A Low Profile, Wideband, Polarization Reconfigurable Antenna Using an Array of Sectorial Loop Antennas for Subsurface Imaging Systems

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Subsurface imaging of buried targets has military, homeland security, civilian, and industrial applications. Military and homeland security applications include the detection of landmines, unexploded ordnance, and underground tunnels. Detection of buried pipelines, wires and cables, and localization of human bodies under collapsed buildings in rescue missions are examples of civilian applications. In oil and gas industry, subsurface imaging is utilized to detect the location of leaks in buried pipelines.

To obtain high range-resolution images in subsurface imaging systems, the operation frequency range must be wide. This requires wideband antennas for the imaging system. Antennas as critical components of subsurface imaging systems must have low profile and light weight to improve the mobility of the imaging systems. Dipoles, different variations of bowtie antennas, and spiral antennas are examples of low profile antennas that are utilized in subsurface imaging systems. Horn, TEM horn, and Vivaldi antennas are the other types of the antennas conventionally used in subsurface imaging systems. Among all, only spiral antennas provide circular polarization. Circular polarization is important in subsurface imaging, since it enables imaging of targets with large aspect ratio (e.g. pipes) independent of their orientation.

In this abstract, a low profile, wideband, circularly polarized antenna with directive beam is proposed for subsurface imaging application. The antenna is formed by an array of four monopole sectorial loop antennas (SLA) mounted on a ground plane. The angle between each two adjacent SLAs is 90^{o} degree. Monopole sectorial loop antennas have been previously used for design of wideband linearly polarized (N. Behdad and K. Sarabandi, IEEE Trans. Antennas Propag., 2005) and circularly polarized omnidirectional antennas (B. Yektakhah and K. Sarabandi, IEEE Trans. Antennas Propag., 2017). All SLAs are coaxially fed by the same amplitude and absolute phase progression of 90° between each two adjacent elements. This creates two orthogonal linearly polarized electric fields on the top of SLAs with 90° phase difference resulting circularly polarized radiation. The handedness of the circular polarization is determined by the sign of the phase progression. Out of phase excitation (with the same amplitude) of only two SLAs (with angular separation of 180°) provides linear polarization along the exited elements. It suggests that by utilizing RF switches in the feed network of the antenna, the polarization can be switched between linear and left-handed and right-handed circular.

An antenna with directive pattern is designed and simulated based on the proposed structure. The antenna is polarization reconfigurable within the range 0.8–2.4 GHz with maximum VSWR of 2.4. Total height and diameter of the antenna is 48 mm and 250 mm, respectively.