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Preliminary experiments about the measure of the magnetic properties of a material by means of TDR probes

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In this contribution, the possibility of measuring possible magnetic properties of materials by means of a TDR probe is studied. A transmission line model is adopted and data in time and frequency domain are exploited together. Simulation results are shown, at the moment based on a bifilar line model.
Magnetic properties of materials can be of interest for several applications. In particular, the presence of magnetic features in the soil or in any substance, might be associated to some contaminant (presumably containing some metallic element as iron, nickel or chromium [1]). This kind of pollution might occur close to some farms, especially regarding the dying of dresses, the production of some medicines, the tanning of leather issues. Moreover, modern agriculture puts in the soil several fertilizing substances, and there is a debate about the quantity of heavy metals spread in the terrain by these activities [2]. Still, some depuration-mud can be affected by an excessive presence of metallic elements, because of the presence of batteries, skins, varnishes, cosmetics, and so on [2]. Moreover, it is thought that the soil on the planet Mars might show magnetic properties [3]. Finally, in GPR prospecting, possible magnetic characteristics of the soil or of the targets might be of interest too [4], but they cannot be retrieved by means of only GPR data [5]. In the present paper, the results of a preliminary study are exposed with regard to the possibility to measure the magnetic properties of a material by mean of a TDR probe [6-7]. In particular a TDR probe is essentially a transmission line (a bifilar model will be exploited in this work) open at the end, form which most of the impinging energy (ideally the whole of thi energy in a lossless medium) is back reflected. In particular, this allows a customary measure of the propagation velocity in the medium if an impulsive signal is generated. In fact, the return time along a path of known length is measured. The propagation velocity provide information about the product between the dielectric permittivity of the material and its magnetic permeability, but does not allow to discriminate between the two quantities, i.e. between the dielectric and the (possible) magnetic characteristics. In many cases, the magnetic characteristics are not relevant and are just neglected (which practically means that we mesure an "equivalent" dielectric permittivity that indeed includes also the magnetic properties of the material, if any. However, if a meaure of reflection coefficient at fixed frequency is performed too, the dependence of this further quantity from the intrinsic impedance of the line provide information about the ratio between the magnetic permeability of the material and its dielectric permittivity. So, the two kind of measurements, combined together, theoretically can allow the discrimination between the two quantities. Some simulation result in this sense will be shown at the conference. The results are preliminary, and in particular, a "scholastic" transmission line model is not precise enough for real cases, because of the presence of higher order modes, as well as some loss for joule effect and for radiation. Notwithstanding the first results are encouraging and make us think that a refining of the model is worth pursuing in order to apply the technique to real materials.

References

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