Miniaturized Radar Depth Sounder for Deployment on Small Autonomous Vehicles

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Land-based ice sheets and glaciers are changing dramatically, and understanding the impact of these changes on sea level requires information on ice thickness in areas where available measurements are limited due to high attenuation and volume clutter. In particular, bed topology and ice/rock interface characteristics near the grounding lines are critical boundary conditions for ice sheet models. To obtain these measurements, we have developed an autonomous and compact radar depth sounder for operation at 14 and 35 MHz. The radar will be deployed on an unmanned aerial vehicle (UAV) to perform surveys over a fine grid to enable 2D SAR processing for improving SNR, suppressing clutter, and 3D imaging.

The radar electronics are housed in three enclosures that are stacked vertically to accommodate three subsections: (1) power conditioning and distribution; (2) digital/RF; and (3) power amplifier/TR switch. The subsystems include both off-the-shelf and custom-designed components developed primarily from wireless communication and ultrasound technologies. The system can transmit 100 W of peak power and sample at rate of 50 MSPS. The total weight of the first prototype system is less than 3 kg and its DC power consumption during nominal operation is less than 20 Watts. Laboratory fiber-optical delay-line loopback tests show about 160 dB of loop sensitivity with 512 hardware presums.

Conformal dipole-based antennas are integrated directly into the fiberglass wing structure of a lightweight UAV using wire and copper tape. Tuned matching networks are used to enable operation at 14 MHz and 35 MHz with 1.2 MHz and 5 MHz bandwidths, respectively. Return loss measurements verified antenna performance and were conducted in an anechoic chamber and during flight tests.

Command and status are accomplished through a low speed serial connection to the on-board autopilot for wireless communication with the ground station, while data are streamed to an on-board high-capacity SD card. Trajectory and time synchronization are provided through on-board and stationary GPS/IMU systems.

The system will deploy in December of 2013 at the WISSARD camp on the Whillans Ice Stream in Antarctica. Surveys will be conducted by towing the radar and platform on a sled followed by radio-controlled and finally autonomous flights. Future development activities will include further miniaturization and bi-static capabilities for deployment on multiple vehicles. We present a complete description of the system as well as initial field results.