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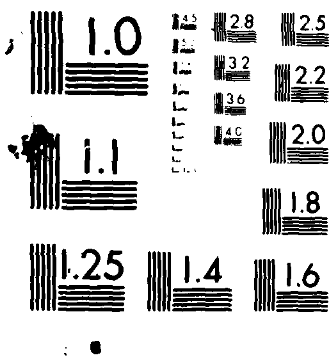

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Receiver selectance is the voltage response characteristics as a function of frequency around the principal response frequency of the receiver. It normally pertains to a linear receiver. For non-linear receivers such as those with clipping or AGC, selectance may be a function of signal level. Selectance of a receiver is measured in terms of voltage response as a function of the spectrum of frequencies, centered around the principal response frequency, which the receiver will amplify with significant gain. The methodology for this test describes three methods and requires only simple and commonly available test equipment. Ref: NBSIR 73-333, Oct 73

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105 19 March 1982
Test Operations Procedure 6-2-576
AD No.

RECEIVER SELECTANCE

1.0 SCOPE. Receiver selectance is the voltage response characteristic as a function of frequency around the principal response frequency of the receiver. It normally pertains to a linear receiver. For non-linear receivers such as those with clipping or AGC, selectance may be a function of signal level. Selectance of a receiver is measured in terms of voltage response as a function of the spectrum of frequencies, centered around the principal response frequency, which the receiver will amplify with significant gain. The methodology for this test describes three methods and requires only simple and commonly available test equipment.* By definition selectance is a measure of the falling off in the response of a resonant device with departure from resonance. It is expressed as the ratio of the amplitude of response at the resonance frequency to the response at some frequency differing from it by a specified amount. (IEEE Std 100-1972)

2.0 FACILITIES AND INSTRUMENTATION. The test item shall be placed in operating condition as outlined in the equipment technical manual.

2.1 Facilities. A communications test facility complete with benches equipped with basic ac power outlets, dc power supplies, and appropriate terminals, leads, and connectors as required. The facility shall have access to an equipment pool and a shielded enclosure.

*This TOP has been taken from the Test Procedures Handbook for Surveillance Receivers Below 100 MHz, NBSIR 73-333, October 1973 which was prepared for the US Army by the Electromagnetic Metrology Information Center of NBS, Boulder,CO 80302. This top is for fixed selectance IF receivers.

Item/Characteristics	Tolerance
Shielded enclosure 100 dB attenuation, minimum	Not required
Power line filter attenuation	-5 dB, + no max
Power line voltage - no control	As available

2.2 Instrumentation. Must have a current calibration certificate. The generators shall either have at least 40 dB harmonic suppression or be backed by a tunable filter to provide the harmonic suppression.

	Item/Characteristics	Tolerance
1.	Signal generators (prior to 1970), precision, variable frequency, AM (amplitude modulated), w/6 dB pad FM generator, precision CW 0.1 to 1.0 volt.	±2 dB output level
2.	Modern Signal Generator, Precision, Variable Frequency AM/FM	±10 dB dynamic range
3.	Input impedance matching network - not needed if lines and all equipment are 50 ohms	±0.5 dB
4.	Frequency meter	±0.1 PPM
5.	RF voltmeter, digital multimeter or RF power meter as required	±3 percent full scale reading
6.	Isolation network	Coaxial hybrid - lower radio frequencies Waveguide coupler - higher microwave radio frequencies

3.0 PREPARATION FOR TEST

3.1 Facilities. Assure facilities conform to minimum requirements.

3.2 Equipment. Testing is conducted in a normal conditioned environment with the usual ancillary equipment to include the isolation network, oscilloscope and oscilloscope camera.

3.3 Instrumentation. All instrumentation is to be set up in accordance with figure 1.

3.4 Characteristics Required (Technical). Record the following:

3.4.1 Test Item. Serial number and nomenclature. Other data if required by test plan.

3.4.2 Instrumentation. Name, type/model, serial number, and calibration due date of each.

3.4.3 Personnel Data. Technician(s)' name(s), MOS/series, and title(s).

4.0 TEST CONTROLS

4.1 Set up all measuring instrumentation and the test item in a screen room to minimize the effects of interfering signals, or in a field area having low measureable interference levels.

4.2 Make the following initial control settings as applicable on the receiver: Band switch, frequency tuning, and IF bandwidth as desired. Set the antenna trimmer to obtain a peak reading on the receiver's signal strength meter (if provided) or peak audio output; the RF, IF and AF gains as required for the test in progress; and the line gain to minimum. Set the beat frequency oscillator, the noise limiter, and squelch level to "off". Set the AGC/MGC mode switch to MGC or AGC depending on output measurement point. The above settings do not apply to digitally tuned receivers because they do not have these controls.

4.3 Set the detector mode to "AM" for the SWEPT-FREQUENCY METHOD.

5.0 PERFORMANCE TESTS

5.1 PROCEDURES FOR POINT-BY-POINT I METHOD. The Point-by-Point I Method of Selectance measurement is conducted in the following manner:

Supply a known variable input signal voltage to the receiver at a variety of frequencies within the principal response range of the receiver with a variable frequency CW signal generator. Adjust the output of the signal generator to maintain a constant output voltage E_o at the voltmeter input terminals.

a. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through a low loss IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency, f_o. If the signal generator output impedance equals Z_s, no matching network is required.

b. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

c. Connect the RF voltmeter across the output terminals of the last IF stage. Use a digital multimeter, if there is no IF output port to calibrate the AGC voltage, the limiter current, or the AF ouptut level with respect to the RF input level. The receiver transfer function can then be read from the calibration curve directly in dB.

d. Set receiver controls as given in paragraph 4.2 above for the desired frequency f_o.

e. Tune the signal generator and the receiver to the measurement frequency, f_o and adjust the antenna trimmer reading to "peak".

f. Adjust the output level of the signal generator to a value (E_{io}, that is approximately 10 dB below the upper voltage level of the receiver's dynamic range (a subtest of TOP 6-2-242).

g. Determine the open circuit signal voltage E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

h. Adjust the sensitivity of the RF voltmeter to produce a convenient, near full-scale deflection, E_o.

i. Measure receiver output voltage, E_o, in volts.

j. Compute the voltage ratio, $R(f_o)$, in decibels as follows:

$$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}}$$

k. Record $R(f_o)$, in decibels, and the measurement frequency, f_o, in kilohertz or megahertz.

l. Tune the signal generator to a new measurement frequency, f_1, above (or below) f_o. The frequency change, f, where $f = f_1 - f_o$, is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the selectance.

m. Leave the receiver tuned to frequency f_o.

n. Adjust the output level of the signal generator to a value, E_{i1}, for f_1 that will again produce receiver output voltage E_o. Do not saturate the receiver's front end when selecting E_{i1}.

o. Determine the open circuit signal voltage, E_{i1}, in microvolts as in step g above.

p. Compute the voltage ratio, $R(f_1)$, in decibels as in step j, above.

$$F(f_1) = 20 \log \frac{E_o}{E_{i1} \times 10^{-6}}$$

q. Record $R(f_1)$, in decibels, and the measurement frequency, f_1, in kilohertz or megahertz.

r. Proceed as indicated in steps l through q, each time changing the frequency (f_2, f_3,...fn) in convenient small steps. Continue until the voltage ratio, R, in decibels, is 0 dB or as small as practicable. Front end dynamic ratio performance has some impact when $E_o = E_{i1} \times 10^{-6}$ for 0 dB voltage ratio.

s. Plot the voltage ratio, R, in decibels, as a function of measurement frequency, f, on rectilinear graph paper. This plot is the selectance of the receiver.

5.2 DATA REQUIRED FOR POINT-BY-POINT I METHOD

a. Record the measurement frequencies in kilohertz or megahertz.

b. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

c. Record the open circuit signal voltage, E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

d. Record the IF output voltages, E_o, in volts.

e. Record the voltage ratios, R(f), in decibels.

5.3 DATA REQUIRED FOR POINT-BY-POINT II METHOD. The Point-By-Point II Method of Selectance measurement is conducted in the following manner:

Supply a constant known input voltage E_{in} to the receiver at a variety of frequencies within the principal response range of the receiver with a variable frequency CW signal generator. Measure the voltage gain between the receiver input terminals and the IF output terminals $R(f_n)$ at the various selected frequencies.

a. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through a low loss IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency , f_o. If the signal generator output impedance equals Z_s, no matching network is required.

b. Connect the FREQUENCY METER to the output port of the signal generator through an ISOLATION NETWORK.

c. Connect the RF voltmeter across the output terminals of the last IF stage. If there is no IF output port use a digital multimeter to calibrate the AGC voltage, the limiter current, or the AF ouptut level with respect to the RF input level. Read the transfer function from the curve in dB.

d. Set receiver controls as given in paragraph 4.2 above for the desired frequency f_o.

e. Tune the signal generator and the receiver to the measurement frequency, f_o and adjust the antenna trimmer reading to "peak".

f. Adjust the output level of the signal generator to a value E_{io}, that is approximately 10 dB below the upper voltage level of the receiver's dynamic range (a subtest of TOP 6-2-242).

g. Determine the open circuit signal voltage E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

h. Adjust the sensitivity of the RF voltmeter to produce a convenient, near full-scale deflection, E_o.

i. Measure receiver output voltage, E_o, in volts for frequency f_o.

j. Compute the voltage ratio, $R(f_o)$, in decibels as follows:

$$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}}$$

k. Record $R(f_o)$, in decibels, and the measurement frequency, f_o, in kilohertz or megahertz.

l. Tune the signal generator to a new measurement frequency, f_1, above (or below) f_o. The frequency change, f, where $f = f_1 - f_o$, is somewhat arbitrary and depends upon the degree of detail with which it is desired to know the selectance. Leave the generator level E_i the same as in step g above.

m. Leave the receiver tuned to frequency f_o.

n. Measure receiver output voltage, E_{o1}, in volts for frequency f_1.

o. Compute the voltage ratio, $R(f_1)$, in decibels as follows:

$$F(f_1) = 20 \log \frac{E_{o1}}{E_i \times 10^{-6}}$$

p. Record $R(f_1)$, in decibels, and the measurement frequency, f_1, in kilohertz or megahertz.

q. Proceed as indicated in steps k through o, each time changing the frequency (f_2, f_3,...fn) in small steps. Continue until the output voltage, E_o, reaches the level produced by the internal noise of the receiver.

r. Plot the voltage ratio, R, in decibels, as a function of measurement frequency, f, on rectilinear graph paper. This plot is the selectance of the receiver.

5.4 DATA REQUIRED FOR POINT-BY-POINT II METHOD

a. Record the measurement frequencies in kilohertz or megahertz.

b. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

c. Record the open circuit signal voltage, E_{io}, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

d. Record the IF output voltages, E_o, in volts.

e. Record the voltage ratios, R(f), in decibels.

5.5 PROCEDURE FOR SWEPT-FREQUENCY METHOD. The Swept-Frequency Method of Selectance measurement uses swept-frequency CW signal generator and an oscilloscope in the following manner:

Supply a swept-frequency signal of constant amplitude to the receiver. Display the detected output voltage from the receiver on the oscilloscope. Supply, also, a linear sweeping voltage with the signal generator for the horizontal deflection circuits of the oscilloscope, and marker signals for calibrating the horizontal frequency scale of the display. Use a camera to photograph the oscilloscope display to obtain a premanent record of the selectance.

a. Connect the input port of the receiver to the output port of the SIGNAL GENERATOR through a low loss IMPEDANCE MATCHING NETWORK that provides the specified source impedance, Z_s, to the receiver at the measurement frequency , f_o. If the signal generator output impedance equals Z_s, no matching network is required.

b. Connect the oscilloscope to the detector as shown in figure 2.

c. Connect the sweeping voltage output from the generator to the horizontal input terminals of the oscilloscope.

d. Set receiver controls as given in paragraph 4.2 above for the desired frequency f_o.

e. Tune the receiver to the measurement frequency, f_o and adjust the antenna trimmer reading to "peak".

f. Adjust the output level of the sweep generator, the sweep width of the sweep generator, and the vertical and horizontal gains of the oscilloscope to produce a display of the detector output voltage having sufficient size to fill the square measurement area of the oscilloscope screen. Use dc coupling in the oscilloscope. If the receiver bandwidth is narrow, use as slow a generator sweep as practicable. The output level is adjusted to provide an input signal voltage that in no greater than 10 dB below the upper voltage

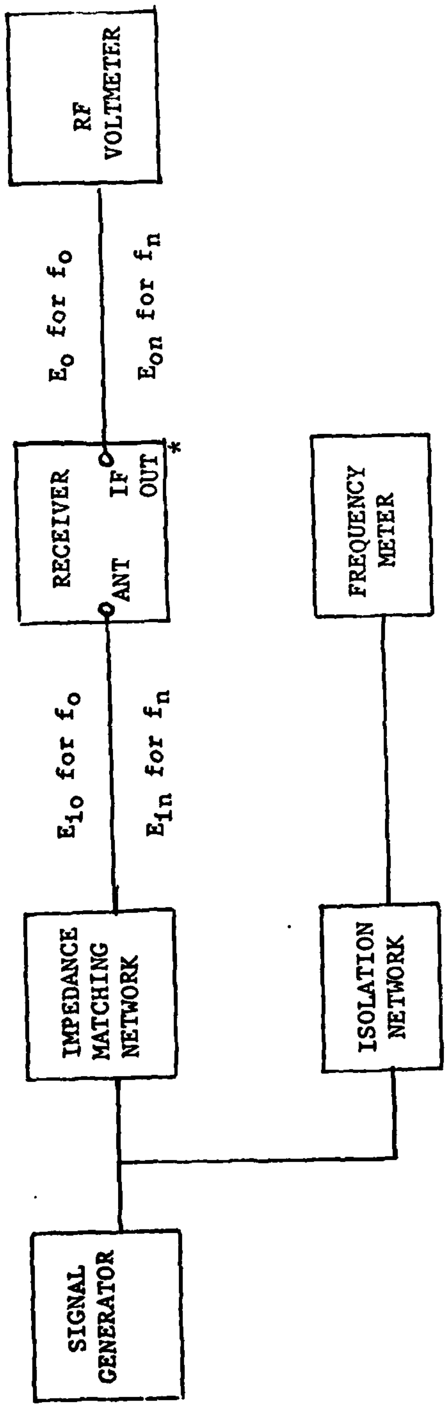


Figure 1. Test setup for selectance, point-by-point methods I and II.
*(Applies only to receivers having an IF output port)

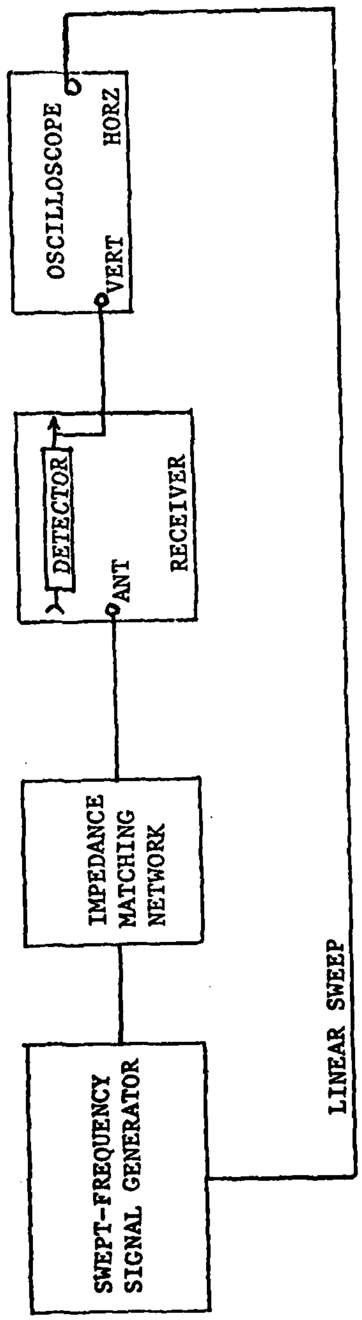


Figure 2. Test setup for selectance, swept-frequency method.

level of the receiver's dynamic range (a subtest of TOP 6-2-242). The sweep width is adjusted to display the full range of frequencies of the principal receiver response, and no more.

g. Turn on sufficient marker generators to calibrate the horizontal scale of the display in kilohertz and megahertz.

h. Having obtained a suitable display, and with frequency marker pips showing, photograph the display. This is the selectance curve of the receiver.

i. Disconnect the vertical input of the oscilloscope from the receiver detector circuit, and apply a signal from a square-wave calibration source to calibrate the vertical scale of the oscilloscope.

j. Determine the vertical scale factor, in volts per centimeter and record this information on the back of the photograph.

k. Determine the horizontal scale factor from the marker frequencies, in kilohertz per centimeter and recored this information on the back of the photograph.

NOTE: This approach will probably work only when selectance requirements are less than 40 dB, i.e., with a vertical scale of 10 cm, 0.1 cm resolution equates to a 40 dB range from max to min.

5.6 DATA REQUIRED FOR SWEPT-FREQUENCY METHOD

a. Record the measurement frequency, f_o, in kilohertz or megahertz.

b. Record the value of source impedance, Z_s, in ohms, connected to the receiver input port.

c. Record the open circuit signal voltage, in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator.

d. Record the vertical scale factor, in volts per centimeter.

e. Record the horizontal scale factor, in kilohertz or megahertz per centimeter.

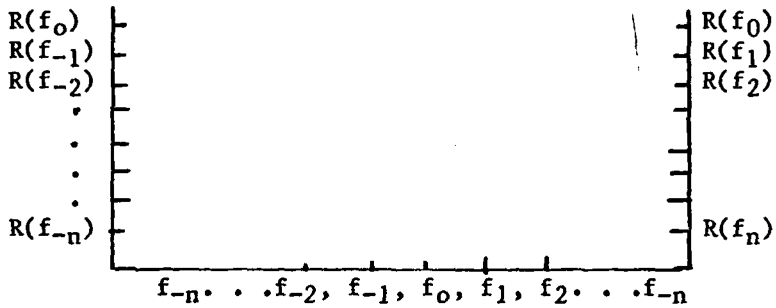
6.0 DATA REDUCTION AND PRESENTATION

The data to be reduced are f_o, f_1, ... f_n in kilohertz or megahertz. These frequency point-by-point data are points on the abscissa of a curve that will illustrate the SELECTANCE characteristics of a radio receiver. The voltage ratio $R(f_o)$ is the ordinate data which is reduced by the corresponding voltmeter input voltage E_o and the signal generator output level E_{io} by use of the following equation:

$$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}} \text{ in decibels}$$

and for f_n frequencies
$(f_{-n} \ldots f_{-2}, f_{-1}, f_o, f_1, f_2 \ldots f_{-n})$

$$R(f_n) = 20 \log \frac{E_{on}}{E_{in} \times 10^{-6}} \text{ in decibels}$$



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APPENDIX A. RADIO RECEIVER SELECTANCE CHECKLIST

1. Facility. The enclosure is checked for damage reducing its effectiveness ______________

2. Power Line. Conducted interference is attenuated at least 100 dB and no evident damage to the filters within the frequency range of interest. ______________

3. Instrumentation. Calibration due date will allow completion of the testing or, with recalibration, the test completion date can be met. ______________

4. Record instrumentation data and characteristics. ______________

5. Safety and security measures instituted. ______________

6. Determine that all instruments are in operating condition. ______________

7. Test item turned-on, warm-up time elapsed, and all controls functioning; it operates satisfactorily. ______________

8. Test item measurements and data recorded. ______________

9. Personnel taking data, recorded, dated, and signed data sheets. ______________

APPENDIX B. DATA SHEETS

	f_m kHz or MHz	E_{io}	E_o	$R(f_o) = 20 \log \frac{E_o}{E_{io} \times 10^{-6}}$ *	$f = f_n - f_o$	E_i
f_o						
f_1						
f_2						
f_n						

*Use $R(f_n)$ formula IAW methods I and II procedures.

APPENDIX C. MEASUREMENT ERRORS

The principal source of measurement error are the following:

a. Uncertainty, ΔE_i, in the measured value of E_i (input in microvolts)

b. Uncertainty, ΔE_o, in the measured value of E_o (output in volts)

c. Uncertainty, Δf, in the measured value of f.

The total relative uncertainty, $\Delta R(dB)$, in decibels in the voltage gain, R, is given approximately, for small uncertainties, by the equation:

$$\Delta R(dB) = 20 \log 1 + \frac{\Delta R}{R},$$

where

$$\frac{\Delta R}{R} = \frac{\Delta E_i}{E_i} + \frac{\Delta E_o}{E_o}$$

Uncertainties ΔE_i and ΔE_o are obtained from the manufacturer's specifications on the output level indicator of the signal generator and on the RF voltmeter, respectively. Uncertainty Δf is obtained from the manufacturer's specifications on the frequency meter. Uncertainties are the plus and minus error measurement capabilities of the instruments used in the test.

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