Antenna Selection for Near Field Range Testing

LadyBug®

Fast, Accurate, Traceable

Antenna Applications using LadyBug RF & Microwave Power Sensors

These tests were conducted to determine suitable antennas for range confirmation tests on manufactured devices. The test results are equally valuable for other applications.

When paired with appropriate antennas, LadyBug power sensors offer versatile solutions for testing radiated characteristics, transmissivity, and antenna performance. The high dynamic range and sensitivity of LadyBug sensors make them particularly well-suited for a wide range of antenna testing applications.

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Objective

- Provide an accurate, low cost test solution for wireless devices requiring radiated power confirmation.
  - Compact Near-Field Test Fixture
    - Antenna
    - Fixture
    - Optional: near-field to far-field correction factor
    - Other transmission properties

Antenna Selection

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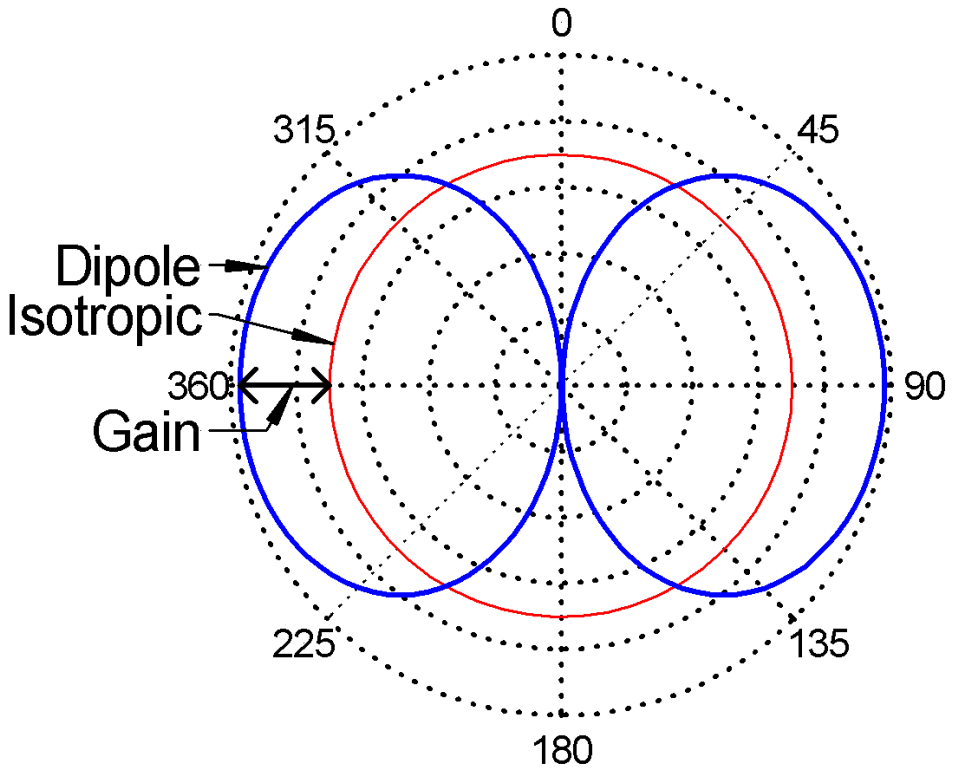
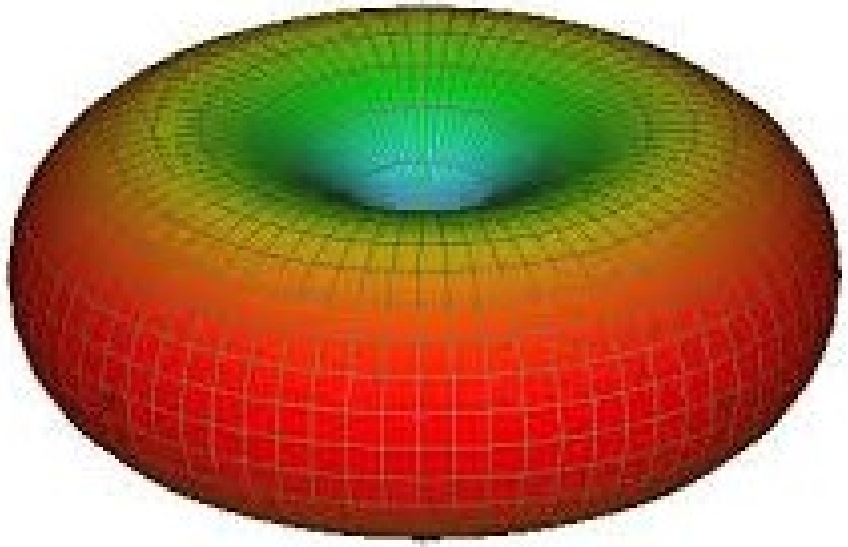
Antenna Selection

- Select & Optimize for Compact Near-Field Test Fixture
- Measure Antenna Gain (at Peak Radiation)





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Antenna Evaluate and Select

Antenna[2]	Gain	Ground & Feed Isolation	System Noise Floor[1]	S11 Match	Overall Ease of Use
1/4 λ monopole	5.1 dBi	Poor	Poor -45 dB to -55 dB	Poor	Hard
1/2 λ axial dipole & ferrite	2 dBi	Okay	Okay -50 dB to -60 dB	Good	Okay
5/4 λ axial dipole	5.1 dBi	Okay	Poor -45 dB to -55 dB	Good	Okay
1/2 λ Tee dipole & ferrite	2.1 dBi	Okay	Okay -55 dB to -60 dB	Best	Good
1/2 λ Tee dipole & filter	0.5 dBi	Best	Best -65 dB to -65 dB	Best	Best

Note 1: Minimum to maximum noise floor measurement:

- **Connect antenna & sensor**
- **Sensor in hand 1/2 meters from objects**
- **Move vertical to horizontal repeat while rotating 360 degrees**

Note 2: Antennas
f = 2.4 GHz
λ = 125 mm
λ = 4.93 in

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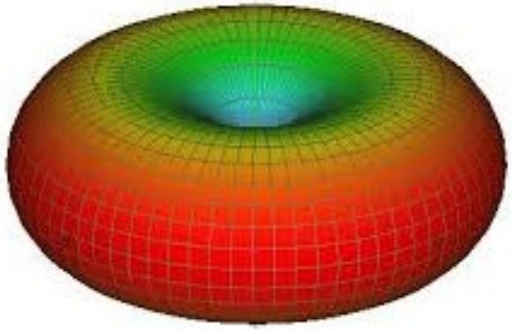
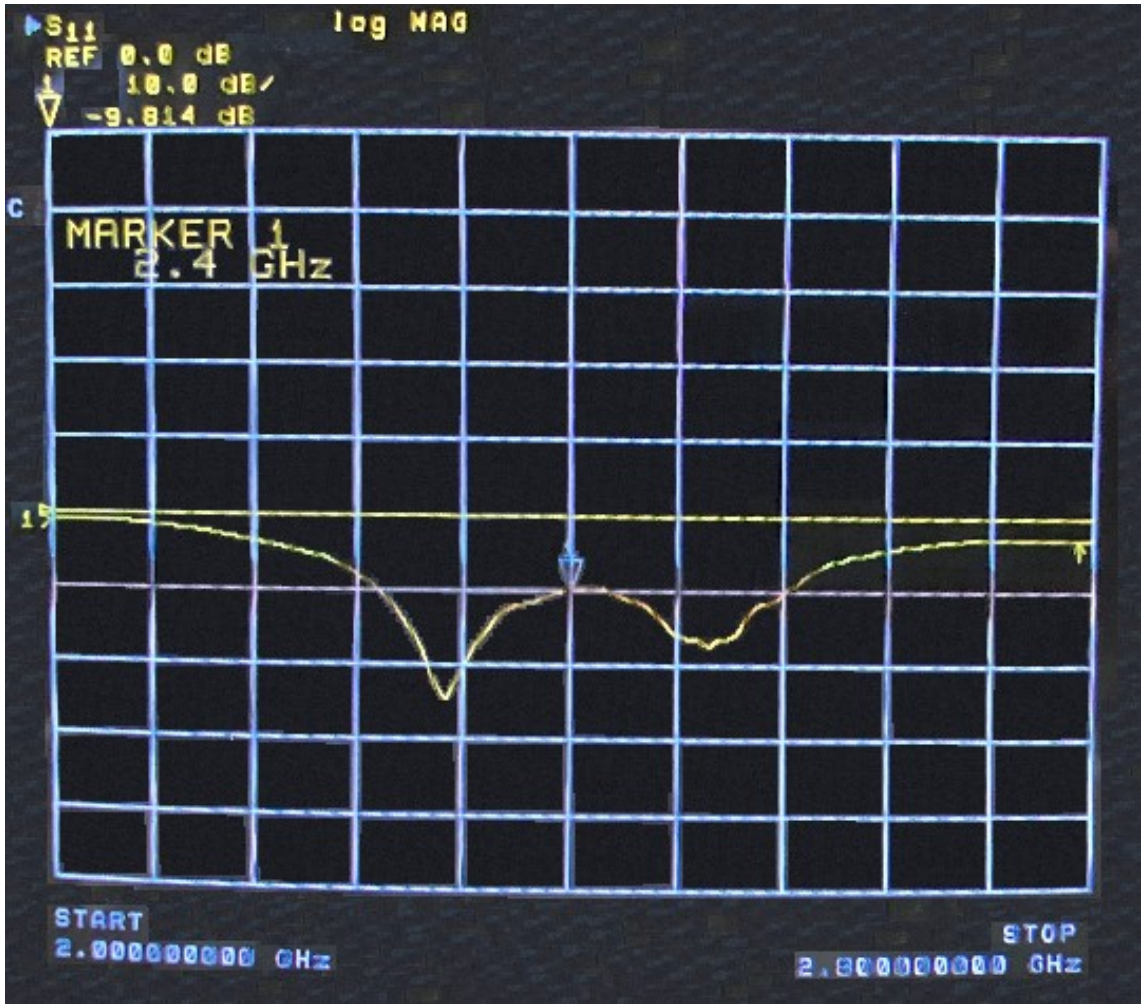
1/2 λ Tee Dipole With Filter

(Polarization: E-field vertical – S11 sensitivity)





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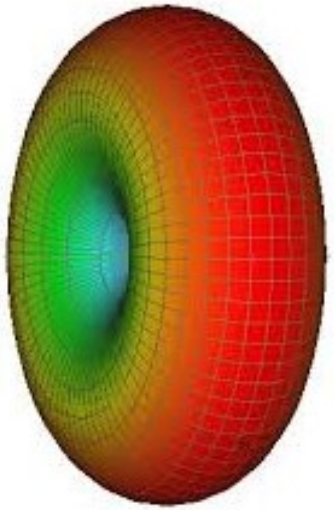
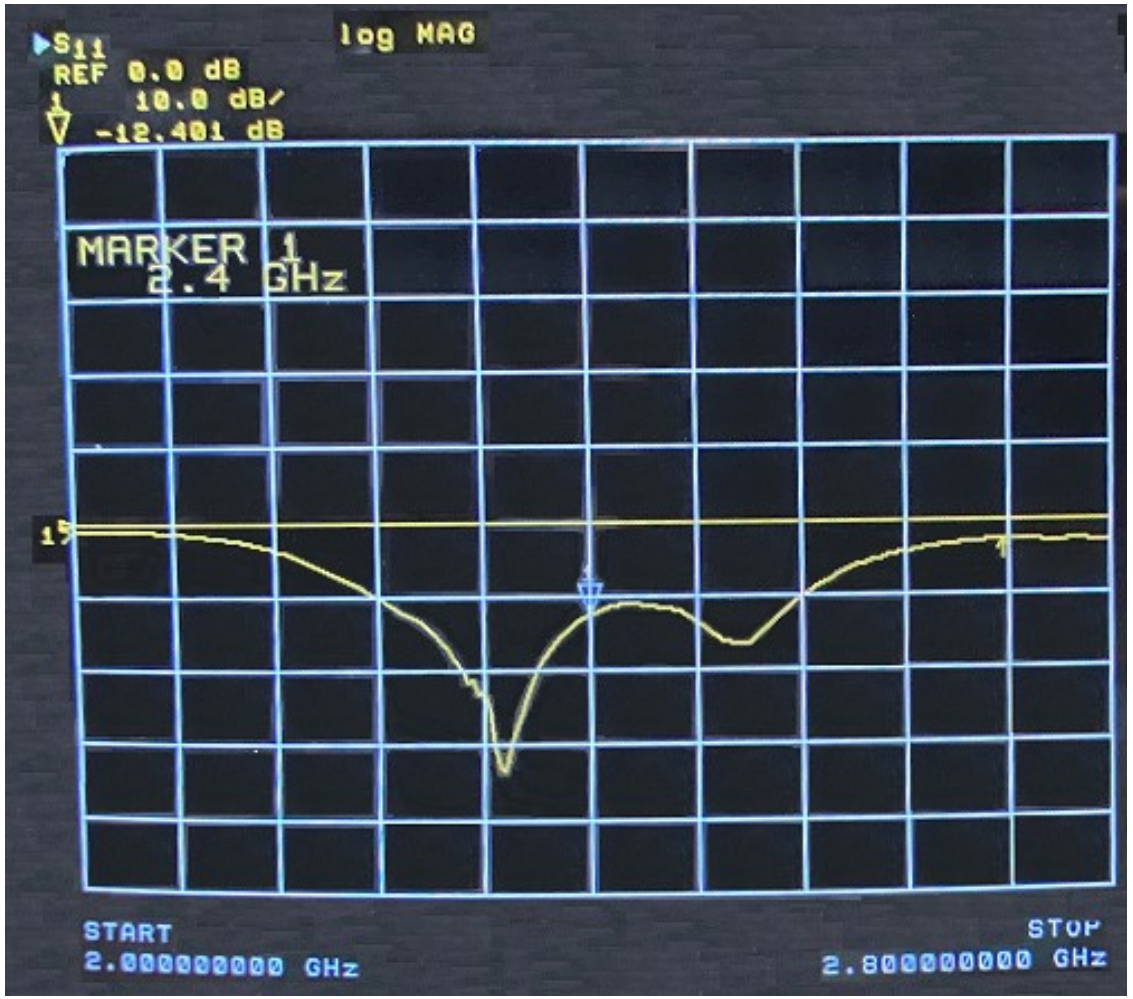
1/2 λ Tee Dipole With Filter

(Polarization: E-field horizontal – S11 sensitivity)





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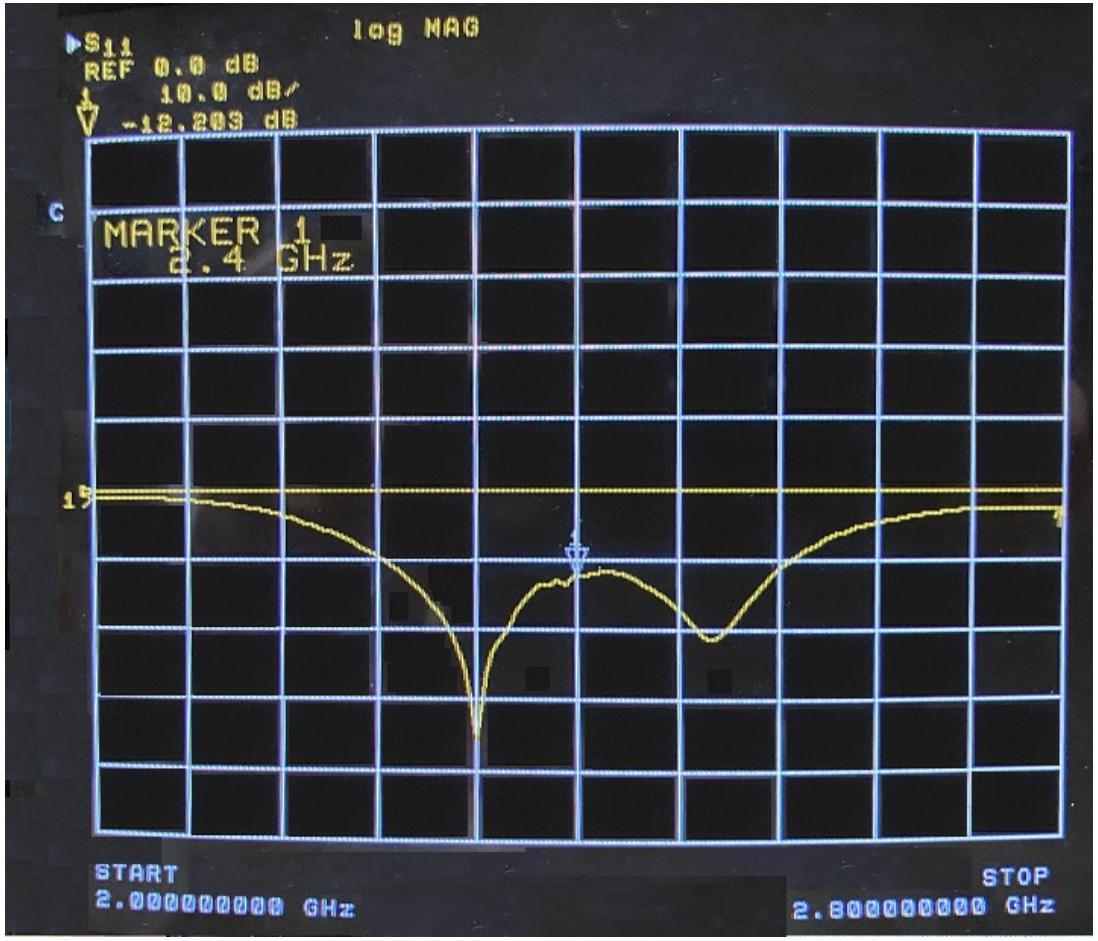
1/2 λ Tee Dipole With Filter

(absorber – S11 sensitivity)



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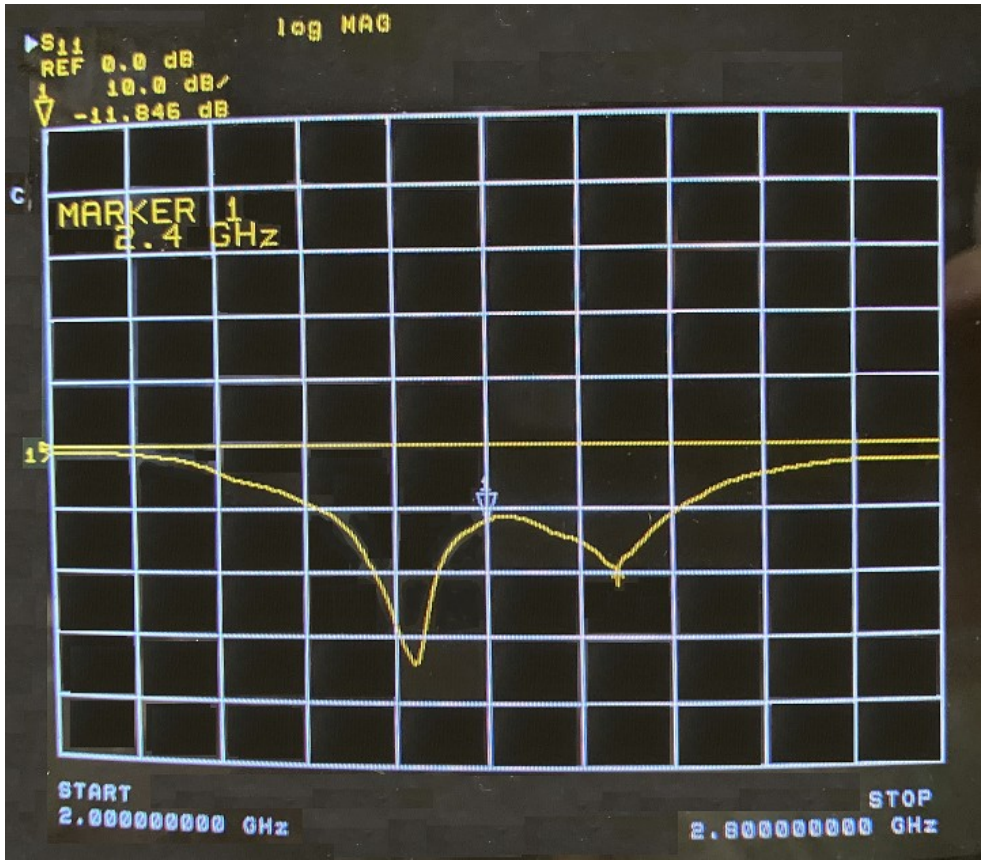
1/2 λ Tee Dipole With Filter

(Heavy Metal – S11 sensitivity)



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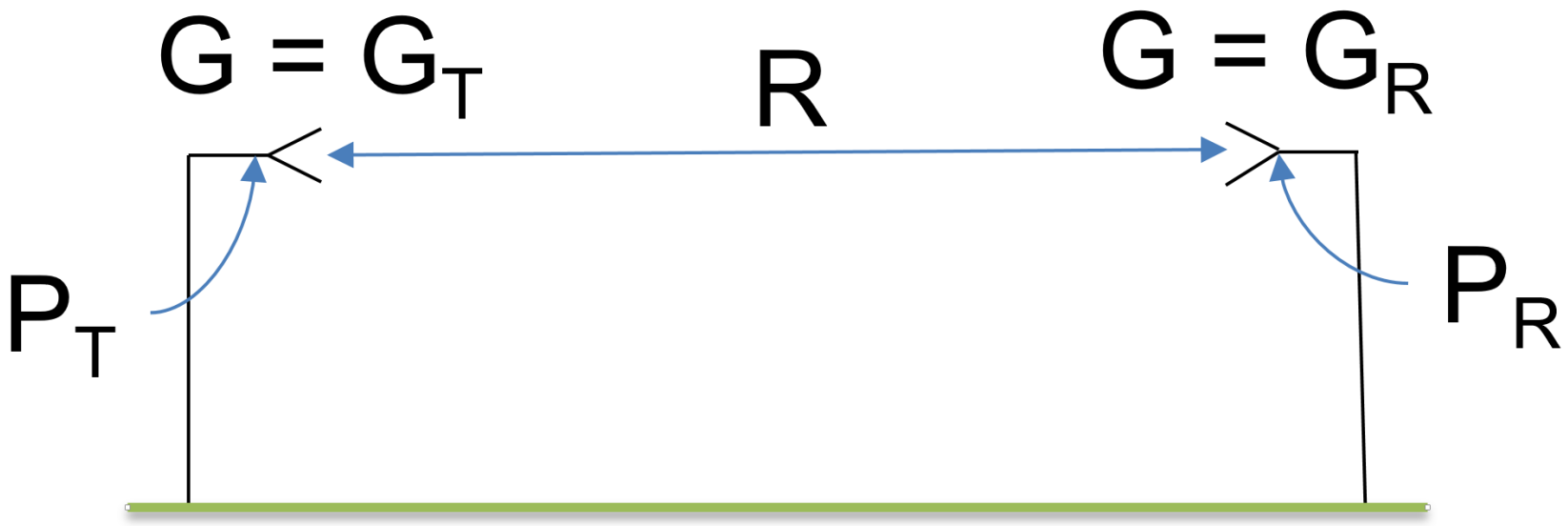
Range Testing



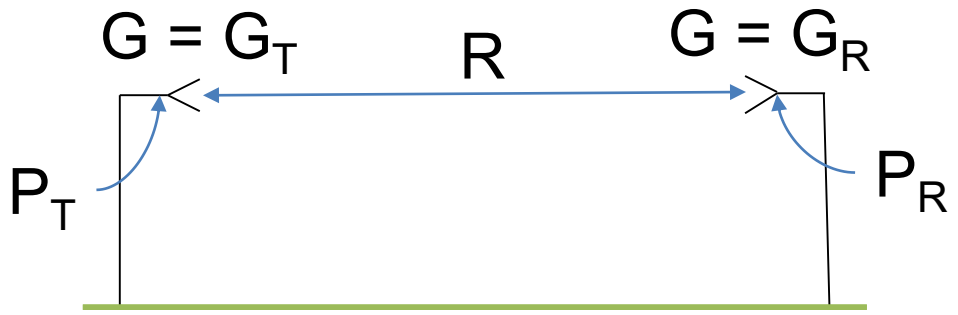
Range Testing

- Math
- Method
  - Back-to-back identical antennas to measure gain & characterize range
- Data
- Results
  - Near-field for far-field correction factor
  - Compact Near-Field Test Fixture requirements

Range Testing: Math

- Friis Transmission Equation: $P_R = P_T G_T G_R c^2/(4\pi R f)^2$
  ➔ Linear: $P_{RT} = P_R/P_T = G_T G_R \lambda^2/(4\pi R)^2$
  ➔ dB: $P_{RT} = G_T + G_R + 20\text{Log}_{10}(\lambda/(4\pi R))$

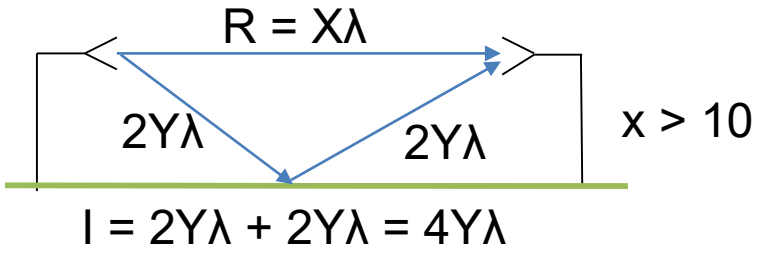
- Assume $G = G_T = G_R$
  ➔ dB: $P_{RT} = 2G + 20\text{Log}_{10}(\lambda/(4\pi R))$



Range Testing: Method & Criteria

Multipath Ground Reflection

(one in phase reflection)



Criteria for maximum far-field interference

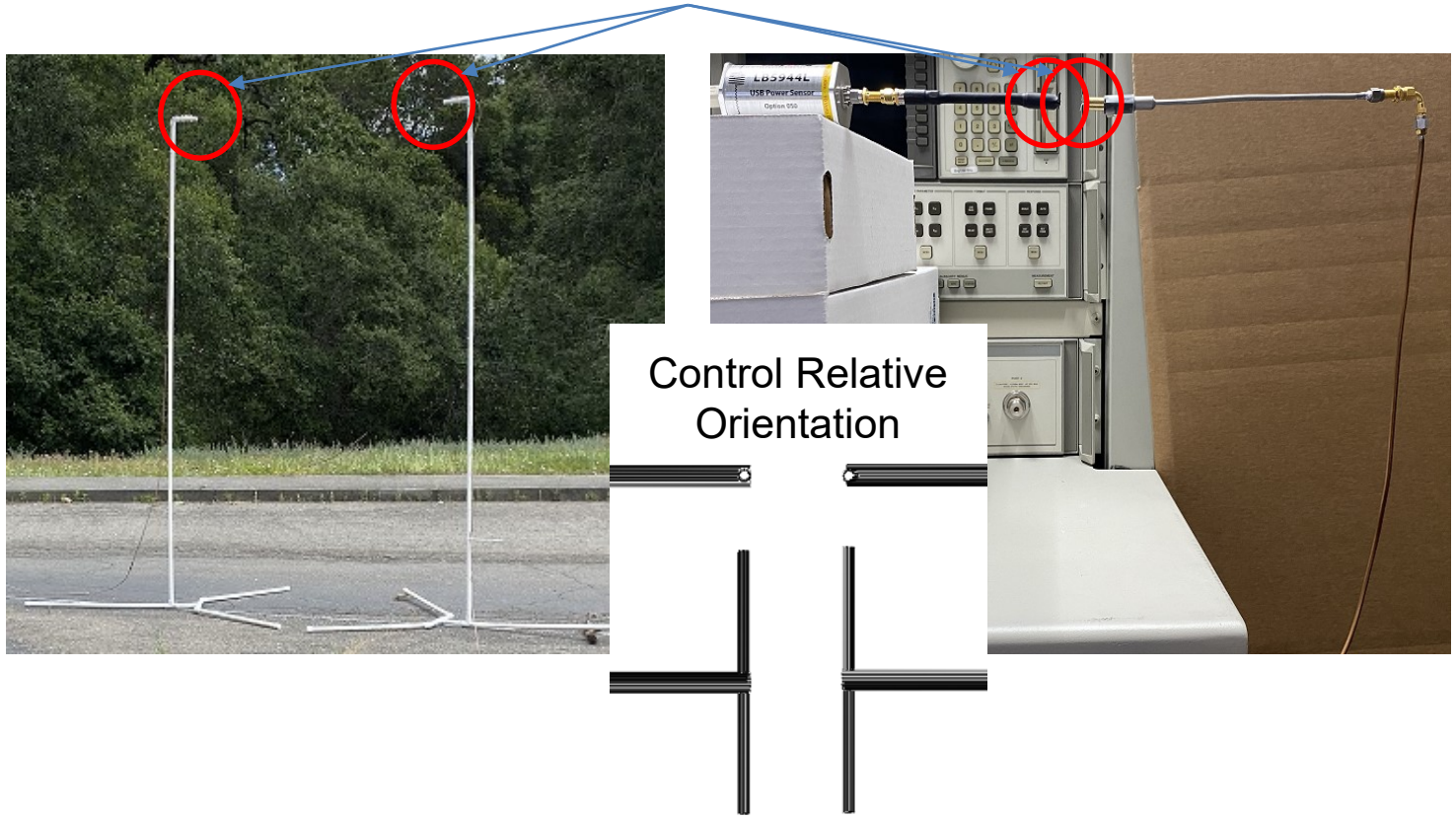
- Max $|_{Y=X} = 1+1/(2+2)^2$ => +0.26 dB
- Min $|_{Y=X+0.5} = 1-1.05/16$ => -0.29 dB

Rules for +0.26/ -0.29 dB Error:

- Near-Field Rule: +0.26/ -0.29 dB; by measure
- Far-Field Setup
- Far-Field Rule: 2R; by distance

Near-Field Setup

Horizontal e-field identical antennas



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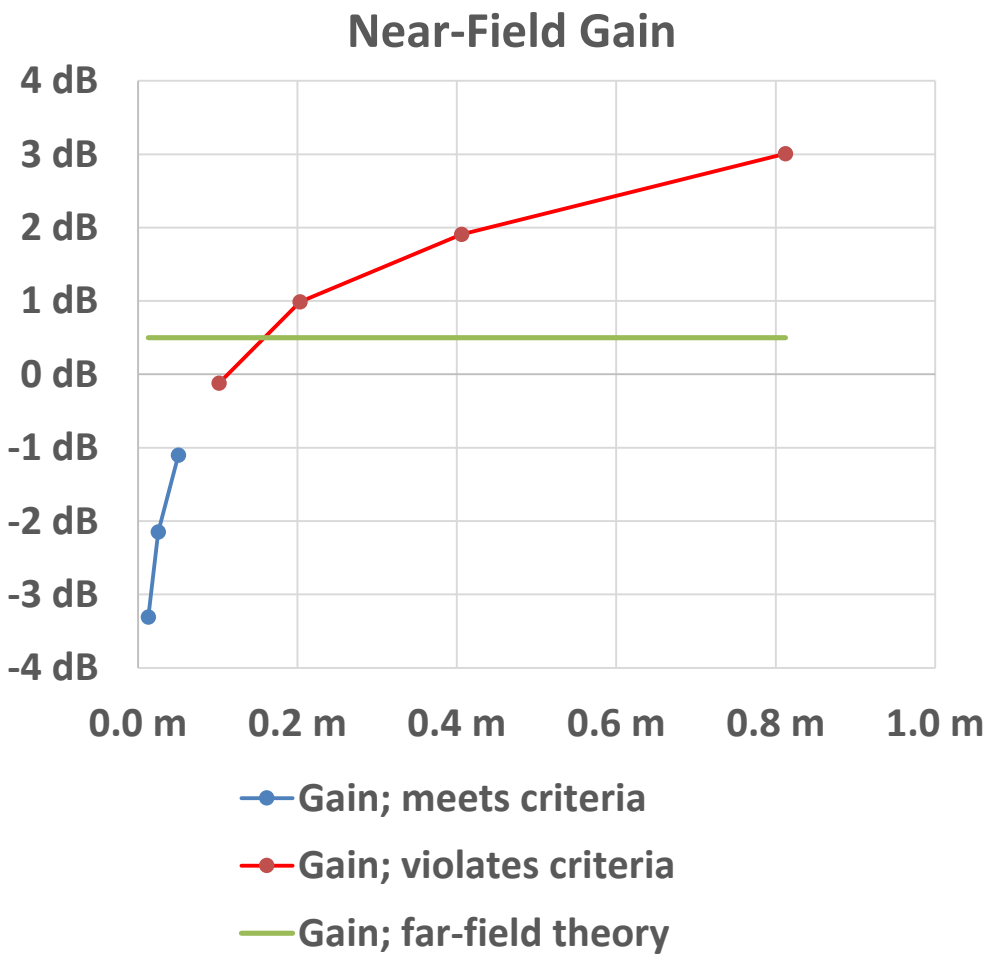
Near-Field Data

Valid Near Field Gains

R (distance)	P_{RT} ($P_R P_T$)	Gain	Multipath Interference (measure)[1]
0.013 m	-8.73 dB	-3.31 dB	0.076 m
0.025 m	-12.43 dB	-2.15 dB	0.102 m
0.051 m	-16.36 dB	-1.10 dB	0.127 m
0.102 m	-20.42 dB	-0.12 dB	0.203 m
0.203 m	-24.22 dB	0.99 dB	0.406 m
0.406 m	-28.40 dB	1.91 dB	0.812 m
0.812 m	-32.22 dB	3.01 dB	1.624 m

Note 1: Criteria experimentally measured to meet +0.26/ -0.29 dB rule



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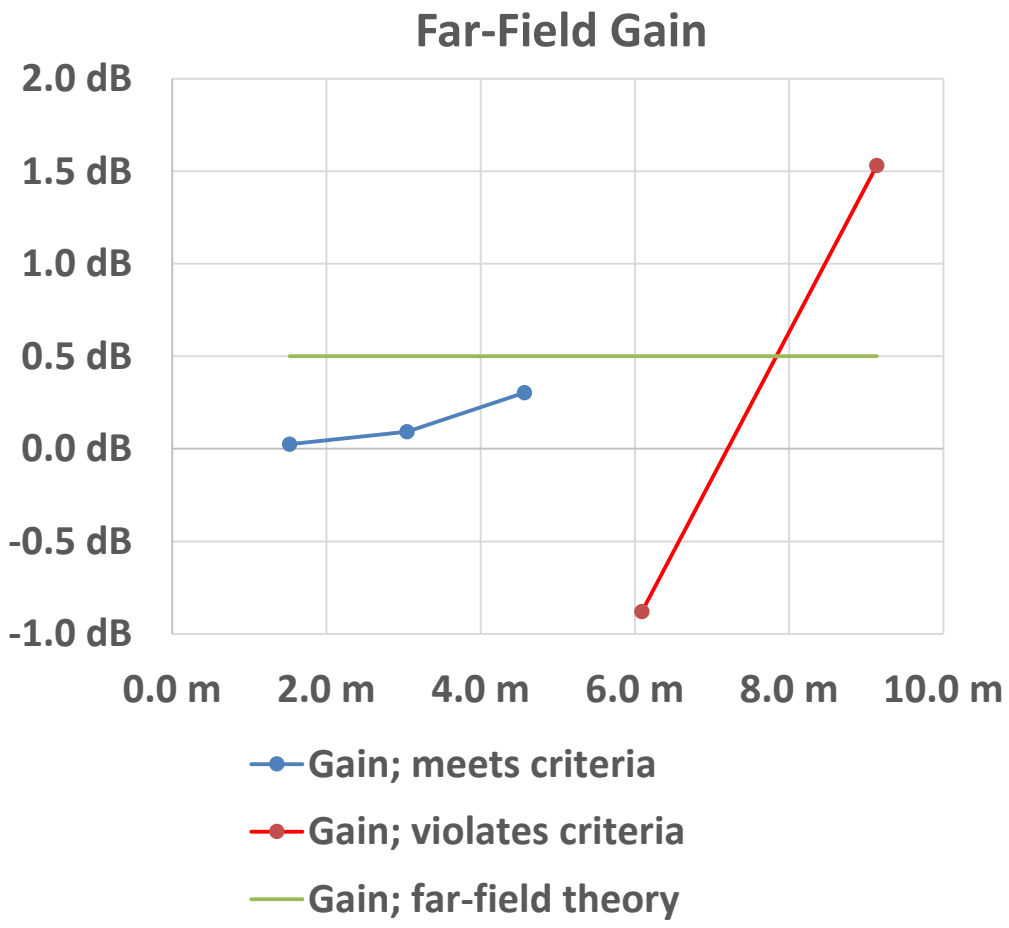
Far-Field Data

Far Field Gain: 0.30 dB vs 0.5 dB from theory

R (distance)	P_{RT} ($P_R P_T$)	Gain	Multipath Interference (measure)[1]
1.523 m	-43.65 dB	0.02 dB	3.046 m
3.046 m	-49.53 dB	0.09 dB	6.091 m
4.569 m	-52.63 dB	0.30 dB	9.137 m
6.091 m	-57.70 dB	-0.88 dB	12.183 m
9.137 m	-56.20 dB	1.53 dB	18.274 m

Note 1: Ground 3.1 m from Antennas; Far-field 2R Rule applied



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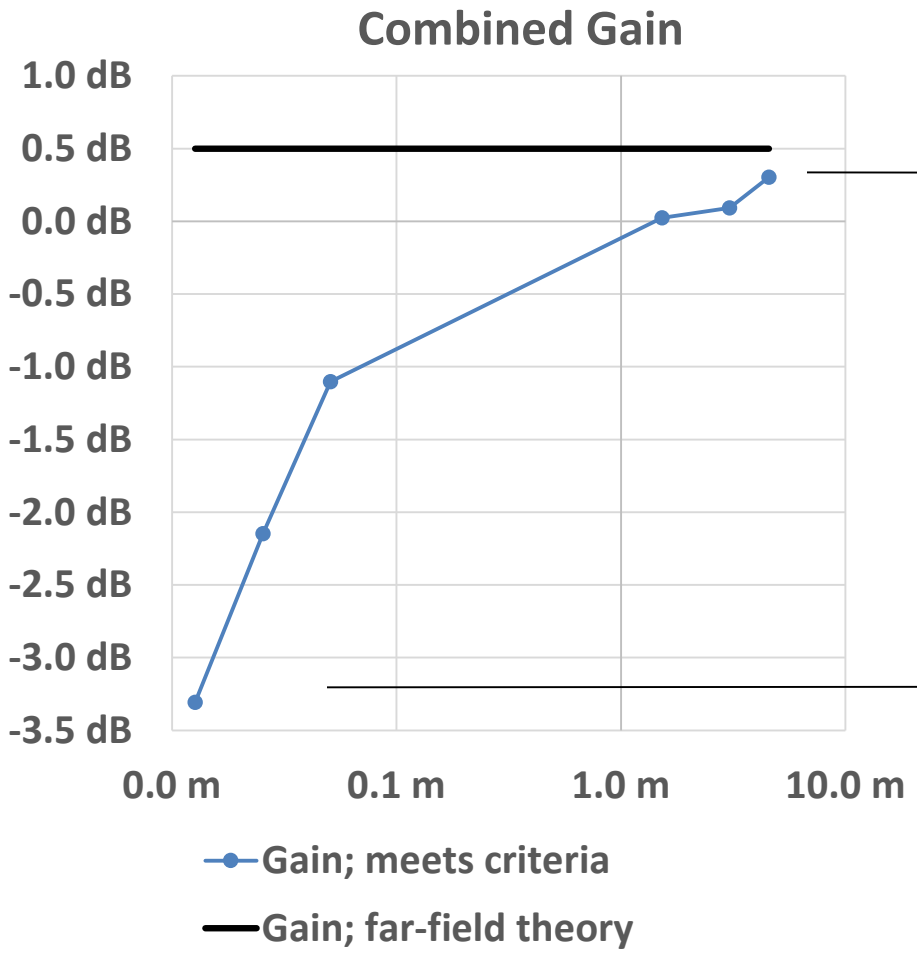
Combined Data: Correction Factor



R (distance)	Near-Field to Far-Field Correction Factor
12.7 mm	3.61 dB = 0.3 dB - (-3.31 dB)
25.4 mm	2.45 dB = 0.3 dB - (-2.15 dB)
50.8 mm	1.41 dB = 0.3 dB - (-1.10 dB)

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Final Antenna Selection

- 1/2 wave tee dipole antenna with integrated filter.
- Cost effective
- Produces selective, repeatable, accurate results
- Antenna designed and manufactured by LadyBug Technologies

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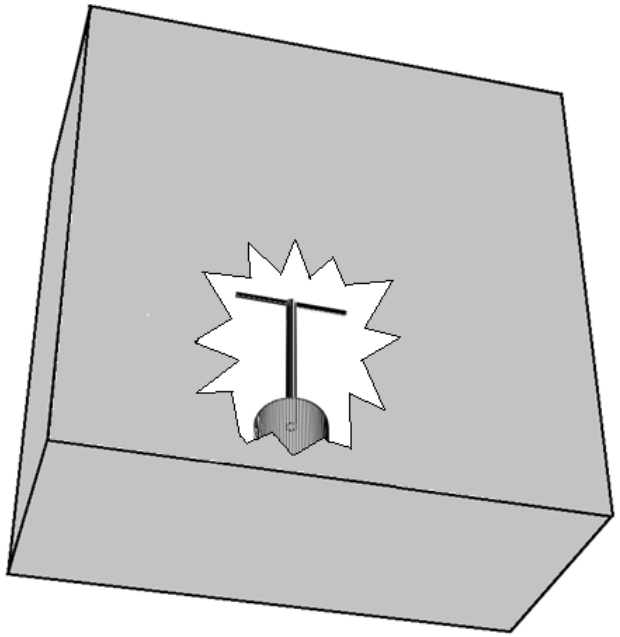
Compact Near-Field Test Fixture Requirements

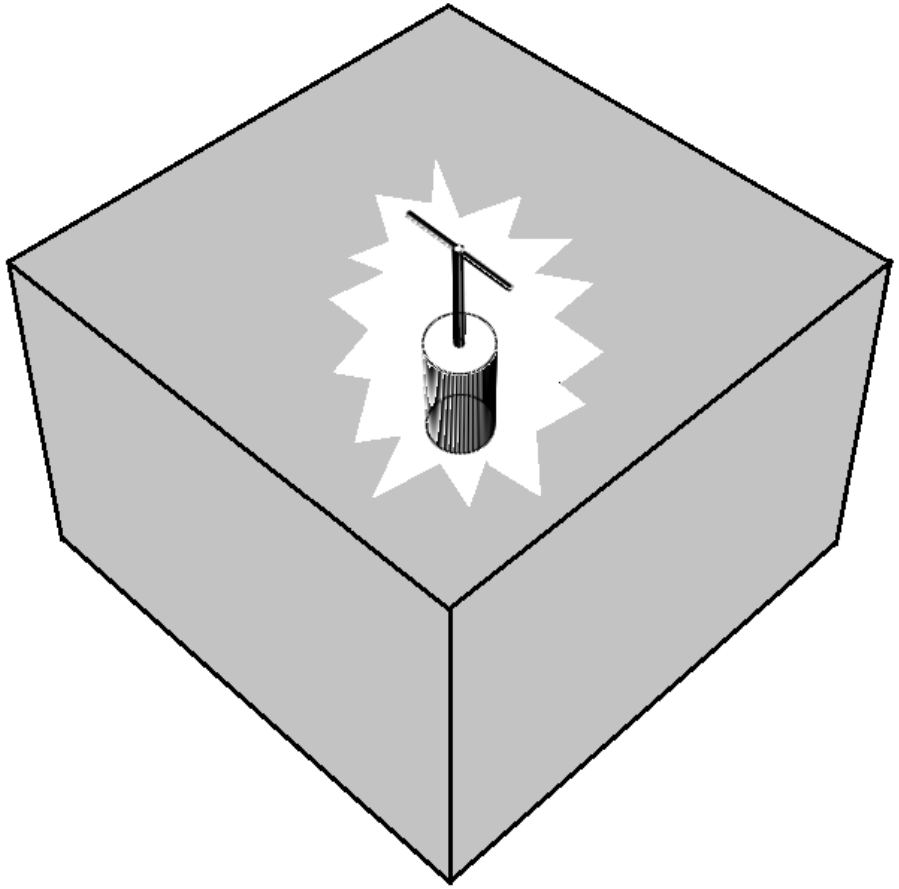
- Use optimized antenna
- Decide antenna spacing: 25.4 mm (1 inch)
- Distance interfering objects (+0.26/ -0.29 dB rule): 102 mm
  - Reduce distances by using low interfering materials and absorber
- Control device and fixture relative antenna orientation
- Apply optional near-field to far-field correction factor: 2.45 dB

Testing Requirement Software

- Fast Go/No-Go Testing for Customer DUT
- Assure Reliable ¼ Mile Operation
- Method to Measure Antenna Gain and Provide Near-Field to Far-Field Correction
- Test Fixture For Fast Go/No-Go Testing for Wireless Devices

Compact Near-Field Test Fixture Options





Below is a test unit

This unit measures - 8dbm when oriented as in the image below.

The same unit measures -5dBm when oriented as in the image below. If placed as image at left, but below the red lines, the measurement is -15 dBm

Final Test Fixture

Test Results

This test system uses LadyBug PMA-12 software. This DUT easily passes. The test is quick and it provides verification both numerically and graphically.

LadyBug sensors are compatible with VISA , making it easy for users of NI, Python and other test environments to perform automated testing.

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Reach out for more information

Contact us to discuss your application

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