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Improving the detectability and imaging capability of ground penetrating radar using novel antenna concepts

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Antennas are key components of Ground Penetrating Radar (GPR) instrumentation. A carefully designed antenna can improve the detectability and imaging capability of a GPR to a great extent without changing the other instrumentations. In this work, we propose four different types of antennas for GPR. They are modifications of a conventional bowtie antenna with great improvement in performance parameters. The designed antennas has also been tested in a stepped frequency type GPR and two dimensional scan images of various targets are presented.

Bowtie antennas have been traditionally employed in GPR for its wide impedance bandwidth and radiation properties. The researchers proposed resistive loading to improve the bandwidth of the bowtie antenna and for low ringing pulse radiation. But this method was detrimental for antenna gain and efficiency. Bowtie antennas have a very wide impedance bandwidth. But the useful bandwidth of the antenna has been limited by the radiation pattern bandwidth. The boresight gain of bowtie antennas are found to be unstable beyond a 4:1 bandwidth. In this work, these problems have been addressed and maximum usable bandwidth for the bowtie antennas has been achieved.

In this work, four antennas have been designed: namely, 1.) RC loaded bowtie antennas, 2.) RC loaded bowtie with metamaterial lens, 3.) Loop loaded bowtie, 4.) Loop loaded bowtie with directors. The designed antennas were characterized for different parameters like impedance bandwidth, radiation pattern and, gain.

In antenna 1, a combined resistive-capacitive loading has been applied by periodic slot cut on the arms of the bowtie and pasting a planar graphite sheet over it. Graphite having a less conductance compared to copper acts as resistive loading. This would minimize the losses compared to lumped resistive loading. The antenna had a 10:1 impedance bandwidth and, a 5:1 pattern bandwidth. In antenna 2, a metamaterial lens has been designed to augment the antenna 1, to improve the forward gain. This antenna had the same impedance bandwidth of 10:1 while pattern bandwidth has been raised to 7:1. In antenna 3, a loop loaded bowtie antenna has been designed. This antenna do not employ any kind of resistive loading, yet achieves an impedance bandwidth of 11:1 and also a usable bandwidth of 11:1. The antenna 4 employs concentric offset loops which acts as directors to improve the directivity. This antenna achieved an impedance bandwidth and a pattern bandwidth of 13:1. All the antennas have a maximum size of about 0.3λ at lowest operating frequency.

An experimental stepped frequency type GPR has been constructed to study the suitability of the fabricated antennas in detecting buried targets. Four experiments have been conducted viz. 1.) To detect a metallic pipe of 1in diameter, 2.) To detect a metallic pipe of 2in diameter 3.) To detect dry bamboo, 3.) To detect rebar in concrete. The detectability and imaging capability of GPR has been found to be improving from antenna 1 to 4.