Parameter Study of Ultra Wideband Loop Antenna

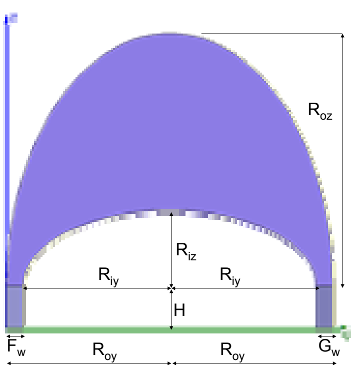
Eric R. Marklein and Daniel Schaubert

University of Massachusetts-Amherst, ECE Dept., Antennas and Propagation Lab.

Loop Antenna Summary

A modified loop antenna has been shown to provide very good performance from 3.1 to 10.6 GHz. The loop is relatively small at lower operation frequencies, making it attractive for RFID tagging applications. The characterization of the loop's key parameters was studied in order to understand how they affect antenna performance. When properly designed, the loop antenna has the potential of exhibiting a reasonably stable input resistance and reactance across the specified frequency range. This will provide a VSWR lower than 2 with respect to the antenna's average input. The loop's characterization was conducted through simulations and confirmed with models built in lab and tested.

Design Approach



Loop antenna parameters

R_{oz}, outer vertical radius

R_{iz}, inner vertical radius

F_w and G_w, feed width and ground width, equal in length

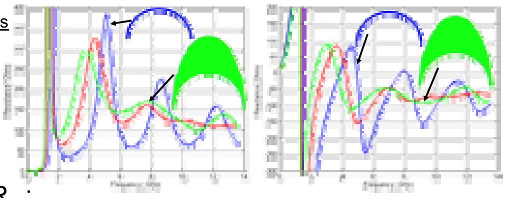
H, height

The many resonances of loop antennas of nonuniform current offer the possibility of manipulating the design to be used for wideband use. By making the loop conductor wider, high frequency antiresonances can be nearly removed, providing an input impedance that stays almost constant across a wide frequency range. The wideband loop antenna was simulated with CASCA's MEMA computational EM software.

Effects of Outer Radius Height R_{oz}

Parameter Values

Roy = 14 mm
Riy = 13 mm
Riz = 13 mm
Fw = Gw = 1 mm
H = 0 mm
+, Roz = 14 mm
o, Roz = 21 mm
Δ, Roz = 28 mm

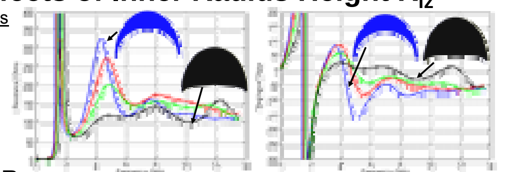


Increasing R_{oz}:
- Decreases the resonant frequencies
- Reduces amplitude of impedance fluctuations

Effects of Inner Radius Height R_{iz}

Parameter Values

Roy = 14 mm
Roz = 21 mm
Riy = 13 mm
Fw = Gw = 1 mm
H = 0 mm
+, Riz = 13 mm
o, Riz = 9.75 mm
Δ, Riz = 6.5 mm
◊, Riz = 3.25 mm

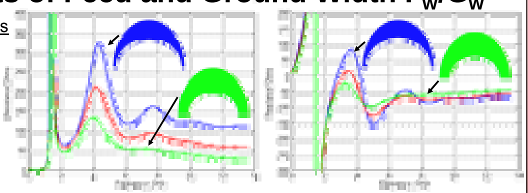


Decreasing R_{iz}:
- Smooths impedance at higher resonances
- Decreases average resistance
- Minimizes reactance

Effects of Feed and Ground Width F_w/G_w

Parameter Values

Roy = 14 mm
Roz = 21 mm
Riy = Riz = Roy - Fw
H = 0 mm)
+, Fw = 1 mm
o, Fw = 2 mm
Δ, Fw = 3 mm

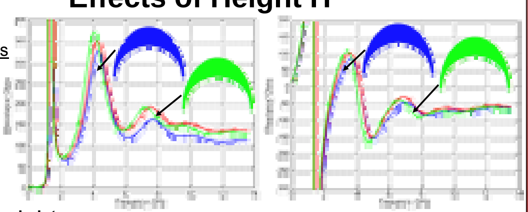


Increasing feed width:
- Reduces the peak resistance and reactance
- Large reactance (can be improved with small R_{iz})

Effects of Height H

Parameter Values

Roy = 14 mm
Roz = 21 mm
Riy = Riz = 13 mm
Fw = Gw = 1 mm)
+, H = 0 mm
o, H = 1 mm
Δ, H = 2 mm



Increasing height:
- Slightly decrease in resonant frequencies

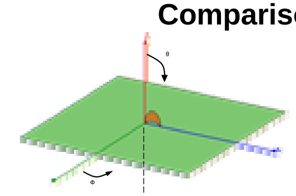
Loop Design Procedure

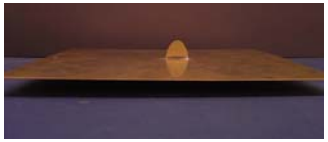
1). Determine values of R_{oy}, R_{oz} and R_{iz}. These are the critical parameters since they will have the greatest effect on the resonant frequency and stabilizing the resistance and reactance.

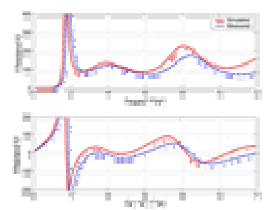
2). Select values for the feed (and ground) width and height. These two parameters should be used as optimization parameters because they have less effect on the resonant frequency and impedance performance across the frequency bandwidth.

3). The average resistance tends to be around 100-120Ω for this loop antenna, so impedance transformation will be necessary for a 50Ω characteristic impedance.

Comparison of Results







Constructed Antenna Parameters

20 mil brass antenna soldered to 50Ω SMA connector at feed and 30 x 30 cm ground plane.

R_{oy} = 14 mm R_{oz} = 21 mm
R_{iy} = 13 mm R_{iz} = 3.25 mm
$F_w = G_w$ = 1 mm H = 1 mm

Sample Co-Polarization Patterns