

# Debugging Communication Range

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## ABSTRACT

In a RF system having the best possible range is important in many cases. There are many factors that can cause poor range. This application report provides a step-by-step guide on which parts of the design could cause shorter range than desired.

**Table 1. Definition of Terms**

Term	Definition
Conducted	The DUT is connected via cable directly to the instrument.
Radiated	Over the air
CW	Carrier Wave (tone)

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## 1 Step 1: Calculate the Theoretical Range

1. Read [Achieving Optimum Radio Range](#). This document describes the fundamental equations used to estimate range and some of the most important factors that impact range.
2. Calculate line-of-sight (LOS) range using the [excel sheet](#) linked to [Achieving Optimum Radio Range](#) with your radio settings.
  - a. Output power
  - b. Chip and data rate used
  - c. Heights of antennas above ground
  - d. Operating frequency
3. Are there any objects between the LOS of the transmitter and the receiver?
  - a. If yes, add a suitable absorption material that can represent the object blocking the LOS.
4. Choose an antenna gain that is realistic for your project.
  - a. Achieving 100% efficiency is not possible. Example: Typical efficiency would be – 4 dBi for a good 433 MHz antenna for a handheld product.

## 2 Step 2:

If the range is not meeting the expected distance based on the results in [Step 1](#), the root cause needs to be determined:

Poor range could be caused by one or more of the following factors:

- Poor sensitivity in the receiver
- Poor TX output power
- Poor antenna design (matching)
- Not optimal settings

The measurement methods depend on what type of equipment you have available.

It is highly recommend for the measurements to use SmartRF™ Studio to control the DUT. If that is not possible, use unmodified settings and code from the software or unmodified code examples before testing with the settings that are used for the product. This is to ensure that the testing of the hardware is done with good known software.

## 3 Step 3: Measure the Conducted Sensitivity

1. Disconnect the antenna and perform conducted measurements at the SMA connector or solder a semi-rigid coax cable at the 50  $\Omega$  point.
2. Preferred: Use a signal generator that is capable of sending data packets. If the signal generator cannot send data packets, just send preamble data.
3. If a signal generator is not available, use an EM/Launchpad as a transmitter. Use coax cables and attenuation between the EM SMA connector and the 50  $\Omega$  point on the custom board.

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**NOTE:** It is difficult to get an accurate number using this method since the exact values of output power and attenuation are normally not known.

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- a. Some energy will also travel over the air from the EM to the DUT. In addition, background noise could impact the results. To get more accurate results, the receiver should be placed in a shielded box.
4. If the conducted sensitivity is poor:
  - a. Are the settings the same as the recommended values from SmartRF™ software? If the sensitivity is good when using SmartRF Studio and not with the settings used for the project the settings has to be evaluated.
  - b. What is the frequency difference between the DUT and the signal source? Ensure that the RF frequency of the DUT sending a CW is as expected given the tolerance on the xtal used.

- c. Is the schematic according to the reference design including all component values?
- d. Is the layout according to the reference design?

#### 4 Step 4: Measure the Conducted Output Power

1. Disconnect the antenna and perform conducted measurements at the SMA connector or solder on a semi-rigid coax cable at the 50  $\Omega$  point.
2. Preferred: Use a Spectrum analyzer. MSP-SA430 or similar does not have the required accuracy. Use 1 MHz RBW for measuring output power and unmodulated carrier on the transmitter.
3. If a SA is not available, then use an EM or Launchpad with a SMA connection point.
  - a. Add a known RF attenuation block between the transmitter's SMA connector (50  $\Omega$  point) and the EM/Launchpad connector.
  - b. Use SmartRF Studio and set the EM/Launchpad in continuous RX and read the RSSI
4. If the conducted power is poor:
  - a. Is the schematic according to the reference design?
  - b. Is the layout according to the reference design?

#### 5 Step 5: Antenna Measurements

If the conducted sensitivity and conducted output power are as expected, and the range is poor compared to the estimated range, the antenna efficiency is likely poor. The required tuning is a function of the ground plane size and the casing meaning that even if the antenna is copied directly from one of our recommended antenna designs the tuning could be not optimal. The *Antenna Measurements* section in the [Antenna Selection Guide](#) contains a more detailed description on how to measure antennas than the summary below.

- Preferred: Use a Network Analyzer (VNA) to accurately tune the antenna. Some mini VNAs are available on the market with a reasonable price tag if a full featured VNA is not available or cannot be rented.
  - Disconnect the radio and add a semi-rigid coax cable or SMA connector at the 50  $\Omega$  point towards the antenna matching network and antenna.
  - Compensate for the length of the semi-rigid cable or SMA with port extensions so they are not included in the antenna measurements.
  - Always measure the antenna in the final casing, otherwise the tuning will be invalid.
  - Always measure the antenna as it would be used in the application. If the device is placed on a metal shelf, the tuning must be made in a similar environment.
  - Measure the resonance of the antenna and make sure the matching is better than VSWR 2.
  - If the resonance is not correct or the matching is greater than VSWR 2, the antenna design has to be reviewed again.
- If measurements with a VNA is not possible then use an EM or Launchpad with a known good antenna.
  - Measure the resonance frequency by sweeping the frequency of the transmitter; measure which frequency the receiver reads as the highest RSSI.

#### 6 Step 6: Still Issues?

If you still have issues post a question on [E2E](#).

The minimum post on E2E must contain information about:

- Which chip was used
- Settings
- Software used
- Results from [Step 1](#) through [Step 5](#)

## 7 References

- [Antenna Selection Guide](#)
- [Achieving Optimum Radio Range](#)

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