tested are operated as specified by the manufacturer. Equipment that is intended for mobile and hand-held use is also tested for function, output power and frequency accuracy at the minimum specified voltage, as well as at the extremes of their rated temperature range.

NOTE: ARRL "Product Review" testing usually represents a sample of only one unit and is not necessarily representative of all units of the same model number. Often, some parameters will vary significantly from unit to unit. The ARRL Laboratory and Product Review editor work with manufacturers to resolve any problems encountered in the review process and these problems are documented in the Product Review.

Related ARRL Publications and Products:
The *2000 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. You can order both versions of the *Handbook* from our web page at http://www.arrl.org/, or contact the ARRL Publications Sales Department at 888-277-5289 (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.

Transmitter Output Power

Test description: The ARRL Lab measures the CW output power for every band on which a transmitter can operate. The unit is tested across the entire amateur band and the worst-case number for each band is reported. The equipment is also tested on any mode of operation for which the transmitter is capable. Typically, the most popular band of operation for each mode is selected. This test also compares the accuracy of the unit's internal output-power metering against the ARRL Laboratory's calibrated test equipment. A two-tone audio input, at a level within the manufacturer's microphone-input specifications, is used for the SSB mode. No modulation is used in the AM and FM modes.

Note that most transmitters are de-rated from maximum output power on full-carrier AM and FM modes. Typically, 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 full power for continuous duty.

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. SSB transmitter testing is typically performed at the transmitter's rated PEP SSB output.

Transmitter Output Power Test Results:

Frequency	Mode	Unit's Meter Minimum Power (W)	Measured Minimum Power (W)	Unit 's Meter Maximum Power (W)	Measured Maximum Power (W)	Notes (99)
1.8 MHz	CW	N/A	0.6W	100 W	101.8W	
3.5 MHz	CW	N/A	0.7W	100 W	107.0W	
3.5 MHz	AM	N/A	<1W	37 (approx.)	37.1W	
7 MHz	CW	N/A	0.7W	100 W	110.1W	
10.1 MHz	CW	N/A	0.7W	100 W	110.8W	
14 MHz	CW	N/A	0.8W	100 W	111.3W	
14 MHz	USB	N/A	0.9W	100 W	109.8W	
18 MHz	CW	N/A	1.1W	100 W	112.0W	
21 MHz	CW	N/A	1.1W	100 W	112.6W	
24 MHz	CW	N/A	1.1W	100 W	112.4W	
28 MHz	CW	N/A	1.1W	100 W	111.8W	
28 MHz	FM	N/A	1.1W	100 W	112.2W	
50 MHz	CW	N/A	0.9W	100W	108.2W	
50 MHz	FM	N/A	0.6W	100W	107.5W	
50 MHz	SSB	N/A	0.8W	100W	106.4W	
50 MHz	AM	N/A	N/A	38 (approx.)	38.0W	

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 (MHz)	Output (dBm)	Notes
20 M	–15.9 dBm	
15 M	–14.4 dBm	
10 M	–15.3 dBm	
6 M	–16.8 dBm	

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 V dc 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. This test is not performed on equipment that can be powered only from the ac mains.

Current Consumption:

Voltage	Transmit Current	Output Power	Receive Current	Lights?	Notes
13.8 V	25.1A	100W	5.6A	ON	

Transmit Frequency Range Test

Test Description: Many transmitters can transmit outside the amateur bands, either intentionally, (to accommodate MARS operation for example), or incidentally, as the result of the design and internal software. 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. Frequencies are as indicated on the transmitter frequency indicator or display. Although most modern synthesized transmitters are capable of operation outside the ham bands, spectral purity is not always legal outside the bands and caution must be used. In addition, most other radio services require that transmitting equipment be type accepted for that service. In most cases, Amateur Radio equipment is not legal for use on other than amateur, MARS or CAP frequencies.

Test Results:

Frequency	Low-Frequency Limit	High-Frequency Limit	Notes
160 M	1.800.000 MHz	1.999.999 MHz	
80 M	3.400.000 MHz	4.099.999 MHz	
40 M	6.900.000 MHz	7.499.999 MHz	
30 M	9.900.000 MHz	10.499.999MHz	
20 M	13.900.000MHz	14.499.999MHz	
17 M	17.900.000MHz	18.499.999MHz	
15 M	20.900.000MHz	21.449.999MHz	
12 M	24.400.000MHz	25.099.999MHz	
10 M	28.000.000MHz	29.999.999MHz	
6 M	50.000.000 MHz	54.000.000 MHz	

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 with the unit operated into a 50-ohm resistive load at nominal temperature and supply voltage. Frequency is also measured at minimum output power, low supply voltage and over the operating temperature range for mobile and portable units. Non-portable equipment is not tested over temperature.

Test Results:

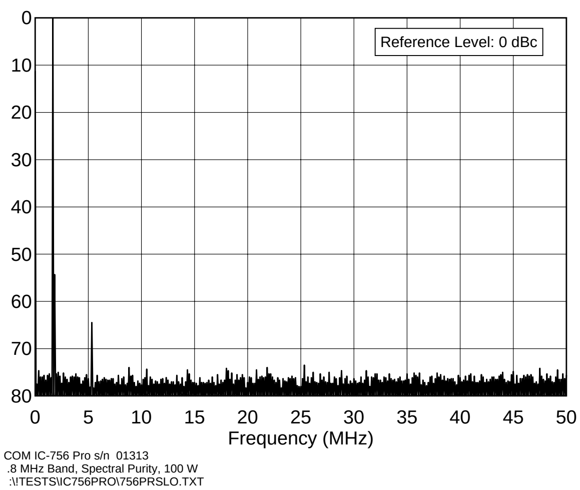
Unit Frequency	Supply Voltage	Temperature	Measured Frequency Full Output Power	Notes
14.000.000MHz	13.8 V	25 C	14.000.015 MHz	
50.000.000 MHz	13.8 V	25 C	50.000.056 MHz	

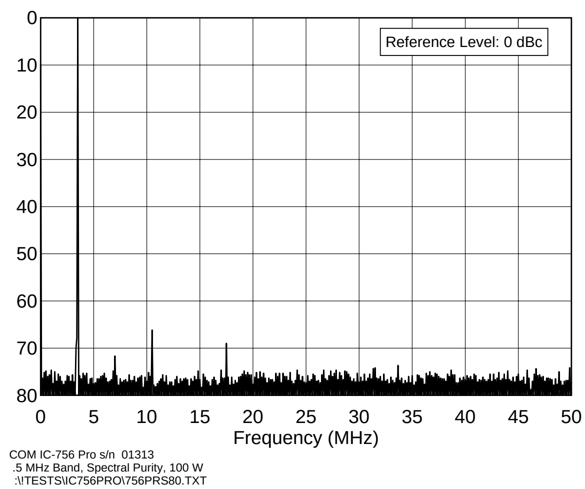
Spectral Purity Test

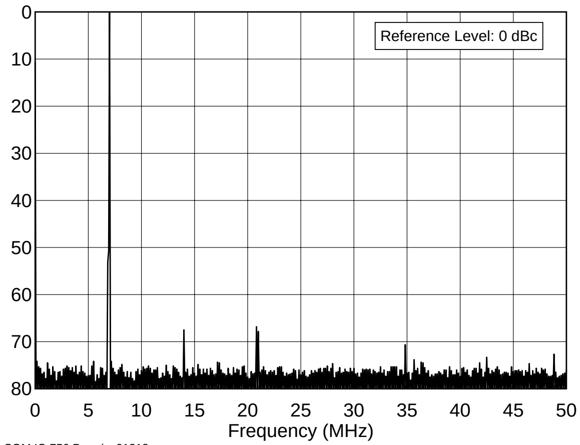
Test Description: All transmitters emit some signals outside their assigned frequency or frequency range. These signals are generally known as spurious emissions or "spurs." Part 97 of the FCC rules and regulations specify the amount of spurious emissions that can be emitted by a transmitter operating in the Amateur Radio Service. The ARRL Laboratory uses a spectrum analyzer to measure the worst-case spurious emission on each band on which the transmitter can operate. 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 is spectrally cleaner than is one whose spurious emissions are –30 dBc.

Spectral Purity Graphs







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.0 MHz Band, Spectral Purity, 100 W
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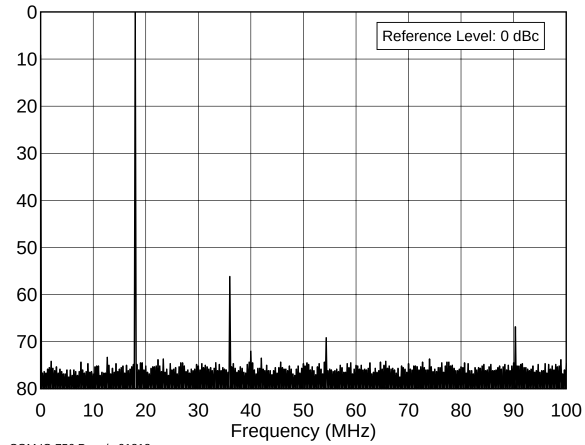

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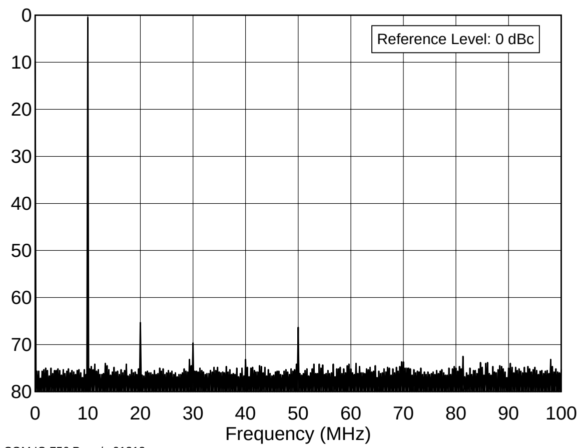

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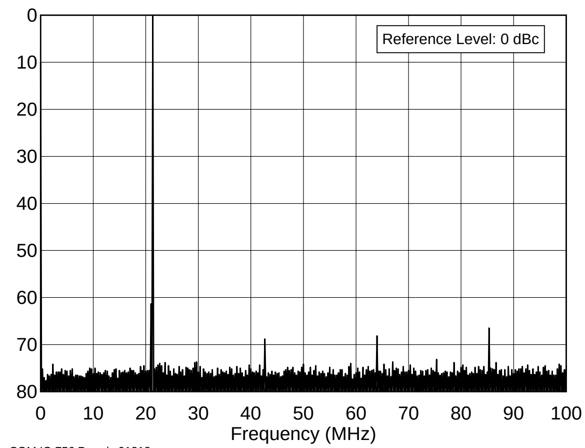

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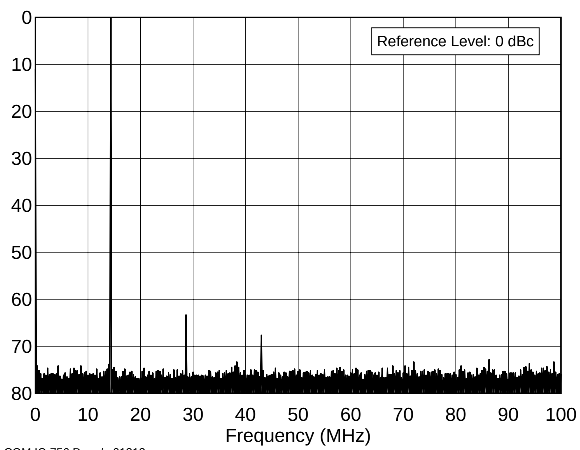

COM IC-756 Pro s/n 01313
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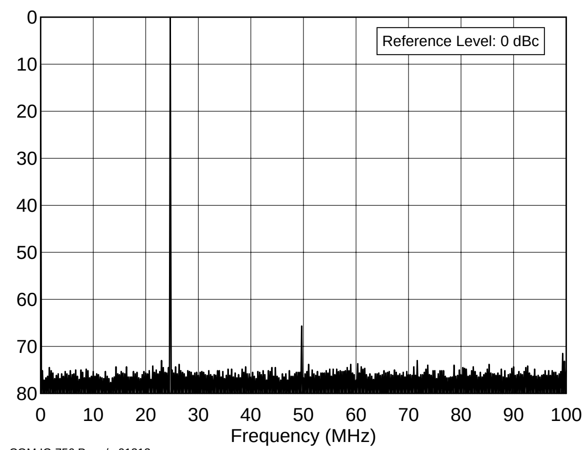

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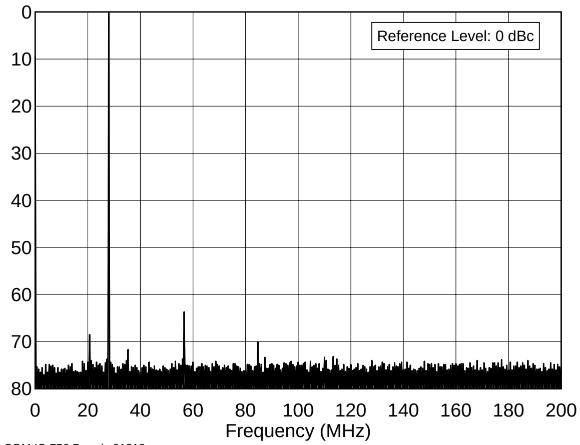

COM IC-756 Pro s/n 01313
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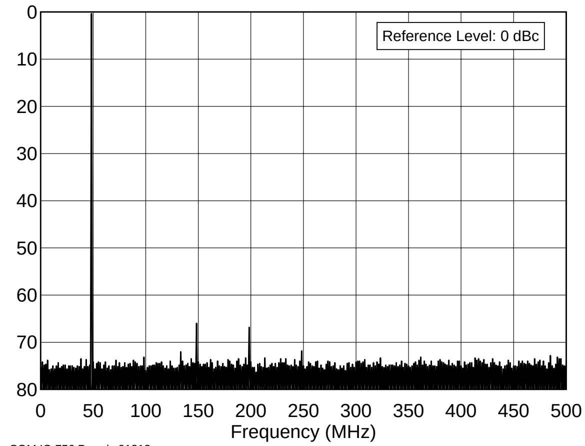

COM IC-756 Pro s/n 01313
0.0 MHz Band, Spectral Purity, 100 W
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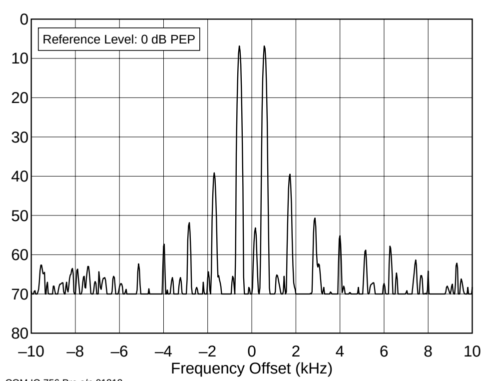
Transmit Two-Tone IMD Test

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 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 are, the better the transmitter is. 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.

Transmit IMD Graphs



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.850 MHz, Transmit IMD, 100 W
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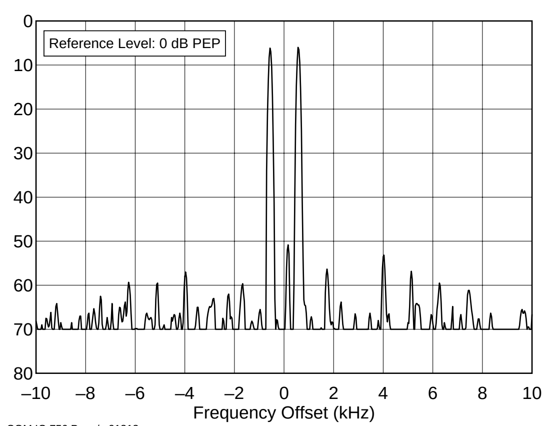

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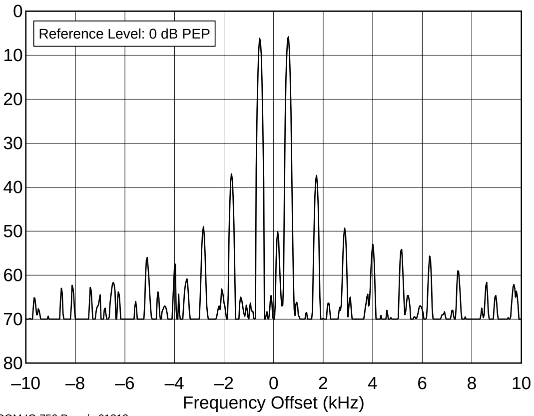

COM IC-756 Pro s/n 01313
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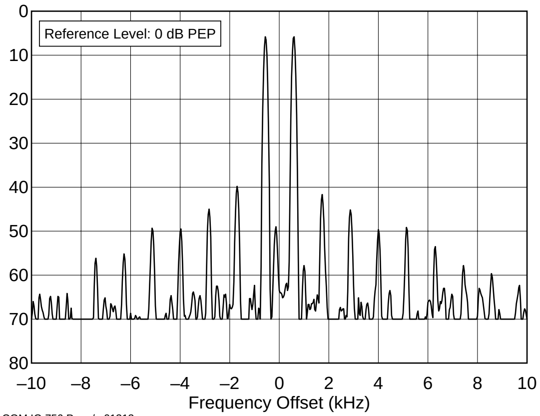

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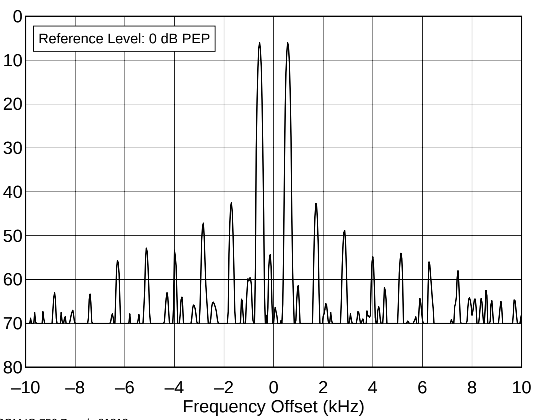

COM IC-756 Pro s/n 01313
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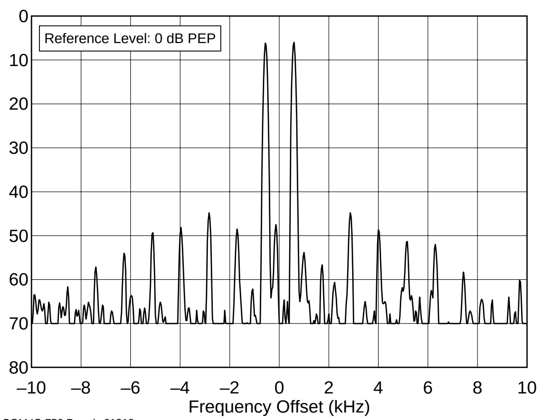

COM IC-756 Pro s/n 01313
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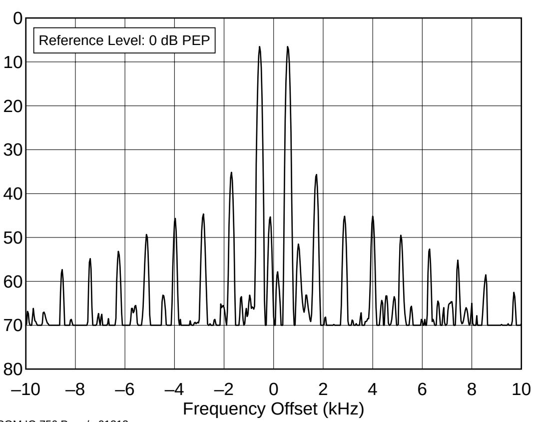

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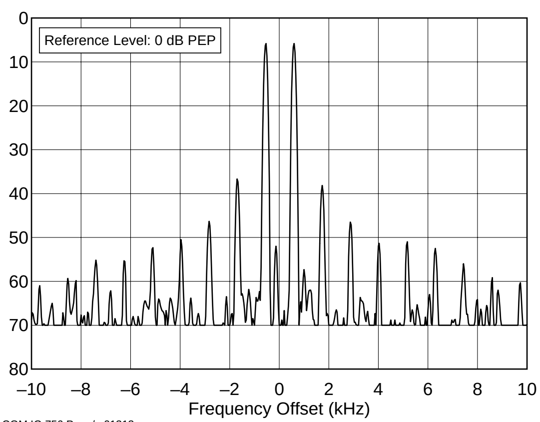

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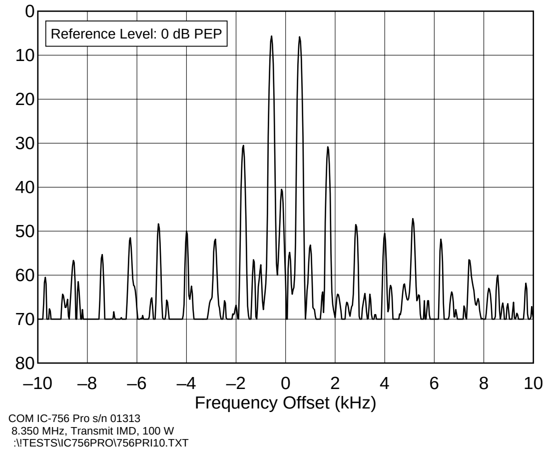
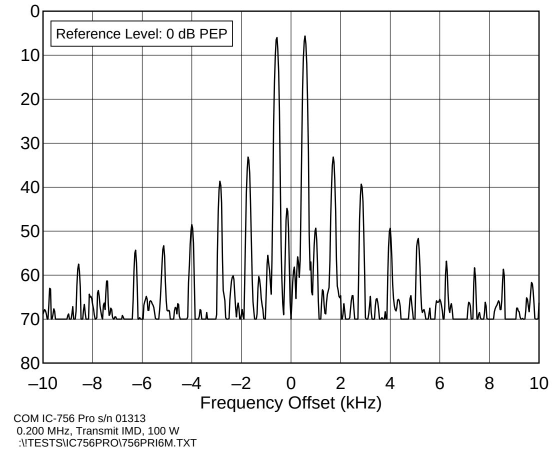




SSB Carrier and Unwanted Sideband Suppression Test

Test Description: The purpose of the SSB Carrier and opposite-sideband Suppression test is to determine the level of unwanted carrier and unwanted sideband 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 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/ Mode	Carrier Suppression (dB)	Opposite Sideband Suppression (dB)	Notes
14.2 MHz USB	64 dB PEP	> 65 dB PEP	
14.2 MHz LSB	60 dB PEP	> 65 dB PEP	
50.2 MHz USB	62 dB PEP	> 65 dB PEP	
50.2 MHz LSB	> 65 dB PEP	> 65 dB 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 delay times from key closure to RF output are also measured. If the transmitter under test has several CW modes, (i.e. VOX, QSK) these measurements are made at rated output power for each mode. A picture of the oscilloscope screen is taken of the results with the QSK on, and with QSK off, 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 "semi-QSK" (or QSK off) 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 at higher keying speeds.

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.

Test Results:

Frequency (MHz)	Mode	First Dit Risetime (ms)	First Dit Falltime (ms)	Following Dits Risetime (ms)	Following Dits Falltime (ms)	First Dit On Delay (ms)	Following Dits On Delay (ms)	Weight %	First Dit Weight %
14.02	QSK	2.0ms	2.0ms	2.0ms	1.5ms	11ms	12ms	31.7%	34.1%
14.02	VOX	1.6ms	2.4ms	1.8ms	2.6ms	11ms	2ms	55%	35%

Note: All Figures are 10 ms/division, unless otherwise noted.
Figure 1 shows the first and second dits with QSK on.
Figure 2 shows the first and second dits with QSK off.

CW Keying Waveforms

Figure 1
CW keying - QSK on

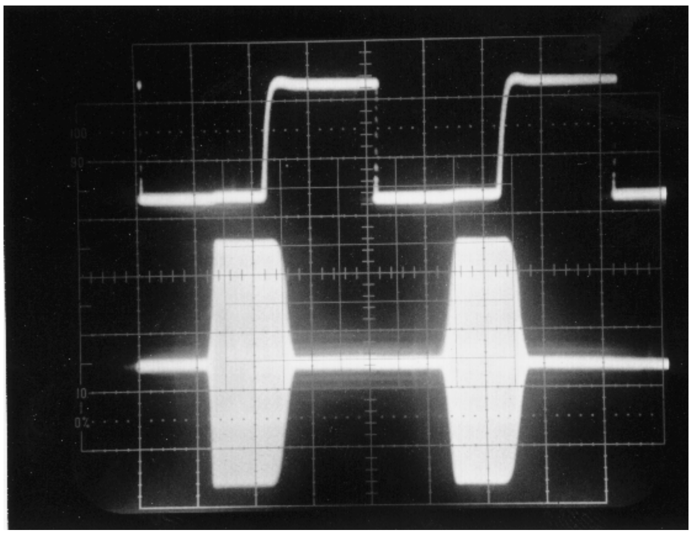
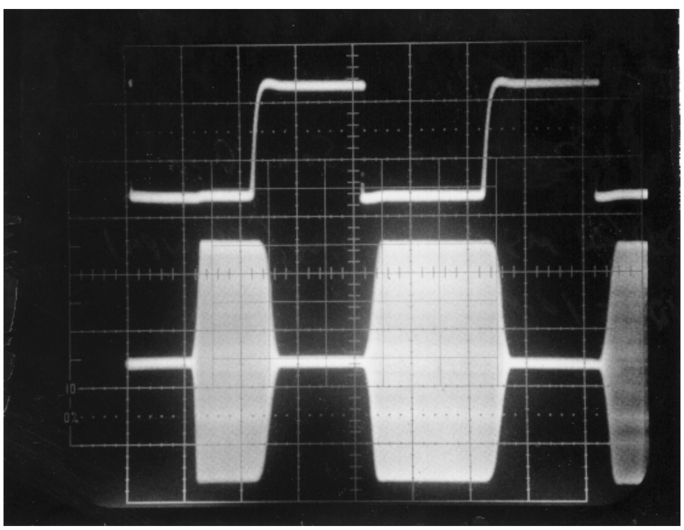


Figure 2
CW keying - QSK off



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
6 WPM	47 WPM	27.3 WPM	

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 AGC Fast	T/R Delay AGC Slow	Notes
14.2 MHz	SSB	23 ms	26 ms	1

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

Transmit Delay Test

Test Description: The purpose of the Transmit Delay test is to measure the time between PTT closure and 50% RF output. It is measured on SSB, modulated with a single tone and on FM, unmodulated.

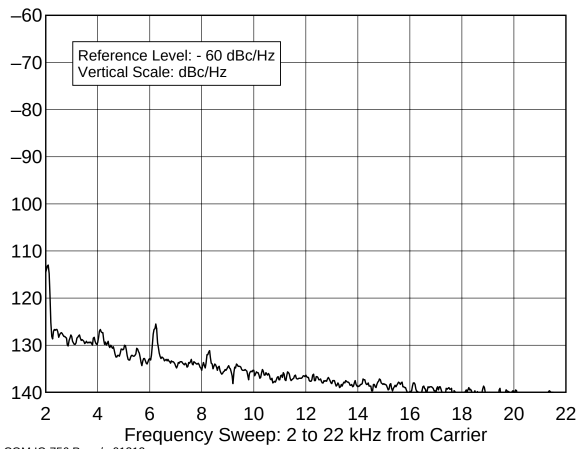
Test Results:

Frequency (MHz)	Mode	On delay	Notes
14.2 MHz 50.2 MHz	SSB FM	20 ms 11 ms	

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.

Transmit Composite Noise Graphs



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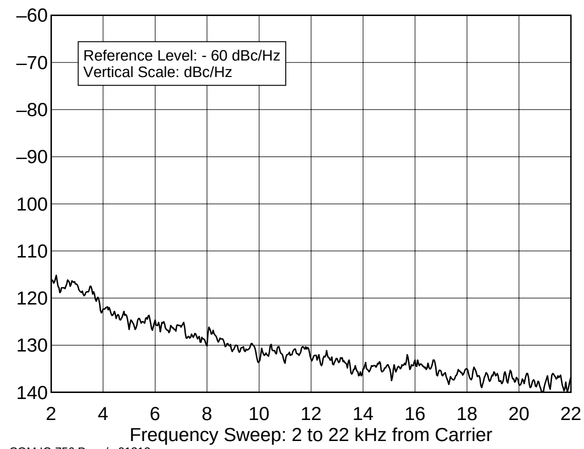

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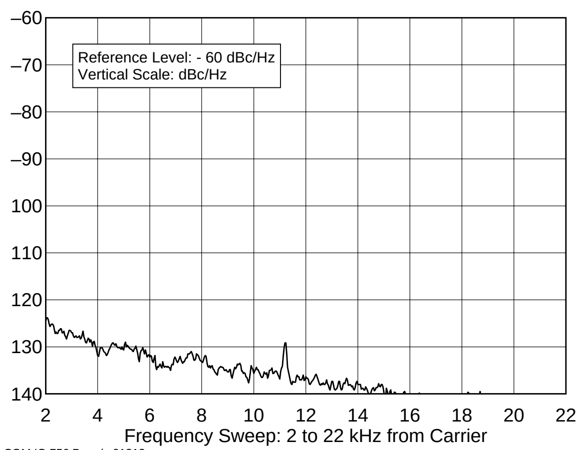


COM IC-756 Pro s/n 01313
4.020 MHz, Phase Noise, 100 W
:\!TESTS\IC756PRO\756PRP20.TXT

Receiver Noise Floor Test

(Minimum Discernible Signal)

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 a skilled operator can copy a signal at considerably less than 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 in HF receivers especially, the system noise is rarely determined by the receiver circuitry. 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 unneeded 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.

Noise Floor:

Frequency	Preamp OFF MDS (dBm)	Preamp 1 ON MDS (dBm)	Preamp 2 ON (MDS) dBm	Notes
30 kHz	–89.0	N/A	N/A	1
150 kHz	–115.0	N/A	N/A	
1.02 MHz	–117.0	N/A	N/A	
1.82 MHz	–125.7	–134.1	–139.6	
3.52 MHz	–126.6	–135.0	–140.7	
7.02 MHz	–127.5	–135.8	–140.3	
10.12 MHz	–126.4	–136.7	–140.5	
14.02 MHz	–127.6	–136.2	–140.3	
18.1 MHz	–127.6	–137.2	–140.8	
21.02 MHz	–126.0	–135.8	–140.7	
24.91 MHz	–126.5	–136.4	–140.1	
28.02 MHz	–126.2	–135.9	–139.7	
50.02 MHz	–126.3	–132.1	–140.3	

Notes:

N/A means not applicable or not measured.

1. For all measurements, the IF filter bandwidth was set for 500 Hz.

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 (MHz)	Minimum Frequency MDS (dBm)	Maximum Frequency (MHz)	Maximum Frequency MDS (dBm)	Notes
0.03 MHz	–89	60 MHz	–100	1

Notes:

1. Measurements made with preamp off.

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 (MHz)	Preamplifier	Sensitivity (μV)	Notes
1.02 MHz	OFF	9.11	1
3.8 MHz	OFF	3.10	
3.8 MHz	ON 1	1.10	
3.8 MHz	ON 2	0.64	
53 MHz	OFF	2.82	
53 MHz	ON 1	1.97	
53 MHz	ON 2	0.68	

Notes:

1. 500 Hz nominal receiver bandwidth used for all tests

FM SINAD Test

Test Description: The purpose of the FM SINAD Test is to determine the sensitivity on FM.

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:

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

If we consider distortion to be merely another form of noise, (distortion, like noise, is something unwanted added to the signal), and a practical circuit in which the signal is much greater than the noise, the SINAD equation can be approximated by the signal to noise ratio:

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

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

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

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

FM Sensitivity test Results:

Frequency (MHz)	Preamplifier	Bandwidth	Sensitivity (dBm)	Sensitivity (µV)	Notes
29.0 MHz	OFF	NAR	–105.4	1.20	
29.0 MHz	OFF	WIDE	–104.4	1.35	
29.0 MHz	ON 1	NAR	–116.1	0.35	
29.0 MHz	ON 1	WIDE	–115.0	0.40	
29.0 MHz	ON 2	NAR	–119.4	0.24	
29.0 MHz	ON 2	WIDE	–118.7	0.26	
52.0 MHz	OFF	NAR	N/A	1.10	
52.0 MHz	OFF	WIDE	N/A	1.17	
52.0 MHz	ON 1	NAR	N/A	0.63	
52.0 MHz	ON 1	WIDE	N/A	0.70	
52.0 MHz	ON 2	NAR	N/A	0.25	
52.0 MHz	ON 2	WIDE	N/A	0.26	

Blocking Dynamic Range Test

Test Description: Dynamic range is a measurement of a receiver's ability to function well on one frequency in the presence of one or more unwanted signals on other frequencies. It is essentially a measurement of the difference between a receiver's noise floor and the loudest off-channel signal that can be accommodated without measurable degradation of the receiver's response to a relatively weak signal to which it is tuned. This difference is usually expressed in dB. Thus, a receiver with a dynamic range of 100 dB would be able to tolerate an off-channel signal 100 dB stronger than the receiver's noise floor.

In the case of blocking dynamic range, the degradation criterion is receiver desense. 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: If possible, 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.

Test Result Summary:

Frequency	Preamp	Spacing	BDR (dB)	Notes
1.020 MHz	OFF	50 kHz	120.6	1
3.52 MHz	OFF	20 kHz	126.6	
3.52 MHz	ON 1	20 kHz	125.0	
3.52 MHz	ON 2	20 kHz	121.7	
14.02 MHz	OFF	20 kHz	126.6	
14.02 MHz	ON 1	20 kHz	125.2	
14.02 MHz	ON 2	20 kHz	120.3	
28.02 MHz	OFF	50 kHz	124.7	
50.02 MHz	OFF	20 kHz	127.3	
50.02 MHz	ON 1	20 kHz	130.1	
50.02 MHz	ON 2	20 kHz	122.3	

Notes:

1. For all measurements, the filter bandwidth was set for 500 Hz.

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. In the case of two-tone, third-order dynamic range, the degradation criterion is a receiver spurious response. If the receiver generates a third-order response equal to the receiver's noise floor to two off-channel signals, the difference between the noise floor and the level of one of the off-channel signals is the blocking dynamic range. 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 3^{rd} 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.

Two-Tone Receiver IMD Dynamic Range Test Result Summary:

Frequency (MHz)	Spacing	Preamp OFF IMD DR (dB)	Preamp 1 ON IMD DR (dB)	Preamp 2 ON IMD DR (dB)	Notes
1.82 MHz	50 kHz	N/A	N/A	88.6	
3.52 MHz	20 kHz	91.6	92.0	89.7	
14.02 MHz	20 kHz	94.6	92.2	88.2	
28.02 MHz	50 kHz	N/A	N/A	91.7	
50.02 MHz	20 kHz	93.3	83.6	89.3	

Notes:
1. For all measurements, the filter bandwidth was set for 500 Hz.
N/A = Not applicable or not measured.

Dynamic Range Graphs:

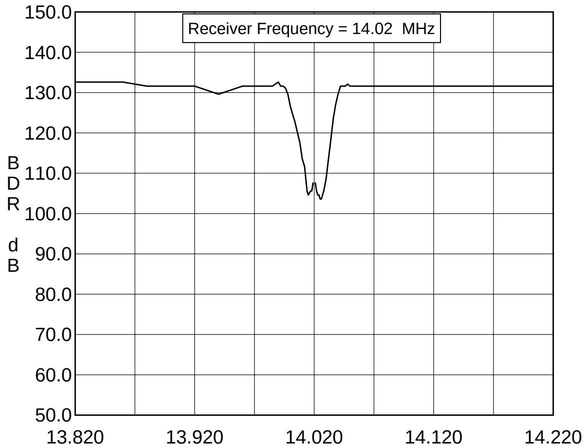
Dynamic range measures the difference between a receiver's noise floor and the receiver's degradation in the presence of strong signals. In some cases, the receiver's noise performance causes receiver degradation before blocking or a spurious response is seen. In either case, if the noise floor is degraded by 1 dB due to the presence of receiver noise during the test, the dynamic range is said to be noise limited by the level of signal that caused the receiver noise response. A noise-limited condition is indicated in the *QST* "Product Review" test-result tables. On the graphs on the following page(s), noise limited measurements are indicated with a small circle drawn on the data point on the graph.

Being "noise limited" is not necessarily a bad thing. A receiver noise limited at a high level is better than a receiver whose dynamic range is lower than the noise-limited level. In essence, a receiver that is noise limited has a dynamic range that is better than its local-oscillator noise. Most of the best receivers are noise limited at rather high levels.

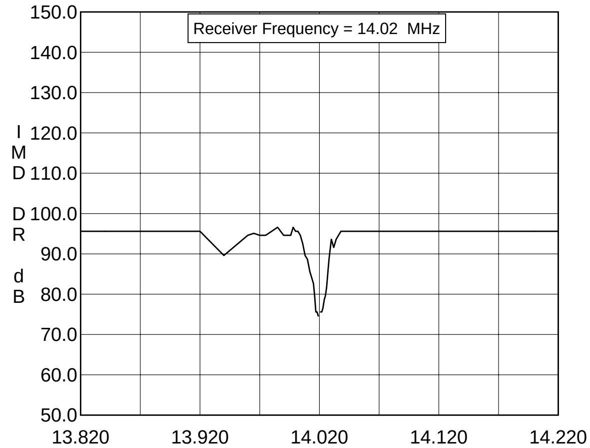
The ARRL Laboratory has traditionally used off-channel signals spaced 20 kHz from the desired signal. This does allow easy comparisons between different receivers. There is nothing magical about the 20-kHz spacing, however. In nearly all receivers, the dynamic range varies with signal spacing, due to the specific design of the receiver. Most receivers have filter combinations that do some coarse filtering at RF and in the first IF, with additional filtering taking place in later IF or AF stages. As the signals get "inside" different filters in the receiver, the dynamic range decreases as the attenuation of the filter is no longer applied to the signal. Interestingly, the different filter shapes can sometimes be seen in the graphs of dynamic range of different receivers. In the case of the ARRL graphs, one can often see that the 20-kHz spacing falls on the slope of the curve. Many manufacturers specify dynamic range at 50 or 100 kHz.

The graphs that follow show swept blocking and two-tone dynamic range. In the blocking test for an HF unit, the receiver is tuned to a signal on 14.020 MHz, the center of the graph. The X-axis is the frequency (MHz) of the undesired, off-channel signal. In the two-tone test for an HF unit, the receiver is tuned to a signal on 14.020 MHz, the center of the graph. The X axis is the frequency of the closer of the two tones that are creating intermodulation. For VHF receivers, or single-band HF receivers, a frequency that is 20 kHz higher than the lower band edge, or 20 kHz from the "traditional" start of the weak-signal portion of the band, is selected.

Swept Blocking Dynamic-Range:



Swept IMD Dynamic-Range:



Second-Order IMD Test

Test Description: This test measures the amount of 2nd-order mixing that takes place in the receiver. Signals at 6.000 and 8.020 MHz are presented to the receiver and the resultant output at 14.020 MHz is measured.

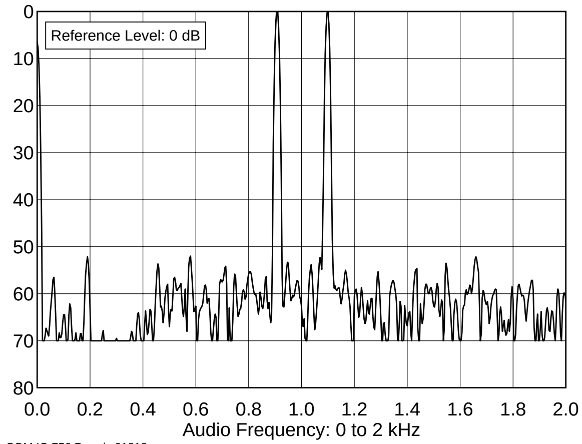
Test Results:

Frequency	Preamplifier	Dynamic Range (dB)	IP2 (dBm)	Notes
14.02 MHz	OFF	96.6	+63.7	
14.02 MHz	ON 1	99.2	+62.6	
14.02 MHz	ON 2	92.3	+42.8	

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 µV (nominally S9), spaced 200 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.

In-Band Receiver IMD Graphs:



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4.020 MHz, AGC Fast, In-Band Receiver IMD
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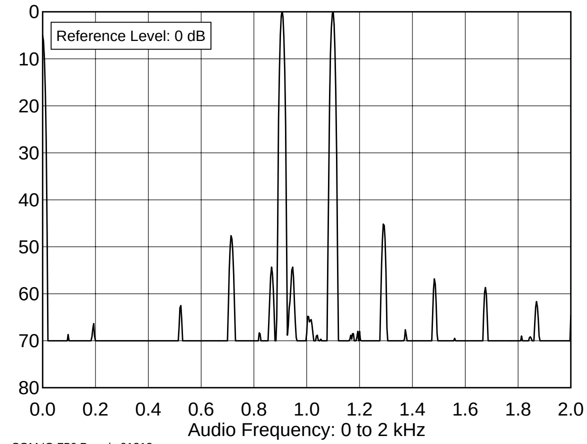

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4.020 MHz, AGC Fast, In-Band Receiver IMD S9+60
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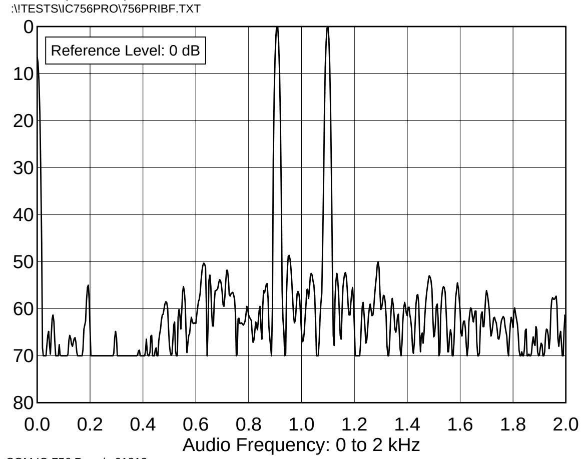

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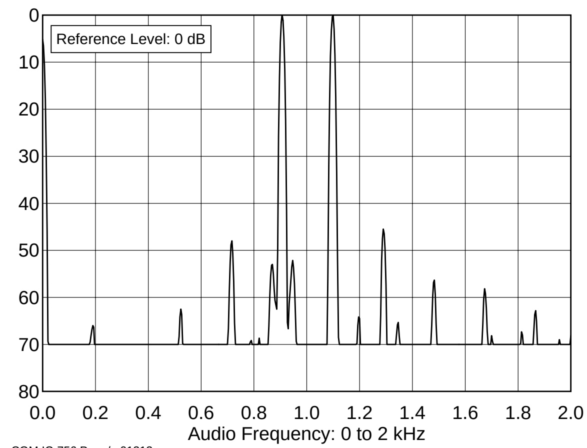

COM IC-756 Pro s/n 01313
4.020 MHz, AGC Slow, In-Band Receiver IMD S9+60
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FM Adjacent Channel Selectivity Test

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 must be performed before this test can be completed.) The greater the number in dB, the better the rejection. The unit is operated with preamp(s) on.

Test Results:

Frequency (MHz)	Frequency Spacing	Adjacent-channel rejection (dB)	Notes
29.0 MHz	20 kHz	76.4 dB	
52.0 MHz	20 kHz	82.0 dB	

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 test the wide-band dynamic range. The greater the dynamic range, the better the receiver performance.

Test Results:

Frequency (MHz)	Frequency Spacing	FM Dynamic Range (dB)	Notes
29 MHz	20 kHz	78.4 dB	
52 MHz	20 kHz	77.0 dB	
52 MHz	10 MHz	105.0 dB	

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 noise floor level. The test is conducted with the receiver in the CW mode using the 500 Hz, or closest available bandwidth. Any audio filtering is disabled and AGC is turned OFF, if possible. The test is performed with the receiver tuned to 14.250 MHz for receivers that have 20 meters, 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 image rejection.

Test Results:

Frequency (MHz)	Calculated Image Frequency	Image Rejection (dB)	Notes
14.2 MHz	143.11 MHz	114.0	
50.2 MHz	179.11 MHz	114.5	

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 turned OFF, if possible. The test is performed with the receiver tuned to 14.250 MHz for receivers 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	1st IF (MHz)	1st IF Rejection	Notes
14.2 MHz	64.455	102.0 dB	
50.2 MHz	64.455	69.8 dB	

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 (W)	Notes
10 %	8 ohms	2.2 W	

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. See also the receiver passband graphs appended to this report.

Test Results:

Unit Mode /Filter BW	Nominal Bandwidth	Low Freq. (Hz)	High Freq. (Hz)	Difference (bandwidth)	Notes
CW Narrow	500 Hz	342	857	515 Hz	1
CW Wide	1200 Hz	74	1262	1188 Hz	
USB Normal	2400 Hz	226	2725	2499 Hz	
LSB Normal	2400 Hz	229	2730	2501 Hz	
AM Normal	6000 Hz	65	3428	3363 Hz	

Notes:
1. CW pitch control centered for all tests

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. This number is not usually critical. A result anywhere between 0.05 and 0.5 μV is usually useful.

Test Results:

Frequency (MHz)	Preamplifier	Mode	Minimum (μV)	Notes
14.2 MHz	OFF	SSB	1.1	
29.0 MHz	ON 2	FM	0.38	
52.0 MHz	ON 2	FM	0.36	

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. The old Collins standard for S9 signal is a level of 50 µV. The Collins standard S unit was 6 dB. However, there is no generally accepted standard among the various current manufacturers.

Test Results:

Frequency (MHz)	Preamplifier	S Units	µV	Notes
14.2	OFF	S9	64.5	
14.2	ON 1	S9	16.4	
14.2	ON 2	S9	8.31	
50.2	OFF	S9	67.6	
50.2	ON 1	S9	29.5	
50.2	ON 2	S9	7.84	
1.02	OFF	S9	232	

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	MODE	Notch Depth	Notes
14.250 MHz	Notch	> 60 dB	

Noise Reduction Test

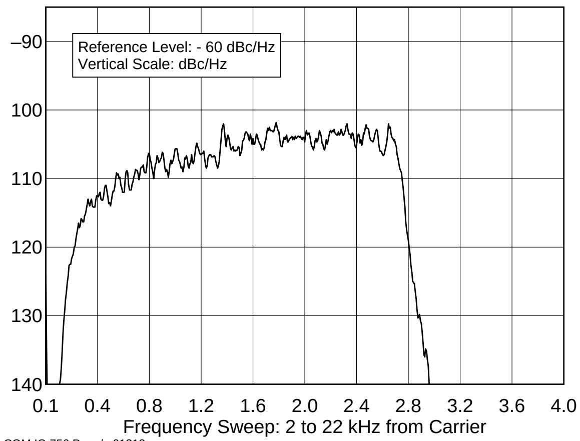
Test Description: There are a number of noise-reduction methods used in modern receivers. Most of them use DSP. In this test, the test engineer uses a test signal that gives about a 20 dB signal-to-noise ratio. The noise reduction is engaged and a measurement or estimate is made of the amount of noise reduction. This is an approximate measurement because the amount of noise reduction is dependent on the original signal-to-noise ratio.

Test Results:

Frequency (MHz)	MODE	Noise reduction	Notes
14.250 MHz	NR	> 15 dB	

Receiver Passband Response

ARRL is still refining the test methods to easily generate receiver bandpass data. For the following graphs, we connected an RF-noise source to the input of the receiver and a spectrum analyzer to the output. After about 10 averages, we obtained a reasonable representation of the receiver bandpass, under actual signal-level conditions. As we refine this test a bit more, we will add a section to the report that better defines the test methods, etc.



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4.020 MHz, USB, 100 W
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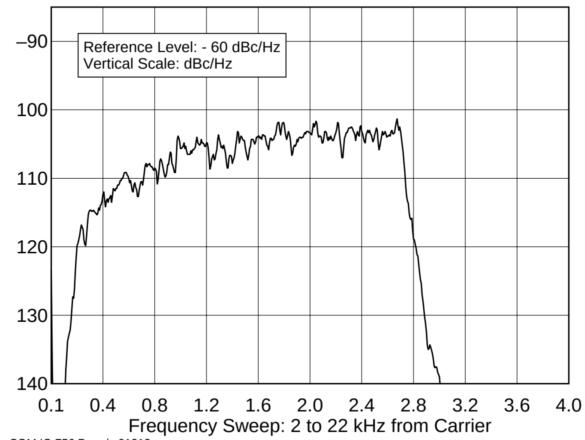

COM IC-756 Pro s/n 01313
4.020 MHz, LSB, 100 W
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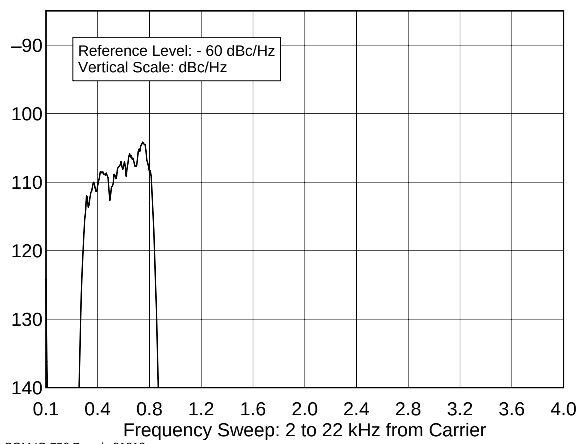

COM IC-756 Pro s/n 01313
4.020 MHz, CW, 100 W
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