Radio Measurements for the Amateur

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Etherkit

https://github.com/NT7S/RadioMeasurements

Chapter 1

Introduction

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Chapter 2

Glossary

AF	Audio Frequency
CW	Continuous Wave, i.e. a single tone
DUT	Device Under Test
RMS	Root-mean-square

Chapter 3

Test Equipment

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Chapter 4

Receiver Measurements

4.1 Minimum Discernible Signal (MDS)

Overview

The purpose of this test is to measure the lowest-level CW signal which can be detected by a receiver. This is defined as a signal input at the receiver antenna port which produces the same amount of AF power output as the intrinsic background noise of the receiver. In other words, when a signal at the MDS level is applied to the antenna port, a 3 dB increase in output power is measured over the receiver's internal noise level measurement.

Equipment List

- RF Signal Generator
- 100 dB Step Attenuator (at least 1 dB steps required)
- AC RMS Voltmeter (preferably with dB scale)
- AF Monitor Amplifier or 8 Ω Resistive Load

Test Setup

Required Cabling

- 2 — 50 Ω jumper cables
  Usually coaxial cables (such as RG-58) with BNC Male-to-BNC Male connectors
- 1 — audio jumper cable
  Varies depending on the connectors on your receiver and AF amplifier or load

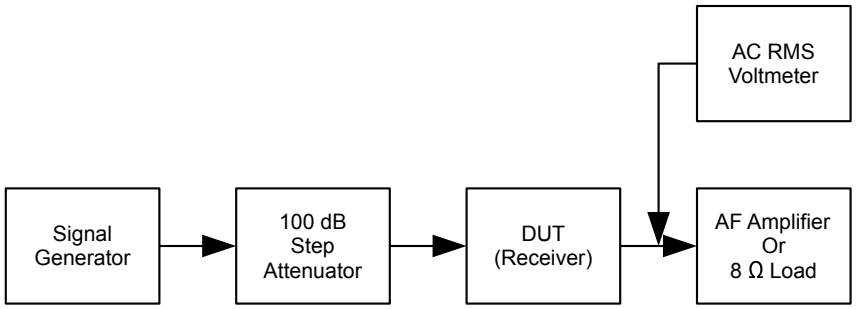

Figure 4.1: MDS Measurement Setup

- 1 — set of voltage probe test leads
  Your choice of connector for measuring AC RMS voltage output

Connections

Make sure all equipment is powered off before making any connections.

- Connect the signal generator output to one port of the step attenuator using a 50 Ω jumper cable.
- Connect the other port of the step attenuator to the DUT (receiver) using a 50 Ω jumper cable.
- Connect the audio output of the DUT (receiver) to the AF amplifier or 8 Ω load using an audio jumper cable.
- Connect the AC RMS voltmeter probes to the properly loaded audio output of the DUT (receiver).

Presets

- Turn ON the signal generator but make sure that the output is OFF. Set the output level to -50 dBm (if you are able to). Set the output frequency to the desired test frequency.
- Set the step attenuator for -40 dB. This will give an initial test signal level of -90 dBm. If you are not able to set your signal generator to -50 dBm, set the step attenuator to give you -90 dBm of test signal output.
- Turn ON the AF amplifier.
- Turn ON the DUT (receiver) and set for the desired measurement band and frequency. Set the AF gain (volume) control fully-counterclockwise (no AF output), then set to an appropriate level for normal listening. If your receiver has AGC, disable it.
- Turn ON the AC RMS voltmeter. Set the meter scale as necessary.

Test Procedure

1. Turn ON the signal generator output. You should hear a CW tone from the AF amplifier.

2. Fine-tune the tune control of the DUT (receiver) until the CW tone is centered in the passband and is at maximum level.

3. Turn OFF the signal generator output.

4. Note the reading of the AC RMS voltmeter in dB. If the meter reading is fluctuating quite a bit, you may need to increase the AF gain control of the DUT (receiver) in order to get a more stable reading.

   AF Noise Power _____

5. The MDS level will be the AF power level 3 dB higher than the measurement made in the previous step. Calculate it below.

   AF Noise + MDS Signal Power _____

6. Turn ON the signal generator output. The reading from the AC RMS voltmeter should be significantly higher than the calculated level in step 5 (if you are using an external AF amplifier, you may need to turn down its gain control). Use the controls on the step attenuator to step down the test signal level until you have a reading on the AC RMS voltmeter that is closest to the figure derived in previous step. Note the amount of attenuation set on the step attenuator, then subtract that from the output level of the signal generator. This is your MDS figure.

   MDS _____

For example, if your signal generator is set to -50 dBm and the step attenuator is set to 81 dB, then your MDS is -131 dBm.

Hints and Tips

- Many QRP receivers and transceivers have a relatively low-level audio output, designed for either headphones-only or for a small speaker. In order to make the most accurate measurement, you may need to turn the AF gain control to maximum.

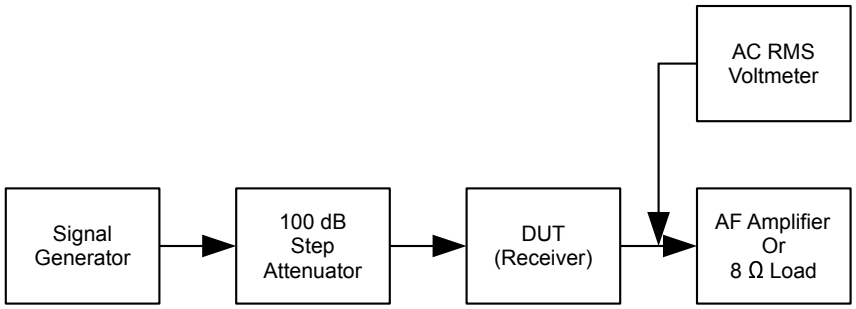

Figure 4.2: MDS Measurement Setup

4.2 IF Rejection

Overview

The purpose of this test is to measure the level a CW signal on the IF frequency can bleed into an receiver and get detected as a valid signal. This is defined as a signal on the IF frequency at the receiver antenna port which produces the same amount of AF power output as the intrinsic background noise of the receiver. For this procedure to work its important to have preformed the MDS measurement as outlined earlier in this document or the noise figure measurement.

Equipment List

- RF Signal Generator
- 100 dB Step Attenuator (at least 1 dB steps required)
- AC RMS Voltmeter
- AF Monitor Amplifier or 8 Ω Resistive Load

Test Setup

Required Cabling

- 2 — 50 Ω jumper cables
  Usually BNC Male-to-BNC Male
- 1 — audio jumper cable
  Varies depending on the connectors on your receiver and AF amplifier or load
- 1 — set of voltage probe test leads
  Your choice of connector for measuring AC RMS voltage output

Connections

Make sure all equipment is powered off before making any connections.

- Connect the signal generator output to one port of the step attenuator using a 50 Ω jumper cable.
- Connect the other port of the step attenuator to the DUT (receiver) using a 50 Ω jumper cable.
- Connect the audio output of the DUT (receiver) to the AF amplifier or 8 Ω load using an audio jumper cable.
- Connect the AC RMS voltmeter probes to the properly loaded audio output of the DUT (receiver).

Presets

- Turn ON the signal generator but make sure that the output is OFF. Set the output level to -30 dBm (if you are able to). Set the output frequency to the desired test frequency.
- Set the step attenuator for -40 dB. This will give an initial test signal level of -70 dBm. If you are not able to set your signal generator to -50 dBm, set the step attenuator to give you -70 dBm of test signal output.
- Turn ON the AF amplifier.
- Turn ON the DUT (receiver) and set for the desired measurement band and frequency. Set the AF gain (volume) control fully-counterclockwise (no AF output), then set to an appropriate level for normal listening. If your receiver has AGC, disable it.
- Turn ON the AC RMS voltmeter. Set the meter scale as necessary.

Test Procedure

1. Turn ON the signal generator output and reduce the attenuation. You should hear a CW tone from the AF amplifier. Adjust the frequency so the tone is sentered in the receiver's passband.

   IF center frequency _____ MHz.

2. Turn OFF the signal generator output.
3. Note the reading of the AC RMS voltmeter in dB. If the meter reading is fluctuating quite a bit, you may need to increase the AF gain control of the DUT (receiver) in order to get a more stable reading.

AF noise power _____

4. 4. The IF rejection power level will be the AF power level 3 dB higher than the measurement made in step 4. Calculate it below.

AF Noise + IF rejection power level _____

5. Turn ON the signal generator output. The reading from the AC RMS voltmeter should be significantly higher than the calculated level in step 4 . Use the controls on the step attenuator to step down the test signal level until you have a reading on the AC RMS voltmeter that is closest to the figure derived in step 4. Note the amount of attenuation set on the step attenuator, then subtract that from the output level of the signal generator. This is your IF rejection power level in dBm.

IF rejection power: _____ dBm.

6. 6. The total IF rejection is now calculated by subtracting the IF rejection power level from the MDS of the receiver.

IF rejection: _____ dB.

For example, if your signal generator is set to 0 dBm and the step attenuator is set to 43 dB, then your IF rejection power level is -43dBm. With an receiver MDS of -131dBm the IF rejection will then be: -43dbm -(-131dBm)=88dB.

Hints and Tips

- Many QRP receivers and transceivers have a relatively low-level audio output, designed for either headphones-only or for a small speaker. In order to make the most accurate measurement, you may need to turn the AF gain control to maximum.

- If the noise vary to much for your readings to be stable, a low pass integrating filter will smooth out the noise and give a stable reading. A suitable filter is a resistor of 10 k in series with the signal lead and a 1 μF capacitor, if the noise vary to much increase the capacitor to 10 μF.

- The IF rejection is the product of the mixer balance and the filter attenuation. Improving the mixer balance will improve the IF rejection.

4.3 Image Rejection

4.4 Opposite Sideband Rejection

4.5 Two-Tone Third Order Dynamic Range

4.6 Blocking Gain Compression

4.7 Noise Figure

4.8 Audio Frequency Response

4.9 Audio Power Output

Chapter 5

Transmitter Measurements

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5.1 Transmitter Power Output

5.2 Transmitter Spectral Purity

5.3 Transmitter Carrier and Unwanted Sideband Suppression

5.4 Transmitter Two-Tone Intermodulation Distortion (IMD)

5.5 Transmitter CW Keying Waveform

Chapter 6

Components and Circuits

Chapter 7

DIY Test Equipment

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