Buried Objects Detection via Magnetic Loop

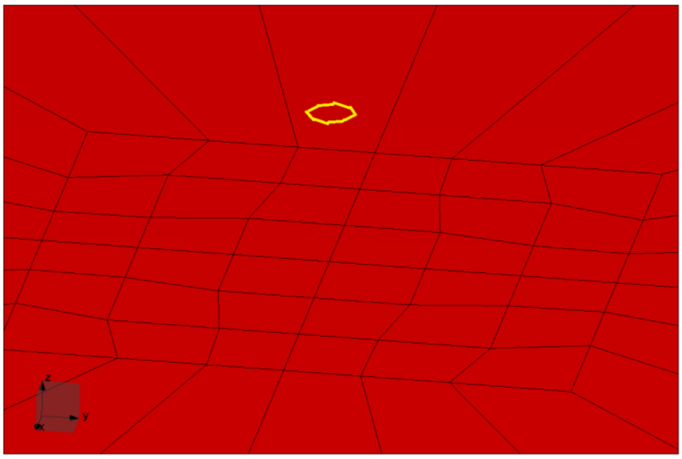
Problem Description

This application note describes use of WIPL-D software suite for simulations of buried objects detection. Simulations are carried out via WIPL-D Pro, full wave EM solver. The product offers excellent speed, accuracy and reliability of results, even at extremely low frequencies (such as needed for this application).

The problem itself consists of thin metallic plate (made of aluminum) buried 3 m under the ground. Magnetic dipole is placed 2.2 m above the ground and swept above the metallic strip in order to detect it. The detection is performed by using the value of magnetic field 68 cm above the ground and below the magnetic dipole. The ground has characteristics of vacuum with conductivity set to 0.01 S/m.

Simulation

The above described model was made and simulated in WIPL-D Pro 3D EM solver. Simulation was carried out at 10 KHz operation frequency. The project consists of: magnetic loop made of wires, ground clump and the metallic object.

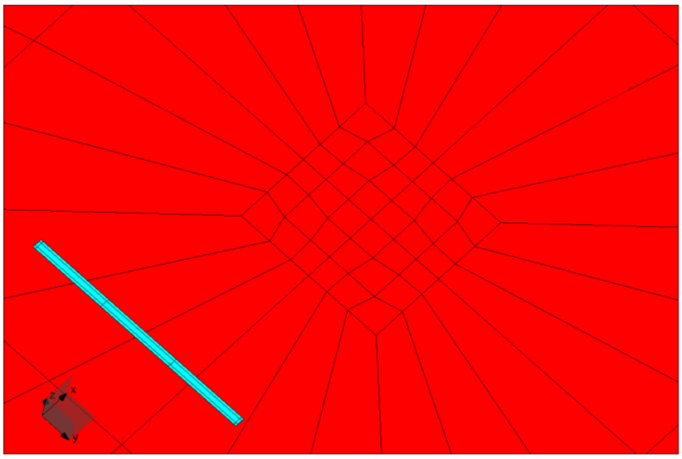


Top view (magnetic loop)

WIPL-D Pro does not allow usage of generic magnetic moments or dipoles. In that sense, the excitation was made as small wire loop (the shape of the circle). Its radius was set to 1/3 m (33 cm). Delta generator was assigned to the feeding wire and the voltage of the generator effectively determines magnetic moment of the loop. The moment was determined in two steps. First the generator was set to 1 V. Current was calculated for such case and the moment is calculated as IS where I is the current magnitude and S is the surface of the loop. Then, the voltage is altered so it provides magnetic moment of 1 Am^2. The mesh of the ground clump below the loop is increased so that it reflects the fact that most significant coupling of loop and ground is performed exactly below the antenna.

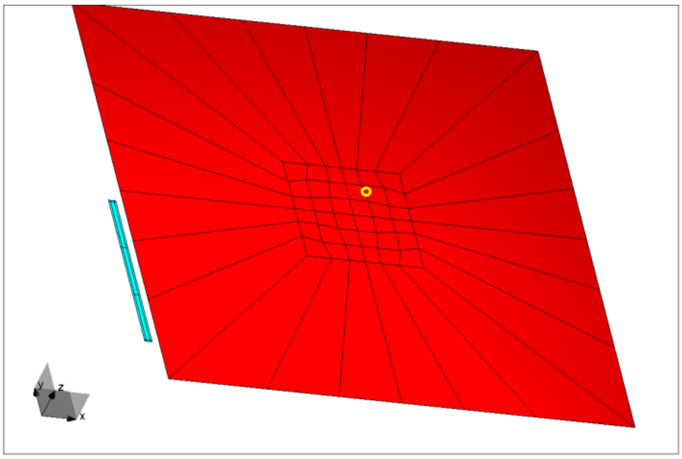
The ground was modeled as simple clump at z=0 plane. Side and bottom of the ground are not modeled. The size of the clump was determined in such a way that increasing it does not affect the final results. In addition, the mesh of the clump is adjusted below the magnetic loop and the area where the buried object is swept.

Buried object was model as simple metallic strip with thickness, but additional segmentation was introduced to ensure the accuracy.



Bottom view (target object)

The entire scenario (clump is intentionally reduced) is shown in the following figure.



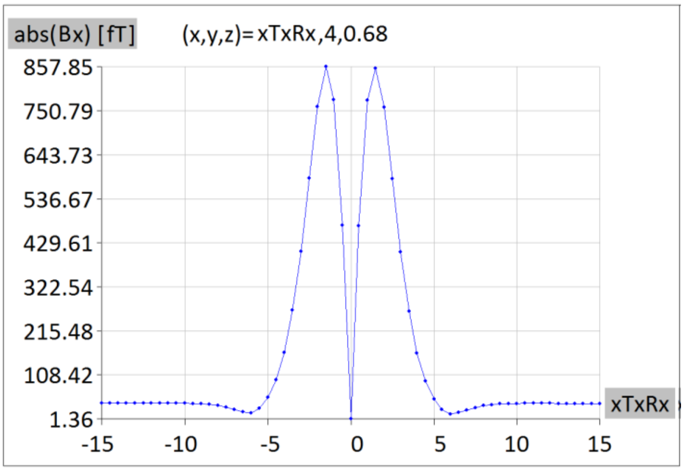
Scenario (clump size reduced)

Simulation was carried out at 10 KHz. It requires extremely low number of unknowns (under 500). Simulation lasts typically 1-2 sec on everyday PC.

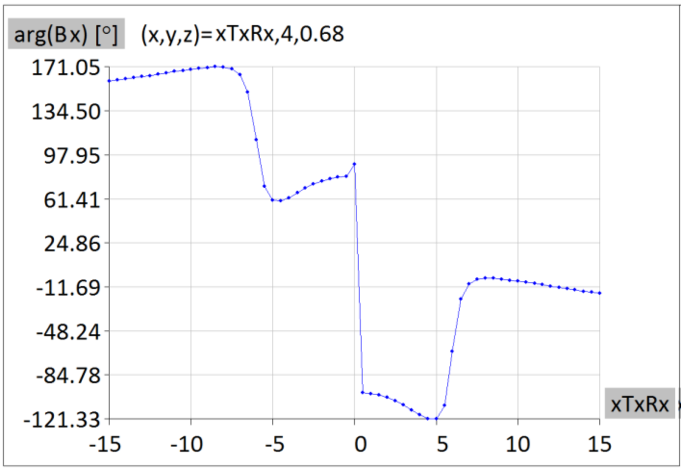
The magnetic loop was moved in the interval [-15 m, 15 m] along the x coordinate so that its surface goes by directly above the metallic strip. Other geometry is kept constant.

Results

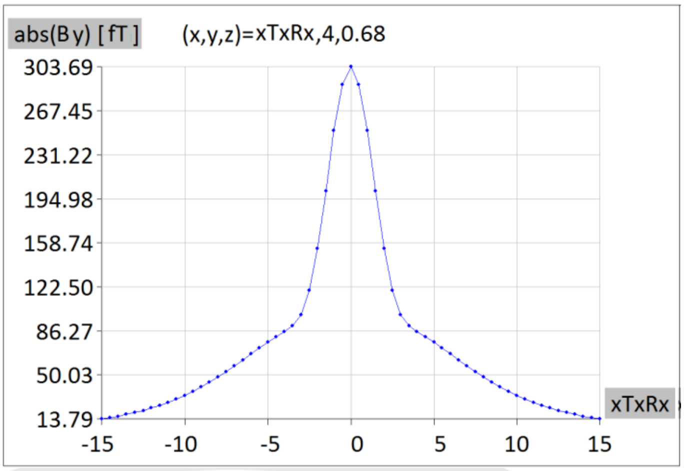
The results of interest are magnetic field (Bx, By, Bz) at the fixed height below the excitation loop. The excitation and observation point are swept alongside x.



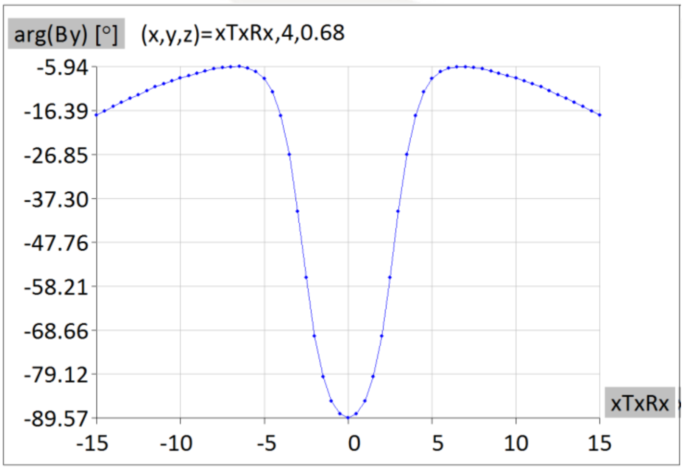
Magnetic field (magnitude of Bx)



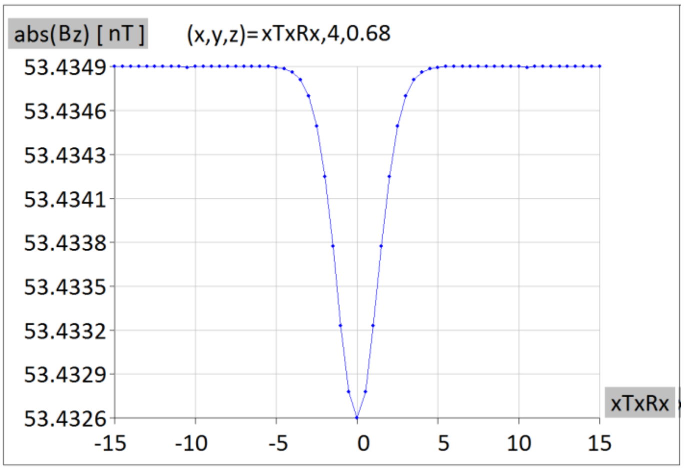
Magnetic field (phase of Bx)



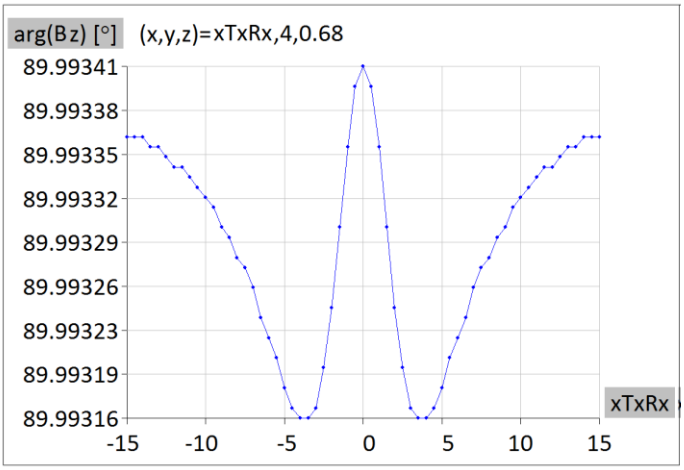
Magnetic field (magnitude of By)



Magnetic field (phase of By)



Magnetic field (magnitude of Bz)



Magnetic field (phase of Bz)