RRI-EEG Internal

Technical Report :

Date :13-05-2019

Response of spherical monopole antenna on real earth modelled as slabs of different dielectric constants and conductivities

A.Raghunathan

Abstract : The figure of merit of any ground based antenna is significantly influenced by the properties of the ground. So to design such an antenna, it is required that the ground properties should be properly understood. The present report presents the simulation results of spherical monopole antenna placed over the ground modelled as slabs of definite thickness with known varying dielectric constants and conductivities.

1. Introduction:

Generally for any antenna, its radiation and impedance properties are governed primarily by the properties of medium surrounding it. For ground based antenna, the electrical properties of earth like dielectric constants and conductivity decide the electrical properties of the antenna. In general, it is difficult to know the properties of real earth. So simulation was carried out in WIPL-D to understand the effect of real earth on impedance and radiation efficiency of antenna. Earth upto certain depth is divided into finite number of slabs and the dielectric constant and conductivity of each of them was varied uniformly one at a time while investigating their influence on return loss and radiation efficiency. Sections below show the simulation results obtained when conductivity and dielectric constant were varied.

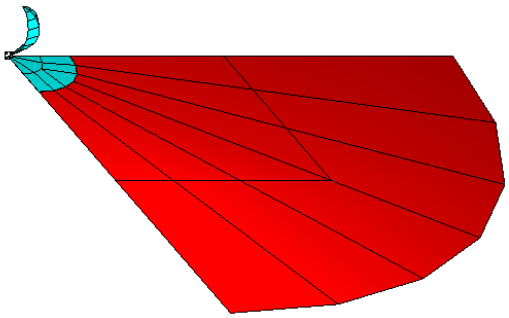
2. Motivation:

To understand the effect of varying dielectric constant and conductivity on the return loss and radiation properties of the spherical monopole antenna.

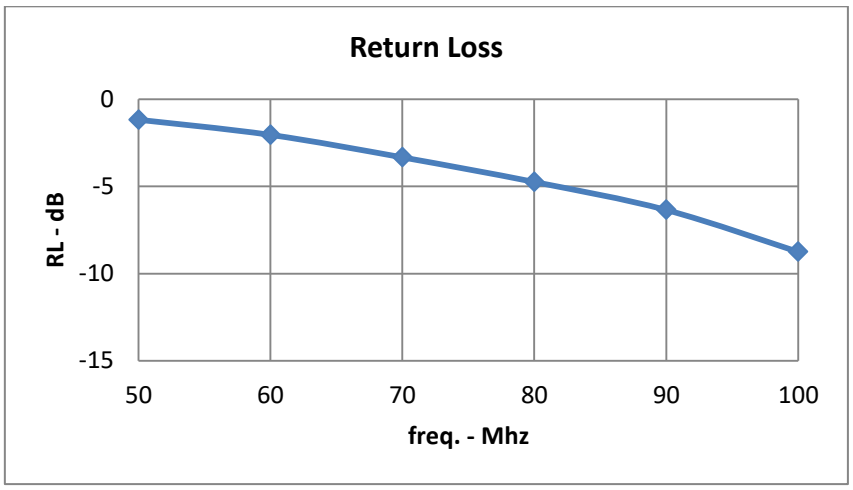
3. Simulation of electrical behaviour of the spherical monopole antenna when placed over the earth of varying properties in the frequency range 50-100 MHz.

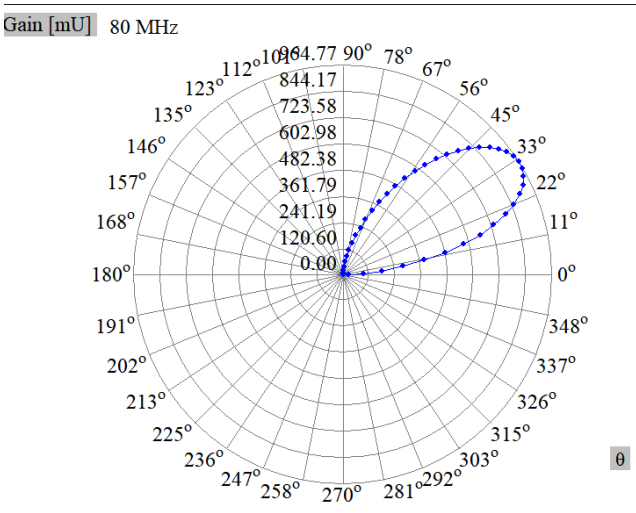
3.1. Sphere over real earth of constant dielectric constant and conductivity over the entire depth (Version 82)

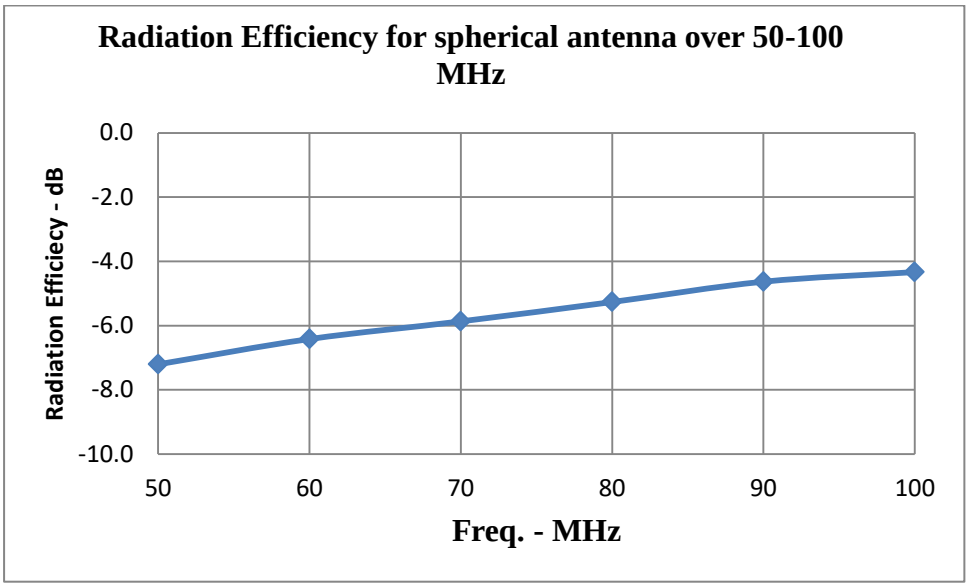
This is considered as a reference for comparing the results of simulations involving varying dielectric constants and conductivities.

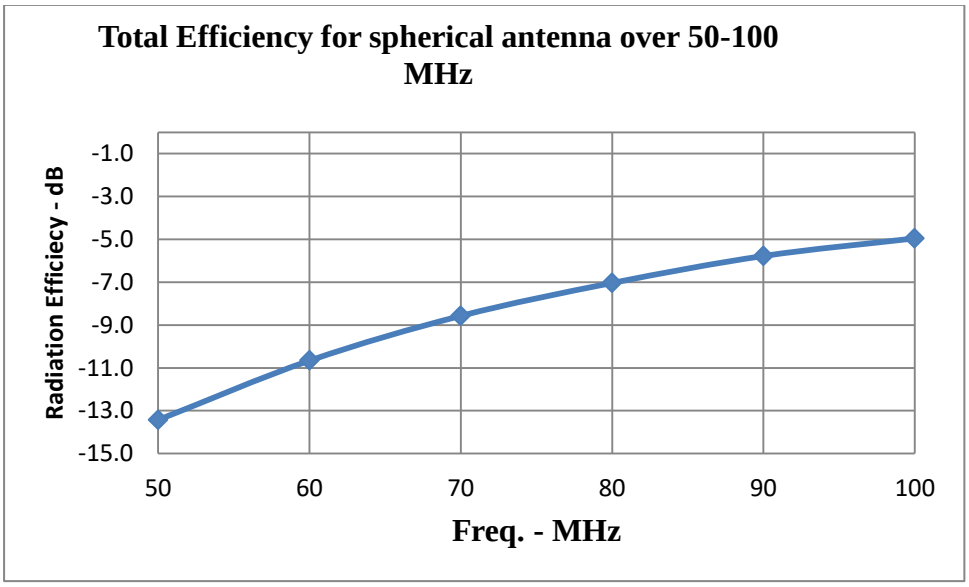


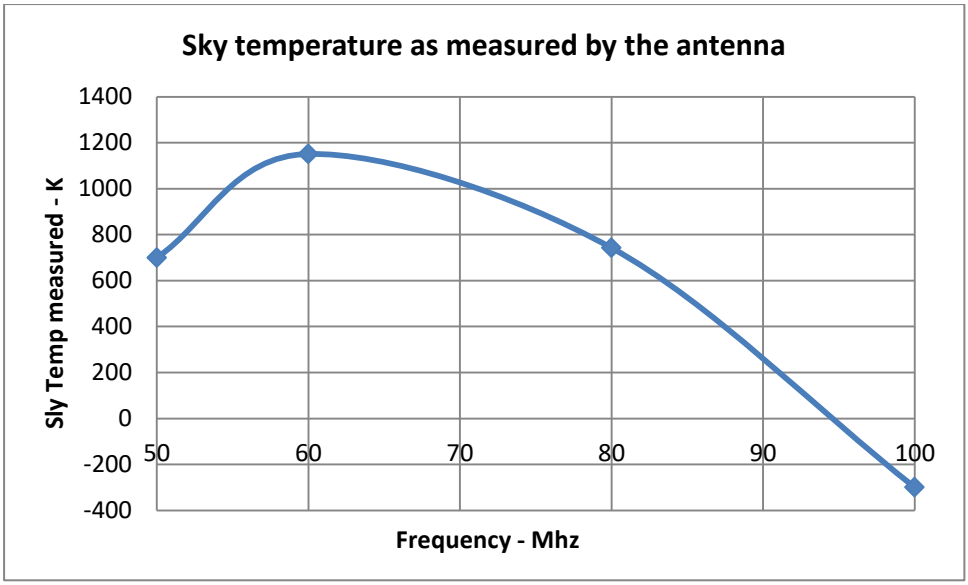
Assumptions about the real earth in the simulation: er = 4, conductivity=0.0007 S/m; Reflector radius = 834mm; Real earth radius = 6m




Gain [mU]
80 MHz
964.77
844.17
723.58
602.98
482.38
361.79
241.19
120.60
0.00
90°
78°
67°
56°
45°
33°
22°
11°
0°
348°
337°
326°
315°
303°
292°
281°
270°
258°
247°
236°
225°
213°
202°
191°
180°
168°
157°
146°
135°
123°
112°
θ

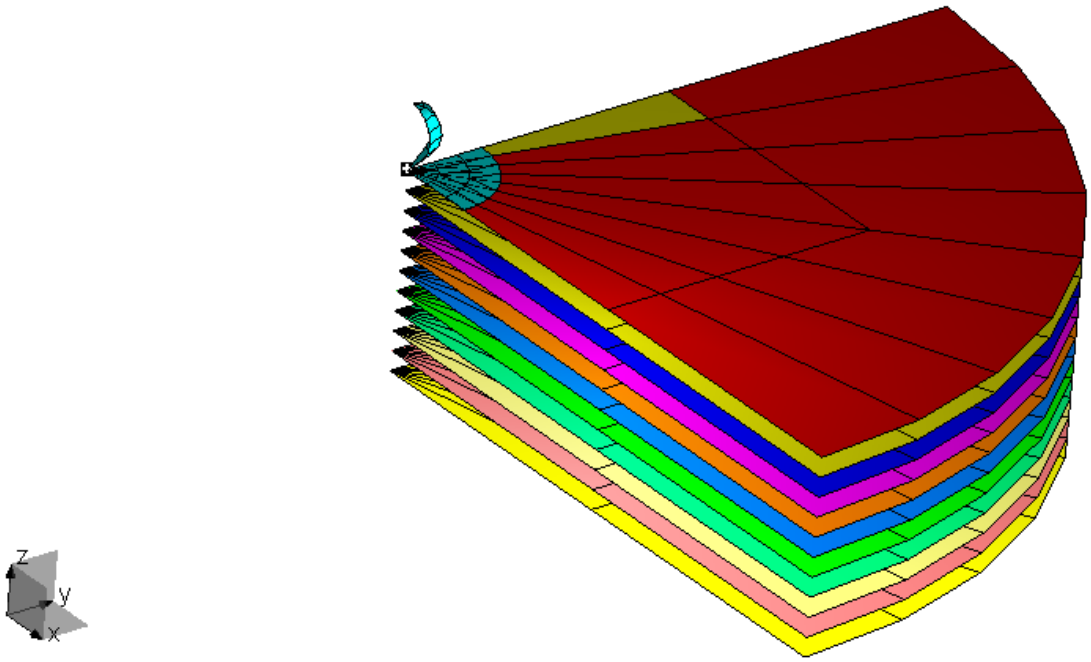

Radiation Efficiency for spherical antenna over 50-100 MHz
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
50
60
70
80
90
100
Freq. - MHz

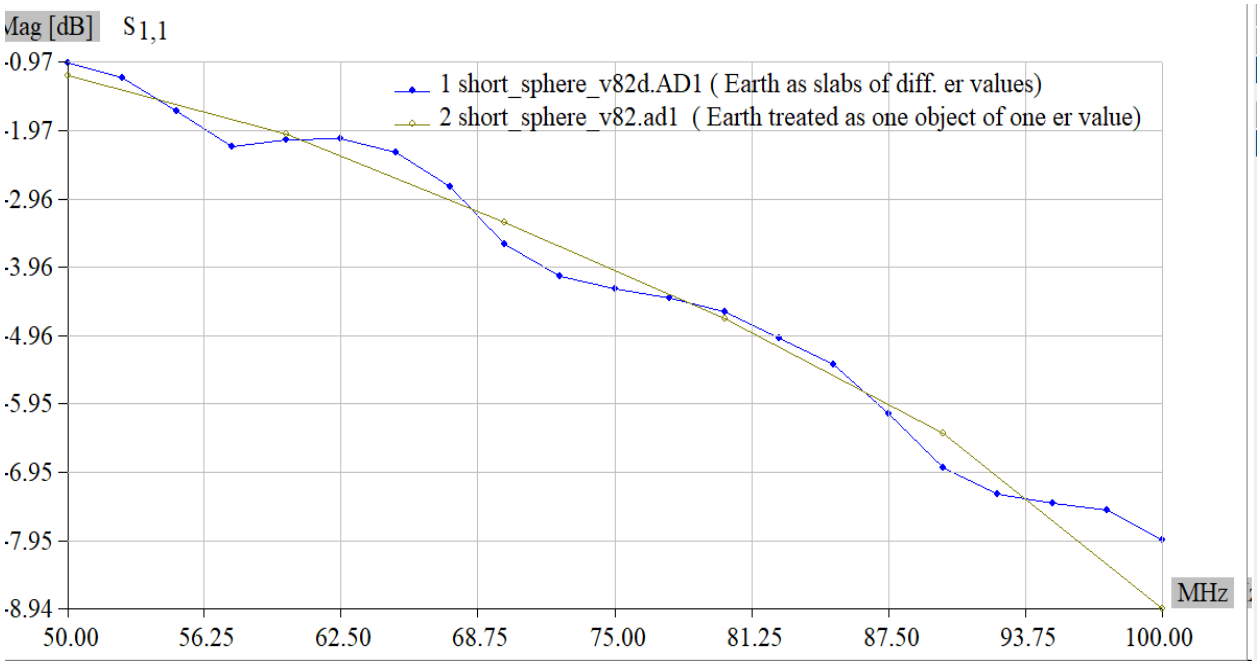

Total Efficiency for spherical antenna over 50-100 MHz
Radiation Efficiecy - dB
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
50
60
70
80
90
100
Freq. - MHz

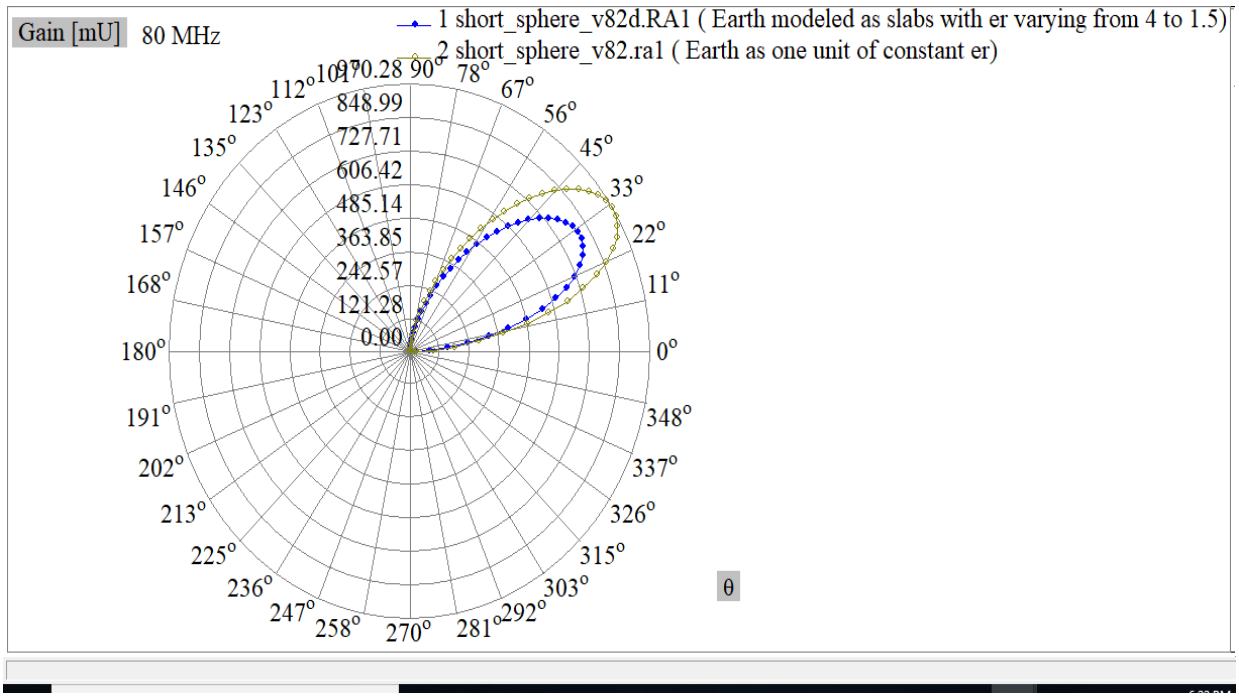


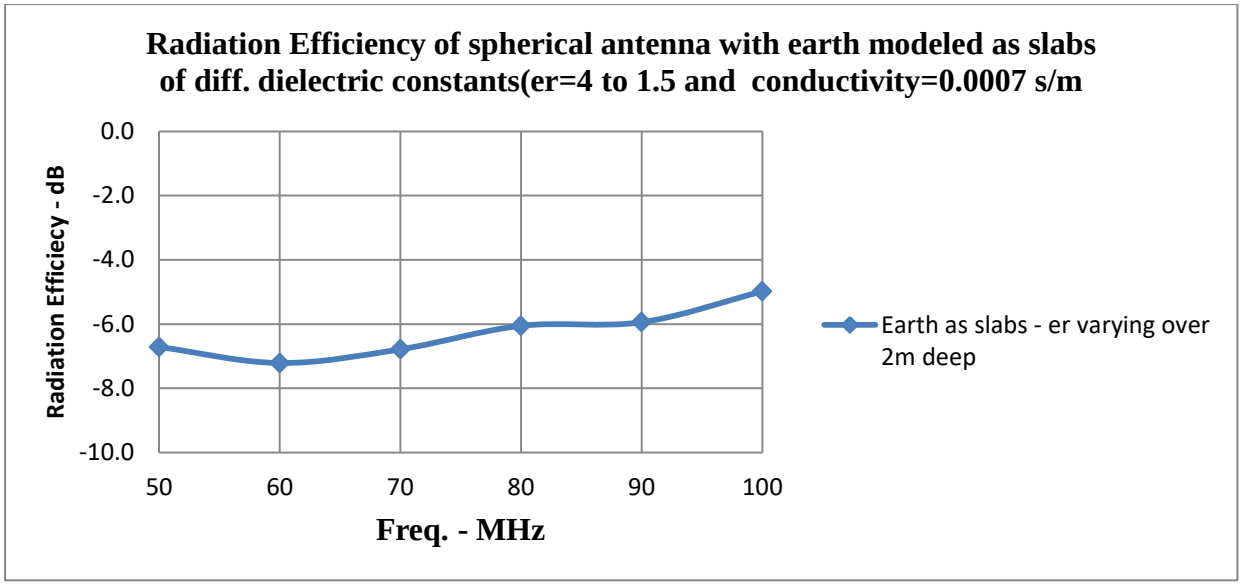
3.2. Modelling real earth using slabs of different dielectric constants and conductivities (version 82d)

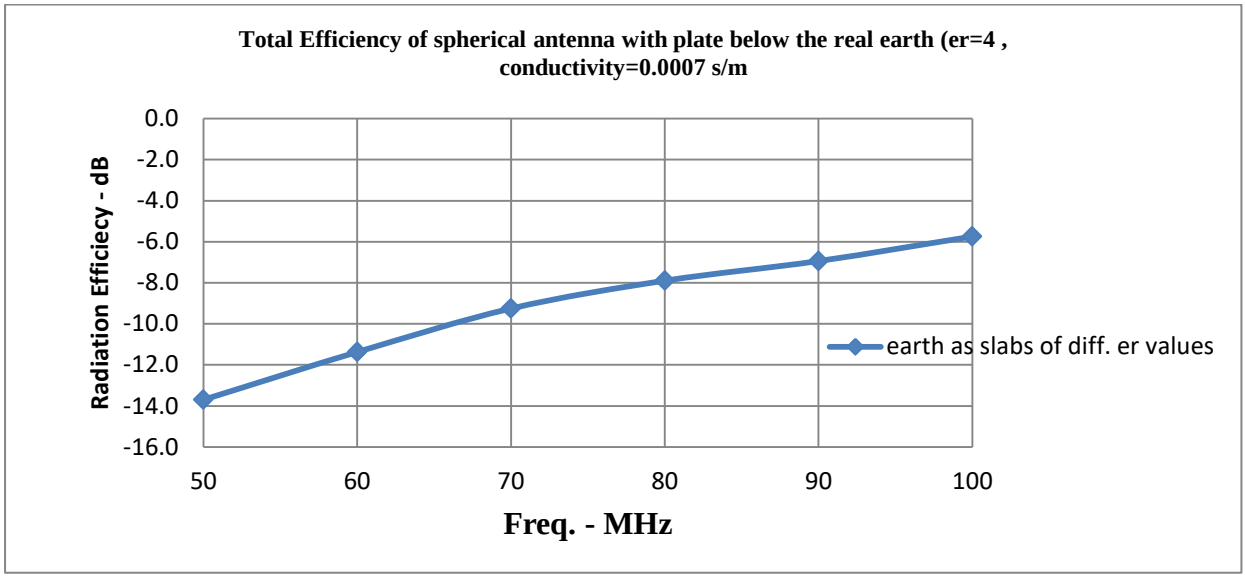
3.2.1 : **Decreasing er** value linearly with depth (2m below the surface) from 4 to 1.5. Conductivity is maintained at 0.0007 S/m throughout.

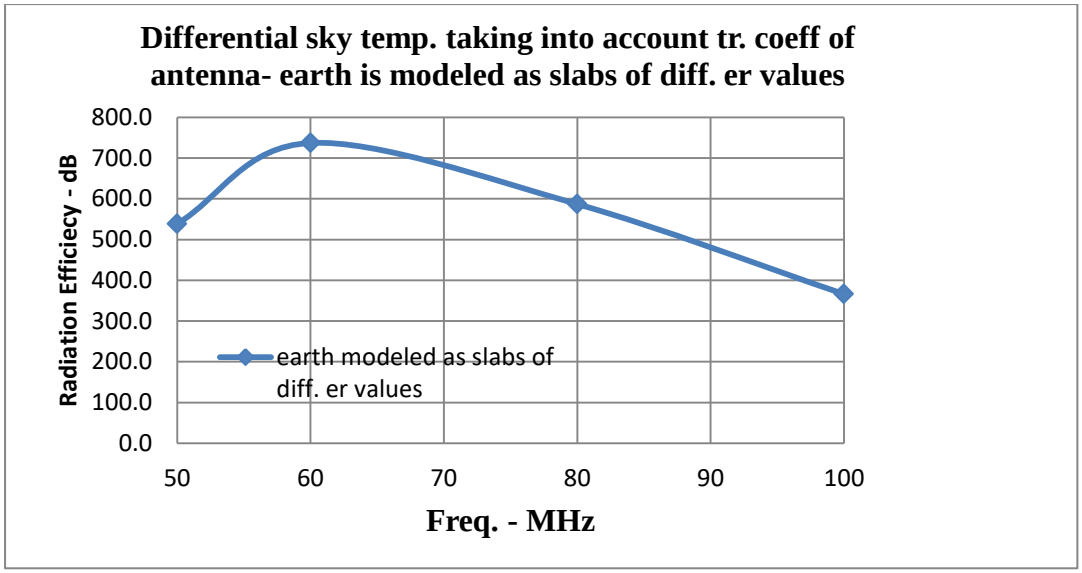



Mag [dB] S1,1
-0.97
-1.97
-2.96
-3.96
-4.96
-5.95
-6.95
-7.95
-8.94
1 short_sphere_v82d.AD1 (Earth as slabs of diff. er values)
2 short_sphere_v82.ad1 (Earth treated as one object of one er value)
MHz
50.00
56.25
62.50
68.75
75.00
81.25
87.50
93.75
100.00

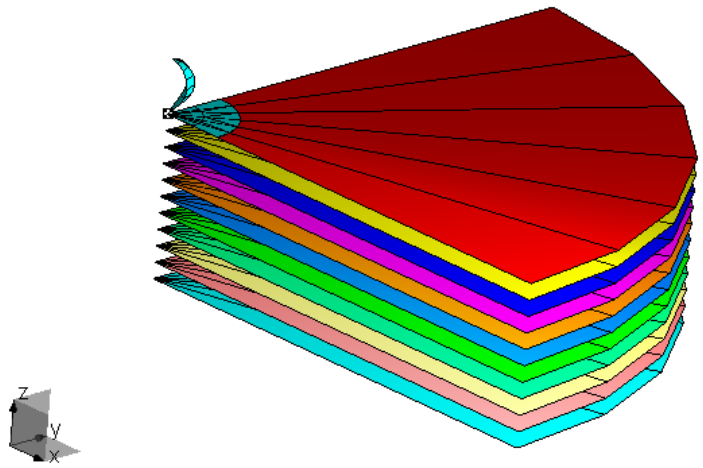

Gain [mU]
80 MHz
1 short_sphere_v82d.RA1 (Earth modeled as slabs with er varying from 4 to 1.5)
2 short_sphere_v82.ra1 (Earth as one unit of constant er)
970.28
848.99
727.71
606.42
485.14
363.85
242.57
121.28
0.00
90°
78°
67°
56°
45°
33°
22°
11°
0°
348°
337°
326°
315°
303°
292°
281°
270°
258°
247°
236°
225°
213°
202°
191°
180°
168°
157°
146°
135°
123°
112°
θ

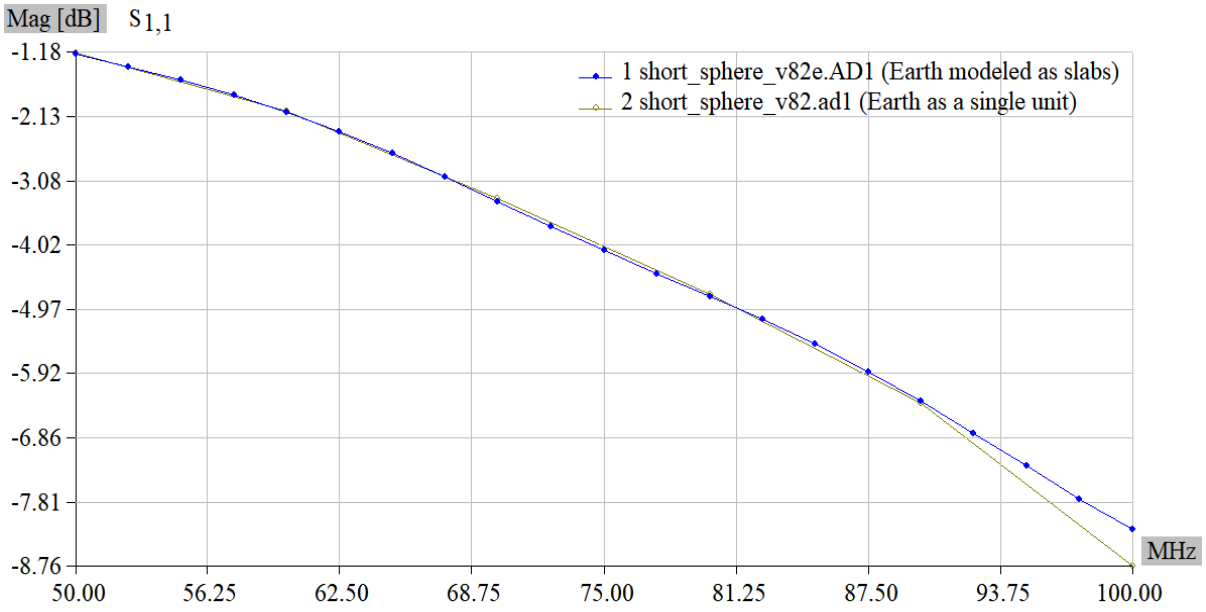

Radiation Efficiency of spherical antenna with earth modeled as slabs of diff. dielectric constants(er=4 to 1.5 and conductivity=0.0007 s/m
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
50
60
70
80
90
100
Freq. - MHz
Earth as slabs - er varying over 2m deep

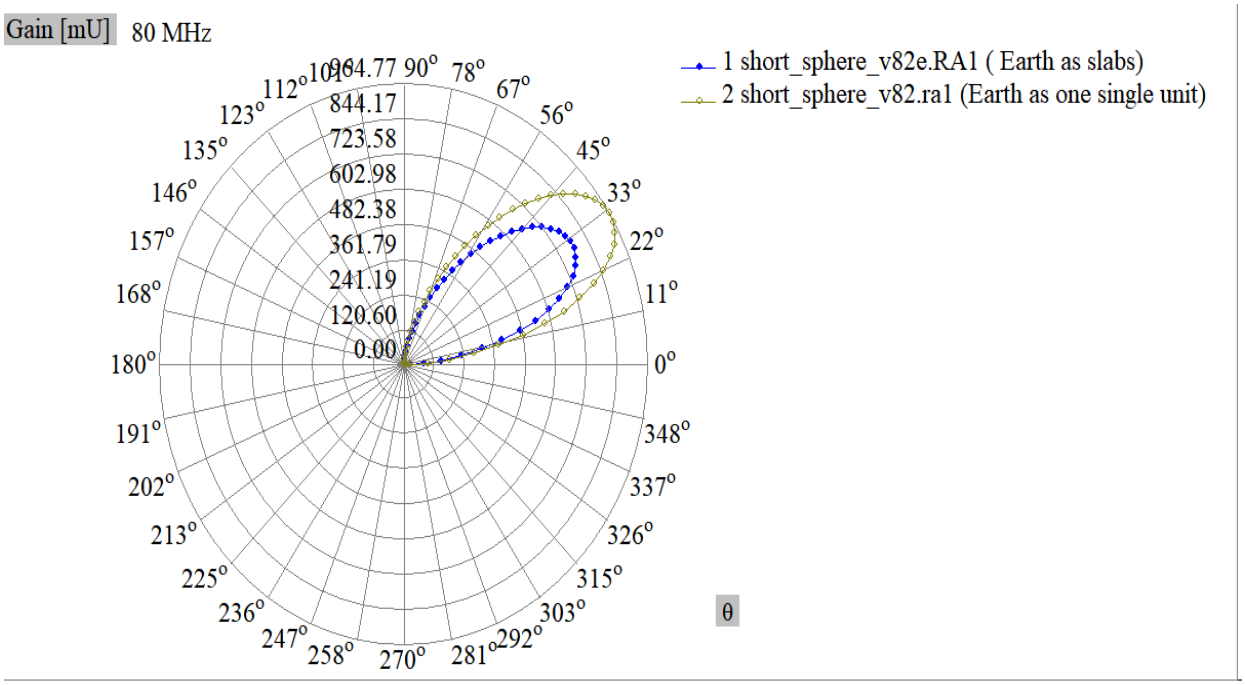

Total Efficiency of spherical antenna with plate below the real earth (er=4 , conductivity=0.0007 s/m
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
-16.0
50
60
70
80
90
100
Freq. - MHz
earth as slabs of diff. er values

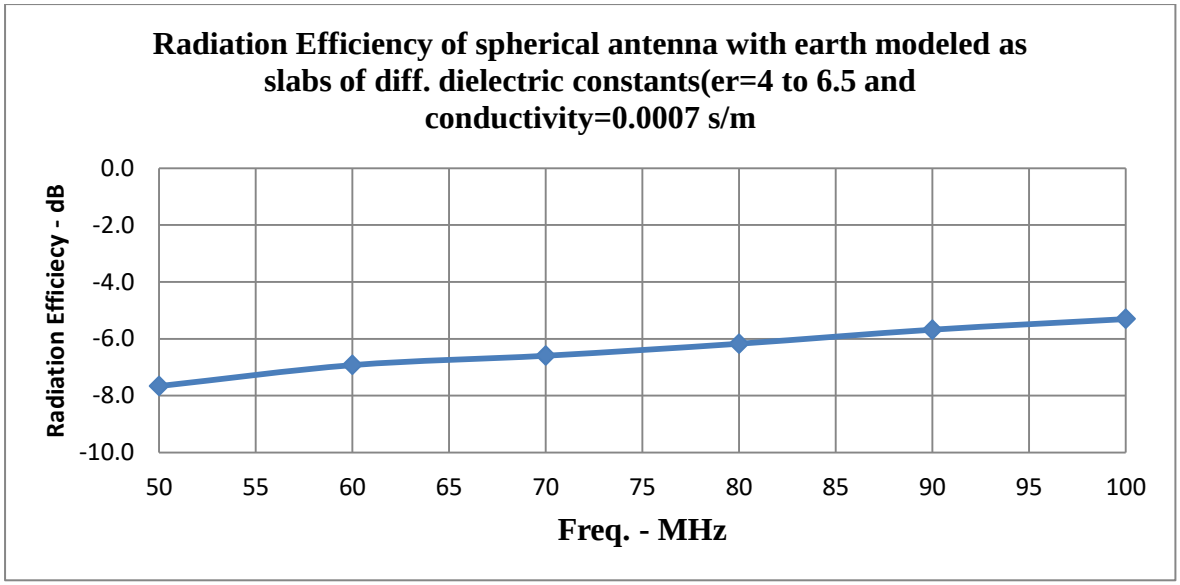


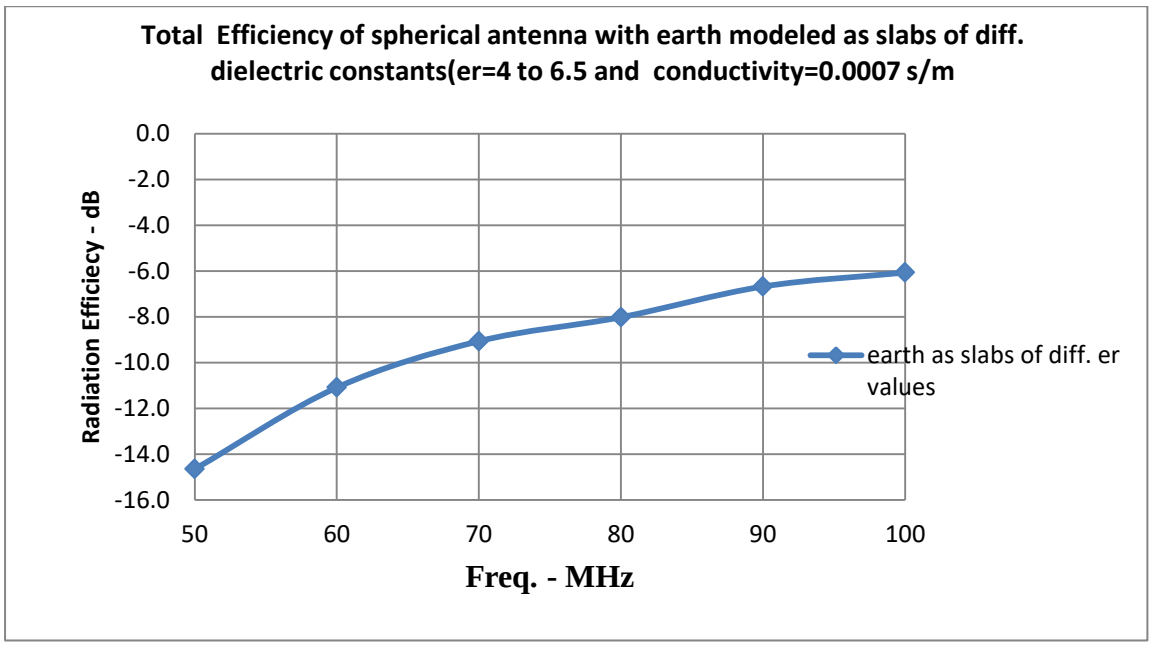
3.2.2 Increasing the er value linearly from 4 to 6.5 with depth (2m deep below the surface) Conductivity is maintained at 0.0007 S/m throughout. (version 82 e)

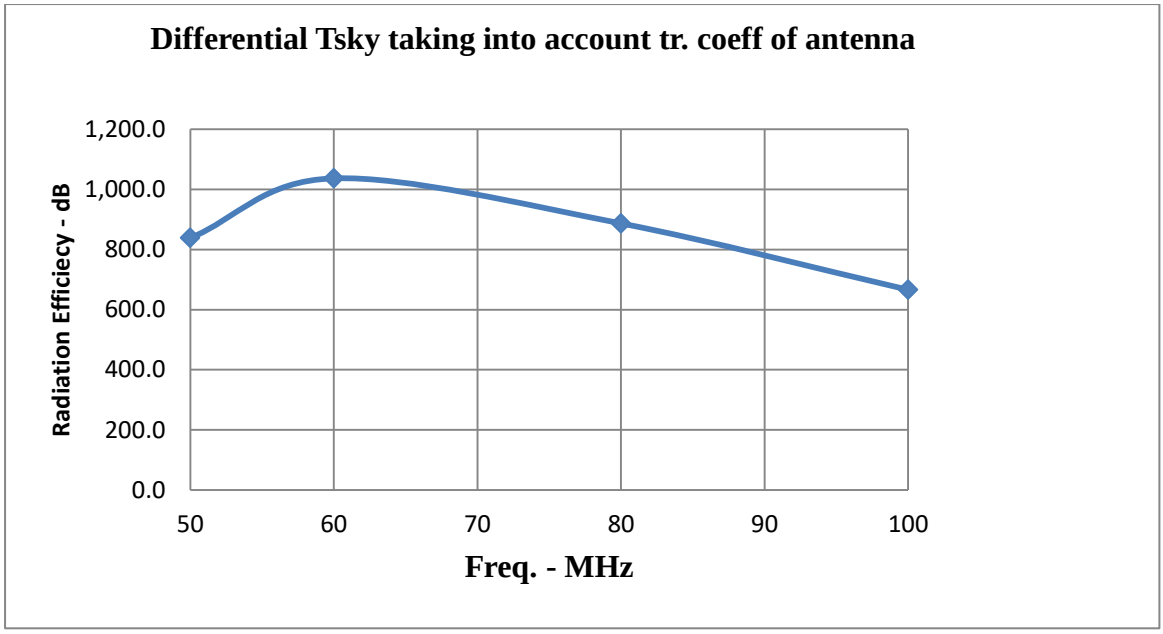



Mag [dB]
S1,1
-1.18
-2.13
-3.08
-4.02
-4.97
-5.92
-6.86
-7.81
-8.76
50.00
56.25
62.50
68.75
75.00
81.25
87.50
93.75
100.00
MHz
1 short_sphere_v82e.AD1 (Earth modeled as slabs)
2 short_sphere_v82.ad1 (Earth as a single unit)

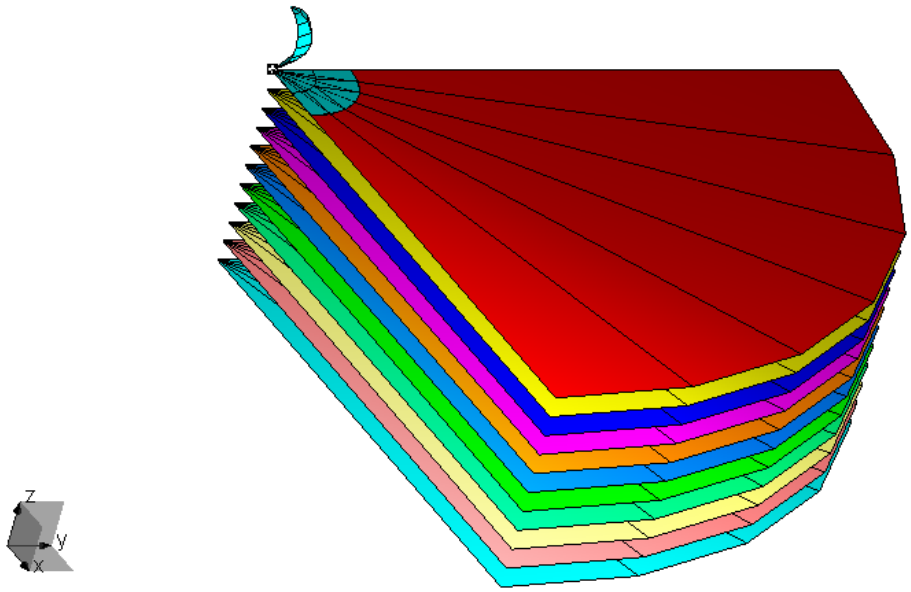

Gain [mU]
80 MHz
964.77
844.17
723.58
602.98
482.38
361.79
241.19
120.60
0.00
90°
78°
67°
56°
45°
33°
22°
11°
0°
348°
337°
326°
315°
303°
292°
281°
270°
258°
247°
236°
225°
213°
202°
191°
180°
168°
157°
146°
135°
123°
112°
θ
1 short_sphere_v82e.RA1 (Earth as slabs)
2 short_sphere_v82.ra1 (Earth as one single unit)

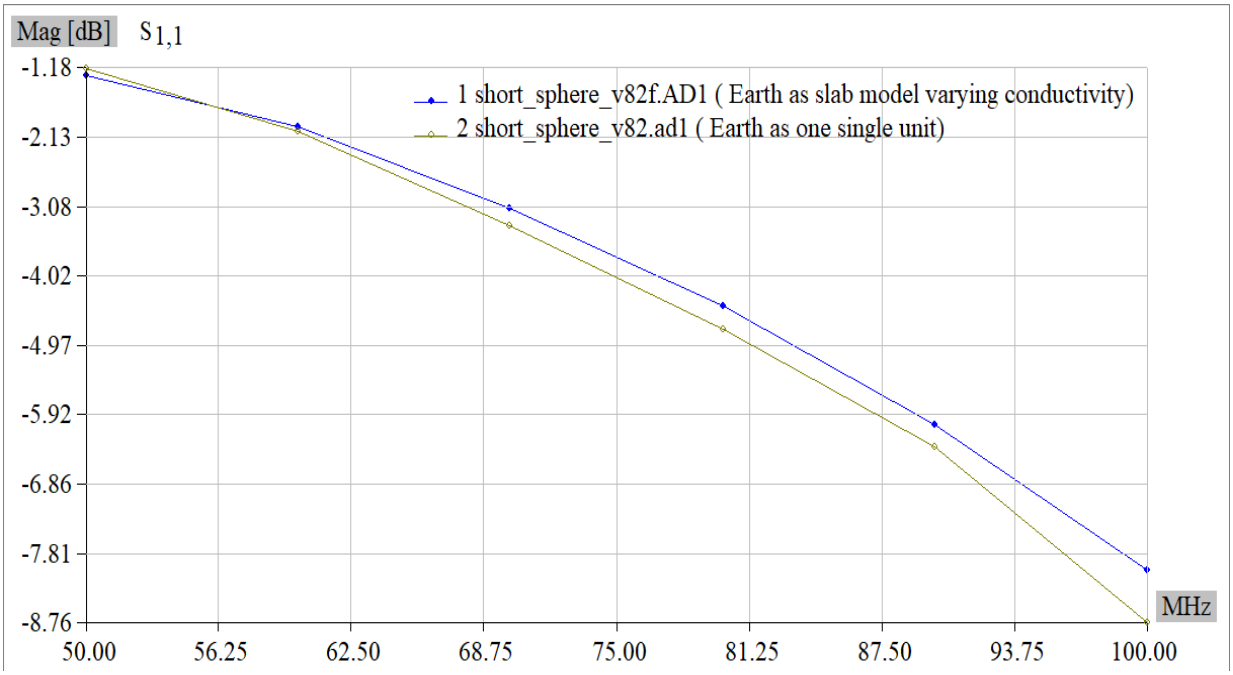

Radiation Efficiency of spherical antenna with earth modeled as slabs of diff. dielectric constants(er=4 to 6.5 and conductivity=0.0007 s/m
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
50
55
60
65
70
75
80
85
90
95
100
Freq. - MHz

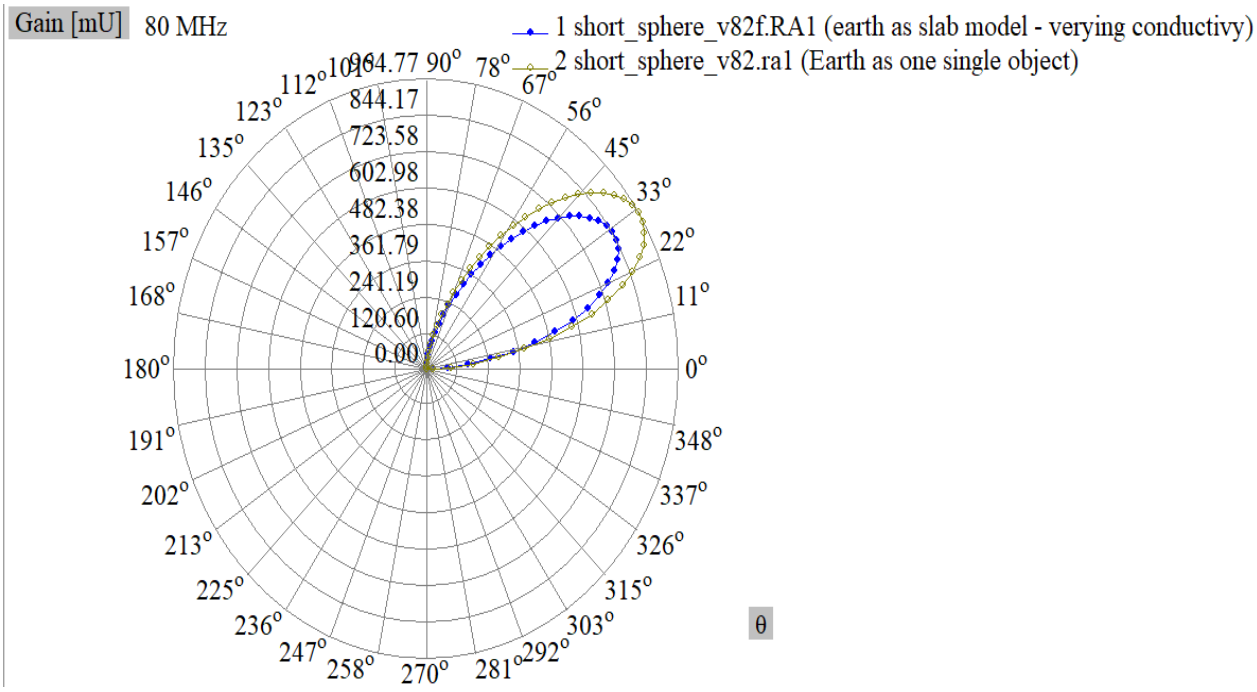

Total Efficiency of spherical antenna with earth modeled as slabs of diff. dielectric constants(er=4 to 6.5 and conductivity=0.0007 s/m
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
-16.0
50
60
70
80
90
100
Freq. - MHz
earth as slabs of diff. er values

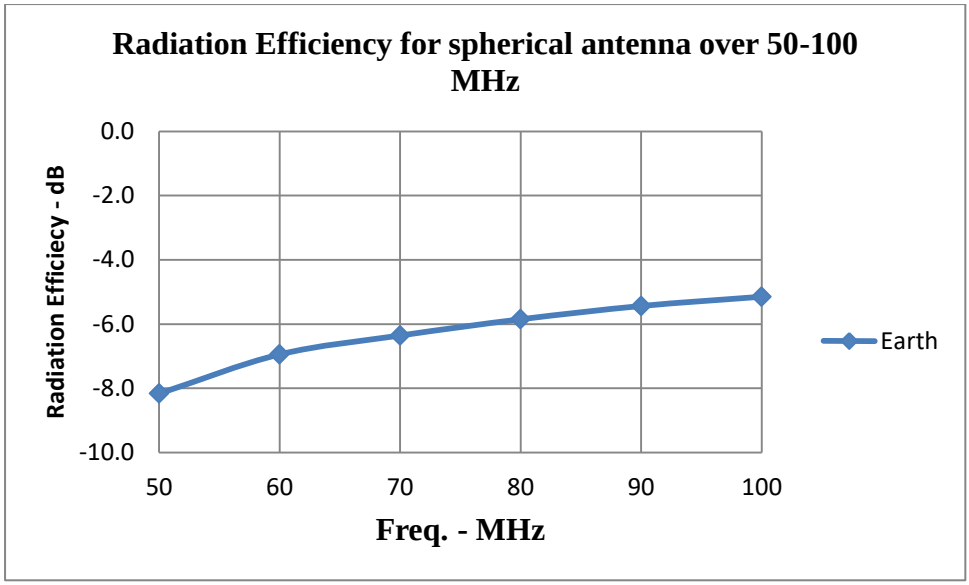


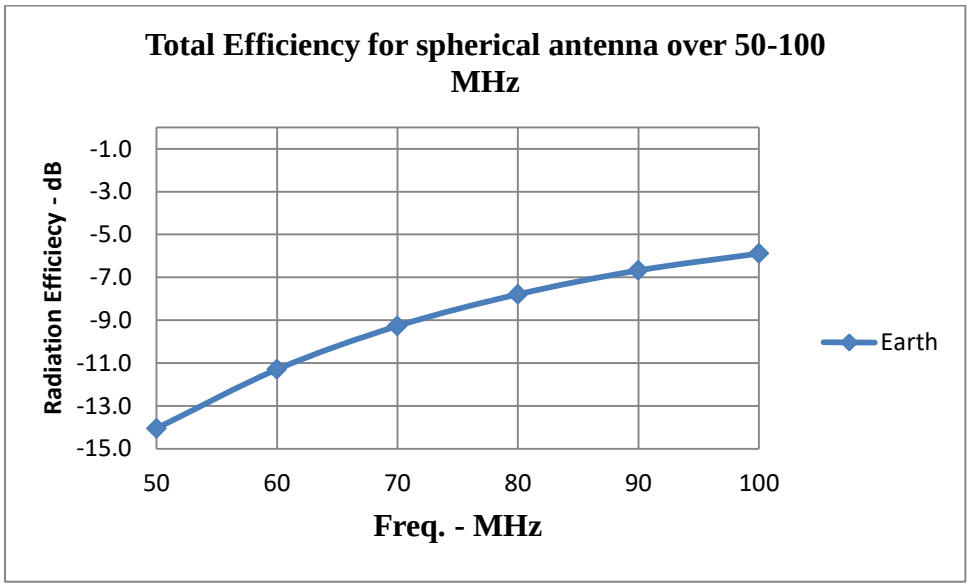
3.2.3 Vary conductivity from 0.0007 S/m to 0.07 S/m maintaining er value at 4




Mag [dB]
S1,1
1 short_sphere_v82f.AD1 (Earth as slab model varying conductivity)
2 short_sphere_v82.ad1 (Earth as one single unit)
-1.18
-2.13
-3.08
-4.02
-4.97
-5.92
-6.86
-7.81
-8.76
50.00
56.25
62.50
68.75
75.00
81.25
87.50
93.75
100.00
MHz


Gain [mU]
80 MHz
1 short_sphere_v82f.RA1 (earth as slab model - verying conductivy)
2 short_sphere_v82.ra1 (Earth as one single object)
964.77
844.17
723.58
602.98
482.38
361.79
241.19
120.60
0.00
90°
78°
67°
56°
45°
33°
22°
11°
0°
348°
337°
326°
315°
303°
292°
281°
270°
258°
247°
236°
225°
213°
202°
191°
180°
168°
157°
146°
135°
123°
112°
θ


Radiation Efficiency for spherical antenna over 50-100 MHz
Radiation Efficiecy - dB
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
50
60
70
80
90
100
Freq. - MHz
Earth


Total Efficiency for spherical antenna over 50-100 MHz
Radiation Efficiecy - dB
-1.0
-3.0
-5.0
-7.0
-9.0
-11.0
-13.0
-15.0
50
60
70
80
90
100
Freq. - MHz
Earth

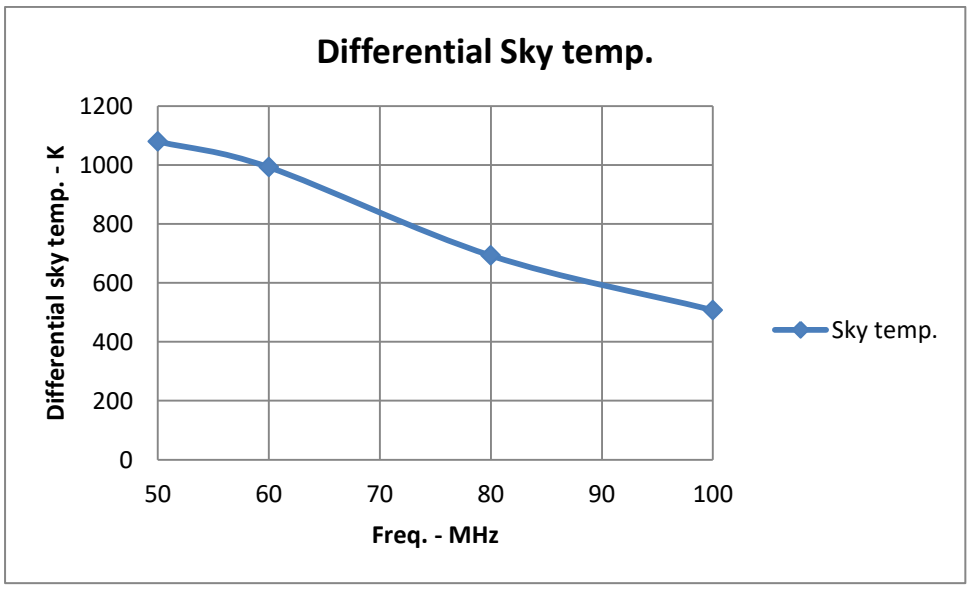

Differential Sky temp.
Differential sky temp. - K
1200
1000
800
600
400
200
0
50
60
70
80
90
100
Freq. - MHz
Sky temp.

Table:

Sl. No.	Version	Variation of Earth parameter	RL at 50 MHz - dB	Differential Tsky – K at 50 MHz
1.	82	Er=4, σ=0.0007 S/m	-1.18	700 K
2.	82d	Er decreasing from4 to 1.5 over 2m depth with σ=0.0007 S/m	-0.97 dB with Ripple seen with 0.5 dB p-p	550 K
3.	82e	Er increasing from 4 to 6.5 over 2m depth with σ=0.0007 S/m	Change is RL is very small	550 K
4.	82f	Er=4, σ increasing from 0.0007 to 0.07 S/m over 2m depth	Slightly increase in RL at 50 MHz. But overall it is poor.	1050 K. But low over most of the band.

5. Conclusion

Modelling the earth using varying er values or conductivities, does result in significant change in the spectral response of return loss. Decreasing er value results in the pass-band ripple while increasing the conductivity results in slightly poor return loss over the band of 50-100 MHz.