UNIVERSITÄT DUISBURG ESSEN
HFT

INVESTIGATION OF TRANSMIT/RECEIVE COIL FOR 7-TESLA MAGNETIC RESONANCE TOMOGRAPHY

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Motivation

- What is MRI (Magnetic ResonanceImaging)
- MRI Fundamentals
- Strength of MRI Scanners

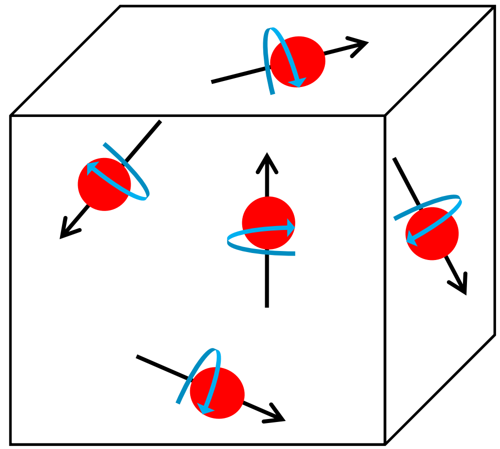
MRI Fundamentals

$$\omega_0 = \gamma B_0$$

Where: ω_0 = Larmor frequency. (MHz)

γ = Gyro Magnetic Ratio. (MHz/T)

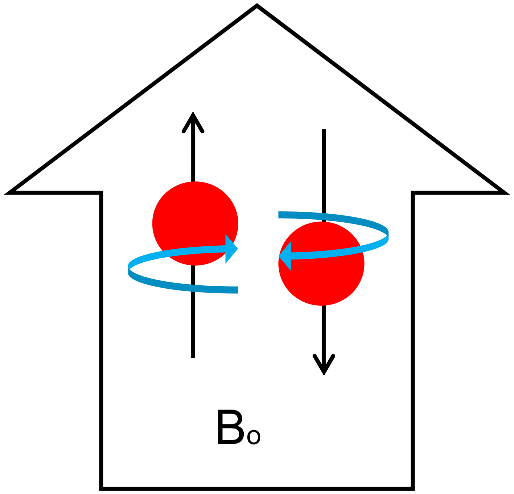
B_0 = Magnetic field strength. (T)



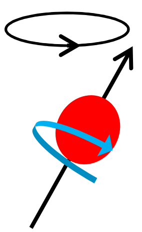
Balanced spinning H atoms

The Larmor frequency for Hydrogen atom in a 7 Tesla magnetic field strength (B_0) is :

42.6 x 7 = 298,2 MHz



Aligned Hydrogen atoms in a magnetic field B_0



Precessing H atoms

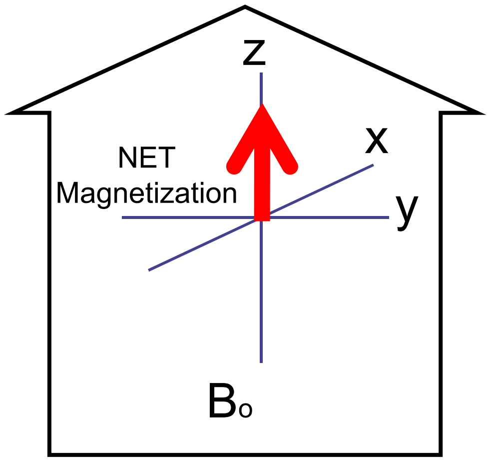
Gyro magnetic Properties of Nuclei

Isotope	Symbole	Spin Quantum number	Gyro Magnetic Ratio (MHz/T)
Hydrogen	^{1}H	1/2	42.6
Carbon	^{13}C	1/2	10.7
Oxygen	^{17}O	5/2	5.8
Fluorine	^{19}F	1/2	40.0
Sodium	^{23}Na	3/2	11.3
Magnesium	^{25}Mg	5/2	2.6
Phosphorus	^{31}P	1/2	17.2
Sulphur	^{33}S	3/2	3.3
Iron	^{57}Fe	1/2	1.4

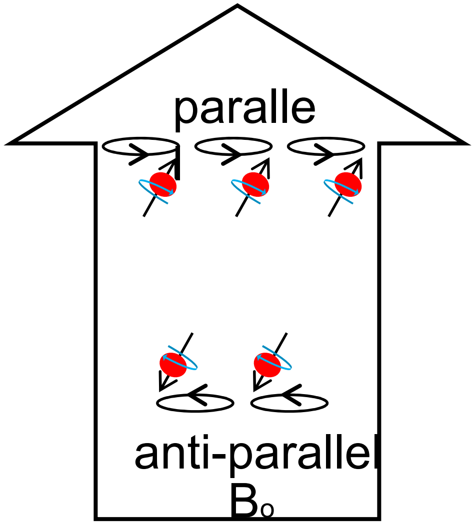
Alignment in B0 field

Vectorial Diagram

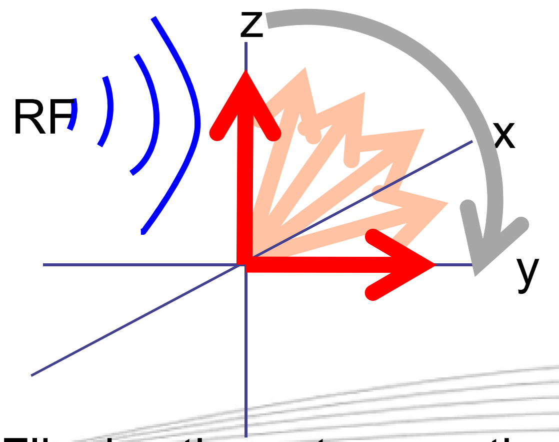
- Net Magnetization in Z direction
- Proton orientation
- X Y Plane excitation



X Y and Z vectors

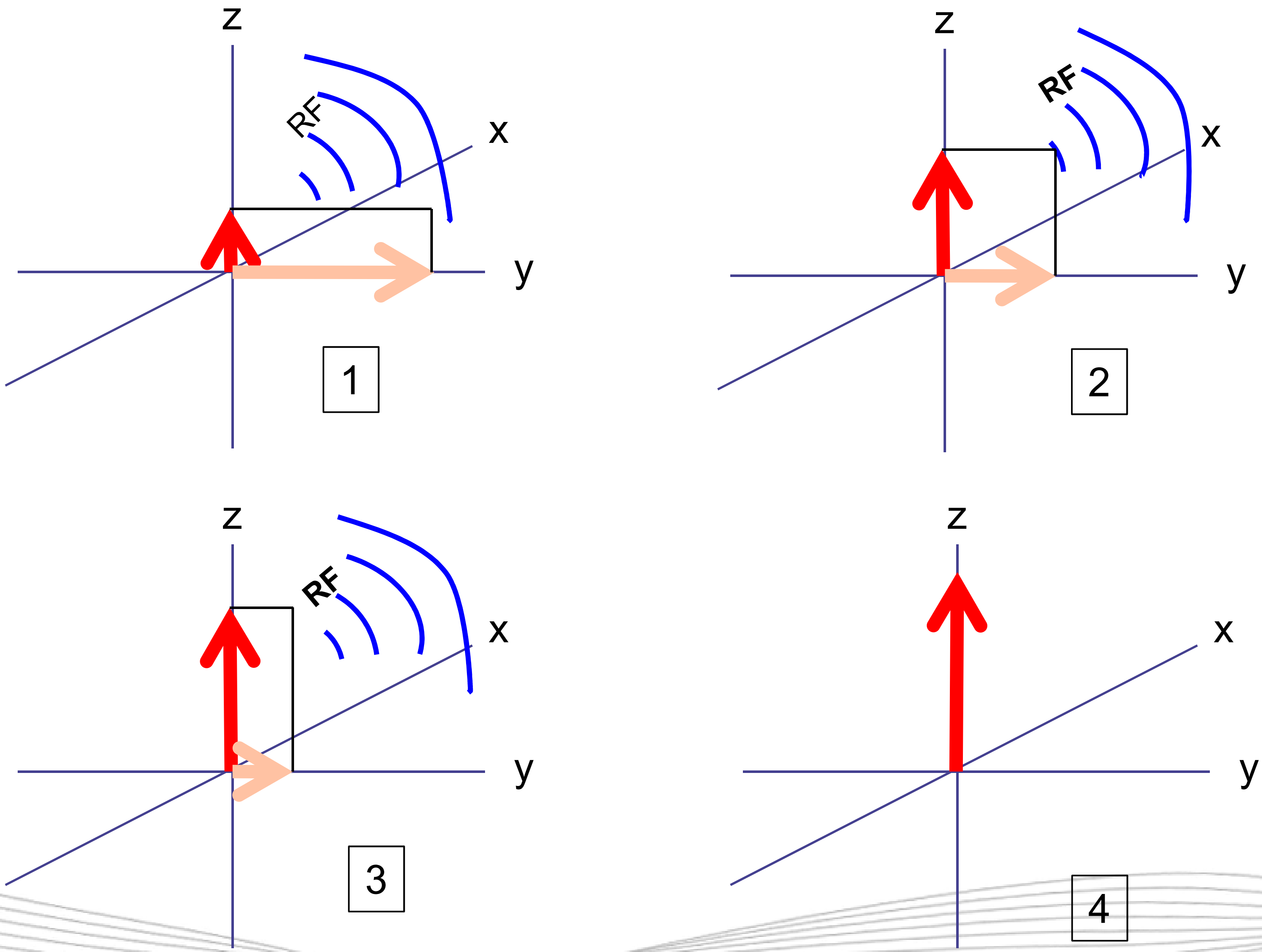


parallel and anti-parallel alignment

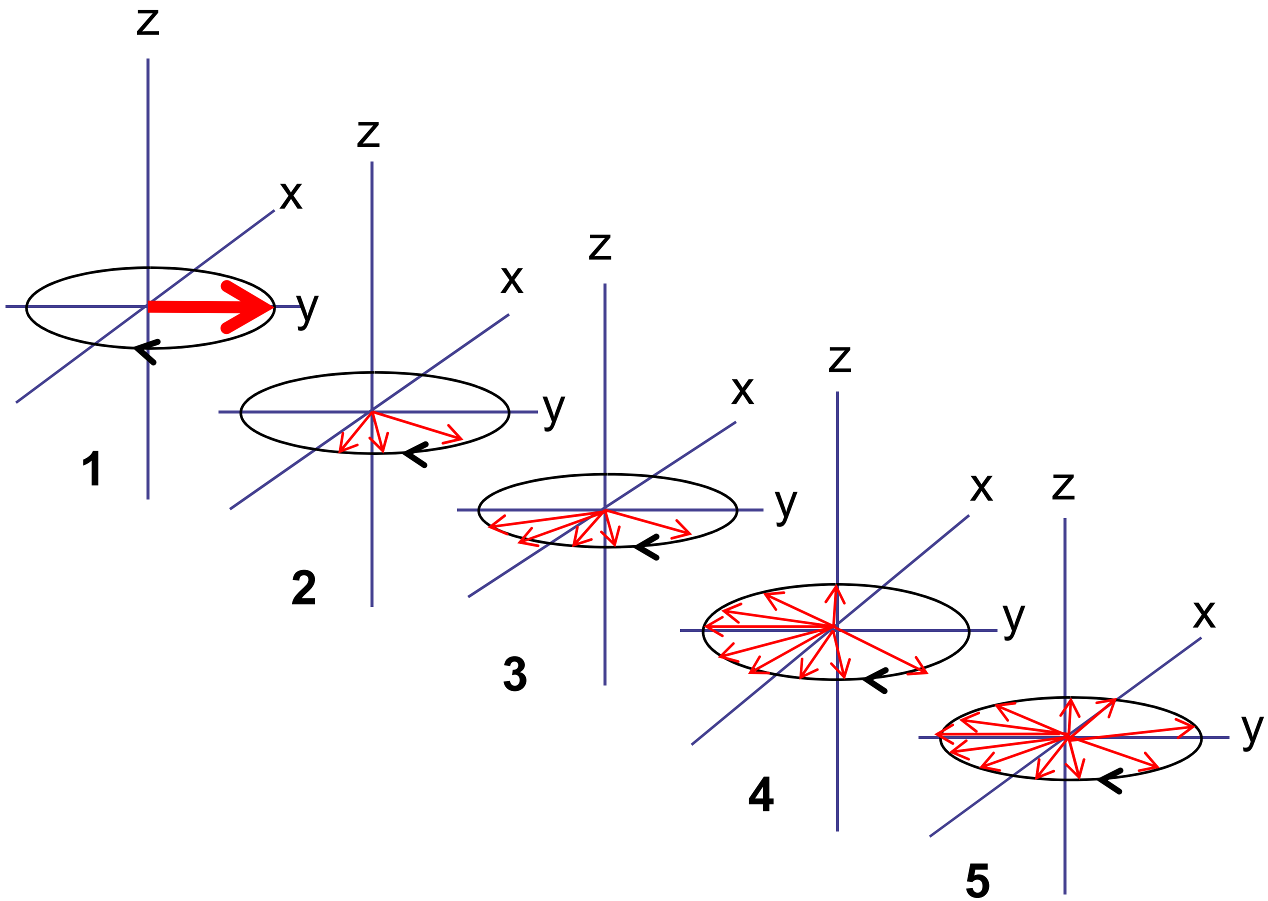


Flipping the net magnetization

Flipping Process

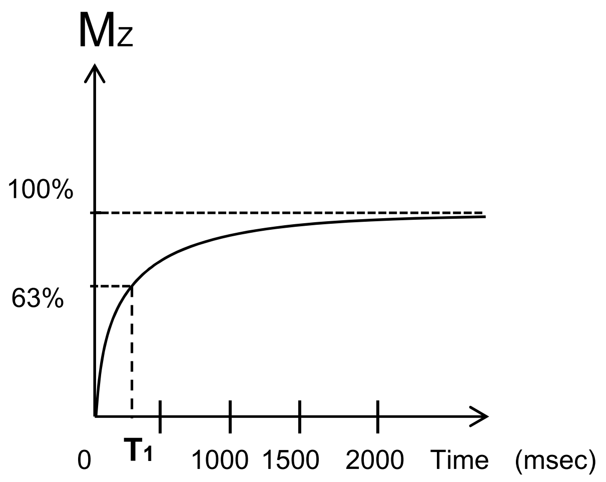


Coherence and Dephasing

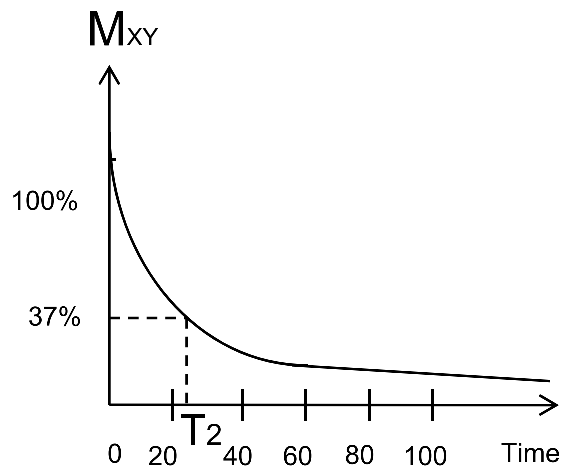


Spin De-phasing process

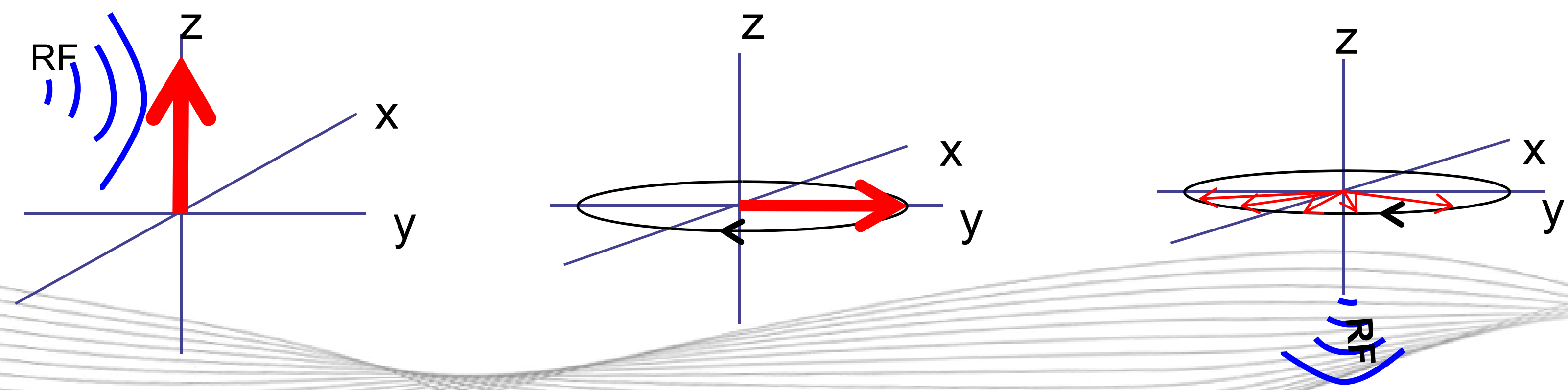
The Time Constants T_1 and T_2



T_1 Curve



T_2 Curve



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Comparing MRI Scanners

- 1.5 Tesla Scanner

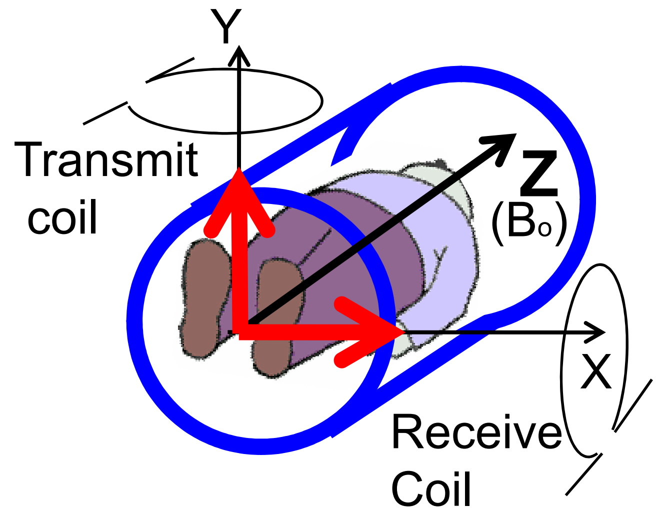
  63.9MHz λ=4.7m

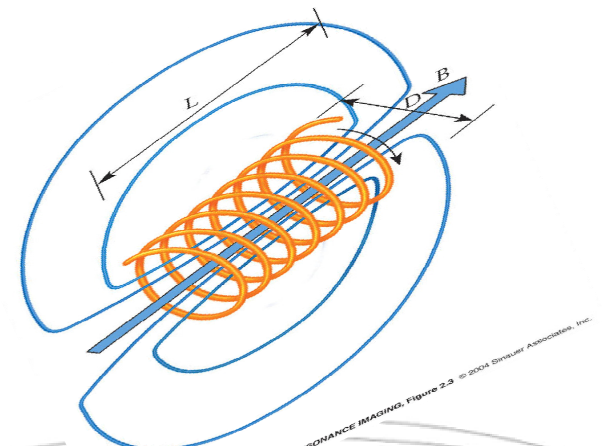
- 3 Tesla Scanner

  127.8MHz λ=2.3m

- 7 Tesla Scanner

  298.2MHz λ=1m

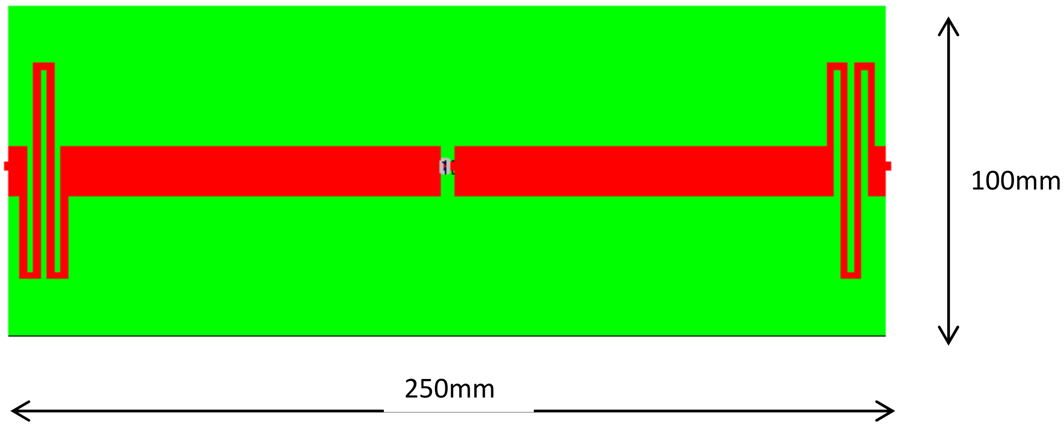




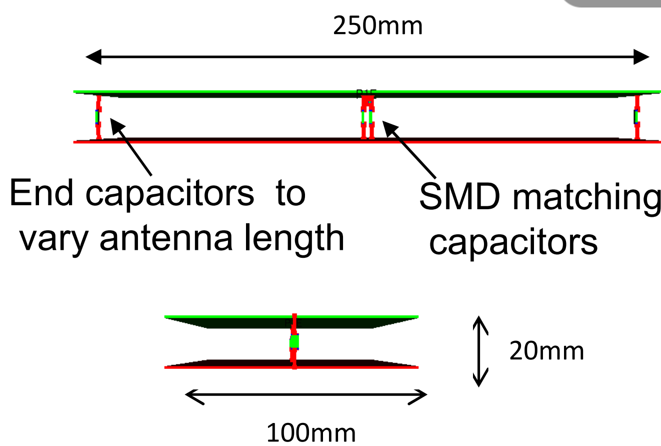
The Magnetic field coil (B_0)

Antenna Modeling

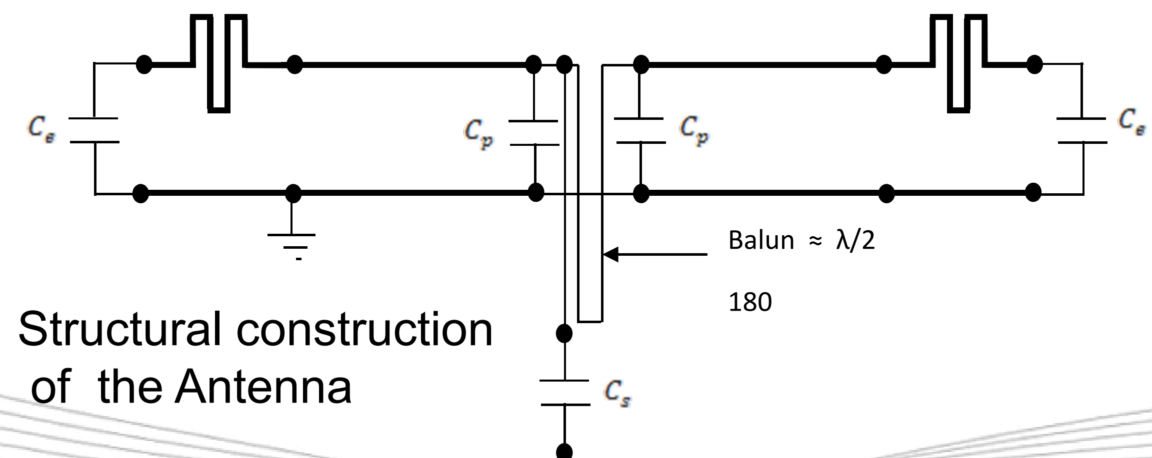
The Microstrip Meander Dipole antenna Design



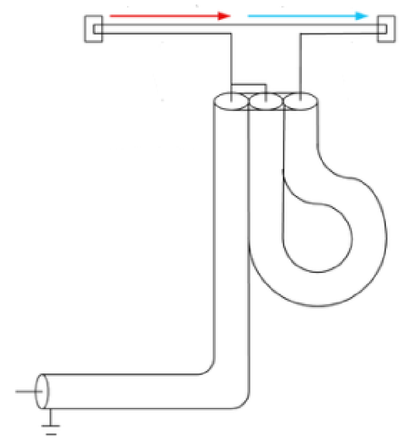
Front view of the Microstrip antenna



Side view of the Antenna



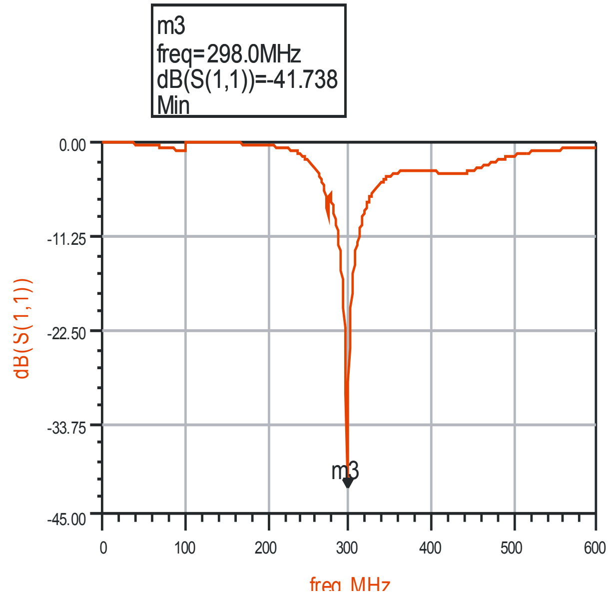
Structural construction of the Antenna



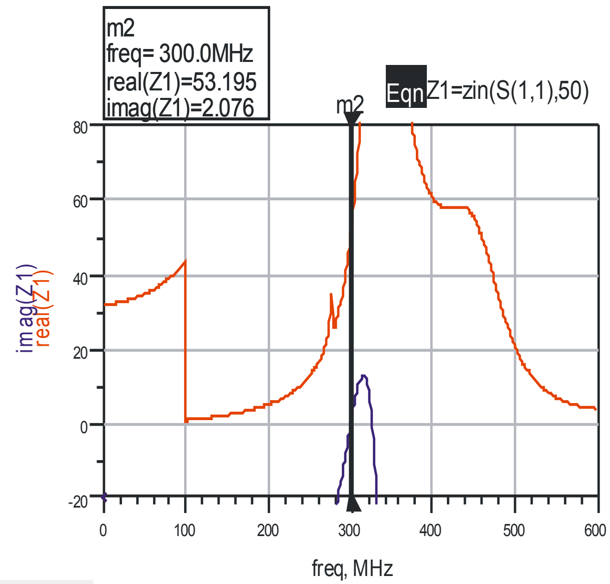
Coax balun

Antenna Simulation

- The S_{11} parameter at resonace frequency 300MHz



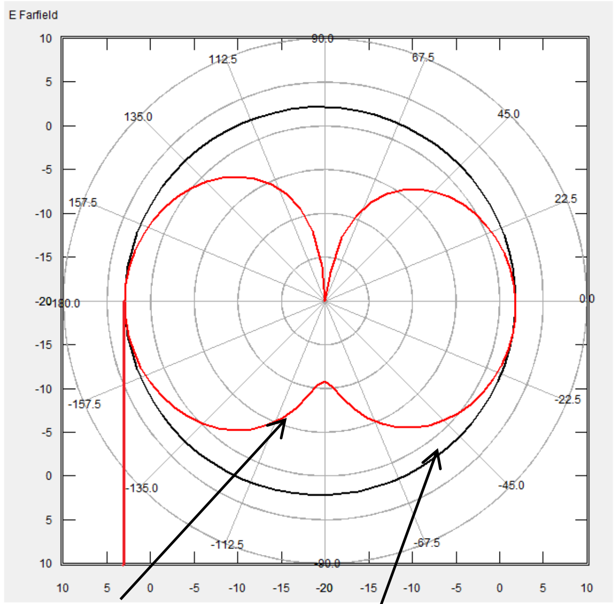
- Input impedance at resonace frequency 300MHz



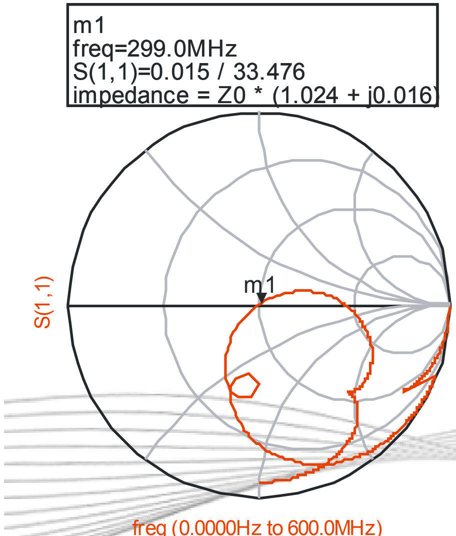
- The Far-field Radiation Pattern

- Impedance matching as a function of frequency on the Smith Chart

- It has a forward Gain of 1.83 dB and 2.83 dB at the back



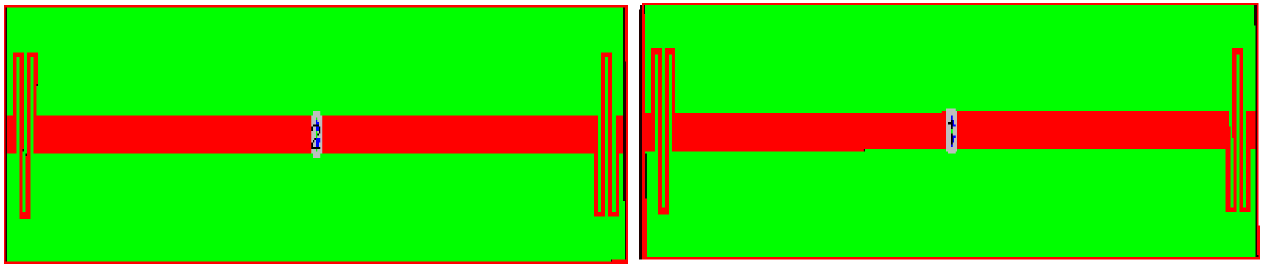
Phi Cut Theta Cut



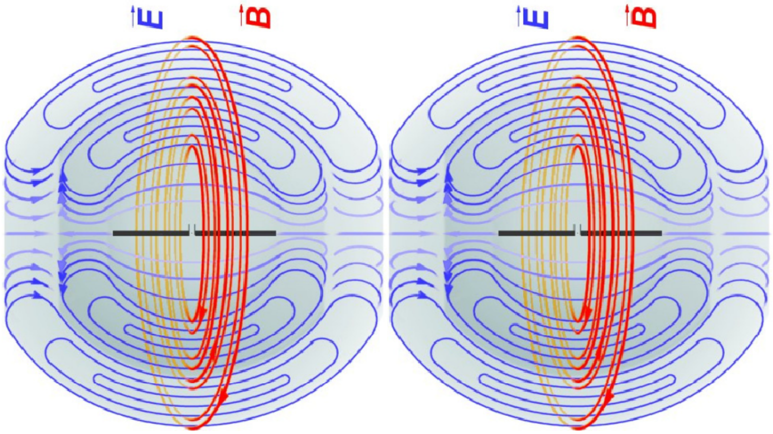
The Smith Chart

Effects of Coupling

E-Plane Alignment



Electric (blue) and Magnetic (red) field distribution



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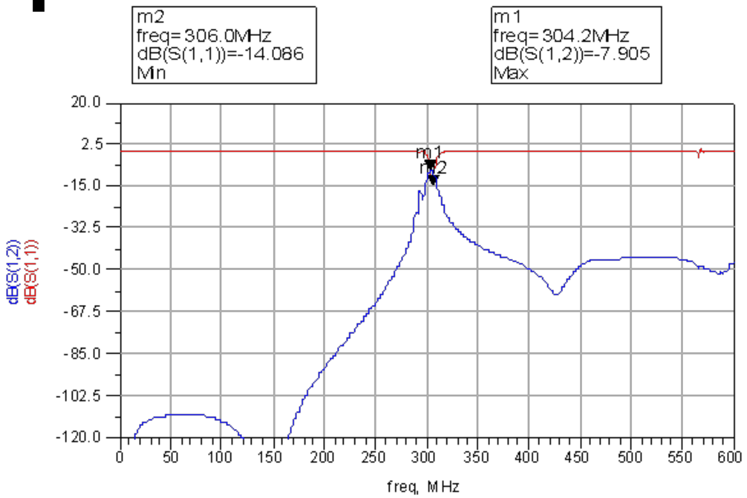
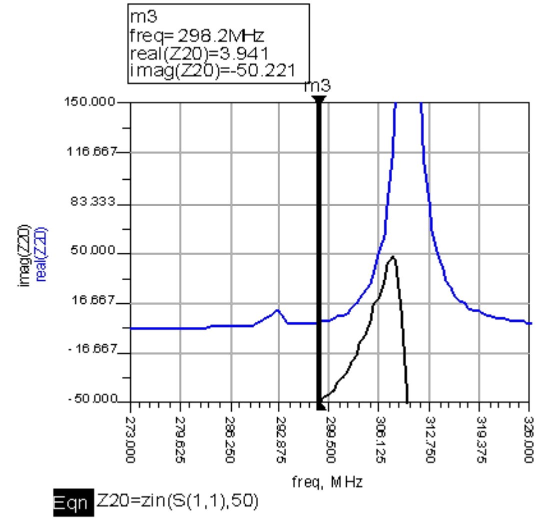
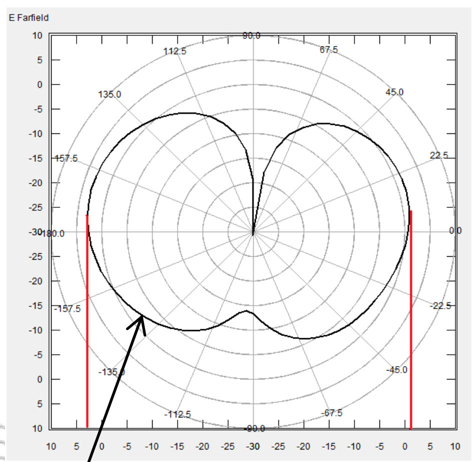
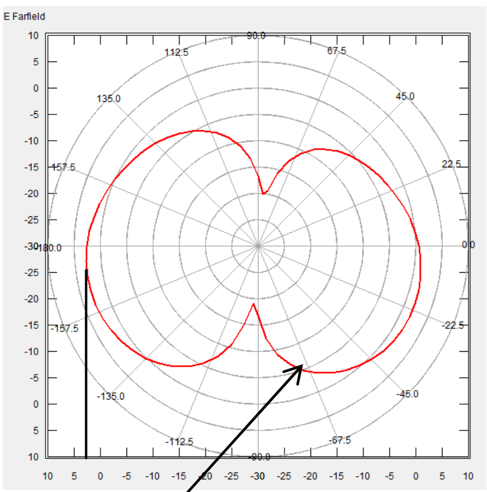
E-plane Simulation results



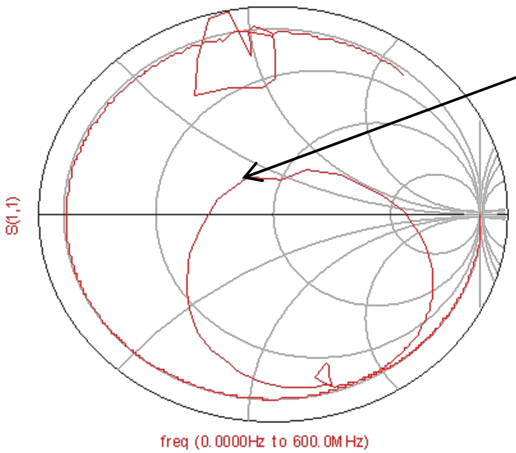




Theta Cut



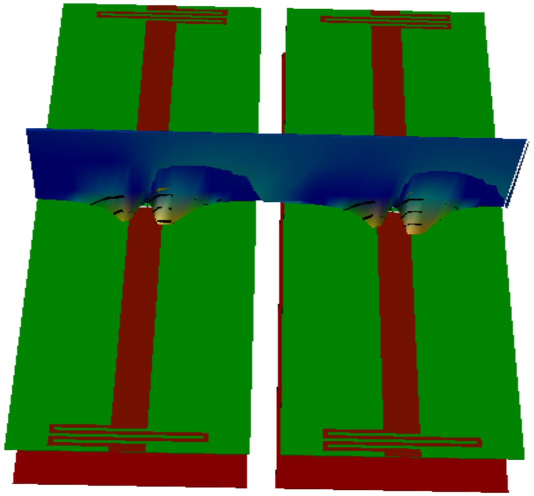
Phi Cut



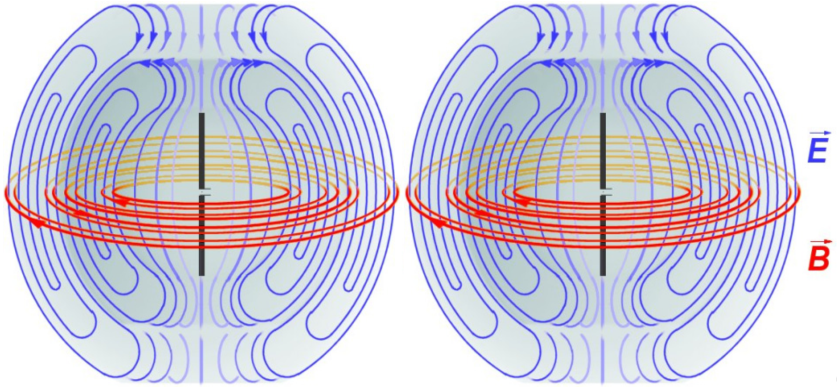
300MHz

The Smith Chart

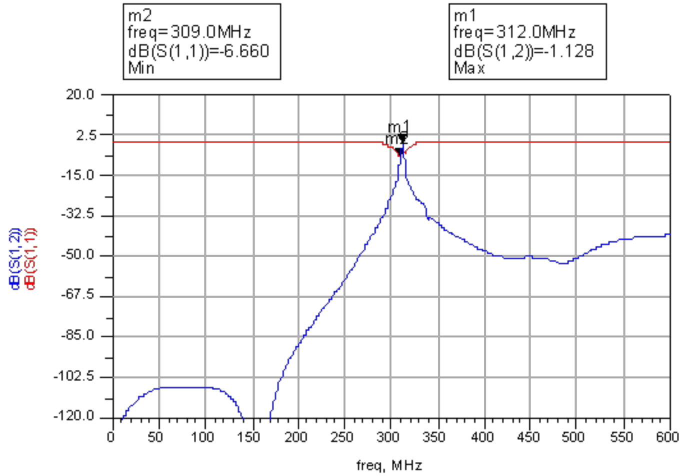
H-plane Alignement

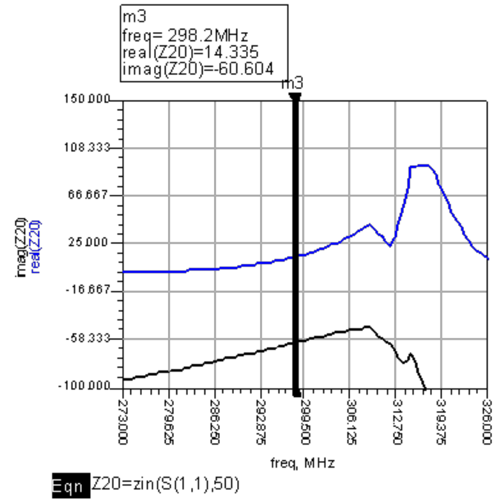


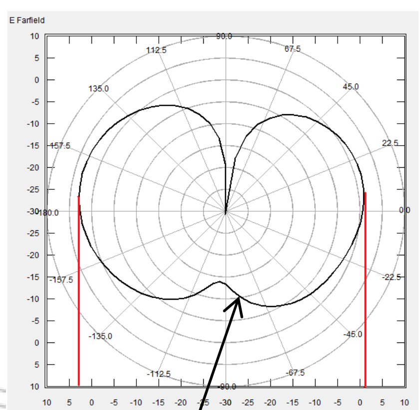
Electric (blue) and Magnetic (red) field distribution



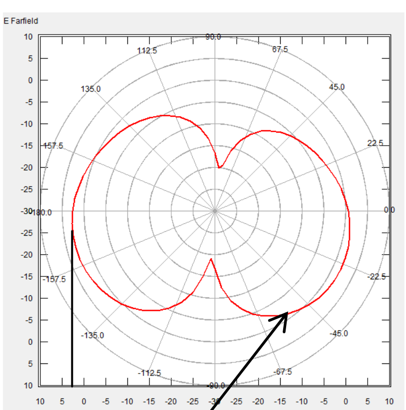
H-plane Simulation results



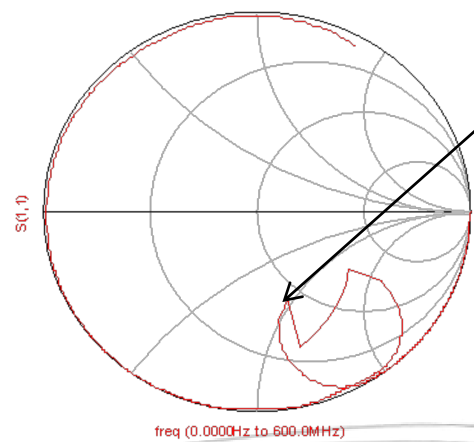




Theta Cut



Phi Cut



300MHz

The Smith Chart

Coupling in E-plane

Table for the Simulation results along the E-Plane

Distance apart in cm	S_{11}/dB	S_{12}/dB	Real impedance In Ohm	Imaginary impedance In Ohm	Resonance Frequency MHz	Percentage Shift in Resonance Frequency MHz
5	-14	-7.9	3.9	-50.2	298.2	2
10	-9.32	-8.60	18.30	2.35	298.2	0
15	-15.37	-15.45	1.71	76.6	298.2	4
20	-12.81	-10.87	9.94	-28.12	298.2	1

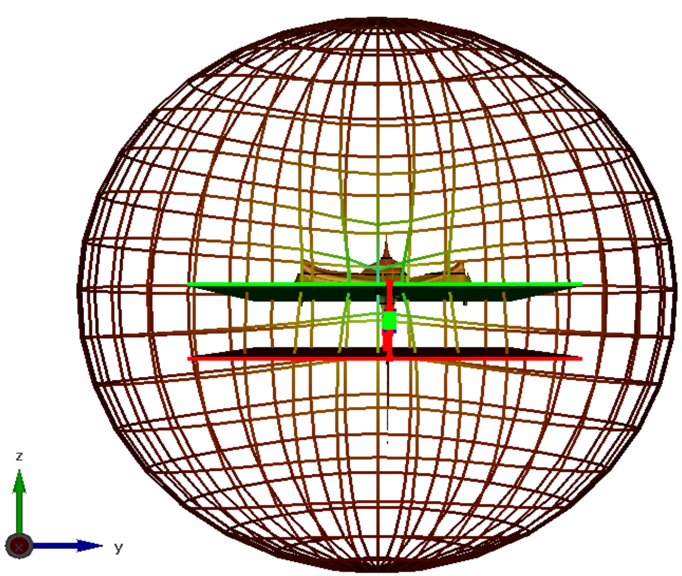
Coupling in H-plane

Table for the Simulation results along the H-Plane

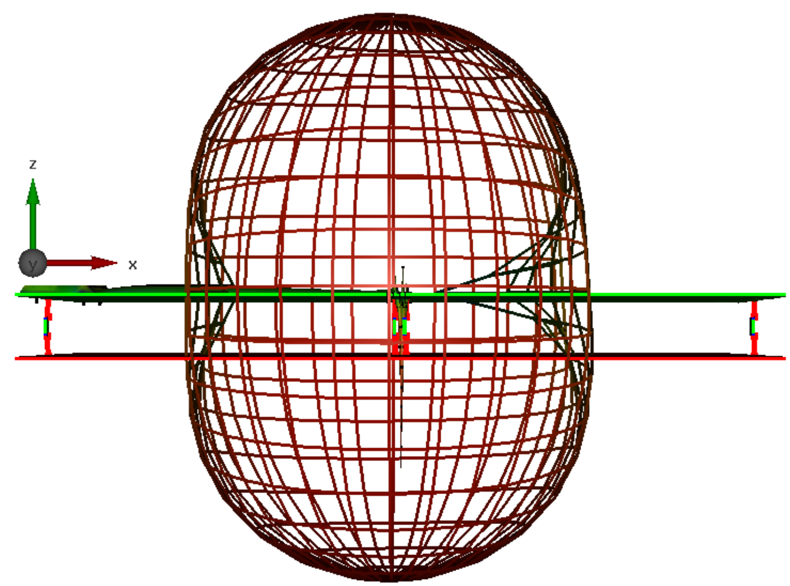
Distance apart in cm	S11/dB	S12/dB	Real impedance In Ohm	Imaginary impedance In Ohm	Resonance Frequency MHz	Percentage Shift in Resonance Frequency MHz
5	-6.66	-1.13	14.34	-60.60	298.2	3
10	-5.05	-10.08	15.69	-26.95	298.2	0
15	-5.47	-18.75	15.21	-25.40	298.2	1
20	-4.79	-21.76	14.44	25.65	298.2	0

EFFECTS OF VARYING THE GROUND PLANE SIZE

Fundamental Size; 250mm Length

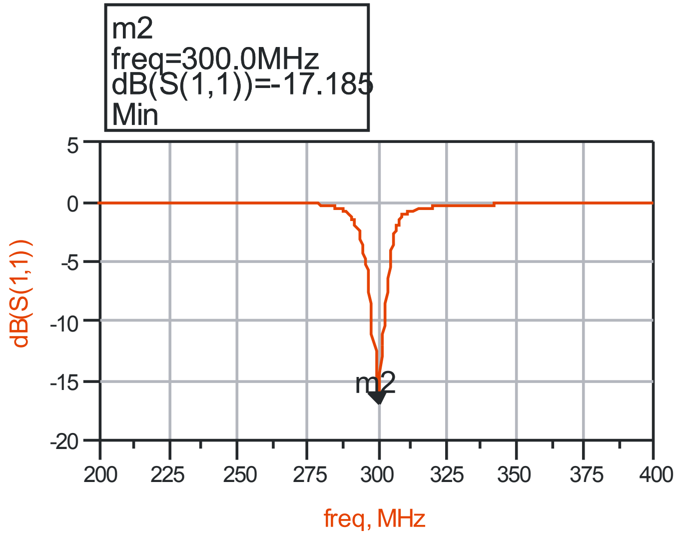


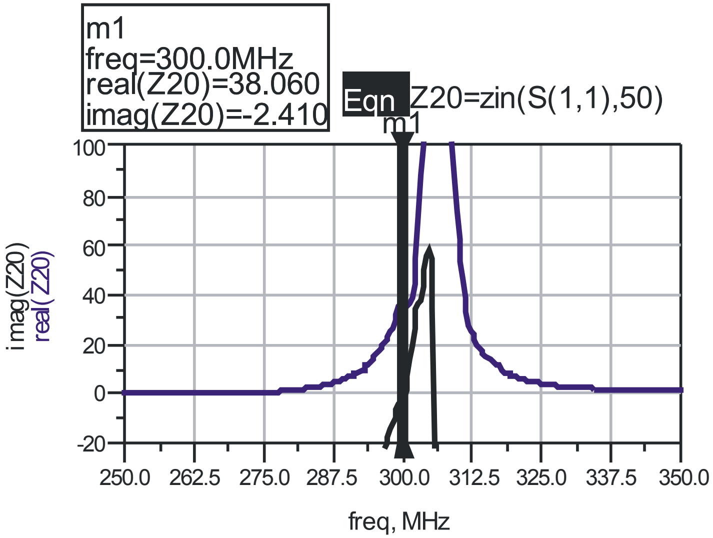
End Fire view

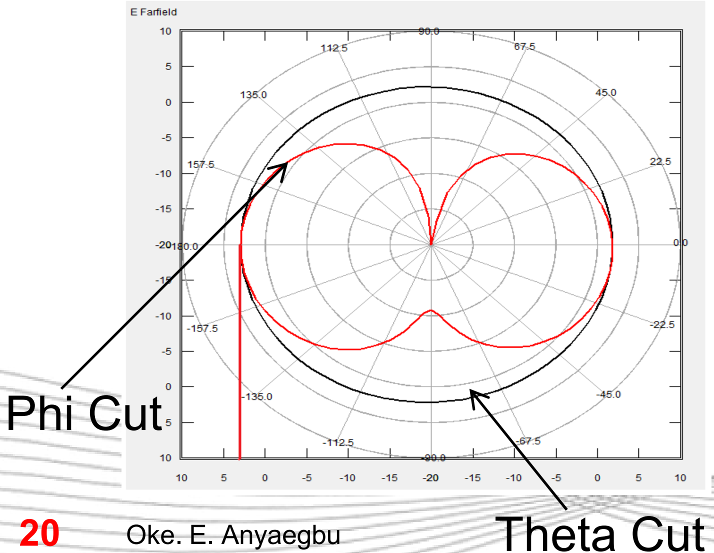


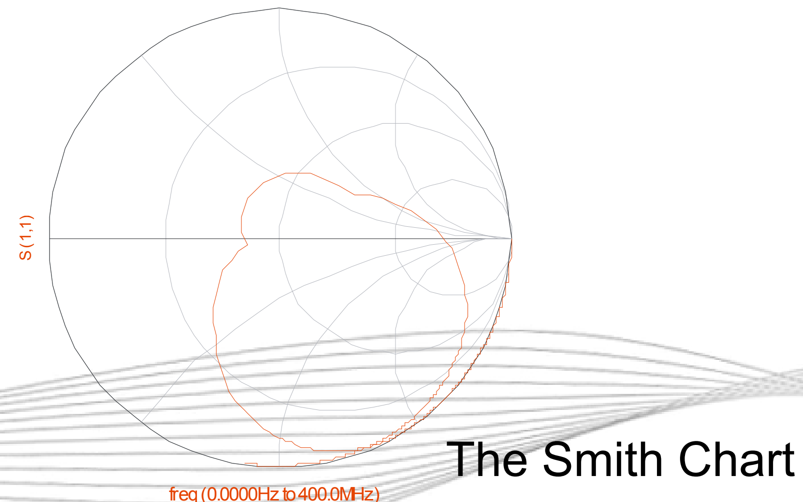
Broad side view

Simulation with Fundamental Size 250mm









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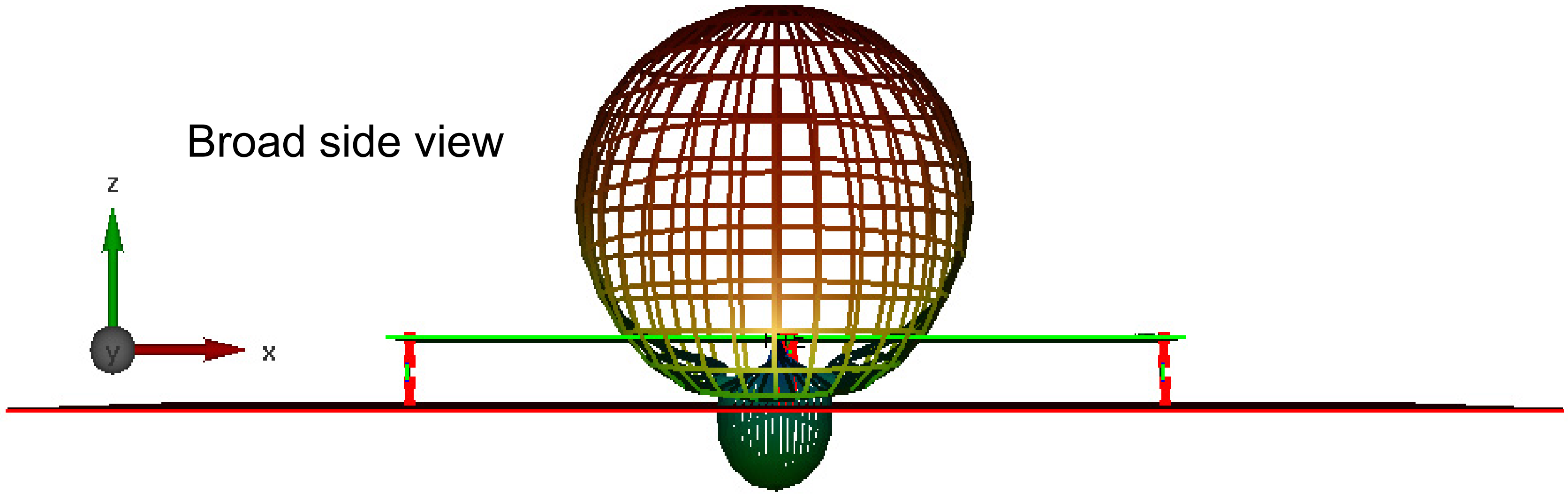
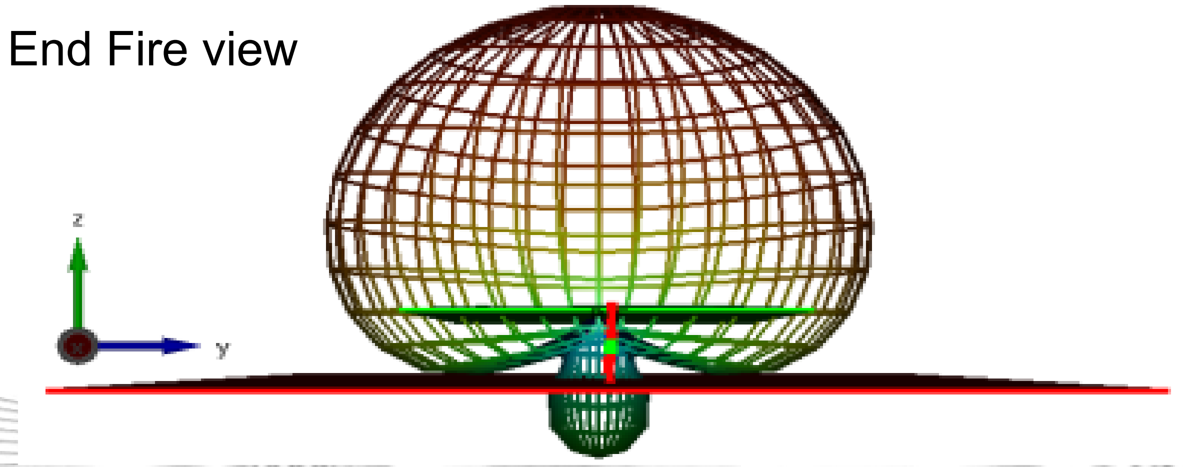
Ground Plane Length at 450mm

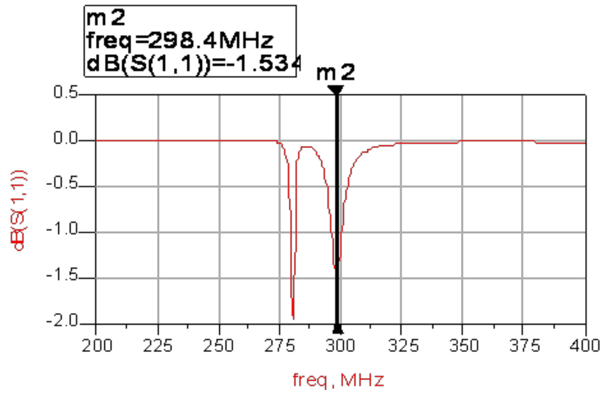
Broad side view

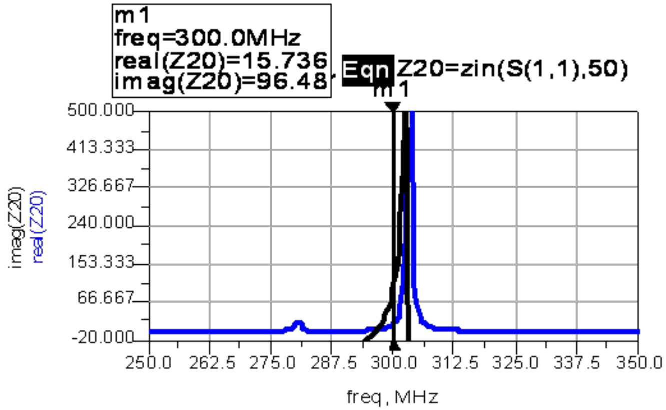


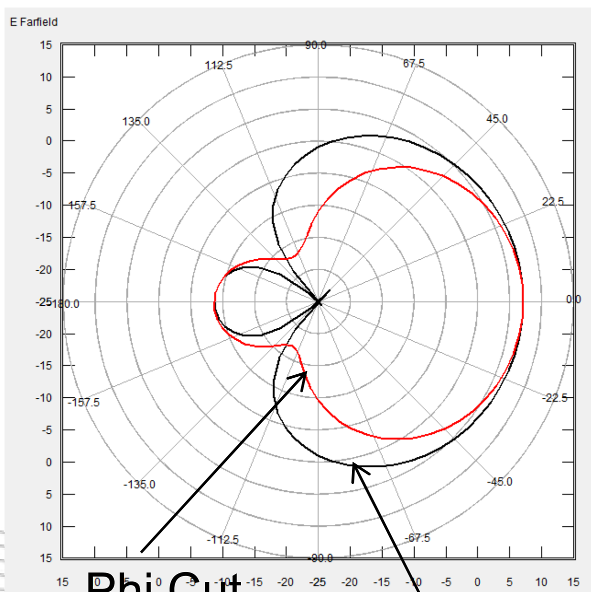
End Fire view

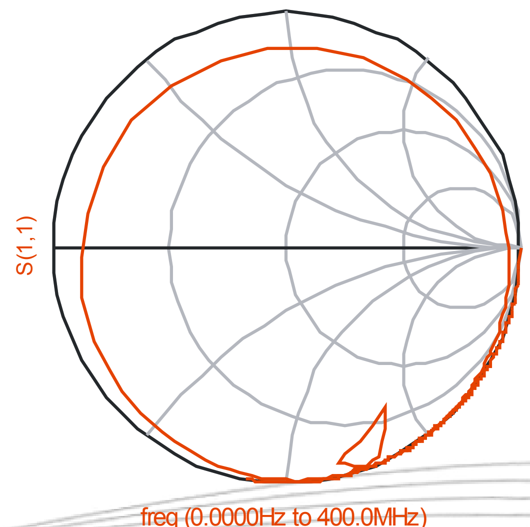


Simulation of Ground at 450mm





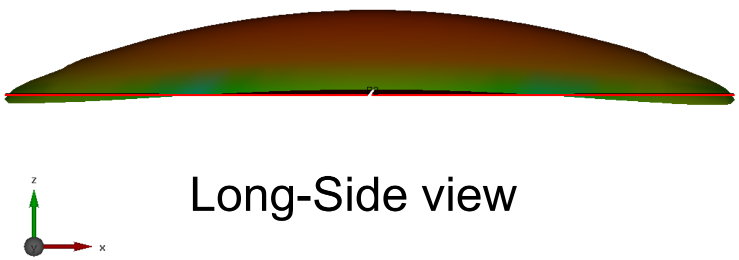




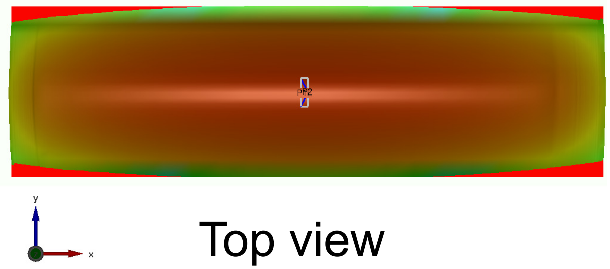
Summary of Ground Size plane Effects

Ground Plane size	S_{11}/dB	Real impedance In Ohm	Imaginary impedance In Ohm	Forward Gain dB	Backward Gain dB	1st Resonance Frequency MHz	2nd Resonance Frequency MHz
0.25λ	-17.18	38.06	-2.41	1.83	2.83	300	
0.36λ	-8.24	105.66	25.03	3.42	5.19	300	
0.45λ	-1.53	15.73	96.48	7.12	-8.75	298.4	280
0.50λ	-1.66	16.21	95.22	7.35	-11.81	298.4	280

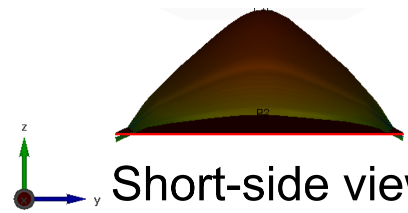
Current and Magnetic field distribution infront of the antennna



Long-Side view

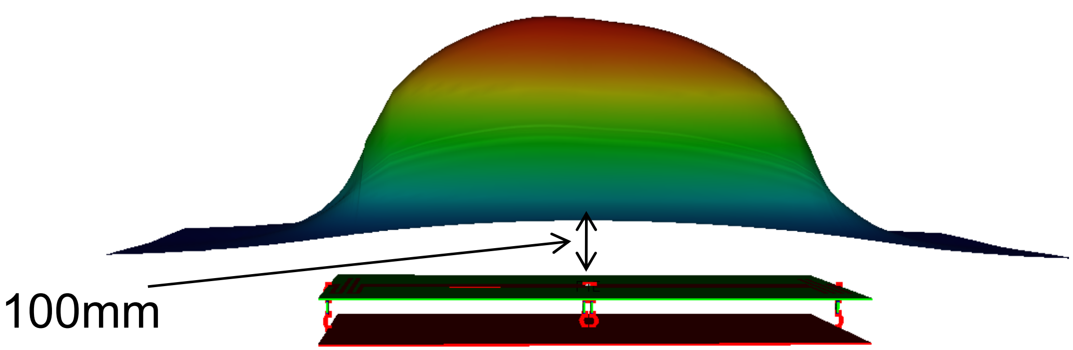


Top view



Short-side view

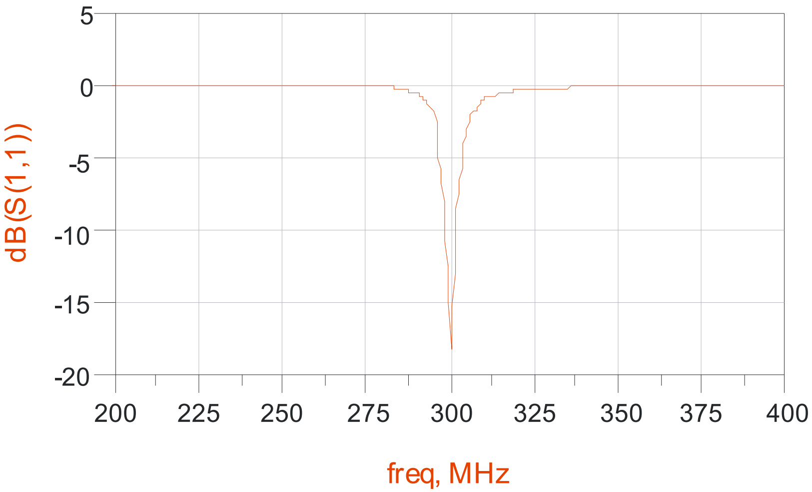
Current distribution

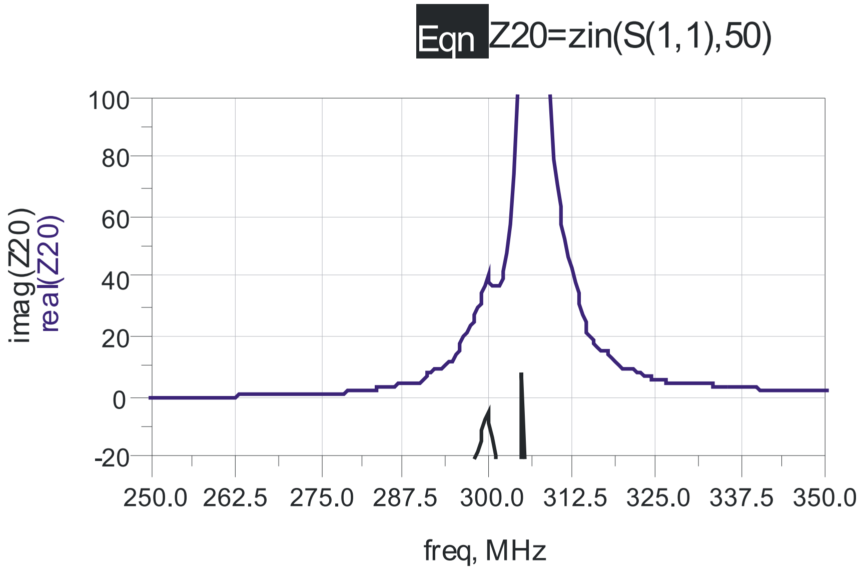


Magnetic field distribution

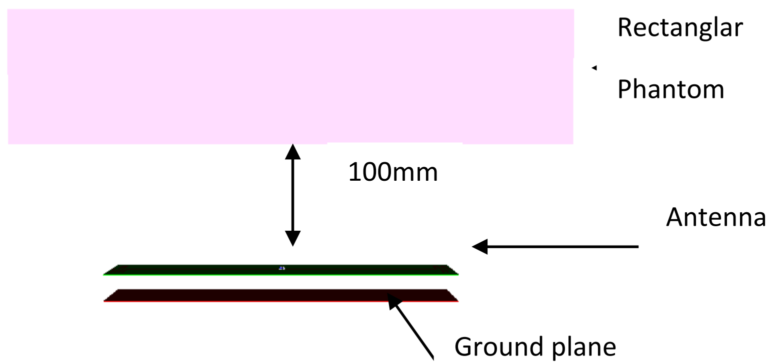
INTERACTION OF DIPOLE ANTENNA AND THE RECTANGULAR PHANTOM

Unloaded Coil Simulation



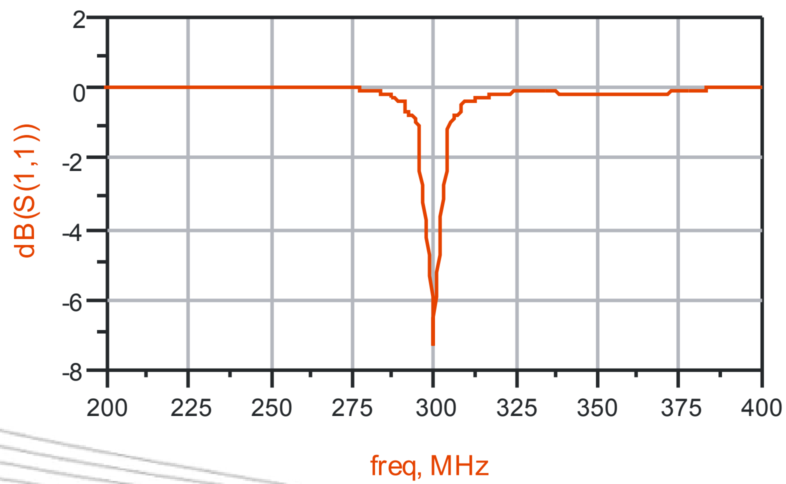


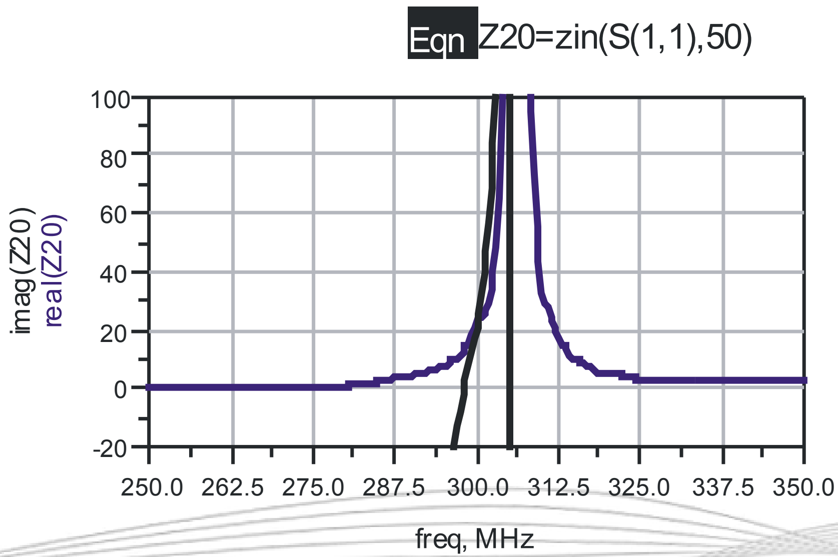
Loaded Coil Simulation



Summary of Loaded and unloaded Coil

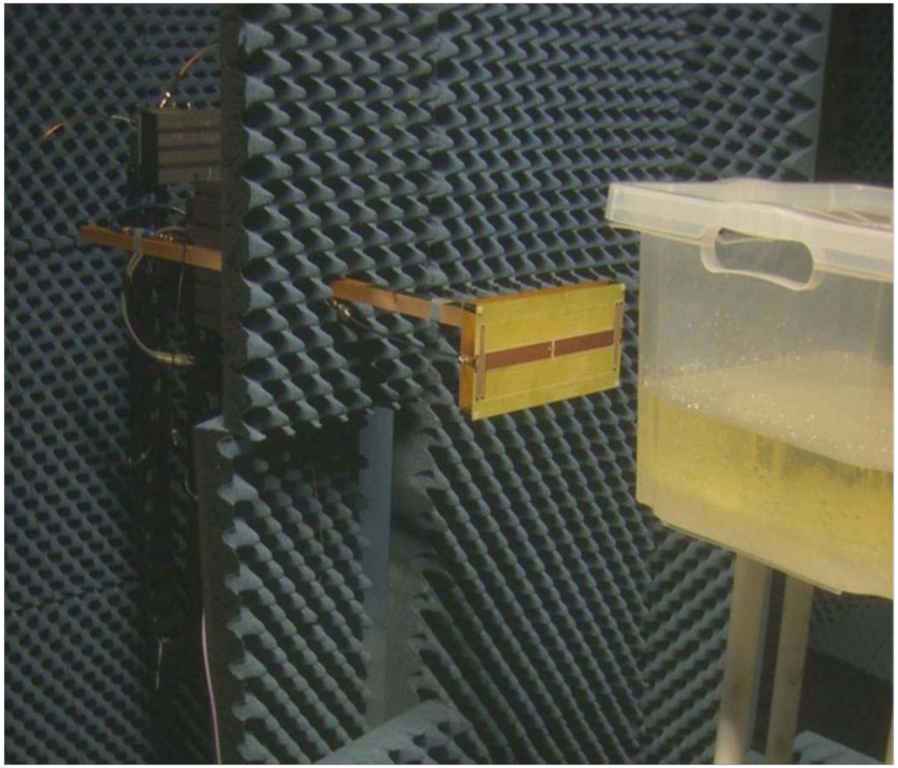
	S_{11}/dB	Frequency/MHz	Q-factor
Loaded	**-7.5**	**300**	**89.82**
Unloaded	**-17**	**300**	**35.98**





Q- Factor as a distance from Phantom

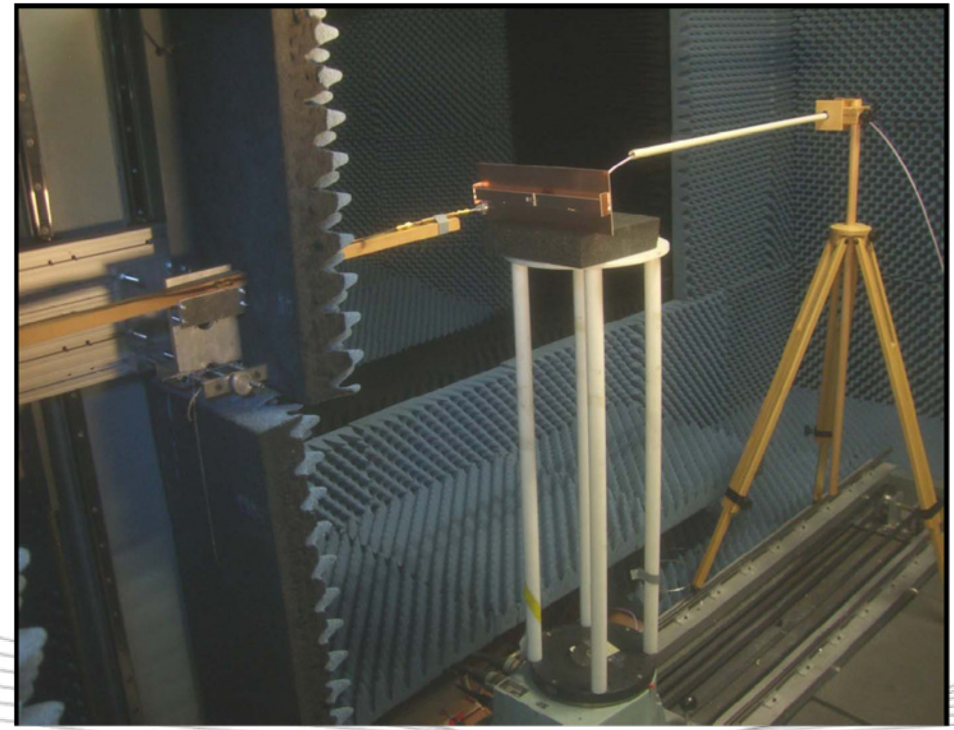
Antenna Loaded with a Homogenous Phantom



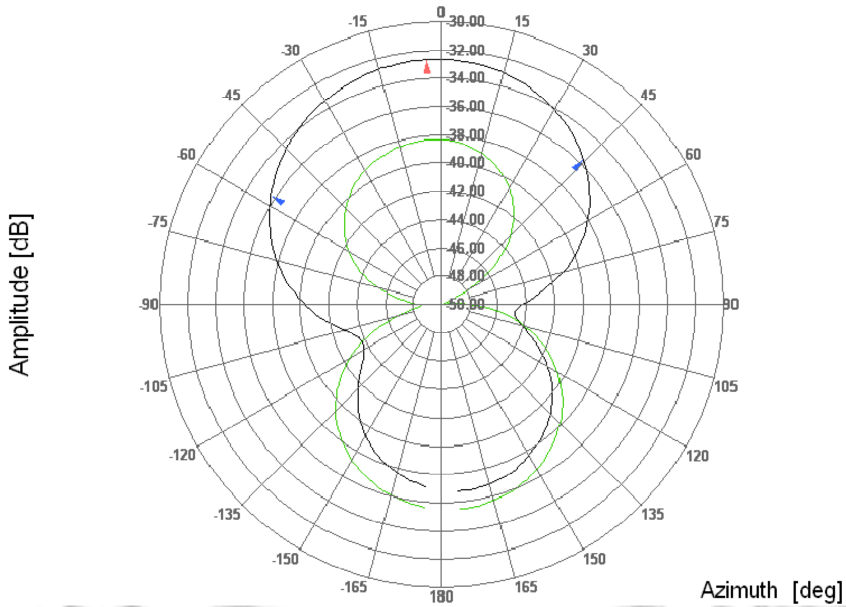
The wheelers Cap for Unloaded Antenna measurement

Near and Far-field measurements of Loop and Dipole type antennas

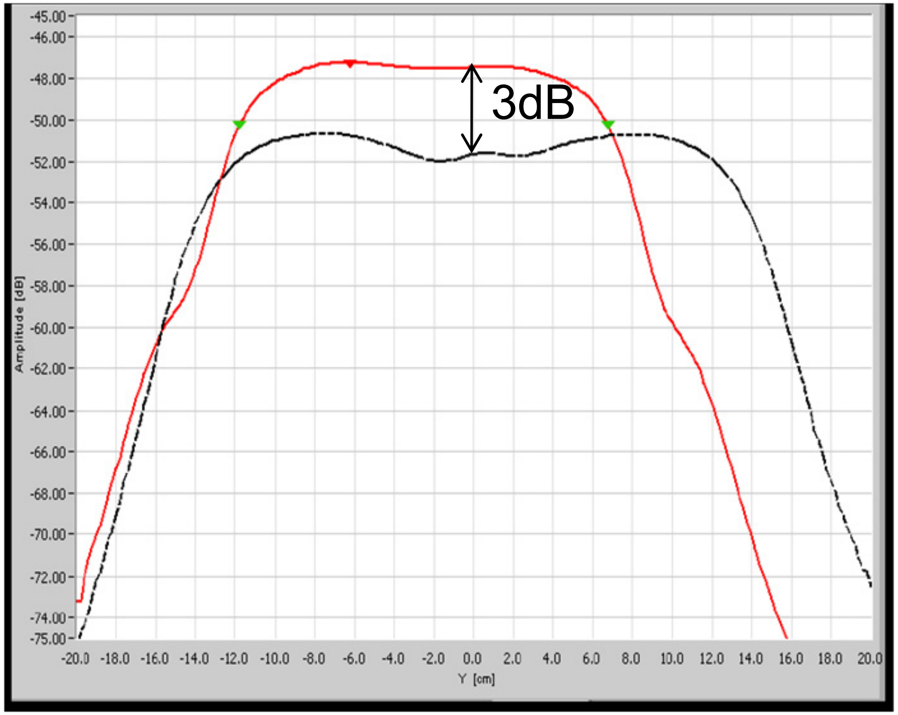
Antenna in Anaechoic Chamber subject to measurements



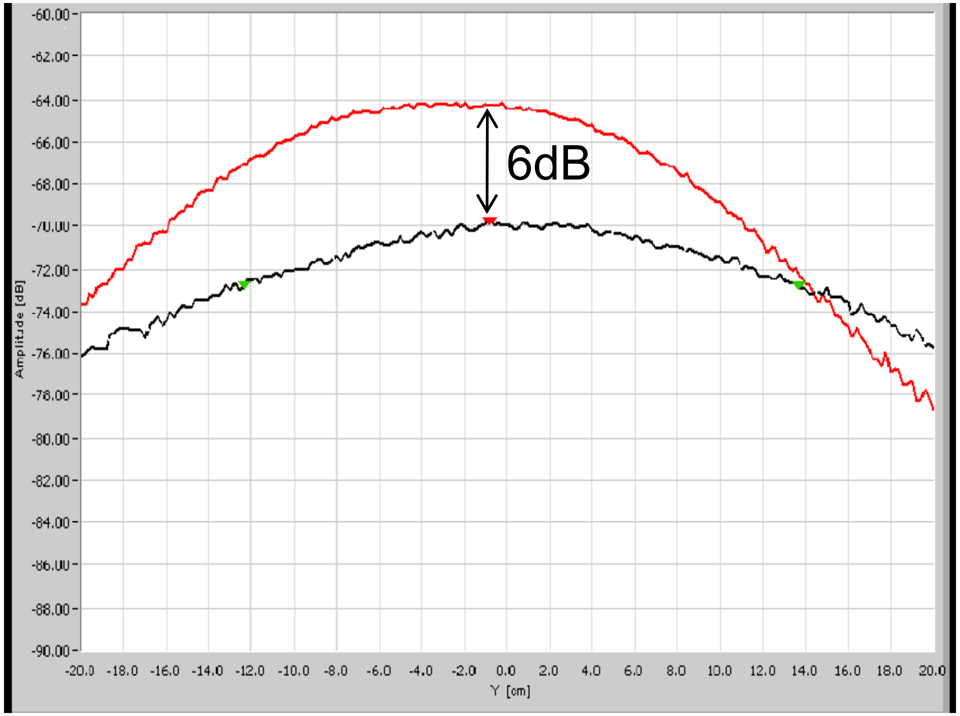
Far-field radiation patterns of Dipole (green) and Loop-type (black)



Current and Magnetic field measurements

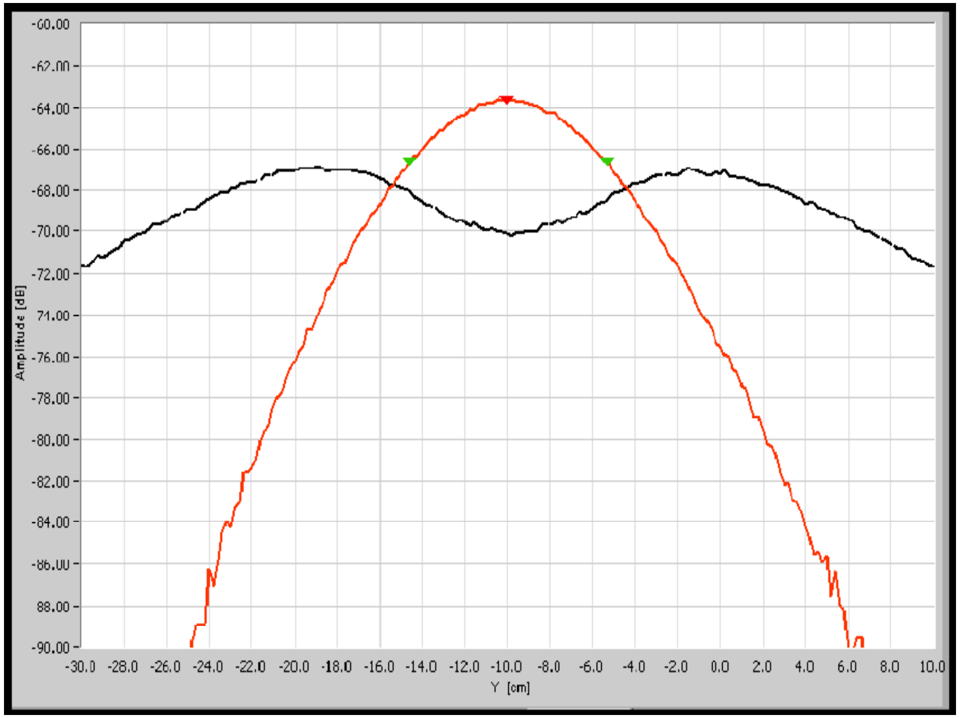


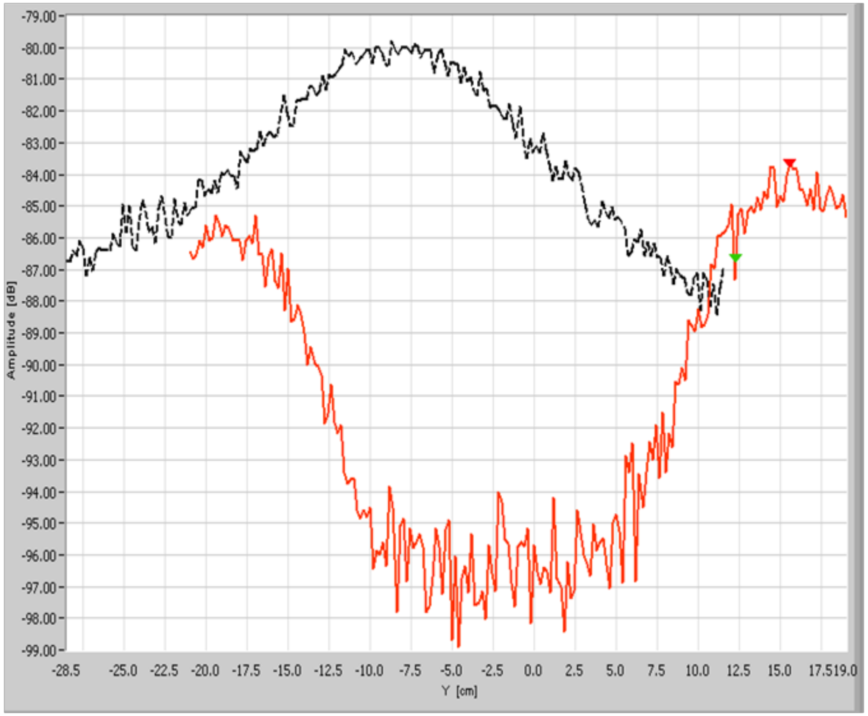
Current distribution at 20mm above the conductor strip
Red (dipole-coil) Black(Loop-coil)



Magnetic field measurements at 100mm above the conductor strip
Red (dipole-coil) Black(Loop-coil)

Magnetic and Electric field measurements





Transversal cut of the magnetic field at 100mm above the conductor strip
Red (dipole-coil) Black(Loop-coil)

Electric field measurements at 100mm above the conductor strip
Red (dipole-coil) Black(Loop-coil)

CONCLUSIONS

The Dipole meander atnenna has the following properties

- It is easy to fabricate
- It is small in size compared to its wave length
- It has a fairly uniform magnetic field distribution
- It also has a very low electric field distribution at the center
- It has a low coupling effect

THE END

THANK YOU