Electronics/Computers

Forward-Looking IED Detector Ground Penetrating Radar

This convoy-mounted IED detector radar could be used on route-clearing vehicles.

NASA's Jet Propulsion Laboratory, Pasadena, California

There have been many developments of mine or metal detectors based on ground penetrating radar techniques, usually in handheld or rover-mounted devices. In most mine or metal detector applications, conditions are in a stationary mode and detection speed is not an important factor.

A novel, forward-looking, stepped-frequency ground penetrating radar (GPR) has been developed with a capability to detect improvised explosive devices (IEDs) at vehicular speeds of 15 to 20 mi/h (24 to 32 km/h), 10 to 20 m ahead of the vehicle, to ensure adequate time for response. The GPR system employs two horn antennas (1.7 to 2.6 GHz, 20 dBi) as transmit and receive. The detector system features a user-friendly instantaneous display on a laptop PC and is a low-power-consumption (3 W) compact system with minimal impact on vehicle operations. In practice, the whole GPR system and a laptop PC can be powered by plugging into a cigarette lighter of a vehicle.

The stepped-frequency continuous-wave (CW) radar scans frequency from 1.7 to 2.6 GHz in 1,000 steps of 0.9 MHz, with the full frequency scan in 60 ms. The GPR uses a bi-static configuration with one horn antenna used as a transmitter and the other used as a receiver so that isolation between transmitter and receiver is improved. Since the horn antennas (20 dBi) are mounted on the roof of a vehicle at a shallow inclination angle (15 to 25° with respect to horizontal), there is a first-order reduction in ground reflection so that a significant amount of the total reflected power received by the GPR comes from the scattering of RF energy off of buried objects.

The stepped-frequency technique works by transmitting a tone at a particular frequency, while the received signal is mixed with the transmitted tone. As a result, the output of the mixer produces a signal that indicates the strength of the received signal and the extent to which it is in phase or out of phase with the transmitted tone. By taking measurements of the phase relationship between the transmitted and received signals over a wide frequency range, an interference pattern is produced showing all target reflections. When a Fourier transform is performed on this pattern, the result is a time-domain representation of targets. Among the advantages of this technique over impulse radar is the ability to transmit and receive much more total energy, and to use non-damped, highly focused horn antennas.

The novelty of the IED detector GPR has been achieved by miniaturization of GPR electronics (single electronics board, 10×5×2 cm), low power consumption (3 W), faster signal processing capability, and minimal impact on vehicle operations.

This work was done by Soon Sam Kim and Steven R. Carnes of Caltech, and Christopher T. Ulmer of Ulmer Systems, Inc. for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. Refer to NPO-47028.

Fully Printed, Flexible, Phased Array Antenna for Lunar Surface Communication

Applications include RFID tags, sensors, smart cards, electronic paper, and large-area flat-panel displays.

John H. Glenn Research Center, Cleveland, Ohio

NASA's future exploration missions focus on the manned exploration of the Moon, Mars, and beyond, which will rely heavily on the development of a reliable communications infrastructure from planetary surface-to-surface, surface-to-orbit, and back to Earth. Flexible antennas are highly desired in many scenarios.

Active phased array antennas (active PAAs) with distributed control and processing electronics at the surface of an antenna aperture offer numerous advantages for radar communications. Large-area active PAAs on flexible substrates are of particular interest in NASA's space radars due to their efficient inflatable package that can be rolled up during transportation and deployed in space. Such an inflatable package significantly reduces stowage volume and mass. Because of these performance and packaging advantages, large-area inflatable active PAAs are highly desired in NASA's surface-to-orbit and surface-to-relay communications.

To address the issues of flexible electronics, a room-temperature printing process of active phased-array antennas on a flexible Kapton substrate was developed. Field effect transistors (FETs) based on carbon nanotubes (CNTs), with many unique physical properties, were successfully proved feasible for the PAA system.

This innovation is a new type of fully inkjet-printable, two-dimensional, high-frequency PAA on a flexible substrate at room temperature. The designed electronic circuit components, such as the FET switches in the phase shifter, metal interconnection lines, microstrip transmission lines, etc., are all printed using a special inkjet printer. Using the developed technology, entire 1×4, 2×2, and 4×4 PAA systems were developed, packaged, and demonstrated at 5.3 GHz.