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IMPROVEMENT OF A METALLIC SHIELD FOR A GPR ANTENNA

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1. Introduction

The work reported in this paper is a result of research collaboration between IRCTR – Delft University of Technology, The Netherlands, and Bandung Institute of Technology (ITB), Indonesia. This work focuses on development of an improved antenna for short-range impulse ground penetrating radar (GPR) applications in which the targets are shallowly buried and small in dimension. Examples of such applications include civil engineering application (e.g., localization of buried pipes or cables) and landmine detection. For these applications the probing pulse should be ultra-wideband (UWB) to obtain sufficient down-range resolution. As UWB signals are transmitted, it is of utmost importance that the antenna be properly shielded to prevent EMI. In this work we attempted to design an improved shield for the UWB antenna. More specifically, the shield should not only protect the antenna against EMI but it should also strengthen radiation in the broadside direction of the antenna.

The finite-difference time-domain (FDTD) method has been used extensively in the design and analysis of the shield. For experimental verification, the improved shield has been constructed and measured. In this work, IRCTR performed the design and theoretical analysis while the antenna/shield construction and measurements were carried out by ITB.

2. The UWB antenna

For the abovementioned impulse GPR applications one needs a UWB antenna that should be able to transmit the probing signal (i.e. a short transient pulse) with minimal ringing as such ringing may obstruct reflections coming from shallowly-buried targets. In this work the probing signal has been chosen to be a monocycle with 0.8-ns duration and we have developed a compact resistively-loaded UWB GPR antenna to be used with this monocycle. It has been shown that the antenna exhibits very small ringing and additionally it has improved radiation efficiency in comparison with commonly used GPR antennas, such as resistively-loaded bow ties and dipoles. The geometry of the antenna is shown in Fig. 1 and its comprehensive description can be found in [1] – [3].

3. Development of the shield

As GPR is generally a bistatic radar, the antennas should be shielded to minimize antenna coupling. Furthermore, the shields should give good protection against EMI and hence they should suppress radiation into the air. In this work, the shield for the UWB antenna in Fig. 1 has been developed to meet those demands and moreover its dimensions have been determined to be as small as possible while still giving minimal impact on the antenna response. In addition, we designed the shield to increase the peak-to-peak amplitude of the radiated field in the broadside direction of the antenna which in practice is the direction normal to and penetrating the ground. As a result, we obtain a shield that is more or less optimized specifically for the UWB antenna excited with the 0.8-ns monocycle.

At first we developed a conventional shield with box-like shape, designated here as the “flat” shield. The antenna and the “flat” shield were modeled with FDTD and a series of simulations were performed with different shield dimensions to find the optimal dimensions which meet the aforementioned demands. The main objectives for these simulations were the highest peak-to-peak amplitude of the transmit waveform in the broadside direction and minimum shield dimensions. The resulting geometry of the “flat” shield is shown in Fig. 2.

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Subsequently, we applied the idea introduced in [4] in which a shield with staircase profile on its top wall is found to give a substantial increase of the amplitude of the waveform transmitted by a GPR antenna. For the UWB antenna in Fig. 1 such a staircase profile has been implemented on the top wall of a second shield, designated here as the "staircase" shield. A series of FDTD simulations have been performed with different dimensions of the shield and the staircase profile, for which the same main objectives were assumed as for the previous simulations. It has been found that the "staircase" shield results in improved performance in comparison with the "flat" shield. The resulting geometry of the "staircase" shield is shown in Fig. 3.

4. Measurements

For experimental verifications both the "flat" and "staircase" shields have been constructed and integrated with the antenna. The constructed shields are shown in Fig. 4. The free-space transmit waveforms of the antenna with the shields have been measured at a distance of 50 cm in the broadside direction, for excitation with the 0.8-ns monocycle. It is shown in Fig. 5 that the "flat" shield contributes to increase of the peak-to-peak amplitude of the transmit waveform by 17%. However, this shield causes undesired impact in the form of oscillation that occurs immediately after the arrival of the transmitted main pulse. As shown in the figure, improvement is achieved by the "staircase" shield which increases the peak-to-peak value of the waveform by 30% with respect to the antenna without shield and 11% with respect to the "flat" shield. Moreover, it can be seen that the "staircase" shield reduces the undesired oscillation following the transmitted main pulse.

Furthermore, the input impedance of the UWB antenna with the shields has been measured and the result is presented in Fig. 6. It is shown that the "staircase" shield shifts the resonance to higher frequencies (around 4 GHz) giving less influence on the response of the antenna when excited with the 0.8-ns monocycle which has meaningful spectral contents in the 0 – 3 GHz range.

5. Conclusions

A design of an improved shield for the compact UWB GPR antenna in [1] – [3] is presented. The shield makes use of a staircase profile on its top wall to increase the peak-to-peak amplitude of the waveform transmitted in the broadside direction. The dimensions and the staircase top wall of the shield have been optimized specifically for the antenna and for excitation with a 0.8-ns monocycle. The shield shows stronger radiation and less impact on the antenna response in comparison with a conventional shield.

References

[1] A.A. Lestari, A.B. Suksmono, E. Bharata, A.G. Yarovoy, L.P. Ligthart , "Small UWB antenna with improved efficiency for pulse radiation," *Proc. Int'l Workshop Antenna Technology (IWAT05)*, Singapore, Mar. 2005.

[2] A.A. Lestari, Y.A. Kirana, A.B. Suksmono, A. Kurniawan, E. Bharata, A.G. Yarovoy, L.P. Ligthart, "Modified bow-tie antenna for efficient transmission of UWB pulses," *Proc. 2004 Int'l Symp. Antennas Propagation (ISAP 2004)*, vol. 1, pp. 521-524, Sendai, Japan, Aug. 2004.

[3] A.A. Lestari, Y.A. Kirana, A.B. Suksmono, A. Kurniawan, E. Bharata, A.G. Yarovoy, L.P. Ligthart, "Compact UWB Radiator for Short-Range GPR Applications," *Proc. 10th Int'l Conf. Ground Penetrating Radar (GPR 2004)*, vol. 1, pp. 141-144, Delft, The Netherlands, Jun. 2004.

[4] L.P. Ligthart, A.G. Yarovoy, Y.A. Kirana, "GPR antenna simulations and optimizations in time domain," *Proc. Int'l Conf. Antenna Theory Techniques*, pp. 21-24, Sevastopol, Ukraine, Sep. 2003.

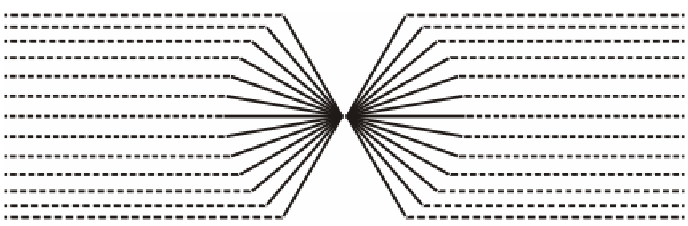
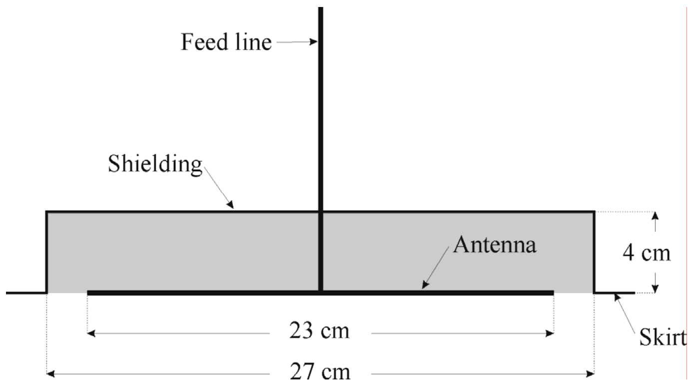
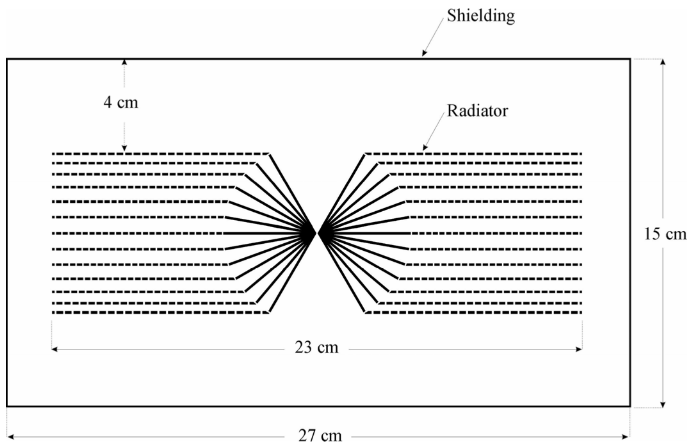


Fig. 1. Geometry of the UWB antenna. The antenna length and width are 23 cm and 7 cm, respectively. The gaps in the horizontal wires are locations of the resistive loading using lumped resistors.

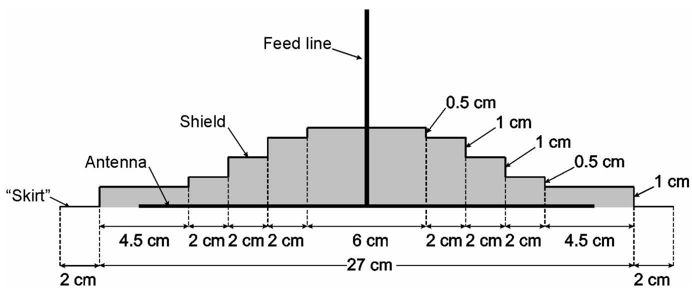


(a)

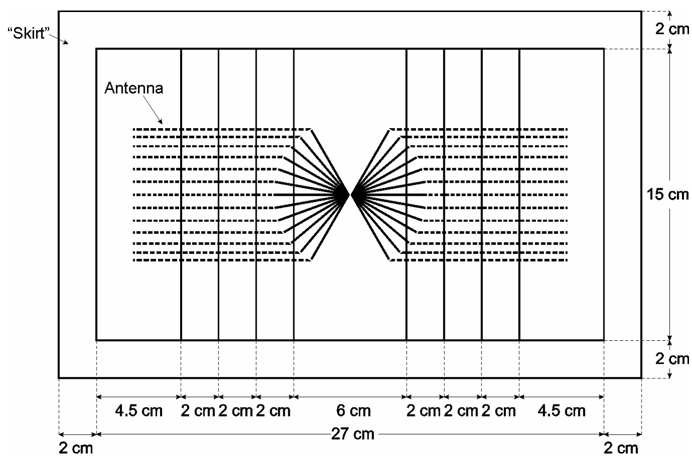


(b)

Fig. 2. (a) Side view, and (b) top view of the "flat" shield.

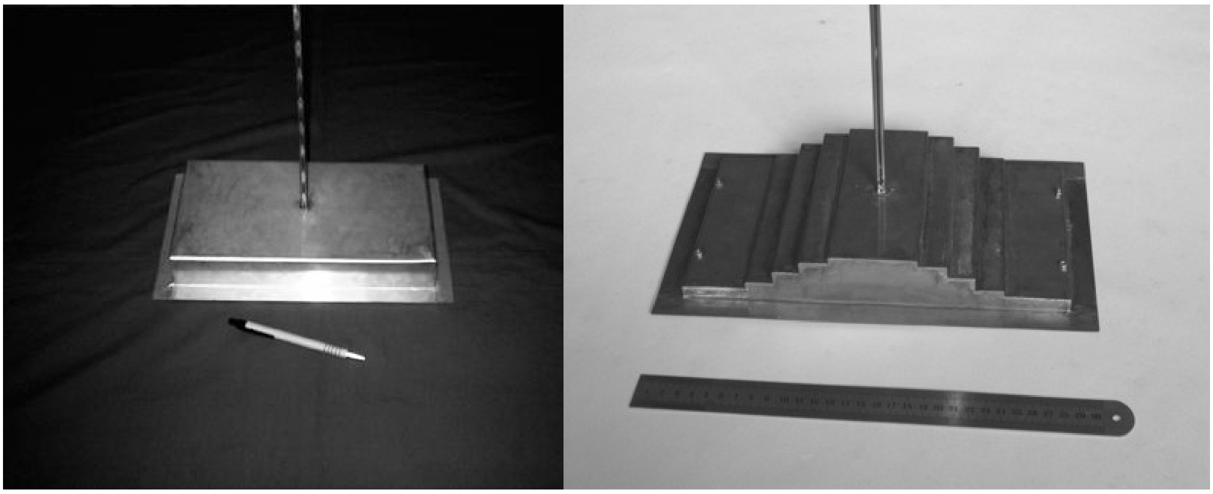


(a)



(b)

Fig. 3. (a) Side view, and (b) top view of the "staircase" shield.



(a) (b)

Fig. 4. Realization of (a) the “flat” shield, and (b) the “staircase” shield.

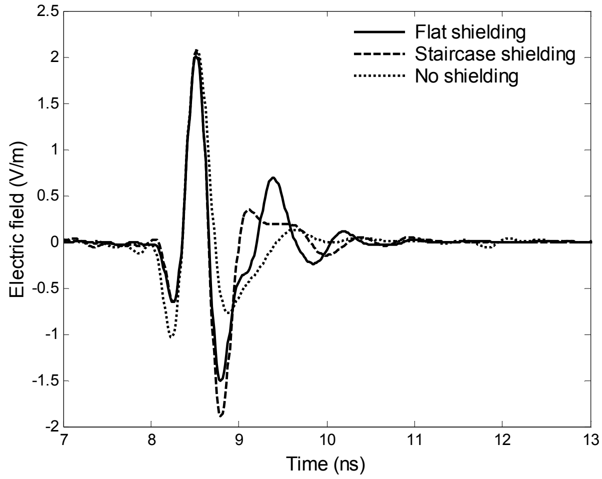
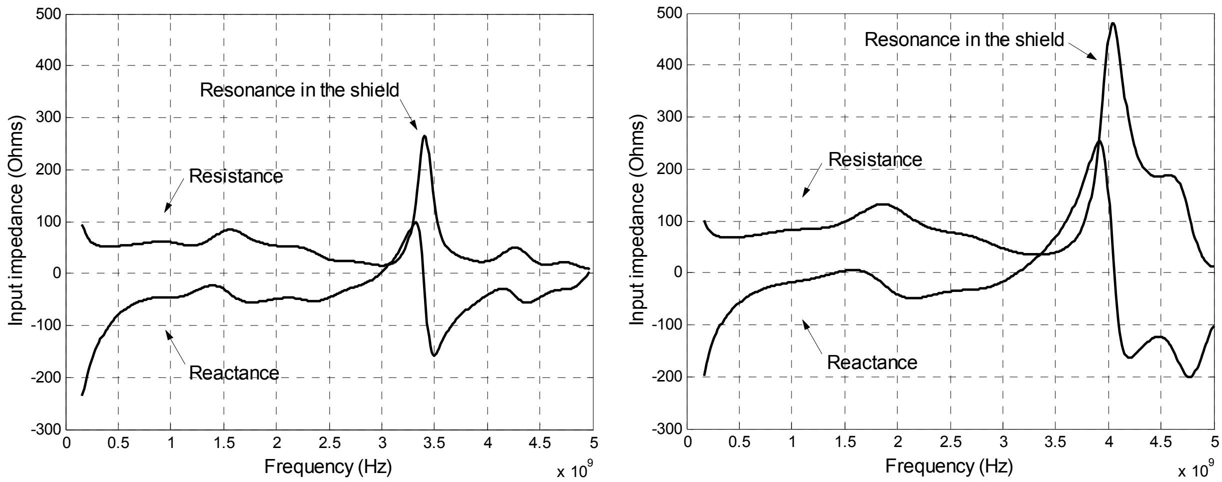


Fig. 5. Measured free-space transmit waveforms of the UWB GPR antenna in Fig. 1 at a distance of 50 cm in the broadside direction of the antenna. The measurements have been done without shield, with the “flat” shield and with the “staircase” shield. A 0.8-ns monocycle was used for excitation.



(a) (b)

Fig. 6. Measured input impedance of the UWB antenna with (a) the “flat” shield, and (b) the “staircase” shield.