Description of Experimental System

Company / Organization: University of Vermont and State Agricultural College

POC: Dryver Huston, (O) 802-656-1922 (M) 802-999-8652, dryver.huston@uvm.edu

Technology Name: Waveform Acquisition Augmented Reality Penetrating Radar

Company / Organization:

University of Vermont and State Agricultural College
Mechanical Engineering Department
33 Colchester Ave.
Burlington, VT 05405

Overview: Research group at our university has been developing advanced penetrating radar systems for the past two decades. The experimental technology integrates new capabilities into air-launched ground and wall penetrating radars. These include photogrammetric position registration with a smart phone, full waveform digitization for reduced radiated emissions, augmented reality presentation of data to user and potentially for using multi-static penetrating radars for improved sensing.

System Description:

The capability planned for demonstration is a wall-penetrating radar that combines full waveform digitization, photogrammetric antenna registration with a smart phone and augmented reality presentation of results with an augmented reality device, i.e. hololens.

The design outcome of the capability is threefold: 1. Full waveform digitization allows for collection of the same amounts of radar data for many fewer emitted pulses versus equivalent sampling approach. This has the potential to dramatically lower radiated emissions and possibly ease FCC/NTIA compliance. 2. Photogrammetric registration allows for recording of position and pose of antennas for integration of 3D movements into data processing. 3. Augmented reality display and feedback to operator provides cognitive feedback and presentation to the operator.

The development of the system to date has primarily been as a ground penetrating radar, with the emphasis on urban utility mapping. It has been modified for wall penetrating capabilities. This system, when further developed, will be a compact handheld ground or wall penetrating radar with augmented reality capabilities for cognitive feedback to the operators and with reduced radiated emissions.

The operating principle of the transmitter/receiver is that of an impulse time-domain system with full waveform digitization. Figure 1 is a diagram of the system. Figure 2 is a picture of the system.

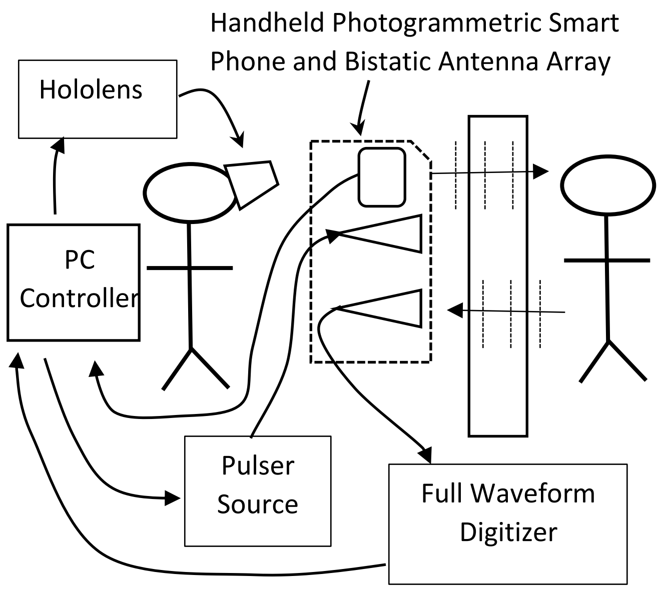

Figure 1. Diagram of system

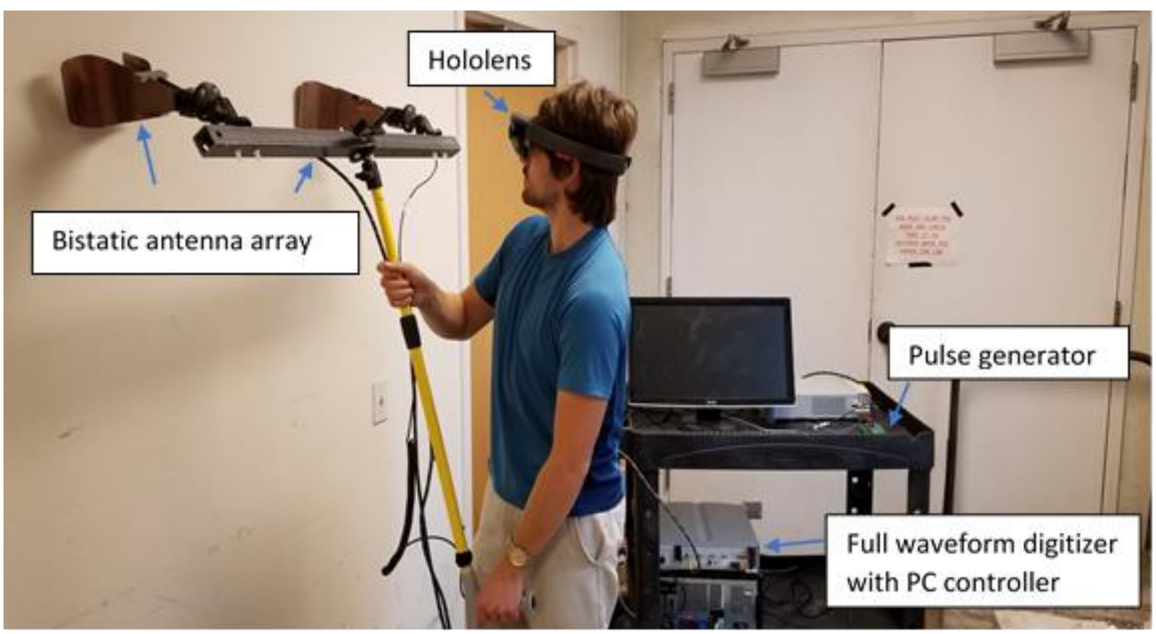

Figure 2. Picture of penetrating radar system

The impulse generator creates pulses of 1 ns duration, with amplitudes on the order of 18 V. The receiver uses full waveform digitization to reduce the number of emitted pulses and overall emitted radiation, Figure 3. The system has the potential to operate effectively with pulse repetition frequency rates as low as 1,000 Hz (pulses per second).

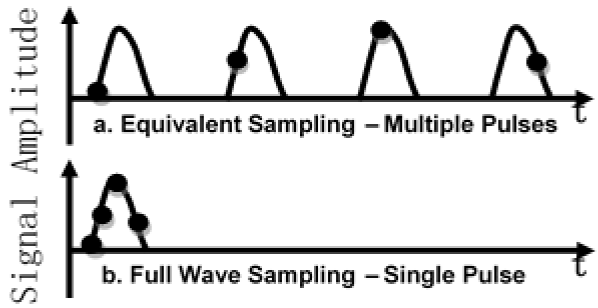

Figure 3. Waveforms illustrating a) equivalent sampling over multiple pulse cycles and b) real-time full wave sampling over a single cycle with fewer pulses required to sample the same information

Comparative Radiated Emissions Tests

An assessment of the radiated electromagnetic emissions used a sandbox testbed. Figure 4 shows the testbed with the air-launched full waveform sampling radar. The antennas are pointing down with a height of about 2 ft.

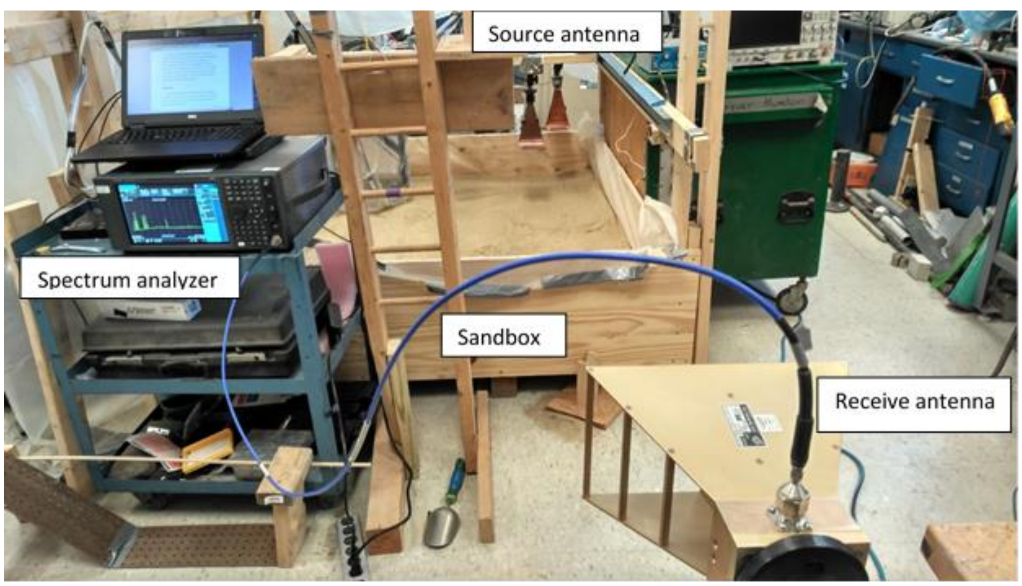

Figure 4. Sandbox testbed for radiated emissions testing with full waveform radar. The air launched antenna points down with an elevation of about 0.6 m. The receiver antenna for measurements is on a tripod in the foreground and connects to a spectrum analyzer. The distance from source to receive antenna is approximately 3 m.

A comparative set of measurements began with a measurement of the background radiation. The subsequent radiated measurements corrected for the background by subtraction. An exception is a frequency-hopping wifi signal centered around 5.4 GHz that could not be removed with a simple background subtraction. Results of the tests appear in Figure 5 to 8. Figure 5 shows the measured radiated emission from the full waveform system operating at a pulse repetition frequency of 10 kHz. Figure 6 shows the measured radiated emission from the full waveform system operating at a pulse repetition frequency of 1 kHz. Figure 7 shows the measured radiated emission from a commercially-available ground-coupled ground penetrating radar – GSSI 400 MHz antenna with SIR-30 and 500 A-scans per second produced by equivalent sampling. Figure 8 shows the measured radiated emission from a commercially-available ground-coupled ground penetrating radar – GSSI 1,600 MHz antenna with SIR-30 and 350 A-scans per second produced by equivalent sampling.

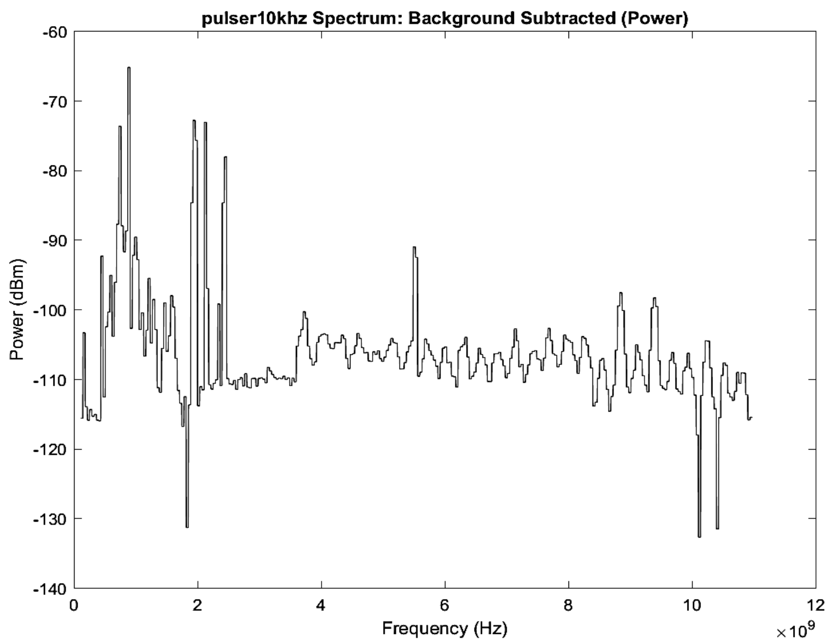

Figure 5. Radiated emissions measured from full waveform digitization radar with pulse repetition rate of 10 kHz.

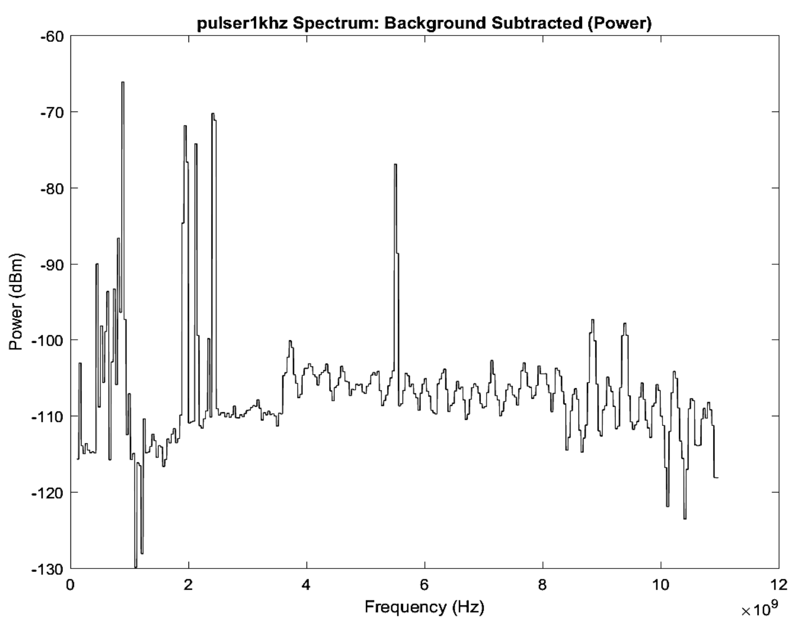

Figure 6. Radiated emissions measured from full waveform digitization radar with pulse repetition rate of 1 kHz.

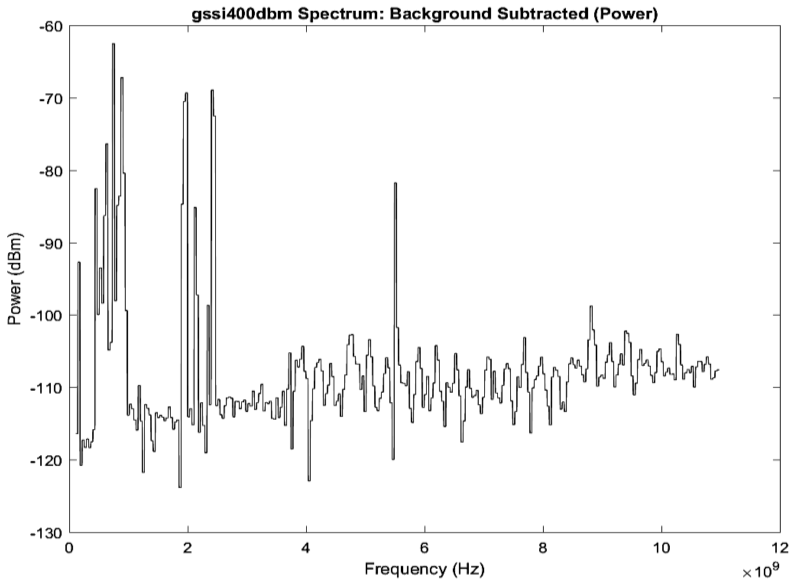

Figure 7. Radiated emissions measured from commercially-available ground coupled radar – GSSI 400 MHz antenna powered by SIR-30

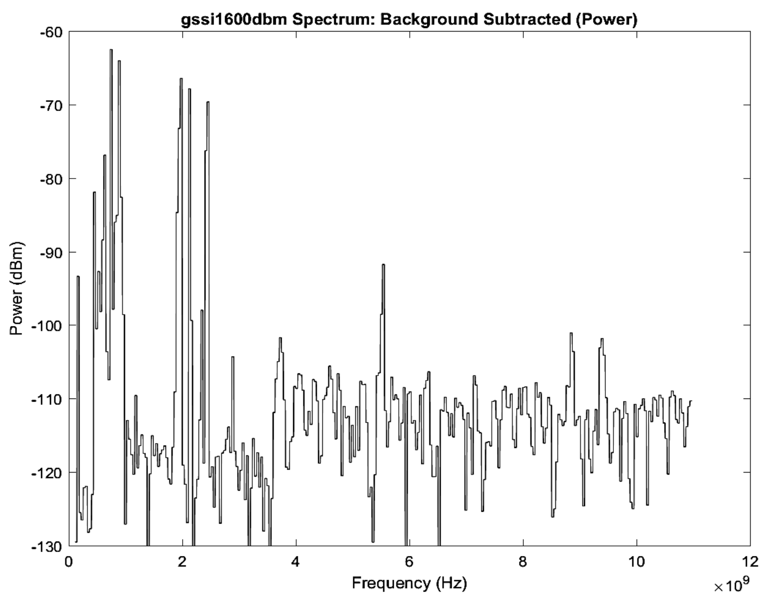

Figure 8. Radiated emissions measured from commercially-available ground coupled radar – GSSI 1,600 MHz antenna powered by SIR-30

Conclusion from Comparative Radiated Emissions Tests

An examination of Figures 5 to 8 indicate that the full waveform air launched digitizing radar is emitting less radiation than comparable commercially-available ground coupled ground penetrating radars that use equivalent sampling. The bulk of the radiated energy for all the systems is less than 3 GHz. It should be noted that these measurements are comparative in nature and the results do not correspond directly to calibrated measurements of absolute radiation amplitudes.