

1.0 ANTENNA INFORMATION

- 1.1 Operating Frequency: 2.4GHz
- 1.2 Antenna Material: FR-4 PCB
- 1.3 Antenna Type: Printed PIFA antenna
- 1.4 Antenna Dimension 45 x 35 mm
- 1.5 Input Impedance 50 Ω
- 1.6 Return Loss (S11): >-30dB
- 1.7 Standing Wave Ratio (SWR):1.05:1
- 1.8 Peak gain: -0.48 dBi on XZ-plane and -1.25dBi on XY-plane
- 1.9 Polarization: Linear

2.0 TEST EQUIPMENT

- 2.1 R&S ZNLE6 VNA, PN: 1323.0012K56, Cal date 1/6/2023, Cal due 1/6/2026
- 2.2 RF coax cable: CBL-20FT-SMSM
- 2.3 RF coax cable: CBL-15FT-SMSM
- 2.4 Rotator motor
- 2.5 Test date: 04/24/2025
- 2.6 RF Test Engineer: Milad Hmeda
- 2.7 Software for plotting: Excel
- 2.8 RF antennas under test were themselves being used as TX and RX antennas to get Gain.

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3.0 ANTENNA DIMENSION

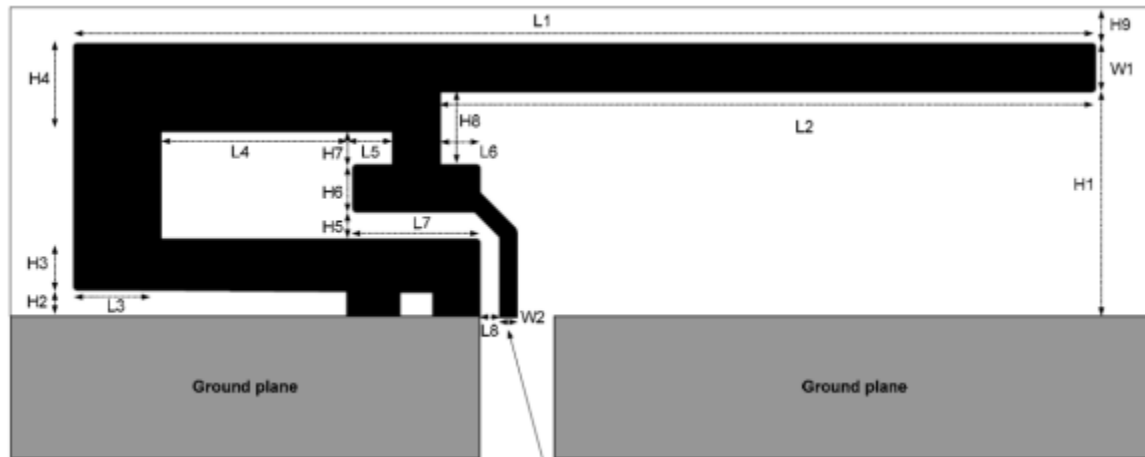


Table 1. Antenna Dimension

Parameter	Dimension	Parameter	Dimension
H1	5.71 mm	W2	0.23 mm
H2	0.75 mm	L1	24.18 mm
H3	1.29 mm	L2	15.00 mm
H4	2.21 mm	L3	2.18 mm
H5	0.66 mm	L4	4.80 mm
H6	1.21 mm	L5	1.00 mm
H7	0.80 mm	L6	1.00 mm
H8	1.81 mm	L7	3.20 mm
W1	1.21 mm	L8	0.57 mm
Total PCB Length	35 mm	Total PCB Width	45 mm

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4.0 RETURN LOSS AND SWR MEASUREMENTS

Figure 1 shows the measured return loss using the R&S VNA. The antenna feedline is matched to the 50Ω port. The return loss is -31dB at 2.41GHz.

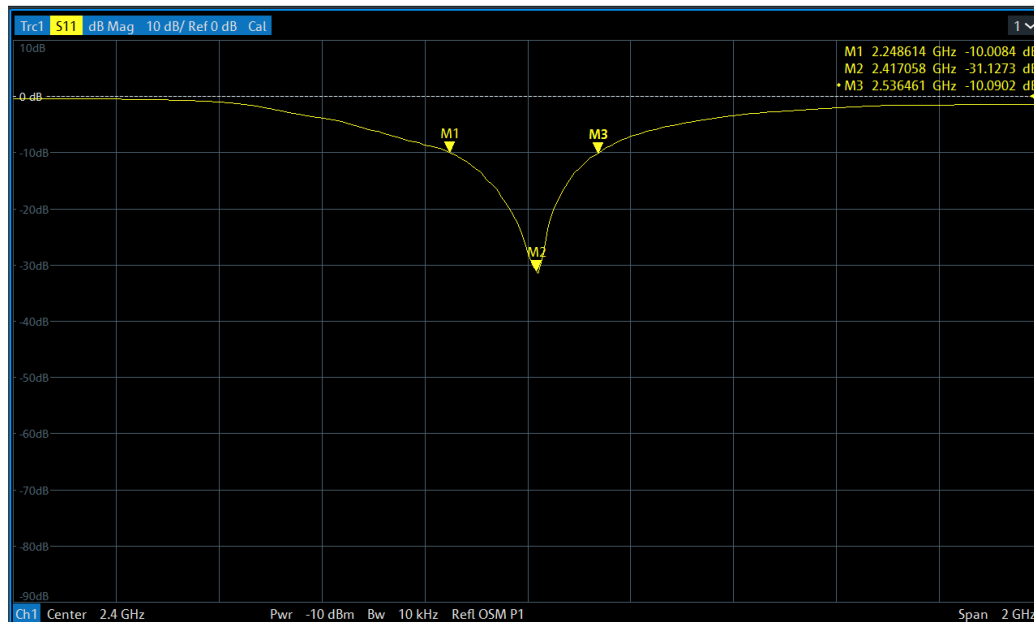


Figure 1. Antenna return loss (S11) vs. Frequency

Figure 2 shows the voltage standing wave ratio (VSWR) measurement using the R&S VNA. The VSWR value is equal to 1.06 :1. The plot shows the antenna feedline matches to the 50Ω port.

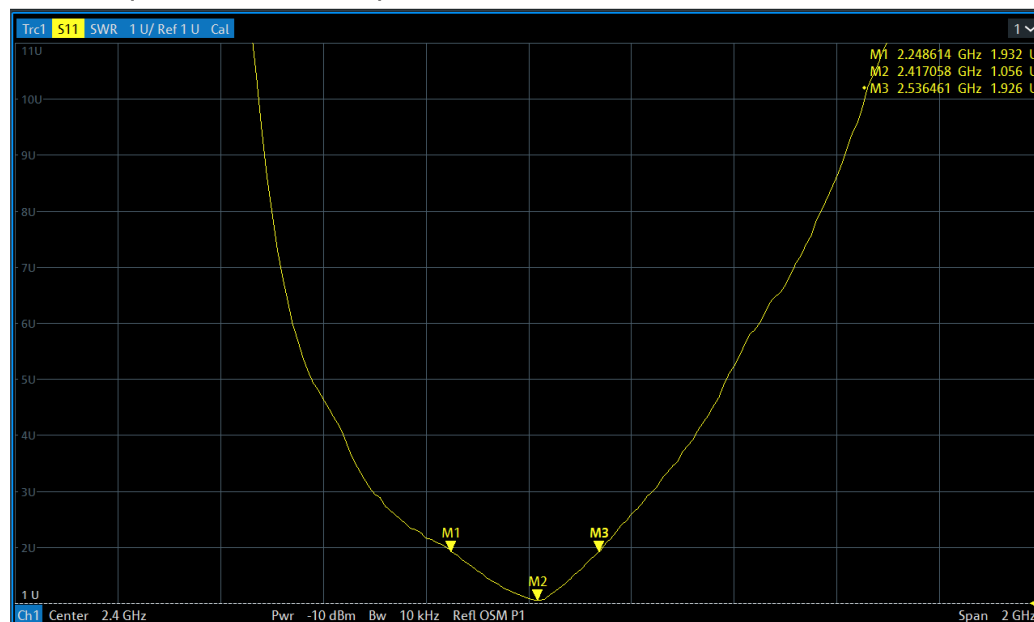


Figure 2. VSWR vs. Frequency

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Radiation Pattern Measurements

The antenna radiation pattern was measured inside the anechoic chamber. In this measurement, the two identical 2.4 GHz PIFA antennas were used as TX and RX. The separation distance between the antennas is three (3) meters. The antennas were tested for XZ and XY plane radiation pattern measurement. Figure 3 shows the radiation pattern measurements. The TX antenna connected to the VNA port #1 by a 20 ft. RF cable and the RX antenna to the VNA port # 2 by a 15 ft. RF cable. The RX antenna was mounted on the motor; the motor rotated incremental azimuth from 0° to 360°, 10 degrees incremental.

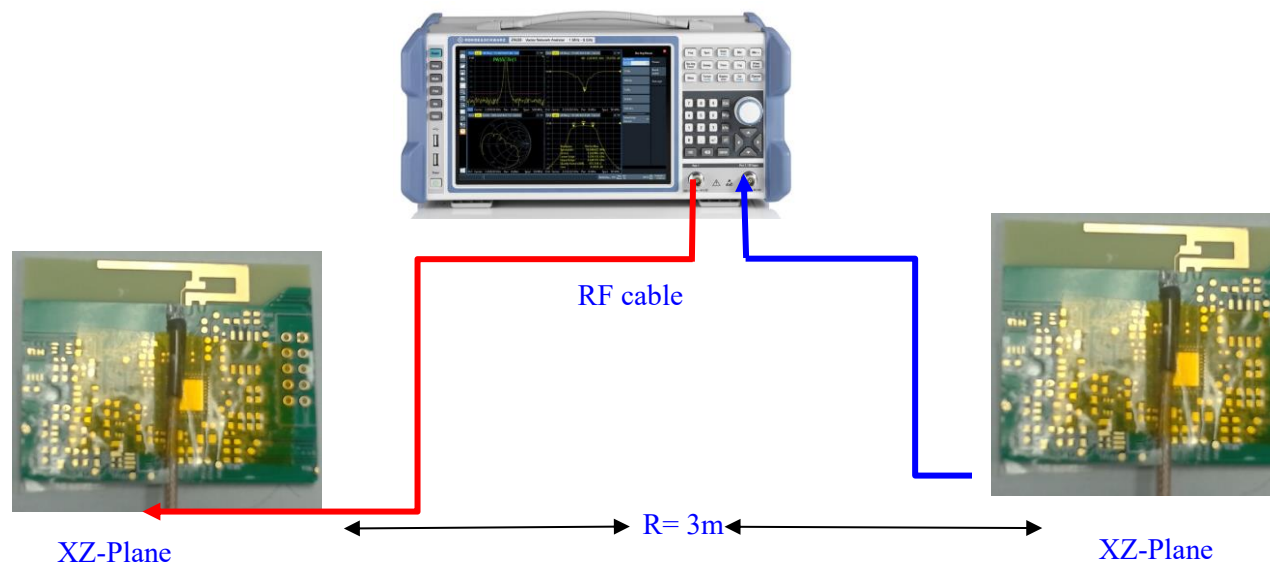


Figure 3. Antenna Measurement Diagram

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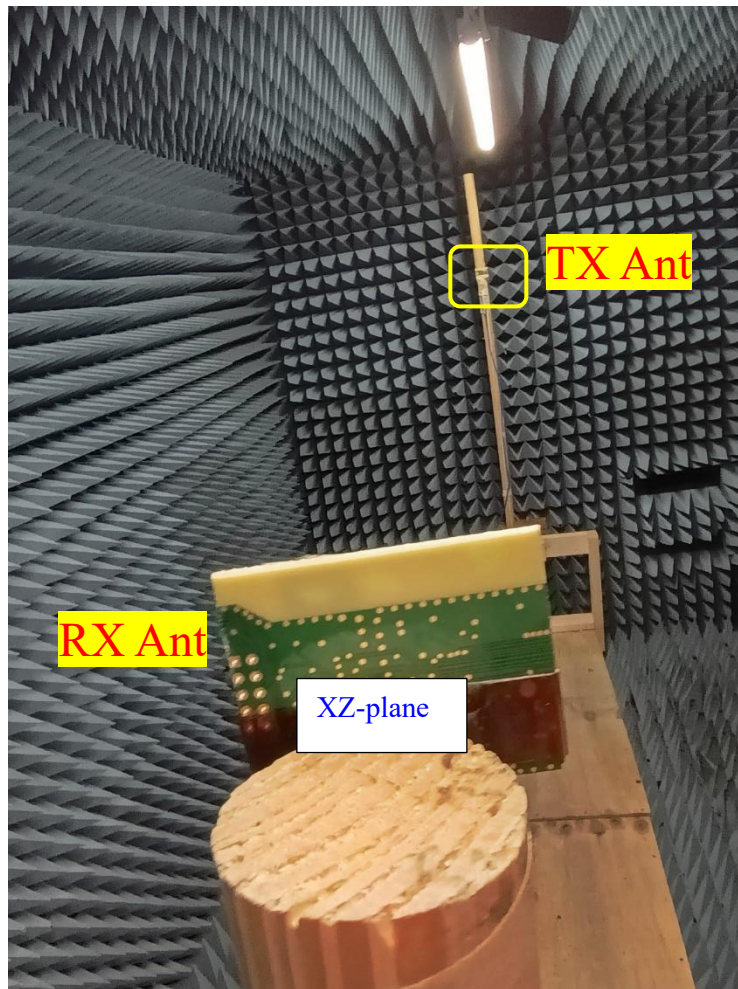


Figure 4. Antenna Measurement Inside the RF Chamber

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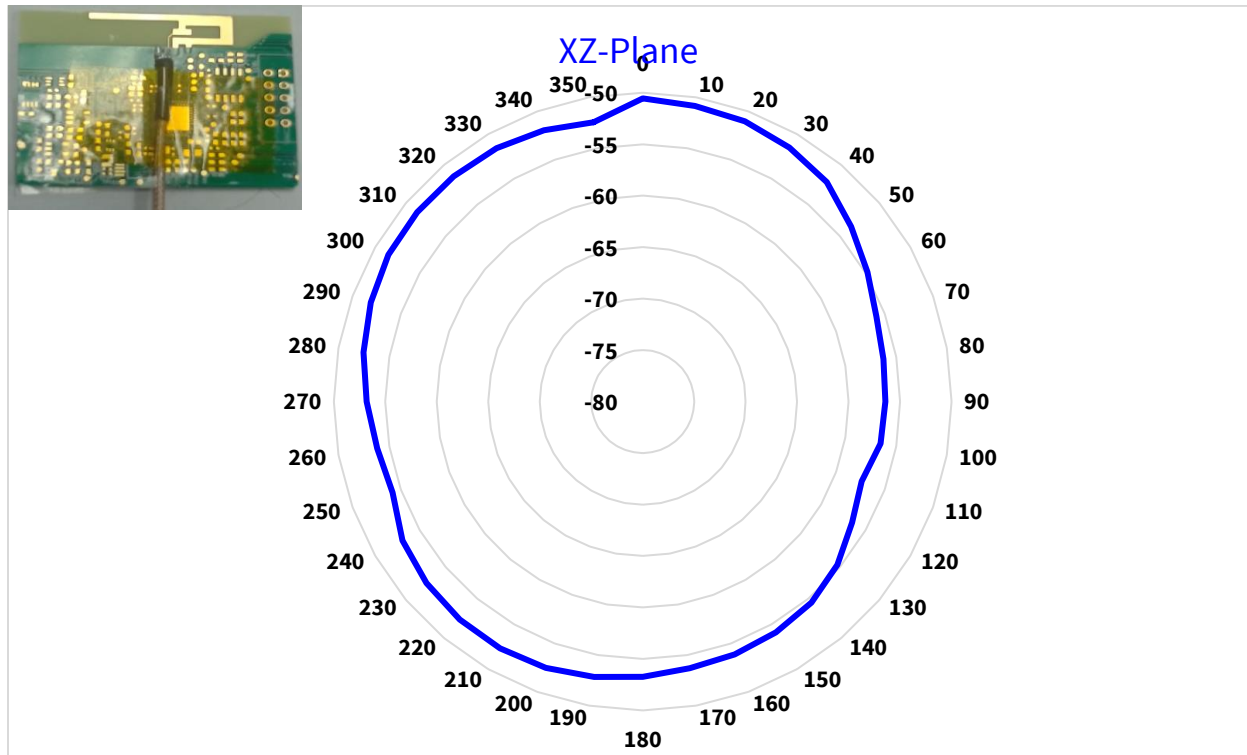


Figure 5. Antennas on XZ- plane omnidirectional radiation pattern in dB scale

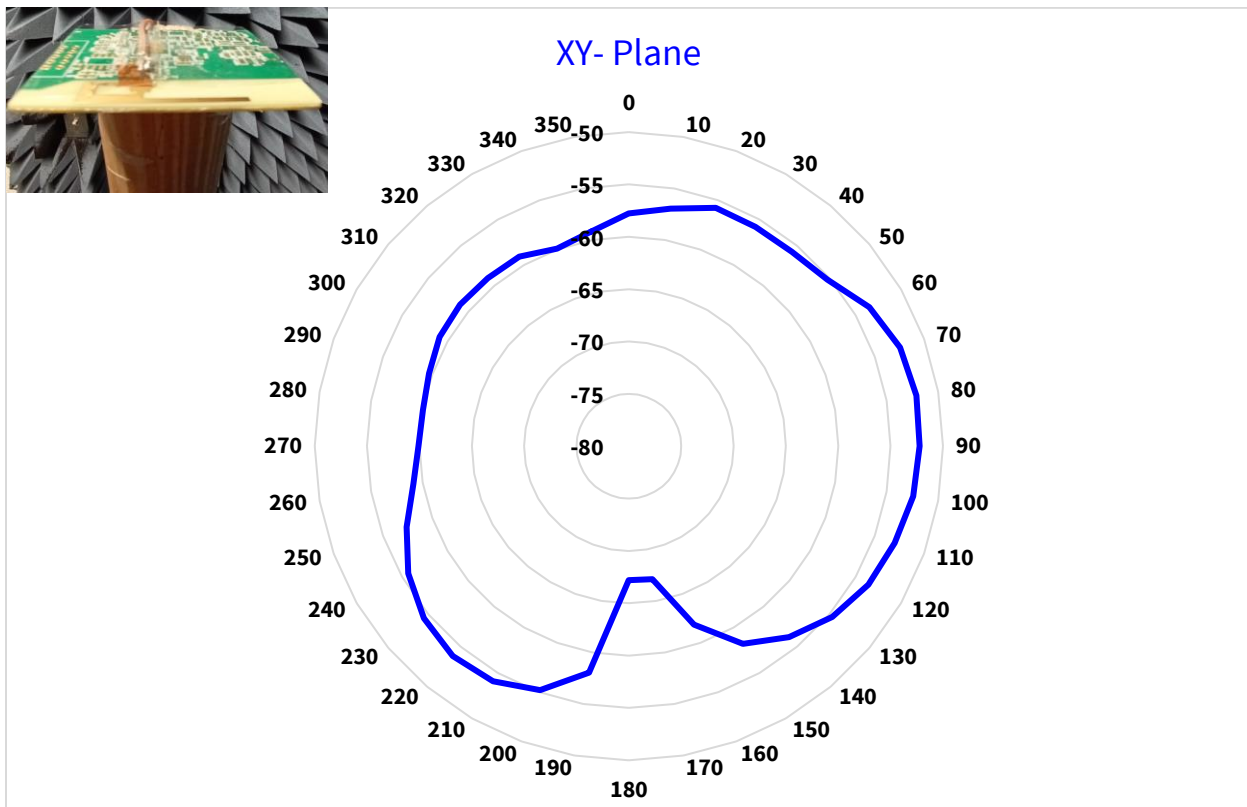


Figure 6. Antennas on XY- plane (flat) omnidirectional radiation pattern in dB scale

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5.0 ANTENNA GAIN

The antenna gain was calculated from the VNA S21 result using the two-antenna method based on the Friis transmission equation.

$$\frac{P_r}{P_t} = \left(\frac{\lambda}{4\pi R} \right)^2 G_t G_r, \text{ where } G_t = G_r = G,$$

or, in dB,

$$G_{dB} = \frac{1}{2} \left[20 \log_{10} \left(\frac{4\pi R}{\lambda} \right) + 10 \log_{10} \left(\frac{P_r}{P_t} \right) \right].$$

Where:

R: the distance between two antennae inside the chamber is 3 meters.

λ : the wavelength.

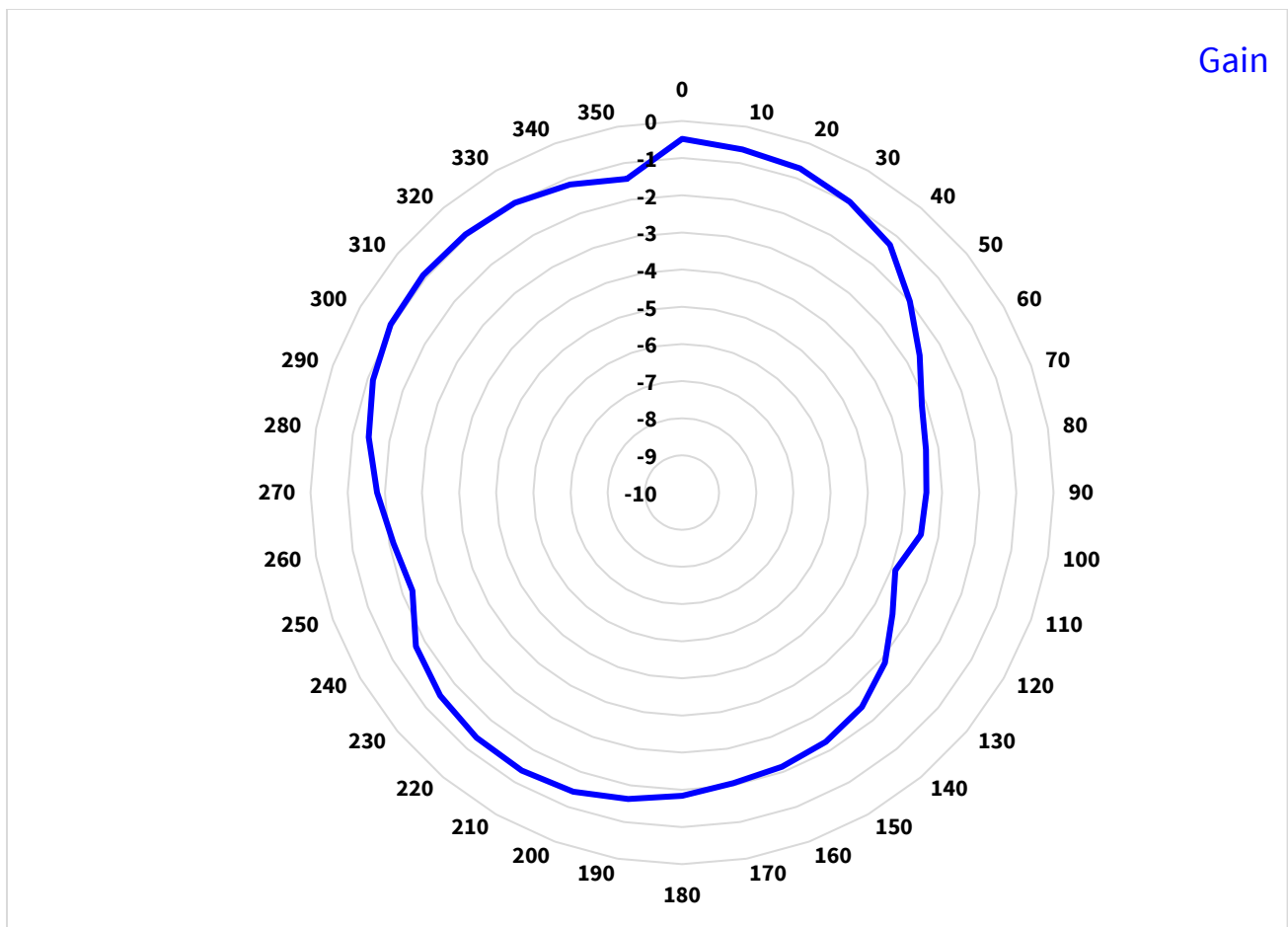


Figure 7. Antenna gain in (dBi) at XZ plane

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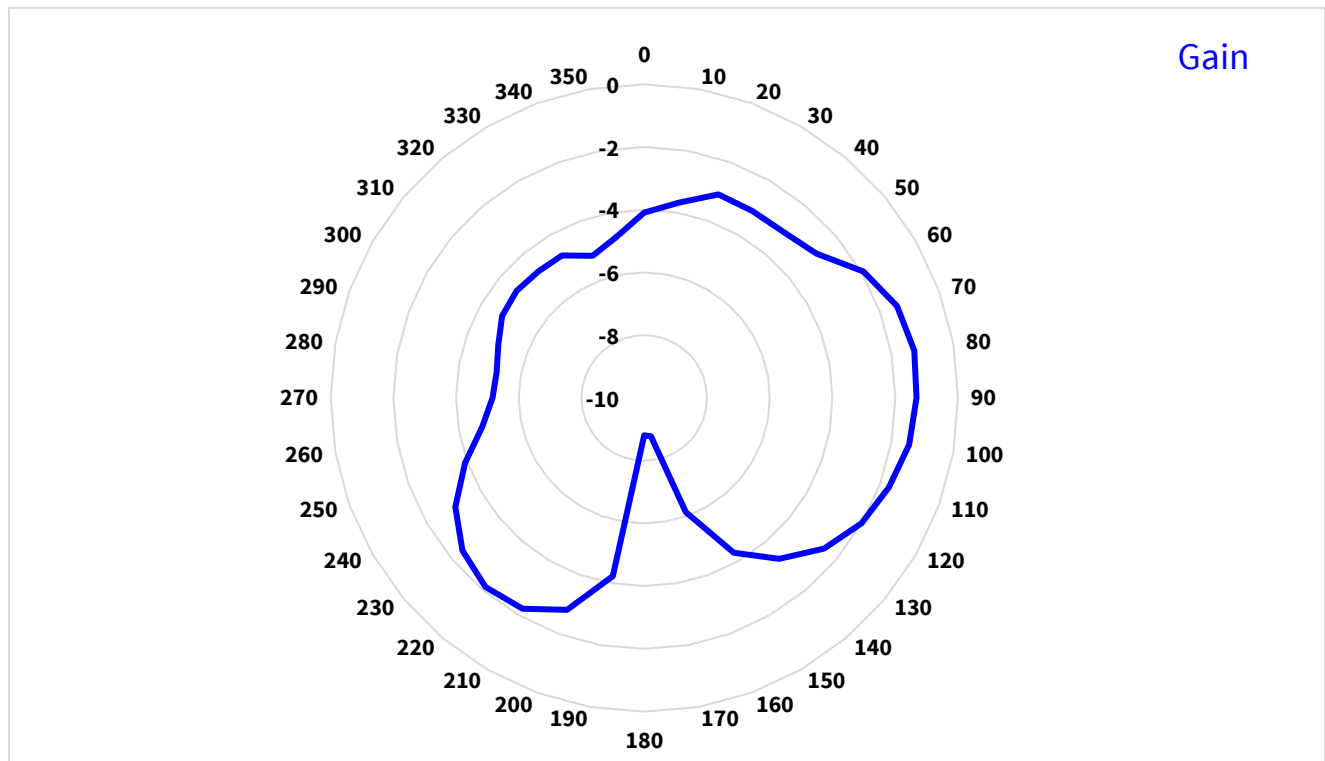


Figure 8. Antenna gain in (dBi) at XY plane (flat)

6.0 CONCLUSION

The 2.4GHz PIFA antenna with 50Ω, 9 cm coax cable was tested for the return loss, VSWR, radiation pattern, and gain by ZNLE6 network analyzer. The antenna's measured results show the antenna is omnidirectional and matched to the 50Ω source. The return loss is higher than -30 dB, the VSWR value is 1.05:1, and the peak gain is equal to -0.48dBi on XZ -plane and -1.25 dB on XY-plane.