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To: EDGES Group

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Subject: Simulations of resistive loss in galvanized steel

Previous studies of the resistive loss in the wire mesh ground plane in memos 179, 239 and 316 assumed a conductivity of 1e6 S/m and permeability of 1 for the galvanized mesh with 5×5 cm spacing and 4mm wire diameter. With this assumption the resistive loss is only of the order of 0.02% and is of little concern. However, the loss could be much higher if a galvanized steel baseplate were to be used under the antenna instead of the aluminum baseplates currently used by EDGES at the MRO.

MHz	Eff% for 1e6 S/m	Eff% S/m with rel. perm =100
50	99.9645	99.6472
100	99.9949	99.9492

Table 1. Antenna efficiency in percent with relative permeability of 1 and 100.

Table 1 lists the antenna efficiencies obtained from FEKO simulations of EDGES-3 in free space with a 2.4×2.4 m ground plane. If a relative permeability of 100 is assumed, which would be the case if the zinc layer is ineffective and the EM waves are reflected from the carbon steel, the loss at 50 MHz increases from 0.04% to 0.35%. Figures 1 and 2 show the residuals to the simulated antenna spectra with 1-term removed from 50 to 120 MHz assuming a sky temperature of a 860K at 100 MHz a spectral index of -2.5 for the 2 cases.

The concern over the effectiveness of the layer of zinc arises from a lack of information on loss as the galvanization is usually just used to protect the underlying steel from corrosion. Various types of steel have different degrees of ferromagnetism and values of relative permeability which change with frequency and magnetic field. At 100 MHz a typical value for carbon steel is 50 to 100 (Kittel[1] 1946) another issue of concern is that the zinc layer is destroyed in the process of welding and is replaced by "zinc" spray whose RF properties are uncertain. A quick test shows that zinc spray paint is non conductive. A simulation of the resistive loss of a 2.4×2.4 cm wire mesh baseplate with conductivity 1e6 S/m and relative permeability 100 is 0.6% or 0.026 dB at 50 MHz which is comparable to the EDGES-2 balun loss and EDGES-3 meander copper wire grid with soil loss.

A simulation of an aluminum 2.4×2.4 m baseplate surrounded out to 4.8×4.8 m with 1e6 S/m and relative permeability to simulate carbon steel produce resulted in a loss of 0.03% compared with 0.2% at 50 MHz for all carbon steel shows that a baseplate with good conductivity is most critical.

[1] Kittel, Charles. "Theory of the dispersion of magnetic permeability in ferromagnetic materials at microwave frequencies." Physical Review 70, no.
5-6 (1946): 281.

The effect of high permeability is too increase the loss via a reduction in the thickness of the skin effect in proportion to the square root of permeability. A similar concern was raided in memo 273 over the presence of nickel in connectors.

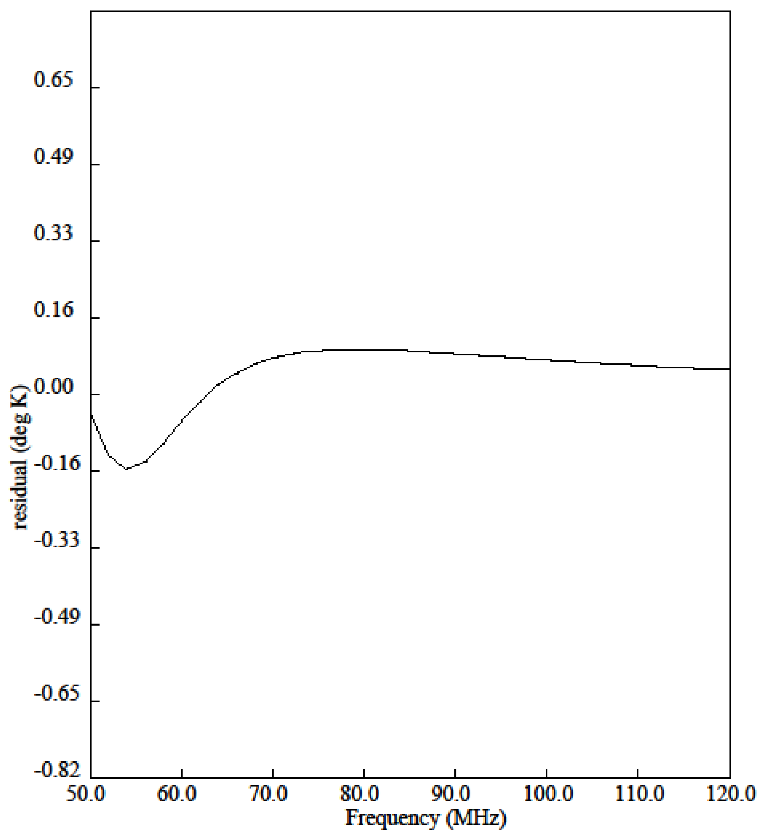

Figure 1. Effect of resistive loss in baseplate with conductivity 1e6 S/m and relative permeability 1.0.

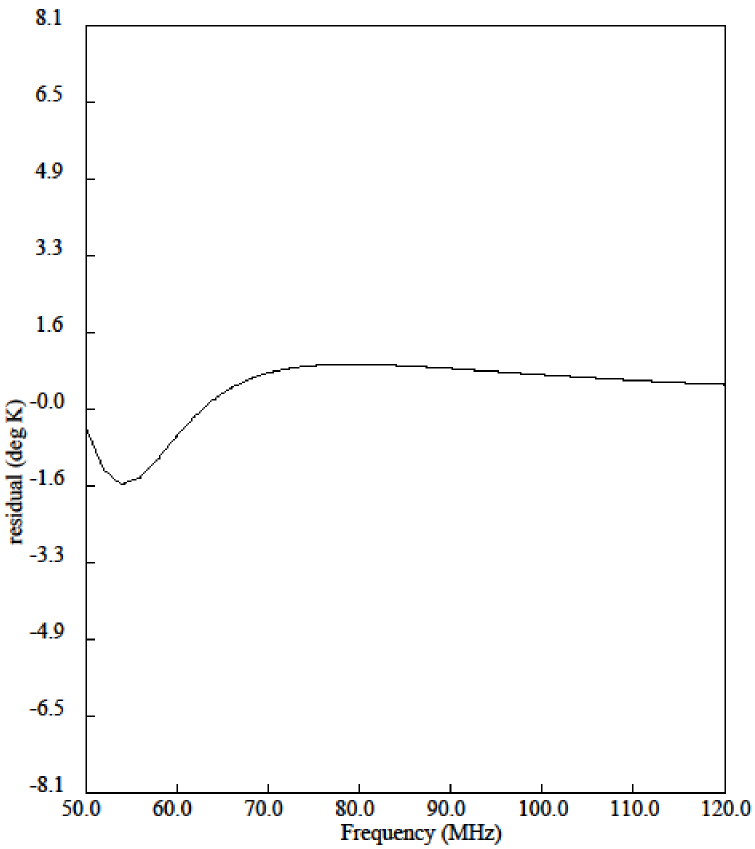

Figure 2. Effect with relative permeability 100.