

Reply to Comments on "An Analysis of a Staked Dipole Probe on a Lossy Earth Plane Using the Finite Difference Time Domain Method"

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We agree completely with the statements contained in the second paragraph of the comments by Wait [1]. We are not surprised that the complex area of a layered earth plane can be related to the complex wave tilt, but we are not aware of any published papers that provide that derivation. However, this does not detract from our analysis and, in fact, sheds some additional light on the performance of the staked probe configuration.

The most important point raised in the comment is in relation to the question of the effect of the strong vertical electric field component on an insulated antenna. This effect will only be present if there is a net vertical component to the probe [2]. Thus, if both ends of the antenna lie on the ground, there will be no net vertical component of the antenna even if the earth is undulating. In practice, flexible cable is used and so the ends are usually within 1 cm of the ground. At very low frequency (VLF), a dipole of 10 m would have a 0.1% vertical component. Thus, the effect is significant only if the vertical field is greater than approximately 1000 times that of the horizontal electric field or the magnitude of the wave tilt $|W| < 10^{-3}$. At magnetotelluric (MT) frequencies, a 1-cm displacement in a total dipole length of 100 m results in an even smaller contribution to the voltage induced in the probe. In our paper, the staked antenna is shown to be susceptible to an air gap between the horizontal arms of the probe and the surface of the earth. This gives an additional voltage at the antenna feed point, which must be subtracted to obtain a true measure of the horizontal electric field. In practice, if the flexible cable does have an air gap anywhere along its length, a magnetic field component will be detected. The size of the magnetic field is directly proportional to the size of the area of the gap. In the case of a flexible cable that has been laid across a fallen tree, is supported by thick grass, lies across a crevasse or gully, or simply as a result of its self-supporting helical structure, this area will be nonzero. If the mean height of the antenna above ground is t , the total area of the loop A_{total} over an infinite half space will be given by

$$A_{\text{total}} = h/\gamma + ht$$

where h is the total horizontal length of the dipole and the contamination ratio will be $|t\gamma| = t/\delta$, where δ is the skin depth in the ground. At VLF in highly conductive grounds, $\delta \cong 10$ m, so that only mean elevations of $t > 1$ m will give significant effects. We would argue that, in both cases, the contamination is unlikely to be significant.

We would suggest that the probe selection criterion be directed toward other factors. Wait [1], [2] has suggested problems with input impedance and that electrostatic coupling may cause significant problems. We agree that the two configurations will have a significant difference in input impedance and noise contamination. Modern electronics can counter these problems relatively simply. Other criteria include the ease of deployment of the probe. Bare rock, permafrost,

and ice-covered regions make probe insertion almost impossible, and an insulated probe is the only option.

Most important in the selection of a probe is the reliability of measurement. We pointed out in the concluding remarks in our paper [3] that a poor electrical contact will give an erroneous reading of apparent resistivity that is 25% of the true value. We further pointed out that this erroneous value might arise, not only as the result of poor stake electrical contact, as described by Zonge and Hughes [4], but as a result of the very structure that is being measured. It is for this reason that we believe an insulated dipole antenna is a more reliable field probe than a staked dipole probe for surface impedance measurements made at frequencies above approximately 1 kHz.

REFERENCES

- [1] J. R. Wait, "Horizontal electric field sensors—staked or not?" this issue, p. 312.
- [2] ———, "On measuring the horizontal electric field just above the earth's surface," *IEEE Trans. Instrum. Meas.*, vol. 43, pp. 481–483, Mar. 1994.
- [3] D. V. Thiel and R. Mittra, "An analysis of a staked dipole probe on a lossy earth plane using the finite-difference time-domain method," *IEEE Trans. Geosci. Remote Sensing*, vol. 35, pp. 1357–1362, Sept. 1997.
- [4] K. L. Zonge and L. J. Hughes, "The effect of electrode contact resistance on electric field measurements," in *Proc. SEG 55th Conv.*, Washington, DC, Oct. 1995.

Extended LVQ Neural Network Approach to Land Cover Mapping

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Abstract—A competitive neural network (NN) learned by the OLVQ1 algorithm has the potential to produce images for land cover mapping. We propose an extended OLVQ1 that adds learning ratios to the original algorithm. Applying it to SPOT-XS data, we show that higher mapping accuracies can be obtained compared to those of conventional methods.

Index Terms—Land cover mapping, learning vector quantization (LVQ), SPOT-XS data.

I. INTRODUCTION

Backpropagation (BP) network approaches for land cover mapping have recently been proposed in [1]–[3]. The learning algorithm based on the steepest descent method often requires large numbers of training iteration and can fall into a local minimum point.

Another network paradigm has been considered to obtain classification results autonomously based on the similarity between the input data. A competitive learning neural network (NN) has been proposed to adopt this paradigm. Applications to remote-sensing image analysis using the competitive learning NN have been previously reported in [4] and [5]. The category corresponding to the output unit may change, depending on initial values and the input sequence of the training data. Therefore, problems arise when we assign the output unit to an appropriate category using this NN.

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