EDGES MEMO #328

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To: EDGES group

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Subject: Simulations of resistive loss in galvanized mesh surrounding aluminum baseplate

FEKO simulations have been made of the EDGES-3 antenna on a 2.4×2.4 aluminum baseplate connected to a 2.4×2.4 m galvanized steel mesh panel with 6mm diameter wires separated by 5 cm on each side. Initially only one panel is attached to one side of the baseplate as shown in Figure 1. The connections to the baseplate are 20 cm apart on every 4th mesh wire Adding more structure stretches the limits of memory and reasonable run time of FEKO at least for the case of a frequency scan from 50 to 120 MHz in 2 MHz steps. Figure 2 shows the configuration with mesh on all 4 sides of the baseplate.

The simulations are made with values of the conductivity of 1e6 and 1e7 S/m and for values of relative permeability of 1 and 100 to cover the full range of possible conditions of galvanized steel. The lowest loss would be obtained if the mesh has a layer of pure zinc more than 70 microns thickness with conductivity 1.7e7. The highest loss would occur if the zinc coating is absent or of poor quality in which case the conductivity could be as low as 1e6 S/m and with a relative permeability of 100 (see memo 209). The high relative permeability is due to the ferromagnetic nature of steel which in turn results a reduction of the skin depth by the square root of the relative permeability. The resistive loss also depends on the dielectric and conductivity of the underlaying soil.

Frequency MHz	Wire conductivity S/m	relative permeability	Soil dielectric	Soil conductivity	Loss in percent	Number sides
50	1e7	1	3.5	2e-2	0.0025	4
50	1e6	1	3.5	2e-2	0.0080	4 case A
100	1e6	1	3.5	2e-2	0.0041	4
50	1e7	1	3.5	2e-2	0.0005	1
50	1e6	1	3.5	2e-2	0.0079	4
50	1e6	1	3.5	1e-2	0.0085	4
50	1e6	1	3.5	1e-3	0.0108	4
50	1e6	100	3.5	1e-2	0.0832	4 case B
50	1e6	100	3.5	2e-2	0.0778	4
50	1e6	100	3.5	1e-3	0.1083	4

Table 1. Resistive loss of the mesh

Simulations with a 2.4×0.0.6m on all 4 sides increases the resistive loss by a factor of approximately 3-5. A repeat of case A in which the loss was calculated for the 60 cm of each mesh closest to the baseplate resulted in a loss of 0.0054% compared with a loss of 0.0026% in each panel the remaining 1.8 m. The loss in the connections from the baseplate is 0.0003% in case A assuming they are 20 cm apart and 1 cm long and as expected this increases by a factor of 5 to 0.0015% for 5 cm long connections for steel without zinc coating this increases to 0.015%. This shows that the mesh close to the baseplate is by far the most critical.

The frequency dependence of the loss is shown for case B in Figure 3. It decreases with frequency because the E field on the mesh from the antenna decreases with frequency so more of the power from the antenna is reflected from the low loss aluminum baseplate as the frequency increases. Figure 4 shows the rms residual to a one term Linlog fit to the sky noise spectrum of 300 K at 150 MHz and spectral index -2.55 and Figure 5 shows the residuals to a 5 term fit.

A test of the effects of using mesh wire diameter reduced from 6 to 3 mm for case B at 50 MHz the loss increases from 0.0832% to 0.1590% which is close to the factor of 2 expected from the area per unit length reduction of the conducting skin layer.

In summary with an effective zinc coating the resistive loss is very small but if the permeability is 100 there is a factor of 10 increase in the loss. Even though the loss is small it is frequency dependent dropping by a factor of about 2 from 50 to 100 MHz. In the case that the zinc coating is ineffective the loss is large enough that a correction for the loss needs to be made.

Addendum

1] A test for a large ground plane

A FEKO simulation was made with 4 more mesh sheets added to extend the mesh to form a 7.2x7.2 m square ground plane. This took 2 days to run at

50 MHz gave a resistive loss of 0.1424% for case B compared with 0.0832%.

Another test with a mesh with 10cm wire spacing shows that the loss increases by a factor of about 1.2 before reaching a limit. Based this result the resistive loss for case B should be scaled up by a factor of about 2 to about 0.2% for a large ground plane. Fortunately the resistive loss is relatively small and is smooth and if the galvanized zinc turns out to be effective the resistive loss for a large ground plane should be less than 0.2% so this is an upper limit on the resistive loss.

2] A test to check effect of resistive loss on the ground plane loss for a finite ground plane loss calculated from the beam fraction below the horizon as in memos 239 and 258.

FEKO simulations made with lossy mesh shows the there is an increase in the loss computed from the beam fraction below the horizon by less than about 10 percent of the resistive loss. Effectively the higher resistivity of carbon steel has little effect on the "shielding" factor of the mesh.

It takes conductivity reduction from 1e6 S/m down to 1e4 S/m to have a significant loss of the shielding of the soil by the mesh. In practice the total ground plane loss can be taken as the sum of the loss calculated from the beam fraction plus the resistive loss.

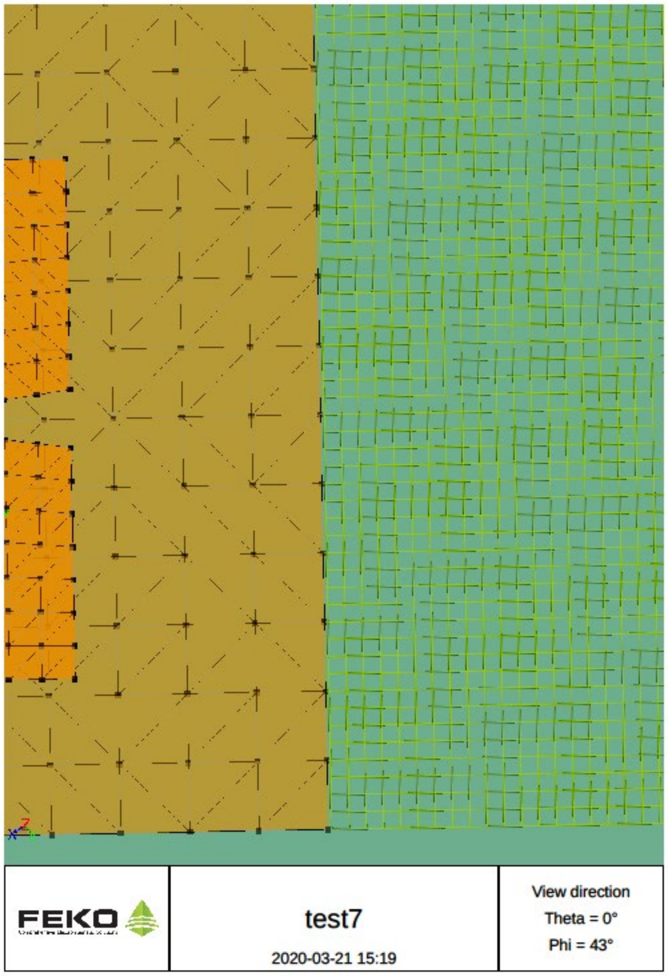

Figure 1. Details of FEKO model showing connections from mesh to baseplate.

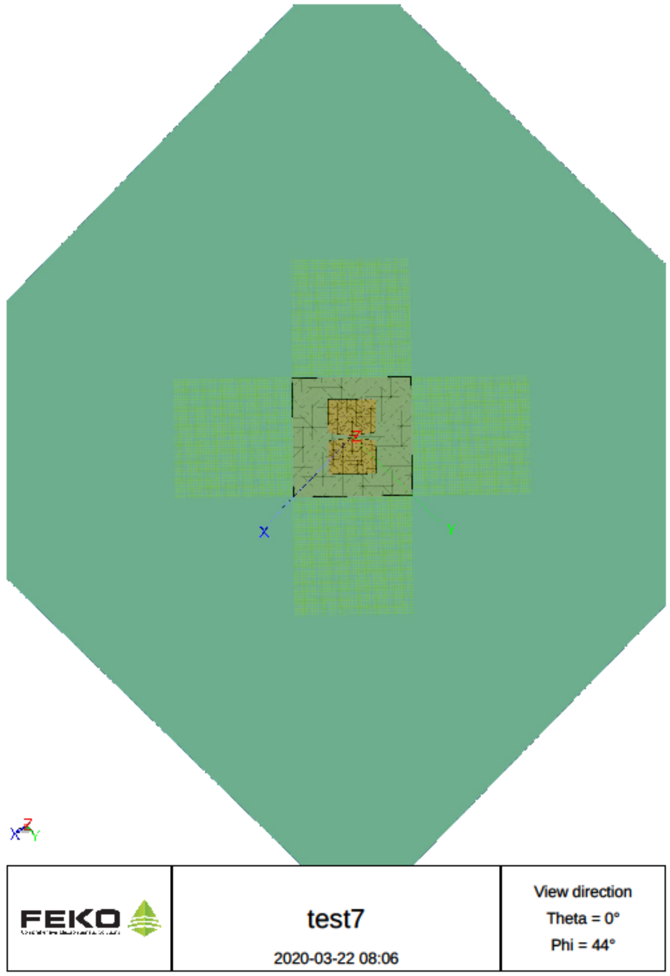

Figure 2. FEKO model for mesh panels on 4 sides of baseplate.

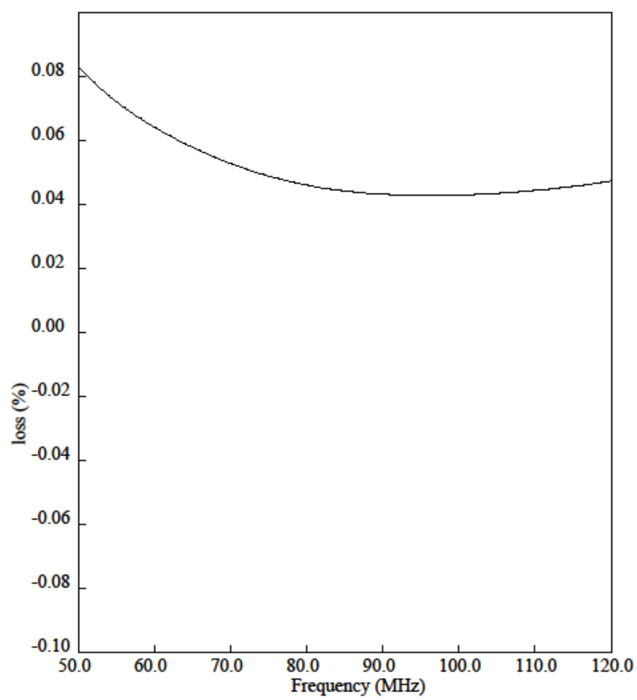

Figure 3. Resistive loss for mesh with conductivity 1e6 S/m permeability 100 over soil with conductivity 1e-2 S/m dielectric 3.5.

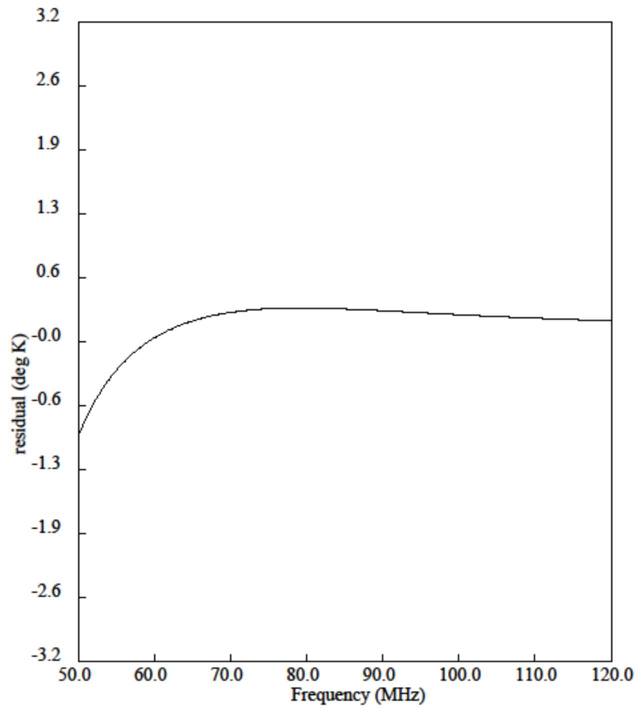

Figure 4. Simulated rms residuals of mesh loss to a 1-term Linlog fit to the sky at GHA = 12hr.

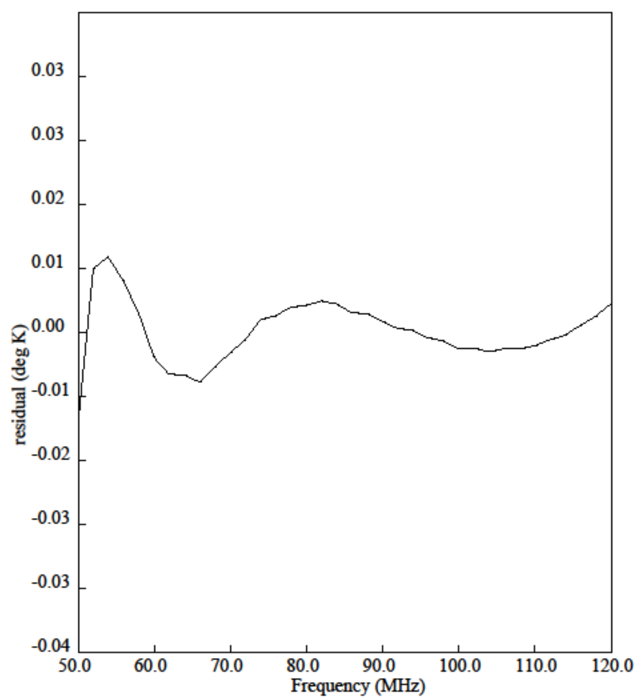

Figure 5. Simulated rms residuals of mesh loss to a 5-term Linlog fit to the sky at GHA = 12hr.