

# Radio Measurements for the Amateur

*November 21, 2014*

JASON MILLDRUM, NT7S

Etherkit

<https://github.com/NT7S/RadioMeasurements>



# Chapter 1

## Introduction

blah



## 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

blah





## 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  $\Omega$  Resistive Load

#### Test Setup

##### Required Cabling

- 2 — 50  $\Omega$  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  $\Omega$  jumper cable.
- Connect the other port of the step attenuator to the DUT (receiver) using a 50  $\Omega$  jumper cable.
- Connect the audio output of the DUT (receiver) to the AF amplifier or 8  $\Omega$  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.

- 4.2 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

blah

- 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

6.1 Crystal Parameters

6.2 Third-Order Intercept

6.3 Noise Figure

6.4 Resonator Q





## Chapter 7

# DIY Test Equipment

blah