ARRL Laboratory
Expanded Test-Result Report
JRC NRD-535D

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Model Information:
Model: NRD-535D   Serial #: 68926
QST "Product Review": May 1997
Reviewer: Larry Wolfgang, WR1B

Manufacturer:
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Related ARRL Publications and Products:

List of Tests:

(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	
Amewritron	AL-800H	
ICOM	IC-706	Mar 96
	IC-756	
	IC-775DSP	Jan 96
	IC-821H	
JRC	NRD-535	
Kenwood	TS-570D	Jan 97
	TS-870S	Feb96
QRO	HF-2500DX	
Ten-Tec	Centaur	
	Omni VI +	
Yaesu	FT-920	
	FT-1000MP	Apr 96

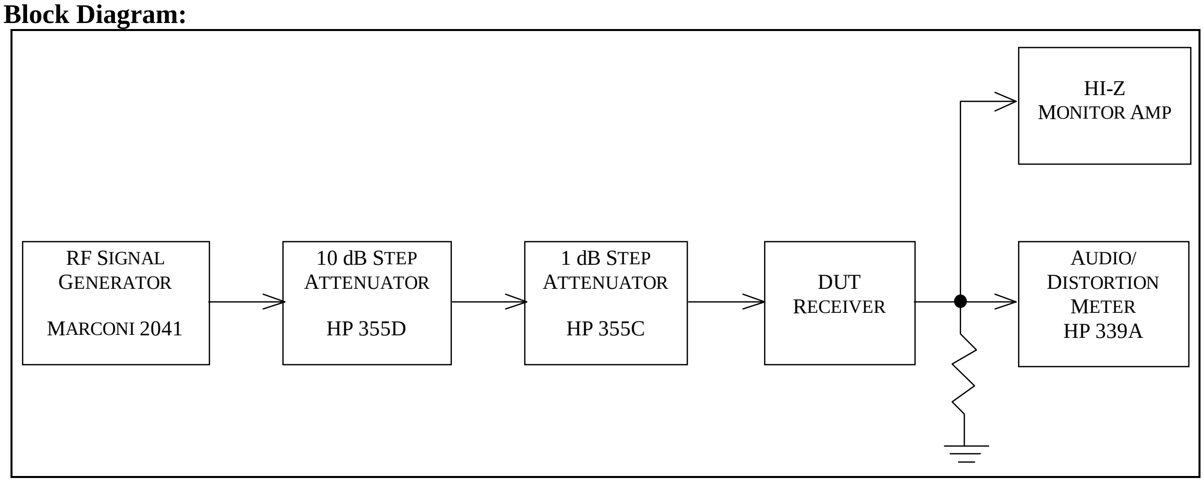
The cost is $7.50 for ARRL Members, $12.50 for non-Members for each report, postpaid. ARRL Members can obtain any three reports for $20.00, postpaid.

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 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, 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 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.

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:

Frequency	MDS (dBm)	Notes
20 kHz	-92.5 dBm	
50 kHz	-115.0 dBm	
180 kHz	-127.9 dBm	
500 kHz	-134.2 dBm	
1.02 MHz	-133.5 dBm	
1.82 MHz	-136.4 dBm	
3.52 MHz	-138.1 dBm	
7.02 MHz	-136.2 dBm	
10.12 MHz	-135.1 dBm	
14.02 MHz	-135.0 dBm	
18.1 MHz	-135.1 dBm	
21.02 MHz	-135.0 dBm	
24.91 MHz	-136.6 dBm	
28.02 MHz	-135.7 dBm	
29.999 MHz	-135.9 dBm	

Notes:
1. For all measurements, the IF filter bandwidth was set for 1000 Hz. The DSP 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
0.1 MHz	-120 dBm	30 MHz	-136 dBm	1

Notes:
1. Unit actually received from 0.0 kHz to 30 MHz, but sensitivity was reduced below about 90 kHz.

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)	Sensitivity (dBm)	Sensitivity (uV)	Notes
1.02 MHz	-111.7 dBm	0.582 uV	1
3.8 MHz	-113.8 dBm	0.457 uV	

Notes:
1. WIDE receiver bandwidth used for all tests

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:

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

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:

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

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 voltage, the better the sensitivity.

Test Results:

Frequency (MHz)	Sensitivity (dBm)	Sensitivity (uV)	Notes
29.0 MHz	-117.6 dBm	0.295 uV	

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

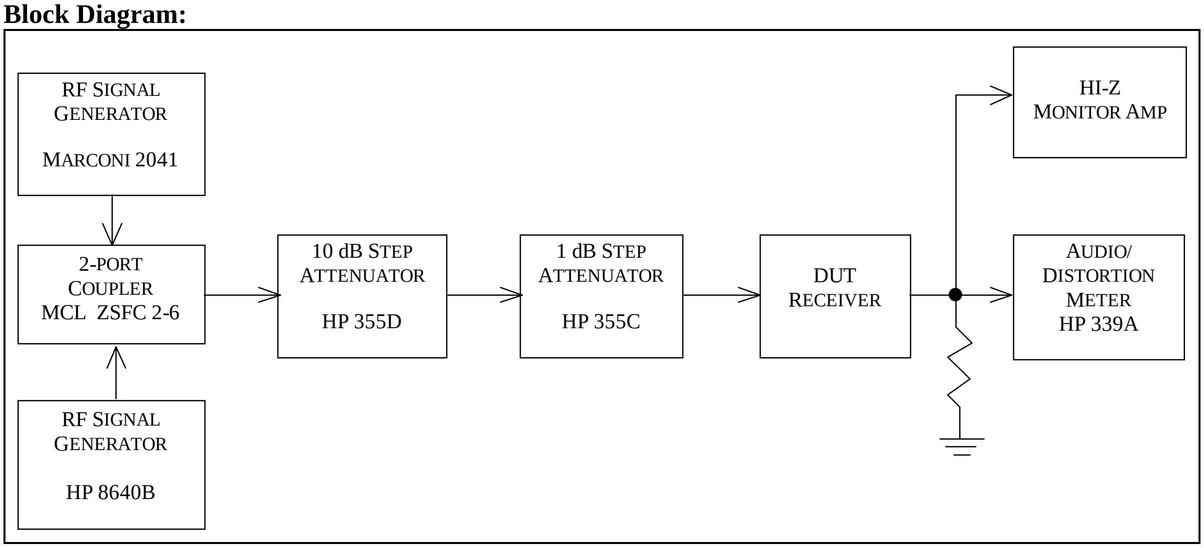
Blocking Dynamic Range Test:

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 frequency. 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.

Block Diagram:



Test Result Summary:

Frequency (MHz)	Spacing	BDR (dB)	Notes
1.02 MHz	50 kHz	132.8 dB*	1
1.82 MHz	50 kHz	132.4 dB*	
3.52 MHz	20 kHz	121.7 dB*	
3.52 MHz	50 kHz	133.1 dB*	
7.02 MHz	50 kHz	132.2 dB	
14.02 MHz	20 kHz	118.0 dB*	
14.02 MHz	50 kHz	127.6 dB	
14.02 MHz	100 kHz	131.4 dB	
21.02 MHz	50 kHz	128.5 dB*	
28.02 MHz	50 kHz	130.2 dB*	

Notes:
(1 dB Compression point at 3.520 MHz: -93 dBm)
1. For all measurements, the IF filter bandwidth was set for 1000 Hz. The DSP filter bandwidth was set for 500 Hz.

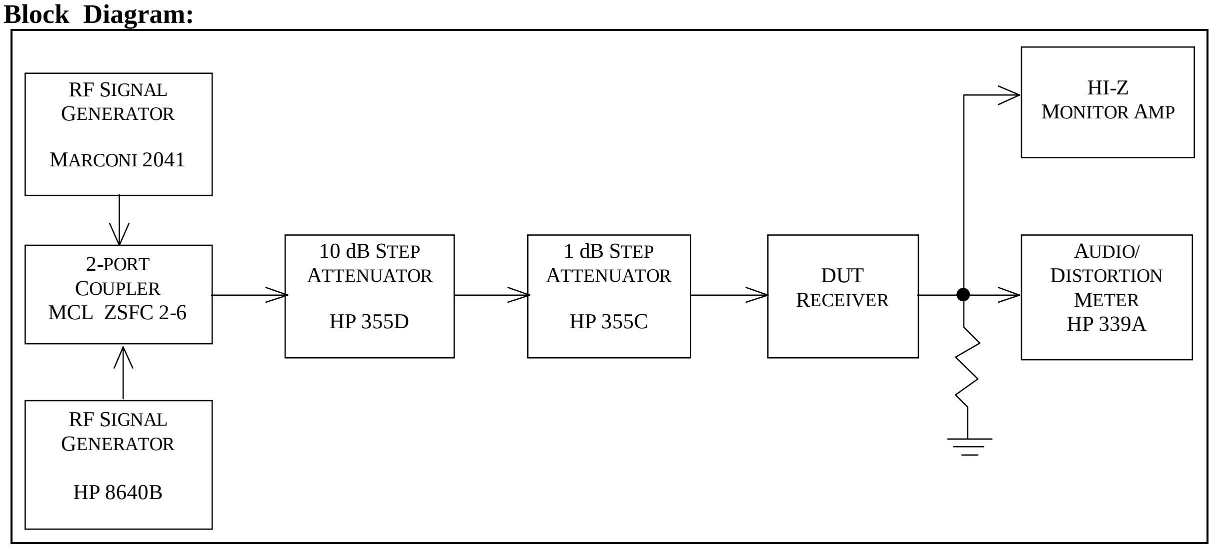
* Indicates that measurement was noise limited at values shown

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 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 $(2f_2-f_1)$. Automated test software also performs a swept test on the 20-meter band. The greater the dynamic range, expressed in dB, or the higher the intercept point, the better the performance.

Key Test Conditions:
If possible. AGC is turned off; the receiver is operated in the linear region. 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:

Frequency (MHz)	Spacing	IMD DR (dB)	IP3 calc from MDS	IP3 calc from S5 levels	Notes
1.02 MHz	20 kHz	90.5 dB*	2.25 dBm*	6.3 dBm	1,2
1.82 MHz	50 kHz	95.4 dB	6.7 dBm	--	
3.52 MHz	20 kHz	94.1 dB	3.05 dBm	4.25 dBm	
3.52 MHz	50 kHz	95.1 dB	4.55 dBm	--	
7.02 MHz	50 kHz	96.2 dB	8.1 dBm	--	
14.02 MHz	20 kHz	94.0 dB	6.0 dBm	5.2 dBm	
14.02 MHz	50 kHz	94.0 dB	6.0 dBm	--	
14.02 MHz	100 kHz	94.0 dB	6.0 dBm	5.2 dBm	
21.02 MHz	50 kHz	95.0 dB	7.5 dBm	--	
28.02 MHz	50 kHz	95.7 dB	7.85 dBm	--	

Notes:
1. For all measurements, the IF filter bandwidth was set for 1000 Hz.

* Indicates that the measurement was noise limited at values shown.

Dynamic Range Graphs:

The following page shows one of the highlights of ARRL test result reports -- swept graphs on receiver two-tone, third-order IMD dynamic range and blocking dynamic range. These graphs are taken using National Instruments LabWindows CVI automated test software, with a custom program written by the ARRL Laboratory.

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. The Laboratory is working on software changes that will show on the test-result graphs which specific frequencies were noise limited. These will be incorporated into future test-result reports.

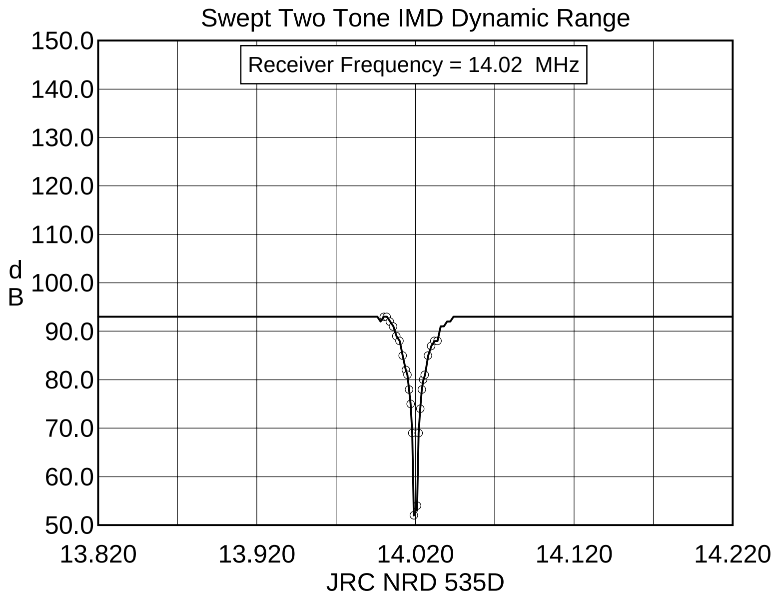
Being "noise limited" is not necessarily a bad thing. A receiver noise limited at a high level is better than a receiver whose dynamic range is lower than the noise-limited level. In essence, a receiver that is noise limited has a dynamic range that is better than its local-oscillator noise. Most of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

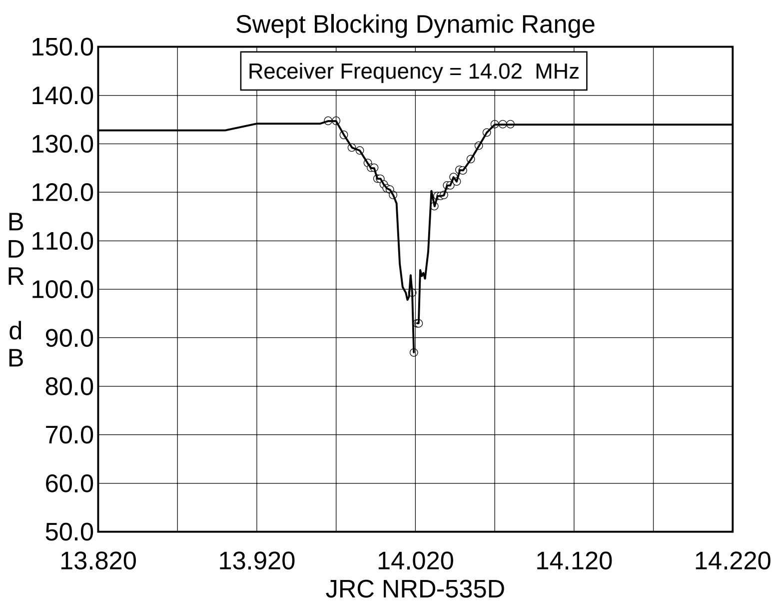
The ARRL Laboratory has traditionally used off-channel signals spaced 20 kHz from the desired signal. This does allow easy comparisons between different receivers. There is nothing magical about the 20-kHz spacing, however. In nearly all receivers, the dynamic range varies with signal spacing, due to 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 computer is not as skilled (yet) at interpreting noisy readings as a good test engineer, so in some cases there are a few dB difference between the computer-generated data and those in the "Product Review" tables. Our test engineer takes those number manually, carefully measuring levels and interpreting noise and other phenomena that can effect the test data. (We are still taking the two-tone IMD data manually.)

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.

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 6.000 and 8.020 MHz are presented to the receiver and the resultant output at 14.020 MHz is measured.

Test Results:

Frequency (MHz)	Mode	Dynamic Range (dB)	IP2 dBm	Notes
14.02 MHz	CW	104.0 dB	+73.0 dBm	1
14.02 MHz	CW	98.4 dB	+71.4 dBm	

Notes:

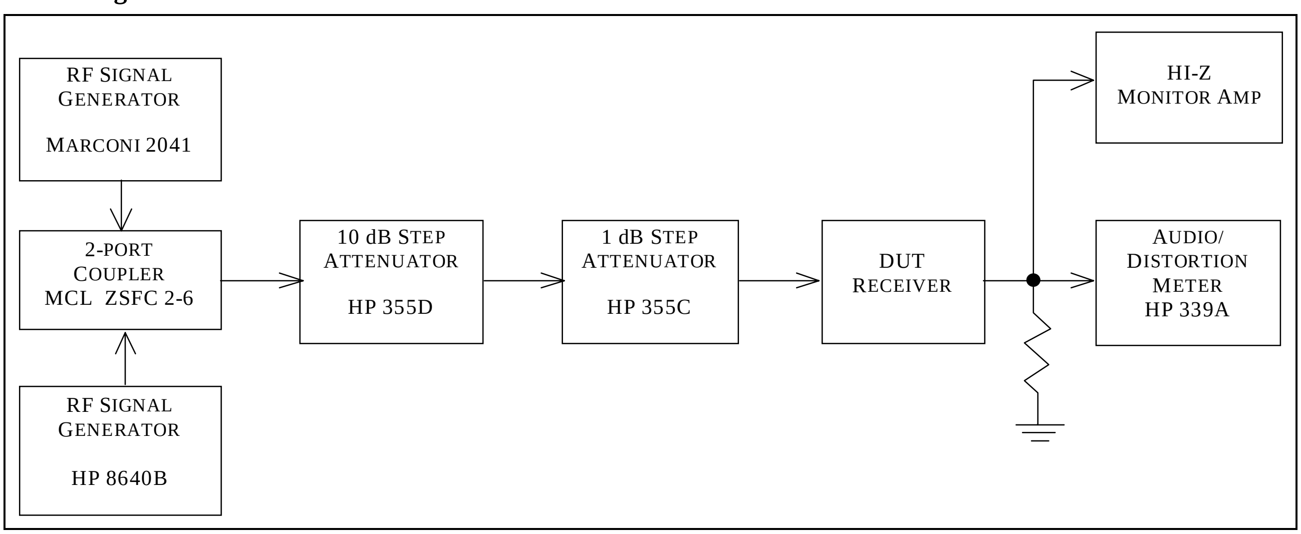
In-Band Receiver IMD Test:

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:

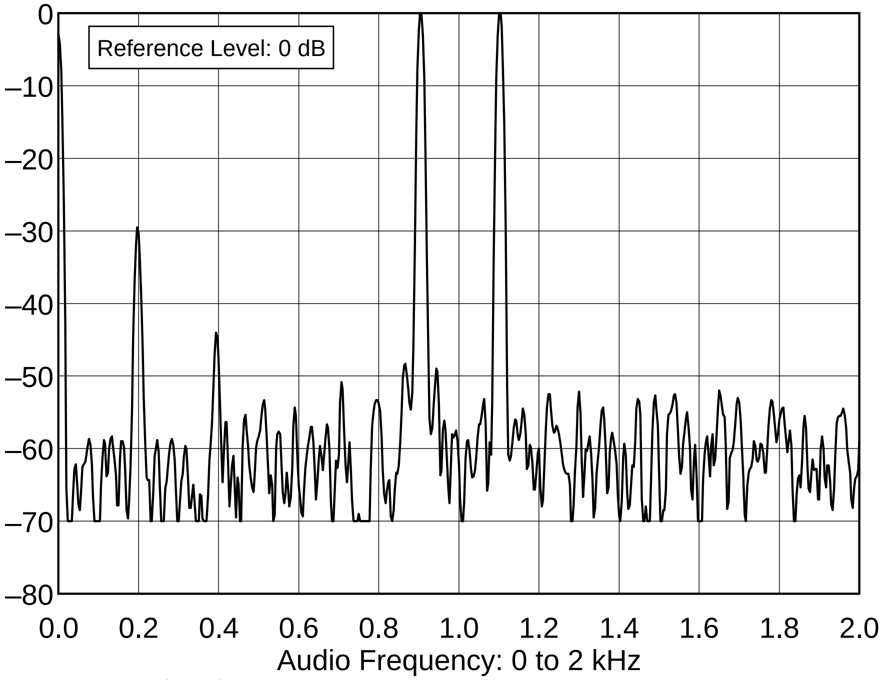
S9 or S9 + 40 dB signals
Receiver set to SSB normal mode, nominal 2 - 3 kHz bandwidth

Block Diagram:

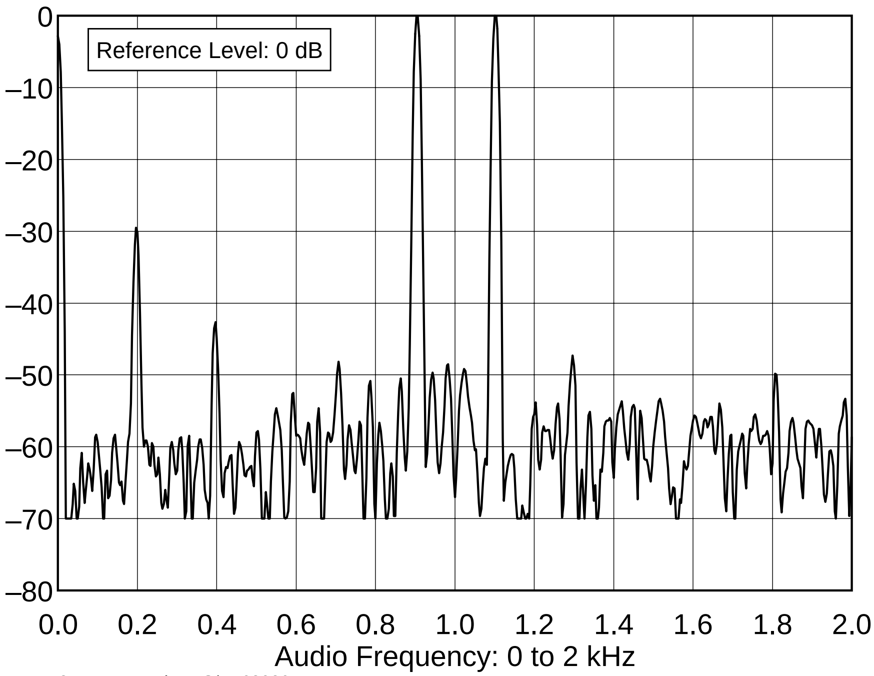


Notes:

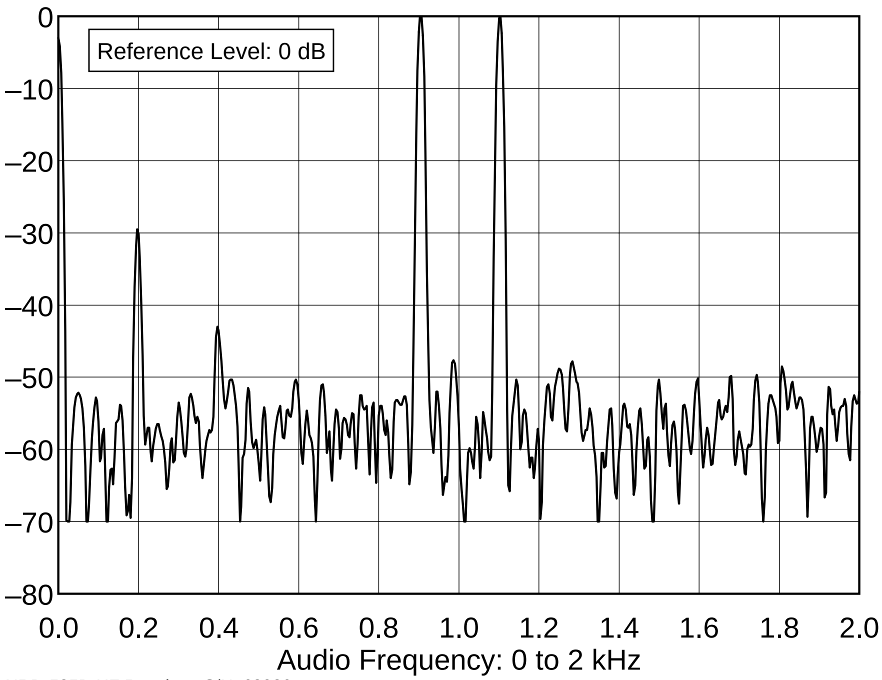
In-Band Receiver IMD Graphs:



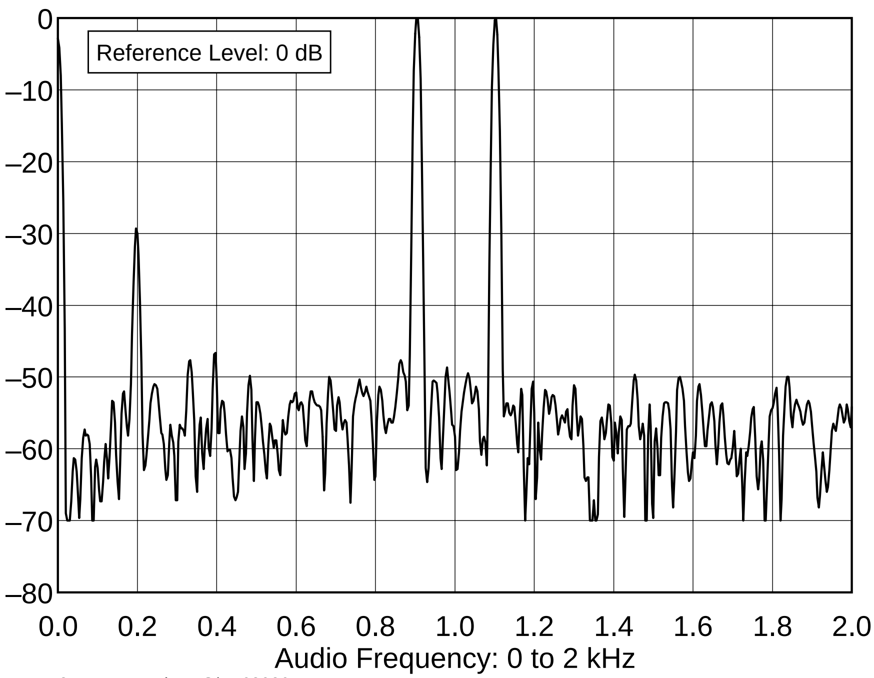
NRD-535D HF Receiver S/N: 68926
14.020 MHz, AGC Fast, In-Band Receiver IMD / Aux Filter
P:\TESTS\NRD535\NRD53IBF.TXT



NRD-535D HF Receiver S/N: 68926
14.020 MHz, AGC Slow, In-Band Receiver IMD / Aux Filter
P:\TESTS\NRD535\NRD53IBS.TXT



NRD-535D HF Receiver S/N: 68926
14.020 MHz, AGC Fast, In-Band Receiver IMD / Wide Filter
P:\TESTS\NRD535\NRD53IWF.TXT



NRD-535D HF Receiver S/N: 68926
14.020 MHz, AGC Slow, In-Band Receiver IMD / Wide Filter
P:\TESTS\NRD535\NRD53IWS.TXT

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 rejection.

Test Results:

Frequency (MHz)	Frequency Spacing (kHz)	Adjacent-channel rejection (dB)	Notes
29.0 MHz	20 kHz	62.4 dB	

Notes:

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

Test Description: **T**he 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 (kHz)	FM Dynamic Range (dB)	Notes
29 MHz	20 kHz	64.6 dB *	

Notes:
* Indicates that result was noise limited at value shown?

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 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 image rejection.

Test Results:

Frequency (MHz)	Mode	Calculated Image Frequency (MHz)	Image Rejection (dB)	Notes
14.250 MHz	CW	155.14 MHz	120.5 dB*	
14.250 MHz	CW	126.64 MHz	120.5 dB*	

Notes:
* = Measurement was noise limited at value shown

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 (MHz)	Mode	1st IF Rejection (dB)	Notes
14.250 MHz	CW	120.5 dB*	

Notes:
1) Measurement was noise limited at this value.

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
Not specified.	8 ohms	2.1 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 Filter Use/Unit Mode	Nominal Bandwidth	Center Freq (Hz)	Low Freq (Hz)	High Freq (Hz)	Difference (bandwidth)	Notes
CW	Narrow	225 Hz	47 Hz	1195 Hz	1148 Hz	
CW	Inter	188 Hz	64 Hz	1701 Hz	1637 Hz	
CW	Wide	1691 Hz	106 Hz	2432 Hz	2326 Hz	
LSB	Inter	1732 Hz	346 Hz	2396 Hz	2050 Hz	
LSB	Wide	178 Hz	83 Hz	2537 Hz	2454 Hz	
LSB	Aux	1681 Hz	125 Hz	2589 Hz	2464 Hz	
USB	Inter	1844 Hz	540 Hz	2545 Hz	2005 Hz	
USB	Wide	2002 Hz	70 Hz	2777 Hz	2707 Hz	
USB	Aux	1739 Hz	79 Hz	2596 Hz	2562 Hz	
USB	Narrow	1851 Hz	838 Hz	2185 Hz	1347 Hz	
LSB	Narrow	1760 Hz	825 Hz	2176 Hz	1351 Hz	
AM	Inter	253 Hz	42 Hz	1185 Hz	1143 Hz	
AM	Wide	178 Hz	42 Hz	2410 Hz	2368 Hz	
AM	Aux	152 Hz	42 Hz	2450 Hz	2408 Hz	

Notes:

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 (MHz)	Mode	Minimum (uV)	Maximum (uV)	Notes
29.0 MHz	FM	0.462 uV	infinite	
14.2 MHz	SSB	0.518 uV	316 mV	

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 (MHz)	S Units	uV	Notes
14.2 MHz	S9	65.2 uV	
14.2 MHz	S5	16.0 uV	
14.2 MHz	S9 + 10	155 uV	
14.2 MHz	S9 + 20	375 uV	
1.0 MHz	S9	88 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: <add more rows as necessary for different conditions>

Frequency (MHz)	MODE	Notch Depth (dB)	Notes
14.250 MHz	Manual	> 30dB	

Notes:

