



AC82101 450 MHz/5G/4G Cellular Chip Antenna

The Antenna Company AC82101 is a surface-mount monopole chip antenna for embedded cellular and cellular IoT (LTE-M/ Cat-M1 and NB-IoT) applications. Supporting the 450 MHz and 617-6000 MHz bands, the AC82101 supports cellular applications in North America, Europe and worldwide.

It is available in tape and reel packaging and is designed for reflow-solder mounting directly to a printed circuit board for high-volume applications.



AC82101
450 MHz/5G/4G Cellular Chip Antenna

Features

- Full-spectrum cellular performance
 - 450-470 MHz, 617- 6000 MHz bands
- Performance at 450 MHz band
 - VSWR: 2.7
 - Peak Gain: 1.7 dBi
 - Efficiency: 52%
- Excellent ground plane size resilience
- Compact package
 - 69 mm x 22 mm x 3 mm
- Reflow- or hand-solder assembly

Applications

- 450 MHz cellular with wideband fallback
- Long-range smart meters
- Smart utility infrastructure
- Asset management
- Tracking devices
- Vending machines
- Cellular IoT
 - LTE-M (Cat-M1) and NB-IoT
- 5G NR RedCap/eRedCap
 - Industrial IoT
 - Ultra-low-power devices
 - Wearables
- Internet of Things (IoT) devices

Ordering Information

Part Number	Description
AC82101	450 MHz, 617-6000 MHz Cellular Chip Antenna
AC93101	AC82101 Evaluation Board with SMA Jack connector

Available from The Antenna Company (sales@antennacompany.com) and select distributors and representatives.

RF/Electrical Specifications

Frequency Range (MHz)	VSWR (max)	Peak Gain (dBi)	Average Gain (dBi)	Efficiency (%)
450 to 470	2.7	1.7	-2.9	52
615 to 705	5.4	0.7	-3.0	50
695 to 805	3.7	2.5	-1.5	72
790 to 960	2.8	2.8	-1.3	76
1425 to 1675	3.2	4.6	-2.4	58
1695 to 2200	2.8	6.2	-1.3	72
2300 to 2400	2.3	5.2	-1.6	70
2480 to 2690	2.9	4.3	-2.1	62
3300 to 4200	3.0	3.9	-2.4	58

Impedance	50 Ω
Polarization	Linear
Radiation Pattern	Omnidirectional
Max Power	5 W

Electrical specifications and plots measured with the antenna mounted on a 70 mm x 130 mm ground evaluation board.

Mechanical Specifications

Parameter	Value
Connection	Surface Mount
Operating Temp. Range	-40 °C to +85 °C (-40 °F to 185 °F)
Weight	9.2 g (0.32 oz)
Dimensions	69.0 mm x 21.8 mm x 3.0 mm (2.72 in x 0.86 in x 0.12 in)

Antenna Dimensions

The dimensions for the AC82101 are shown below in Figure 1.

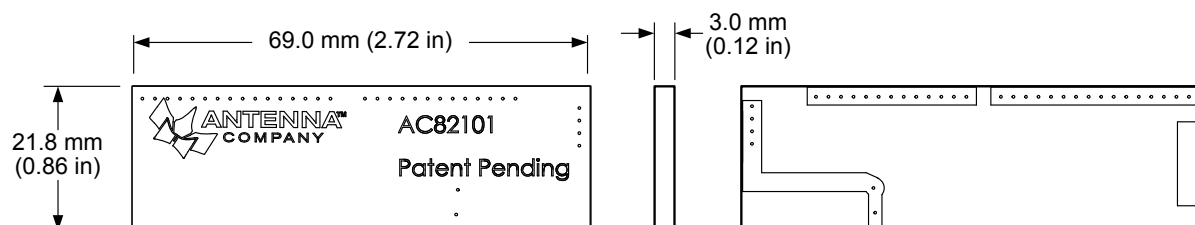


Figure 1. AC82101 Antenna Dimensions

VSWR

Figure 2 provides the voltage standing wave ratio (VSWR) across the antenna bandwidth. VSWR characterizes the power reflected from the antenna back to the transmitter. A lower VSWR value indicates better antenna performance at a given frequency. Reflected power is also shown on the right-side vertical axis as a measure of the percentage of transmitter power reflected back from the antenna.

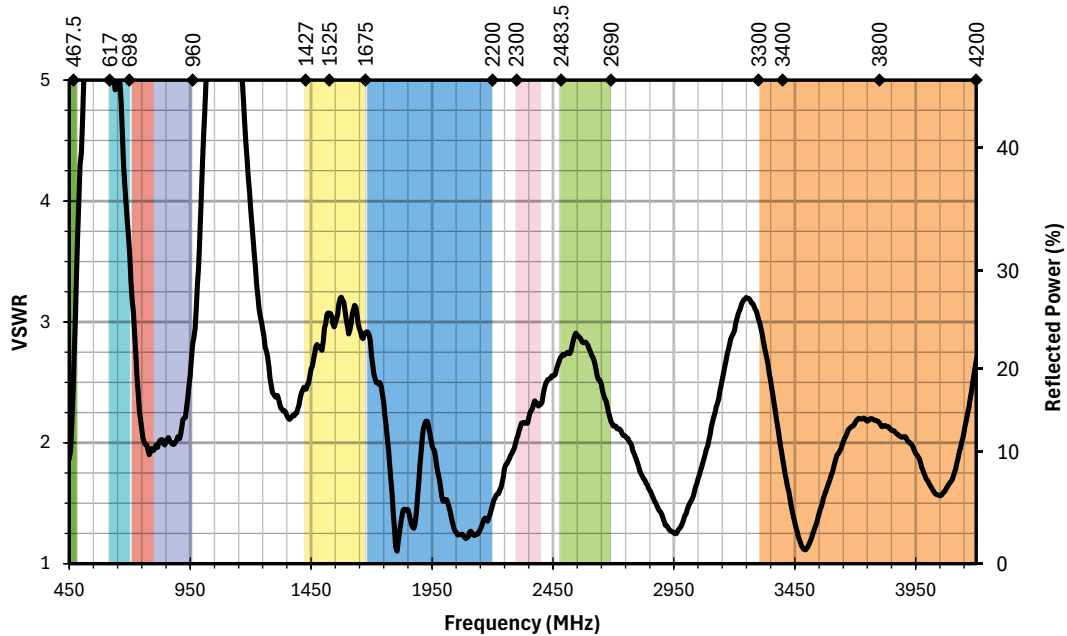


Figure 2. AC82101 Antenna VSWR with Frequency Band Highlights

Return Loss

Return loss (Figure 3) represents the loss in power at the antenna due to reflected signals. A higher magnitude return loss indicates better performance. Return loss is the negative of input reflection coefficient, in decibels (dB), and the two values are often used interchangeably.

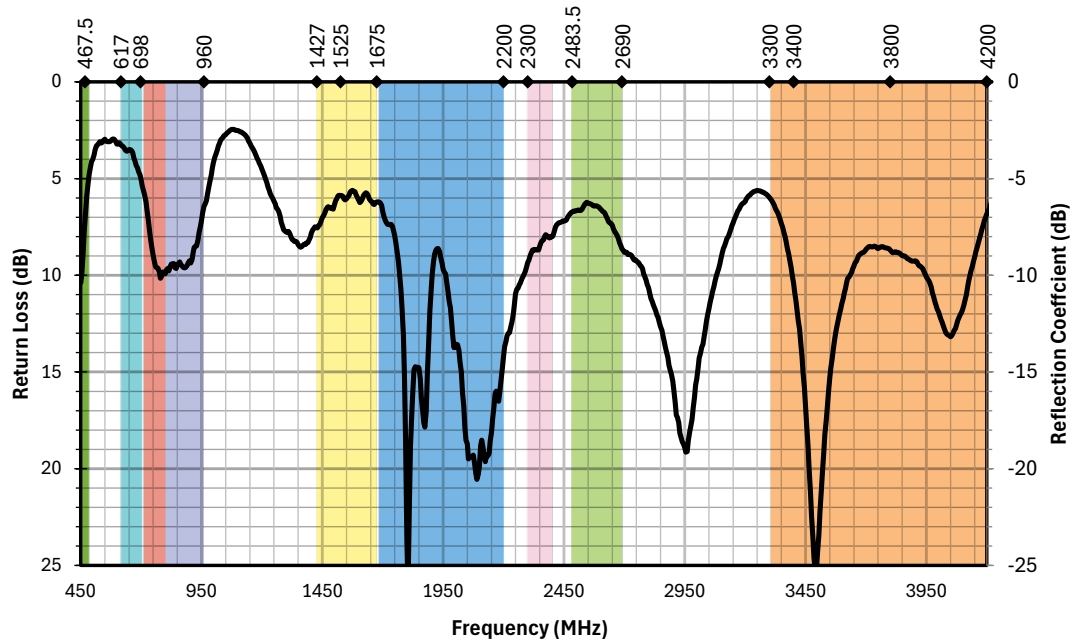


Figure 3. AC82101 Antenna Return Loss with Frequency Band Highlights

Peak Gain

Peak gain (Figure 4) provides a measure of the maximum conversion of antenna input power to radio waves at a given frequency. Peak gain does not account for the directionality of gain in 3-dimensional space.

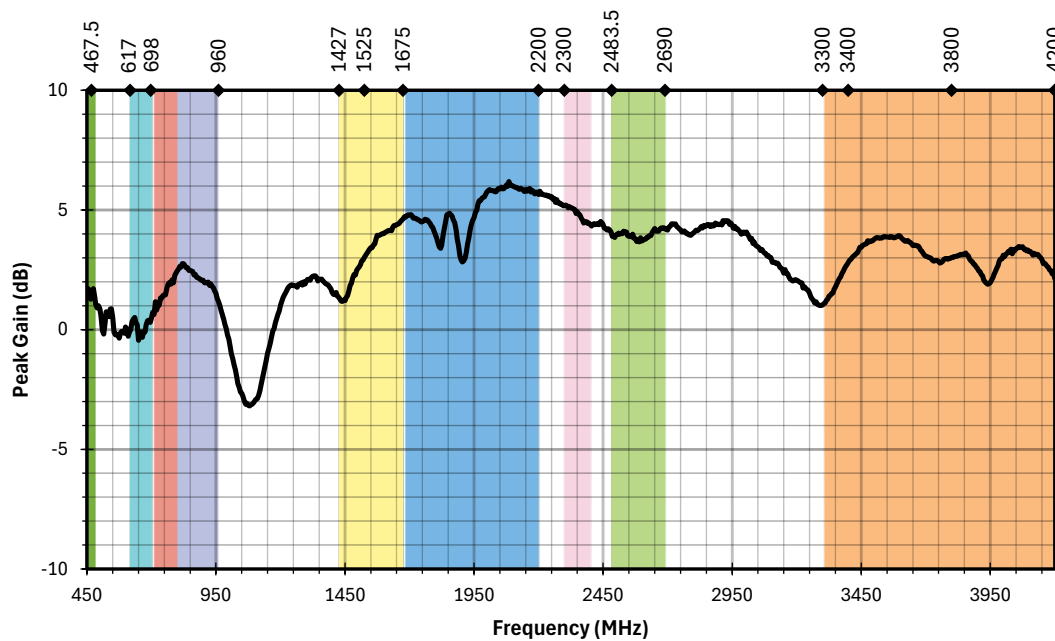


Figure 4. AC82101 Antenna Peak Gain with Frequency Band Highlights

Average Gain

Average gain (Figure 5) is the average of all antenna gain in 3-dimensional space at each frequency, providing an indication of overall performance without expressing antenna directionality.

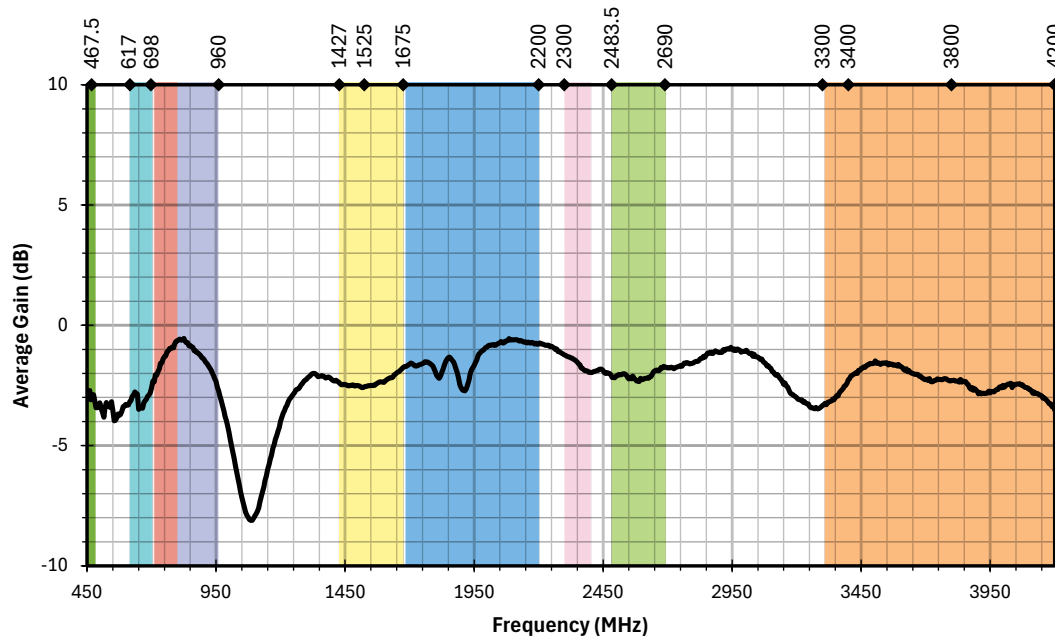


Figure 5. AC82101 Antenna Average Gain with Frequency Band Highlights

Efficiency

Efficiency (Figure 6) is the ratio of power delivered to the antenna relative to the power radiated at the antenna, expressed as a percentage, where a higher percentage indicates better performance at a given frequency.

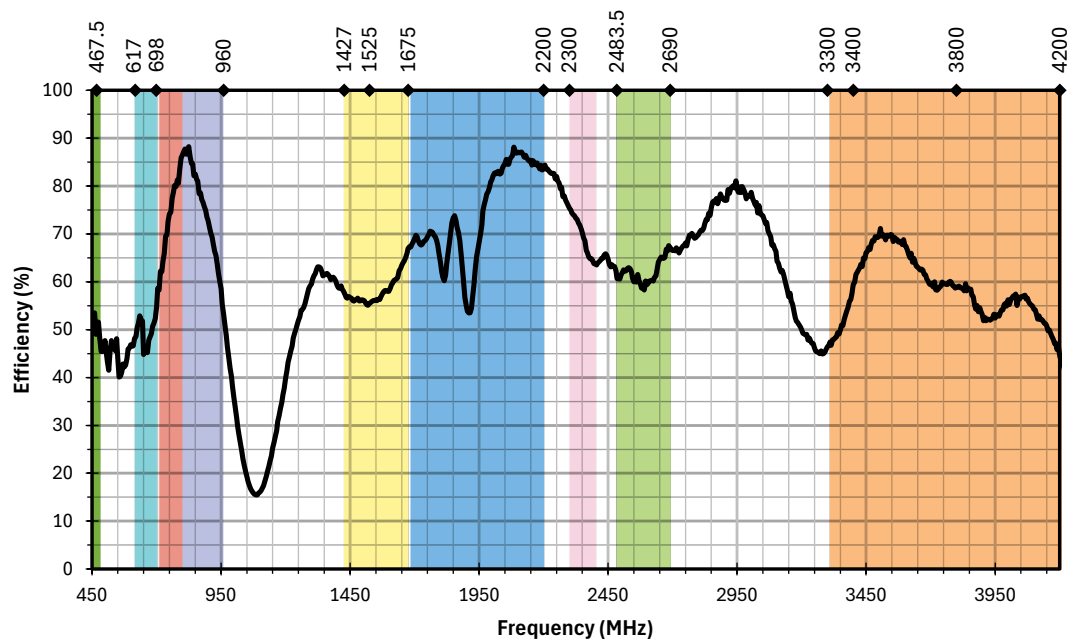
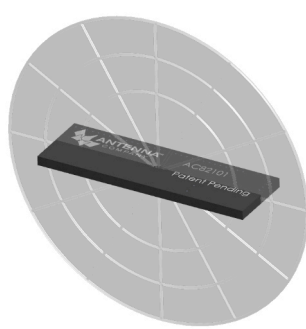


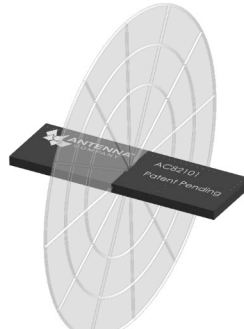
Figure 6. AC82101 Antenna Efficiency with Frequency Band Highlights

Radiation Patterns

Radiation patterns provide information about the directional performance of the antenna by plotting gain in three orthogonal planes at the high-, low- and center-frequencies of an antenna frequency band. Antenna radiation patterns (Figure 7) are shown using polar plots covering 360 degrees with the plane of reference depicted above the plots. Note: when viewed with typical PDF viewing software, zooming into radiation patterns is possible to reveal fine detail.



XZ-Plane Gain

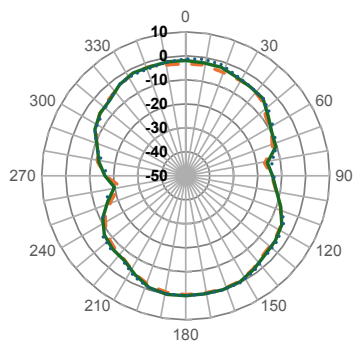


YZ-Plane Gain

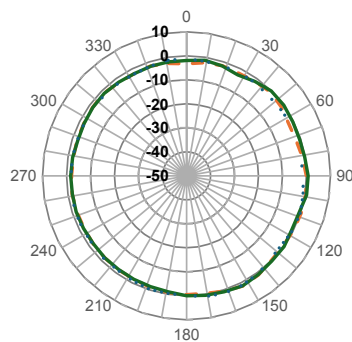


XY-Plane Gain

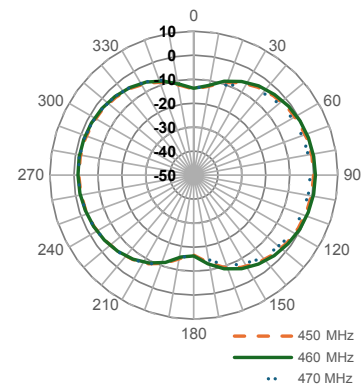
450 MHz to 470 MHz (460 MHz)



XZ-Plane Gain

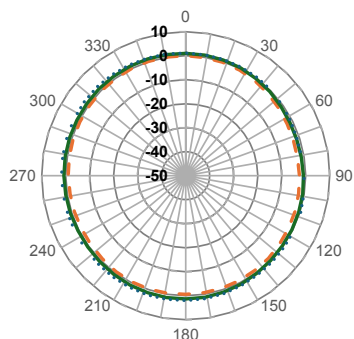


YZ-Plane Gain

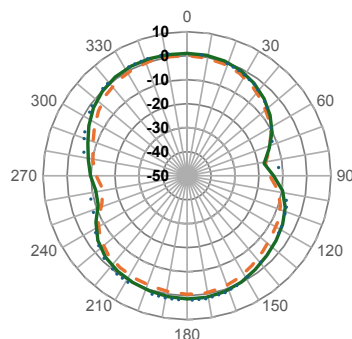


XY-Plane Gain

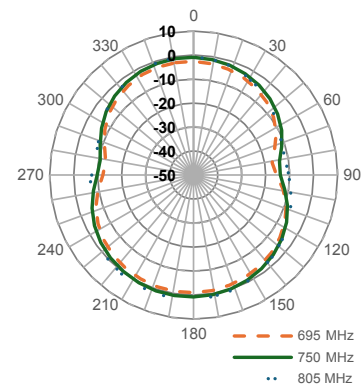
695 MHz to 805 MHz (750 MHz)



XZ-Plane Gain

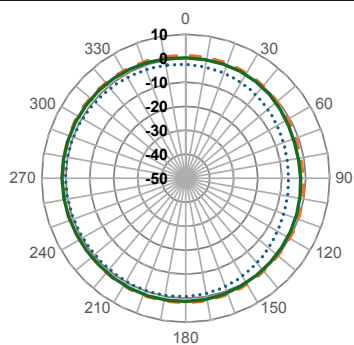


YZ-Plane Gain

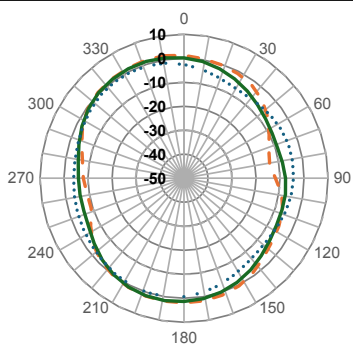


XY-Plane Gain

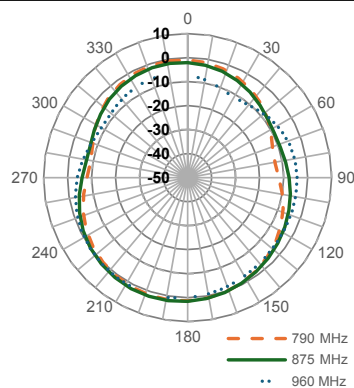
790 MHz to 960 MHz (875 MHz)



XZ-Plane Gain

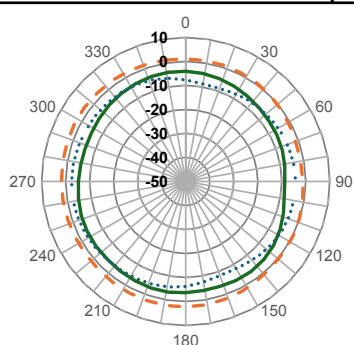


YZ-Plane Gain

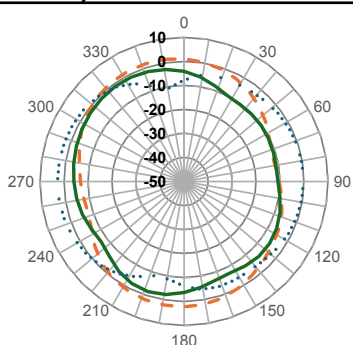


XY-Plane Gain

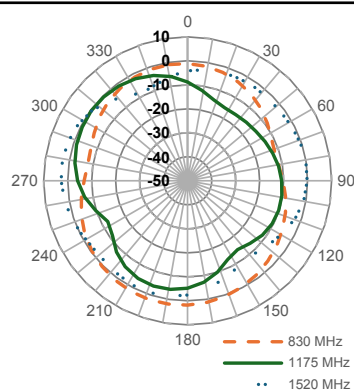
830 MHz to 1175 MHz (1520 MHz)



XZ-Plane Gain

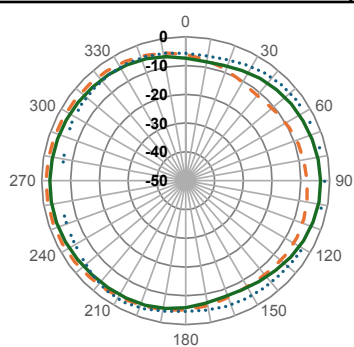


YZ-Plane Gain

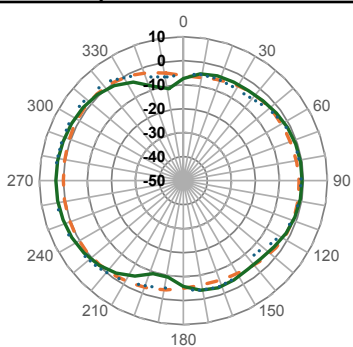


XY-Plane Gain

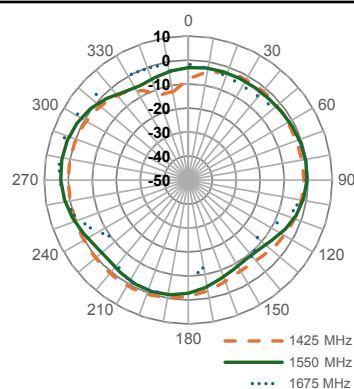
1425 MHz to 1675 MHz (1550 MHz)



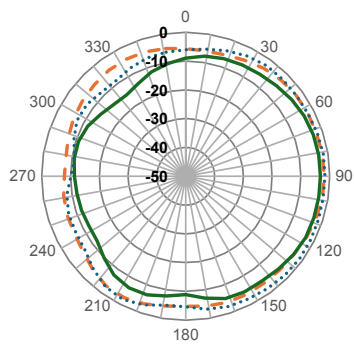
XZ-Plane Gain



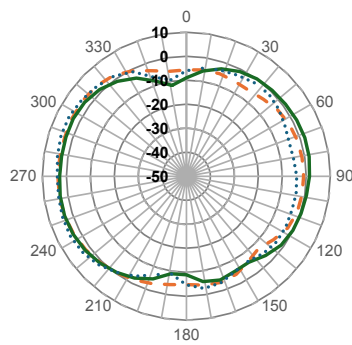
YZ-Plane Gain



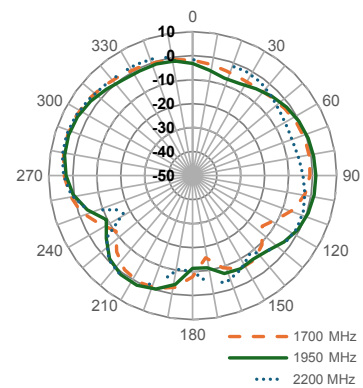
XY-Plane Gain

1700 MHz to 2200 MHz (1950 MHz)

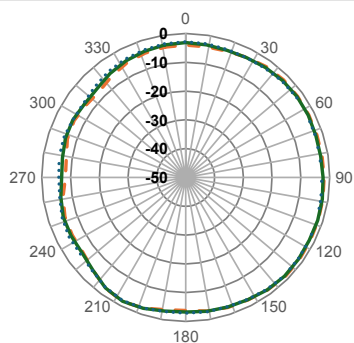
XZ-Plane Gain



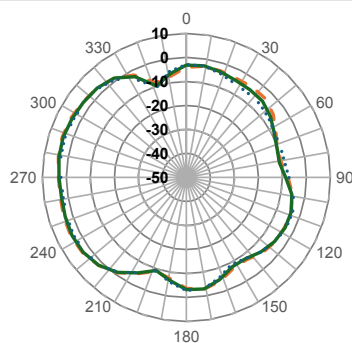
YZ-Plane Gain



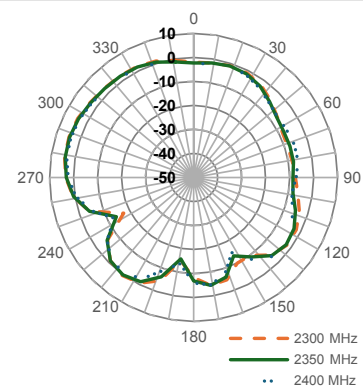
XY-Plane Gain

2300 MHz to 2400 MHz (2350 MHz)

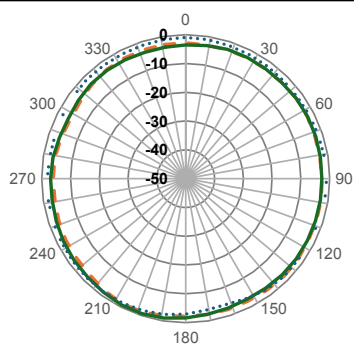
XZ-Plane Gain



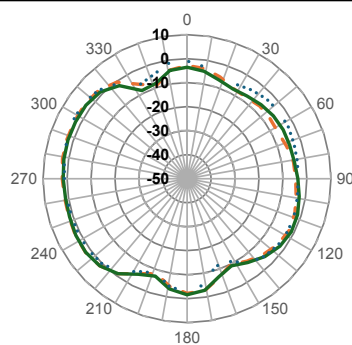
YZ-Plane Gain



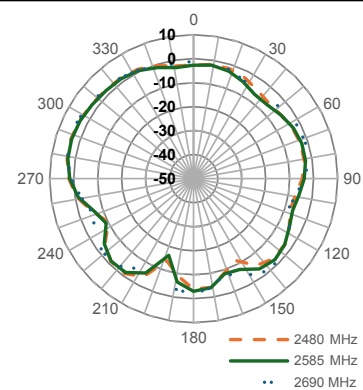
XY-Plane Gain

2480 MHz to 2690 MHz (2585 MHz)

XZ-Plane Gain



YZ-Plane Gain



XY-Plane Gain

3300 MHz to 3800 MHz (3550 MHz)

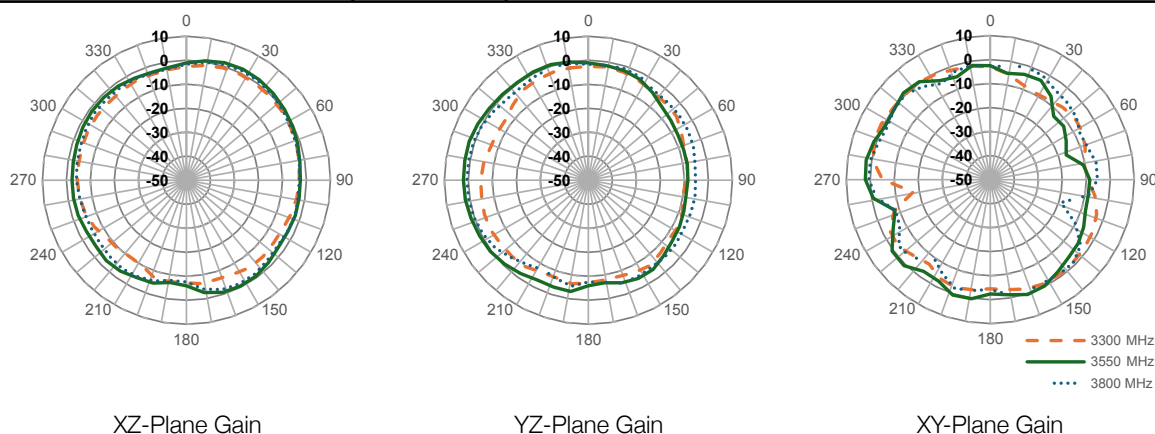


Figure 7. Radiation Patterns for AC82101 Antenna

Recommended Layout

The recommended printed circuit board (PCB) layout for the AC82101 is shown in Figure 8. This layout is used for the AC82101 evaluation board (p/n AC93101) which is available for purchase as listed under Ordering Information. The recommended layout includes a PCB transmission line (Feedline) from the antenna through a Pi-filter matching network (Figure 9) to the RF front end, two mechanical connections, and two RF feeds which are part of the RF element feeding through to the bottom side of the PCB. The layout also requires a ground plane adjacent to the antenna, with a recommended keep out area. The signal definitions for the AC82101 antenna are provided in Table 1.

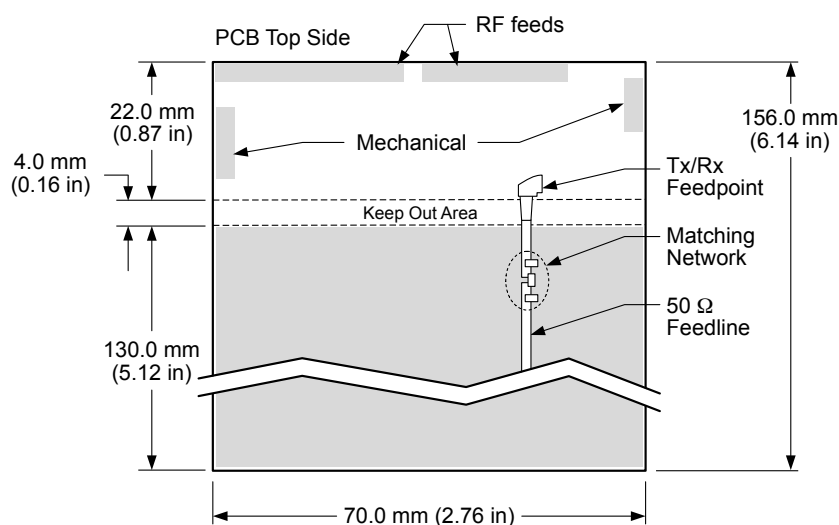


Figure 8. AC82101 Recommended Layout

Table 1. Signal Definitions for the AC82101 Antenna

Connection	Description
Tx/Rx Feedpoint	Signal feedpoint for Rx/Tx to system
RF Feeds	Solder for internal RF connection
Mechanical	Solder for mechanical attachment of the antenna

Note: No solder connection to GND

Pi Filter Matching Network

Pi filter surface mount components should be 0603 size. 0402 size components are also supported. The components in Table 2 are recommended to optimize performance on the recommended layout, but adjusting matching components may improve end-product antenna performance depending on the effects of the enclosure, PCB and other electronic components. If no matching is necessary, the series element (x2) may be populated with a zero-ohm resistor and no components in the other two positions.

Table 2. Recommended Components

Component	Value
x1	n/a
x2	4.0 pF +/- 0.1 pF capacitor
x3	13 nH +/- 2% inductor

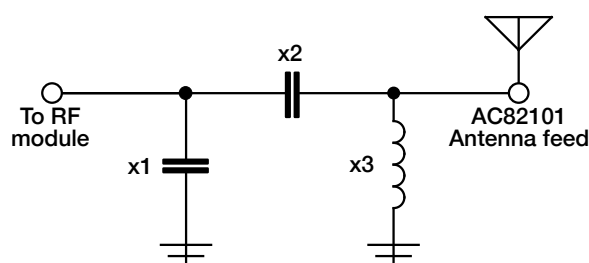


Figure 9. Recommended Pi Matching Network

Ground Plane Recommendations

The AC82101 is a 1/4-wave monopole antenna, and requires a ground plane on the PCB to which it is mounted. The Antenna Company recommends a minimum 70 mm x 130 mm or larger ground plane. The AC82101 should be mounted at the short edge of the board with a 4.0 mm keep out area between the antenna and the edge of the ground plane (see Figure 8 see layout drawing), and none of the ground plane should be underneath the antenna. If the ground plane is placed too close to the antenna it may impair antenna function rather than promote it. Other ground plane sizes and antenna mounting locations are possible. The AC93101 evaluation board has a 130 mm ground plane which was used for the performance standard in this datasheet. Expanded performance data for different ground plane sizes is provided later in this datasheet.

Transmission line for Embedded Antennas

For most designs, The Antenna Company recommends a microstrip transmission line for the AC82101. A microstrip transmission line is a controlled PCB trace that runs over the ground plane to maintain the 50 Ohm characteristic impedance for optimal signal transfer between the antenna and RF front end. Important practices to apply when designing a transmission line are:

- Minimize transmission line length for best signal performance.
- Use RF components that maintain a 50 Ω impedance.
- For designs subject to significant electromagnetic interference, a coplanar waveguide transmission line may be used on the PCB.

Reflow Solder Profile

The recommended reflow profile is presented according to information in Figure 10 And Table 3.

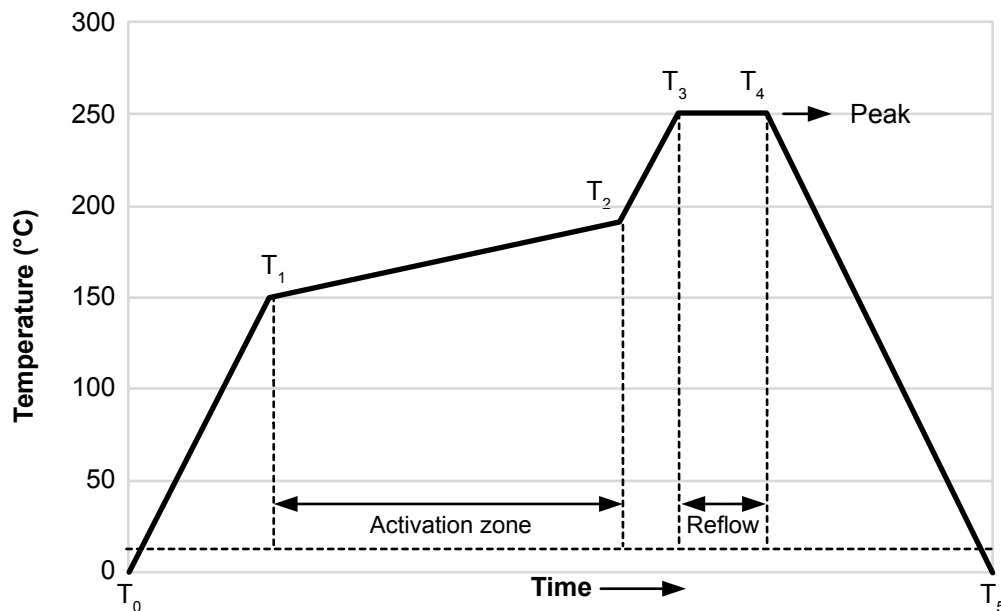


Figure 10. Suggested Solder Reflow Profile

Table 3. Reflow Temperature Table

Time Index	Reflow Phase	Temperature Range	Time
T0 - T1	Heating Zone	0 to 150 °C	Controlled 1 °C~3 °C/sec
T1 - T2	Activation Zone	150 to 190 °C	60 s to 120 s
T3 - T4	Reflow	220 to 250 °C (peak)	Above 45 s
T4 - T5	Cooling Zone	Cool down	Controlled~4 °C/sec

Packaging

The AC82101 is packaged as tape and reel. Figure 11 shows the layout of the tape. Dimensions are provided in Table 4. The specifications for the reel are shown in Figure 12 and Table 5.

Each reel is placed in a vacuum-sealed electro-static (ESD) bag with dessicant packs inside. 2 bagged reels are placed in a carton 330 mm x 330 mm x 180 mm. (13.0 in x 13.0 in x 7.1 in)

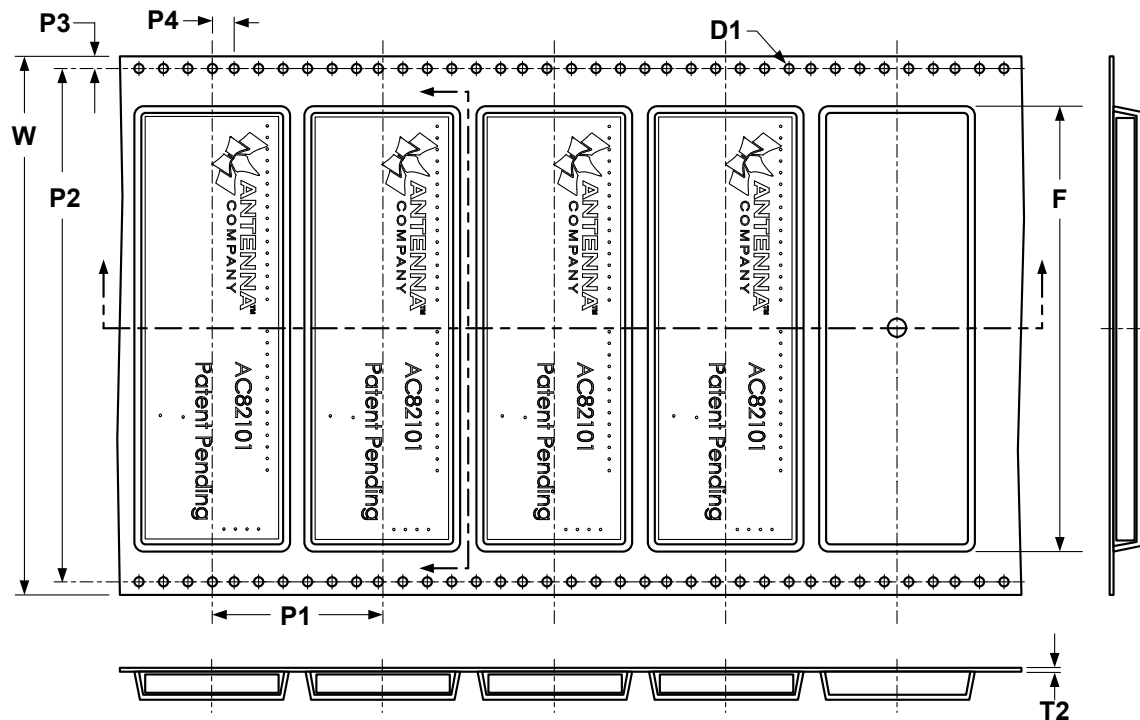


Figure 11. Tape Layout for the AC82101 Packaging

Table 4. Dimension Chart for the AC82101 Tape Packaging

Tape Dimensions		
Symbol	Dimension (mm)	Tolerance
D1	Diameter 1.5	± 0.1
F	(69.8 mm)	Reference
P1	28.0	± 0.2
P2	84.4	± 0.2
P3	1.8	Reference
P4	4.0	± 0.2
T2	0.5	± 0.1
W	88.0	± 0.3

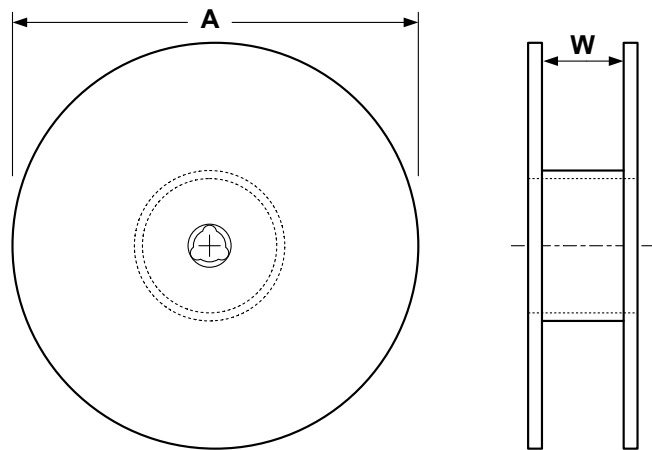


Figure 12. Reel Specifications for the AC82101 Antenna

Table 5. Reel Dimensions for the AC82101 Antenna Packaging

Reel Dimensions		
Symbol	AC82101	Unit
Qty per reel	450	Each
Tape width	88.0	mm
A	320	mm
W	19	mm

Multiple Comparative Ground Plane Length Data

The charts on the following pages represent the performance of the AC82101 antenna when mounted to evaluation boards with various lengths of ground planes ranging in length from 100 mm to 160 mm.

Table 6. Ground Plane Dataset Color Chart

Dataset Colors	Ground Plane Width	Ground Plane Length
Red	70 mm	100 mm
Orange	70 mm	110 mm
Yellow	70 mm	120 mm
Green	70 mm	130 mm
Blue	70 mm	140 mm
Indigo	70 mm	150 mm
Violet	70 mm	160 mm

VSWR

Figure 13 shows the voltage standing wave ratio for all of the ground plane lengths shown in Table 6.

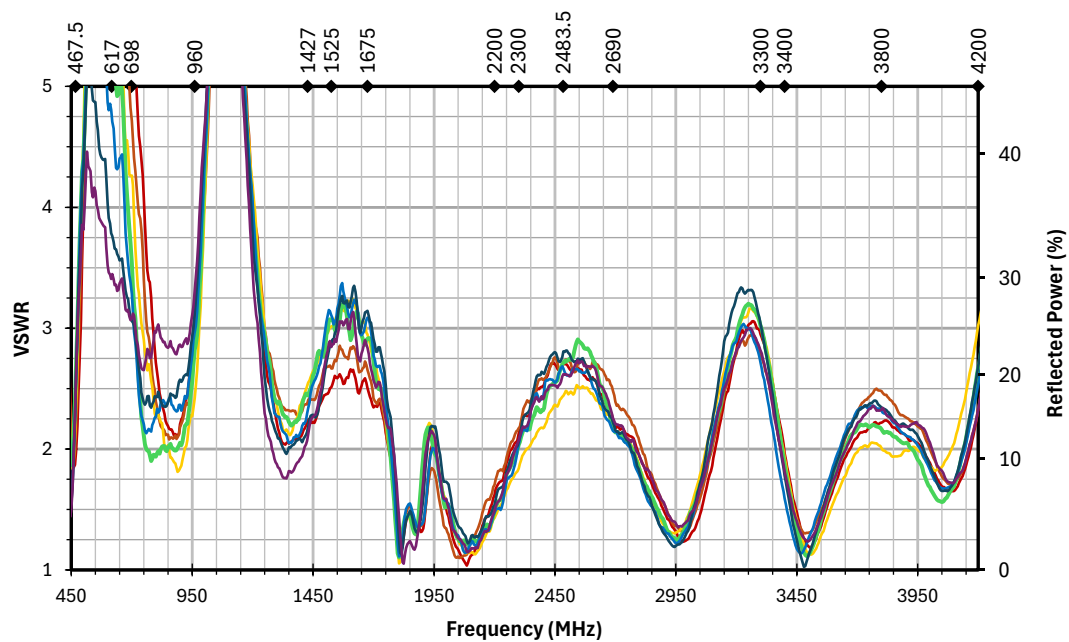


Figure 13. AC82101 Antenna VSWR on Various Ground Plane Sizes

Return Loss

Figure 14 shows the return loss for all of the ground plane lengths shown in Table 6.

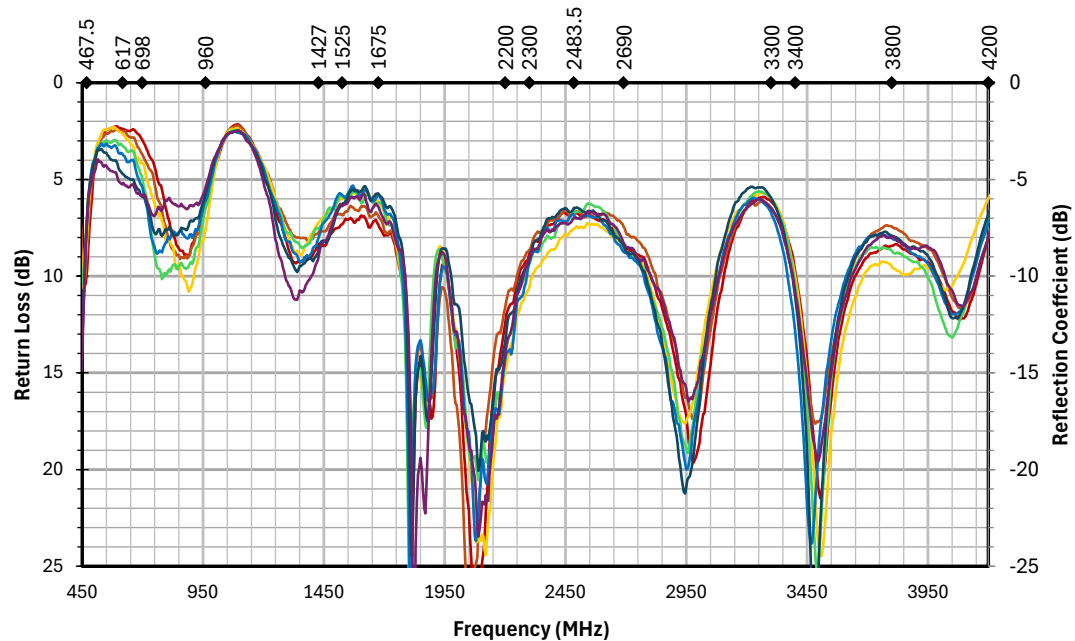


Figure 14. Antenna Return Loss on Various Ground Plane Sizes

Peak Gain

Figure 15 shows the peak gain for all of the ground plane lengths shown in Table 6.

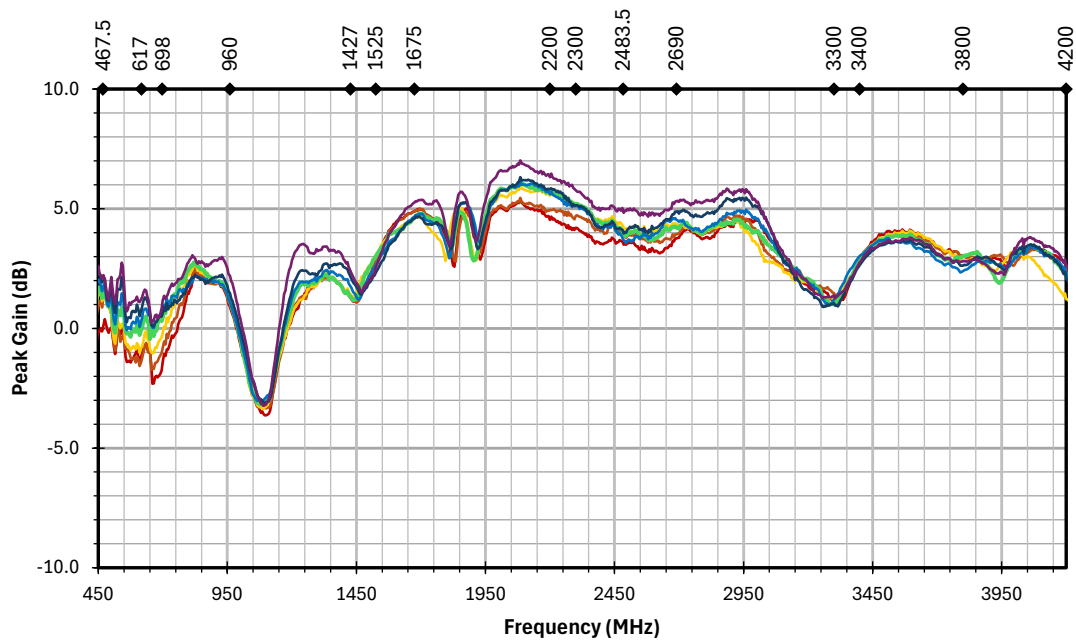


Figure 15. AC82101 Antenna Peak Gain on Various Ground Plane Sizes

Average Gain

Figure 16 shows the average gain for all of the ground plane lengths shown in Table 6.

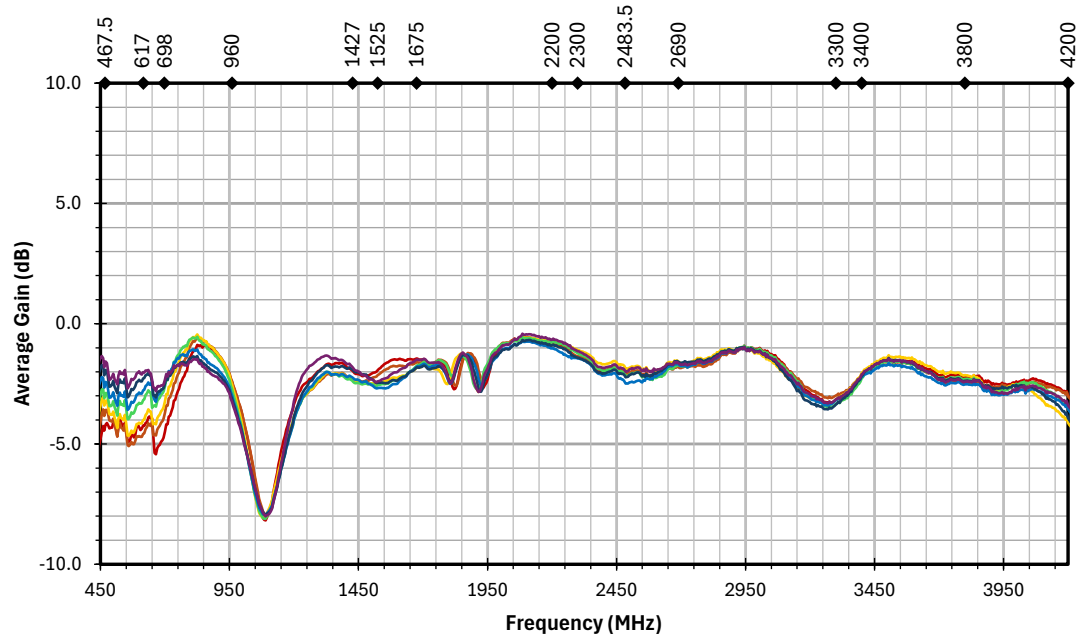


Figure 16. Antenna Average Gain on Various Ground Plane Sizes

Efficiency

Figure 17 shows the antenna efficiency for all of the ground plane lengths shown in Table 6.

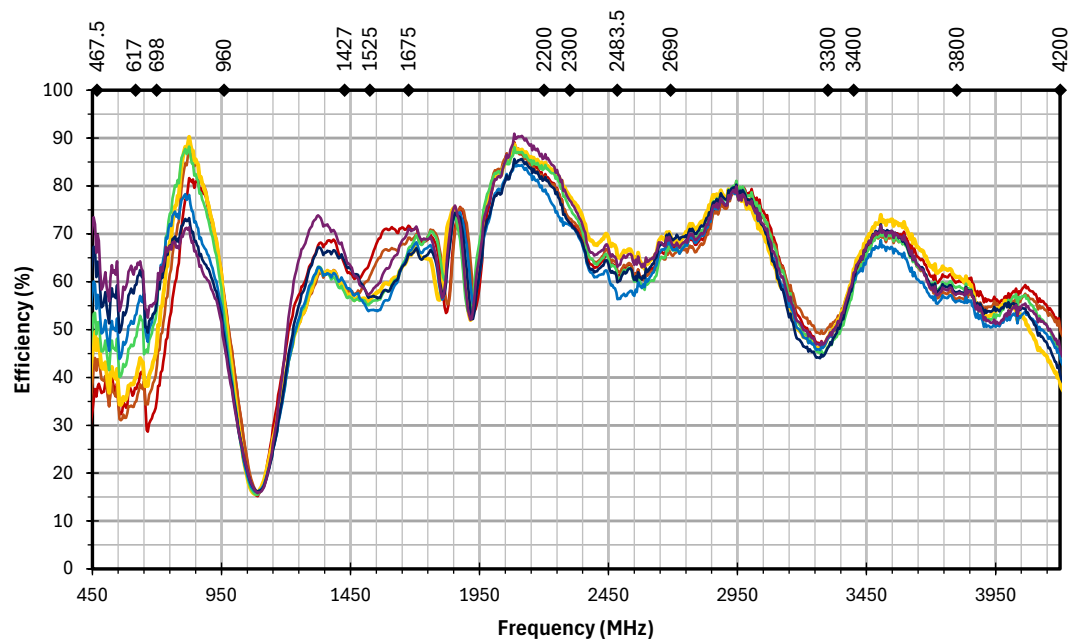


Figure 17. Antenna Efficiency on Various Ground Plane Sizes

Antenna Definitions and Useful Formulas

VSWR - Voltage Standing Wave Ratio. VSWR is a unitless ratio that describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. VSWR is easily derived from Return Loss.

$$VSWR = \frac{10^{\left[\frac{\text{Return Loss}}{20}\right]} + 1}{10^{\left[\frac{\text{Return Loss}}{20}\right]} - 1}$$

Return Loss - Return loss represents the loss in power at the antenna due to reflected signals, measured in decibels. A larger magnitude return loss value indicates better antenna performance at a given frequency. Return Loss is easily derived from VSWR.

$$\text{Return Loss} = -20 \log_{10} \left[\frac{VSWR - 1}{VSWR + 1} \right]$$

Efficiency (η) - The total power radiated from an antenna divided by the input power at the feed point of the antenna as a percentage.

Total Radiated Efficiency - (TRE) The total efficiency of an antenna solution comprising the radiation efficiency of the antenna and the transmitted (forward) efficiency from the transmitter.

$$TRE = \eta \cdot \left(1 - \left(\frac{VSWR - 1}{VSWR + 1} \right)^2 \right)$$

Gain - The gain of an antenna is the ratio of its radiation intensity in a given direction (G) to the radiation intensity that would be obtained if the total power accepted by the antenna were radiated isotropically (identically in all directions). Realized gain is antenna gain accounting for input reflection and mismatch losses. Realized gain is typically labeled simply as “gain” in antenna datasheets.

$$G_{db} = 10 \log_{10}(G)$$

$$G_{dBd} = G_{dBi} - 2.51\text{dB}$$

Peak Gain - The highest antenna gain across all directions for a given frequency range. A directional antenna will have a very high peak gain compared to average gain.

Average Gain - The average gain across all directions for a given frequency range.

Maximum Power - The maximum signal power which may be applied to an antenna feed point, typically measured in watts (W).

Reflected Power - A portion of the forward power reflected back toward the amplifier due to a mismatch at the antenna port.

$$\left(\frac{VSWR - 1}{VSWR + 1} \right)^2$$

decibel (dB) - A logarithmic unit of measure of the power of an electrical signal.

decibel isotropic (dBi) - A comparative measure in decibels between an antenna under test and an isotropic radiator.

decibel relative to a dipole (dBd) - A comparative measure in decibels between an antenna under test and an ideal half-wave dipole.

Dipole - An ideal dipole comprises a straight electrical conductor measuring 1/2 wavelength from end to end connected at the center to a feed point for the radio.

Isotropic Radiator - A theoretical antenna which radiates energy equally in all directions as a perfect sphere.

Omnidirectional - Term describing an antenna radiation pattern that is uniform in all directions. An isotropic antenna is the theoretical perfect omnidirectional antenna. An ideal dipole antenna has a donut-shaped radiation pattern and other practical antenna implementations will have less perfect but generally omnidirectional radiation patterns which are typically plotted on three axes.

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Patent Information. Patent pending.

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