The BYU microSAR System

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Synthetic Aperture Radar (SAR) has been very successfully used in a variety of studies of the Earth. SAR instruments operate independent of solar illumination and can see through clouds. Unfortunately, the costs associated with existing SAR systems often preclude them from extensive studies requiring frequent revisit. Also, spaceborne SAR systems have limited spatial resolution. These limitations can be overcome by using a small, low-cost, high-resolution SAR systems designed for operation on a small UAV. Such a sensor is ideally suited for focused studies requiring high resolution and frequent revisit.

Brigham Young University (BYU) has successfully developed a very low-cost, compact, low-power SAR system, known as a microSAR. Multiple flight units have been fabricated. The microSAR sensor is designed for flight on a small (6 foot wingspan) Aerosonde UAV. Smaller than a cigar box, the microSAR low power system is designed for low-altitude (300 m) operation (See Figs. 1-3). Designed for "turn-on and forget" operation, the system collects data continuously for over an hour. Data is stored on a compact flash disk. After a flight, the flash disk is loaded onto a laptop and processed into images using custom developed SAR image and autofocusing software. Processing time on a conventional laptop is similar to the data collection time. GPS position and velocity data is supplied by the UAV.

A functional block diagram of the bistatic microSAR instrument is shown in Fig. 4. A photograph of the full system is shown in Fig. 5. The RF subsystem (Fig. 1) consists of a 3"x3.4"x3" stack of custom microstrip circuit boards. Minimal enclosures are used to reduce flight weight. The LFM-CW system operates at 5.4 GHz in the unlicensed WiFi band and transmits 1 W of power. The operating bandwidth is 90 MHz. A simple homodyne IF system is used which provides de-ramping. Designed for operation at 300-1000' and 20-50 m/s, the microSAR has a swath width of 200-300 m with nominal 1 look spatial resolution of ~10 x 60 cm, which is averaged down to 1 m x 1m in processed imagery. The maximum range is ~700 m.

A custom designed FPGA-based A/D board handles data collection and storage (Fig. 2). It continuously collects the de-ramped SAR data at 330K samples/sec and stores it to removable compact flash disks. Two identical microstrip antennas (Fig. 3), each approximately 4" x 12", are mounted to the UAV body in flight. A single RF coax line (SMA connectors) connects each of the antennas to the RF subsystem. The current design uses DC/DC converters to convert the nominally +18VDC supply from the UAV to the various voltages needed in the system. Power consumption during operation is nominally 16 W. The total system weight is less than 2 kg, including antennas and cabling.

Initial testing of the system is done from a moving vehicle ("car-SAR" – see Fig. 6) in a nearby canyon. Imaging the canyon walls from the highway simulates flight operation from the UAV. A sample image is shown in Fig. 7. The system has been successfully operated from small aircraft over the Arctic Ocean as well as locally. Sample images from a local flight on a small manned aircraft are shown in Fig. 8.

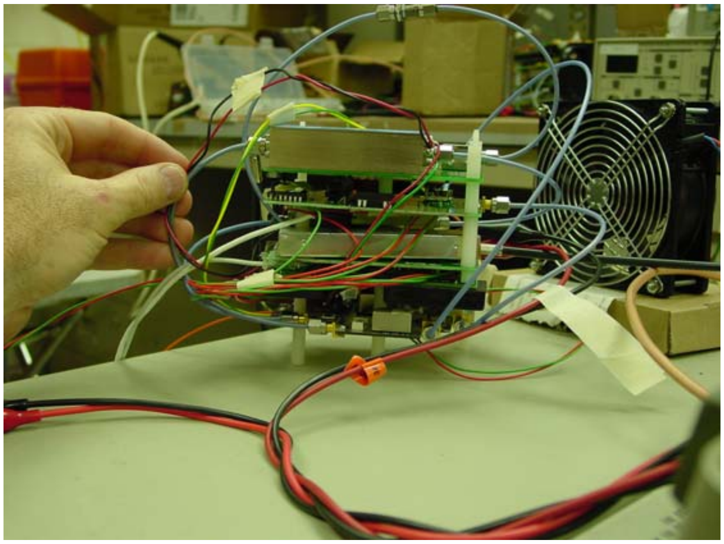

Figure 1. Photograph of microSAR RF stack. To minimize weight, no enclosure is used.

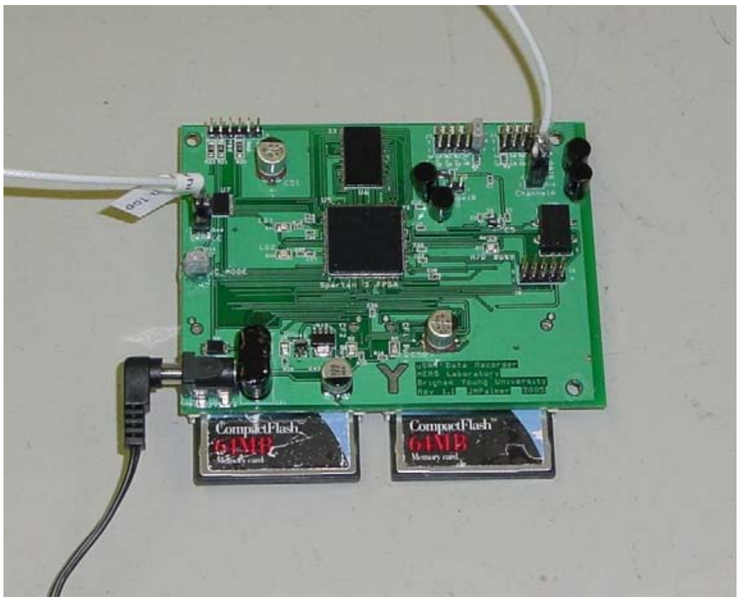

Figure 2. mcroSAR data acquisition module consisting of a PC104 A/D and single board computer. Data is stored on Compact Flash devices.

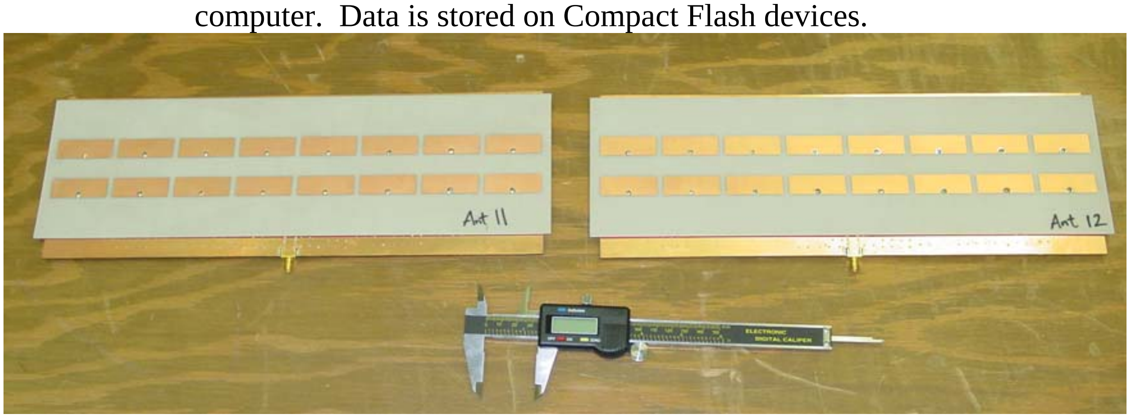

Figure 3. mcroSAR antennas consisting of two flat panels made out of high frequency circuit board material. Each is connected to the RF stack using a single RF cable. They are mounted with the long direction aligned with the flight direction with the radiating side (shown) pointed to one side of the vehicle.

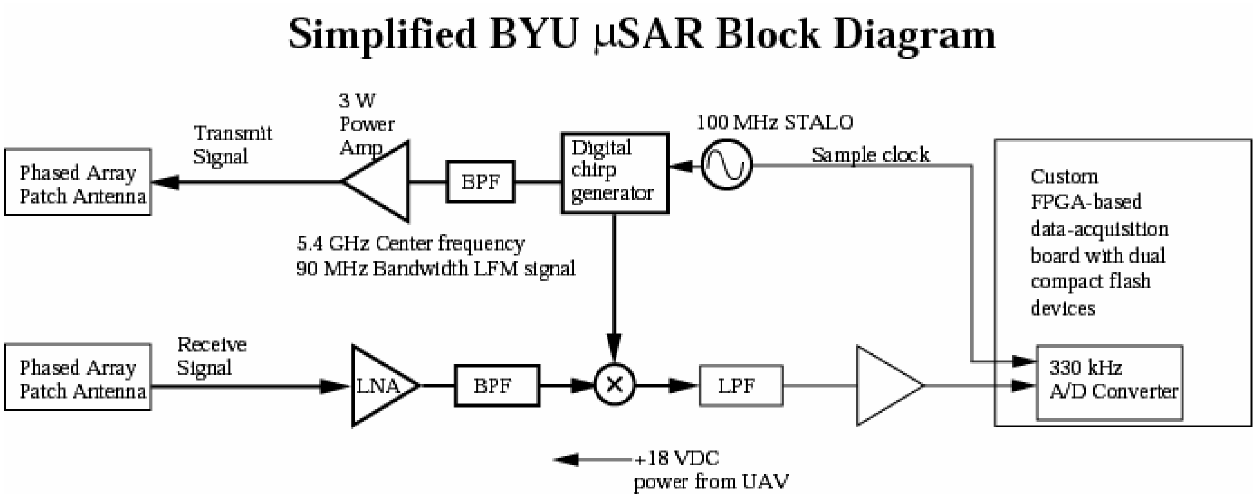

Figure 4. BYU microSAR block diagram.

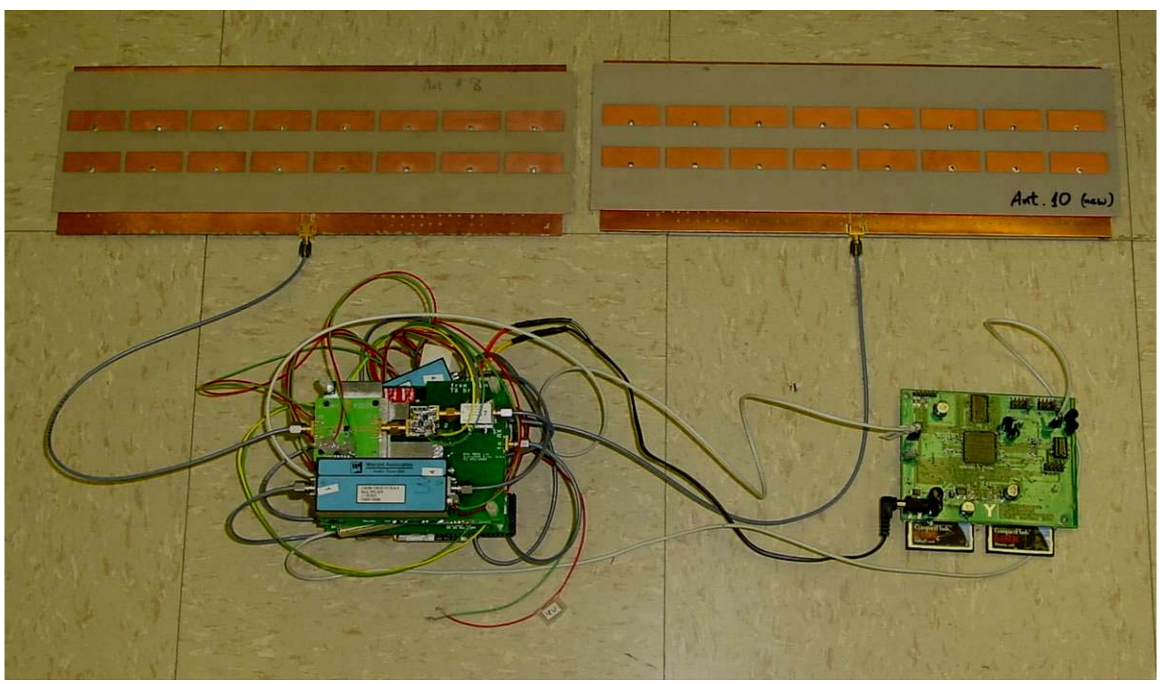

Figure 5. Photograph of complete BYU microSAR system ready for flight on a small UAV.

Figure 6. Testing the microSAR system on a vehicle ("car-SAR"). Note orientation of antennas relative to motion direction and the direction of the patches.

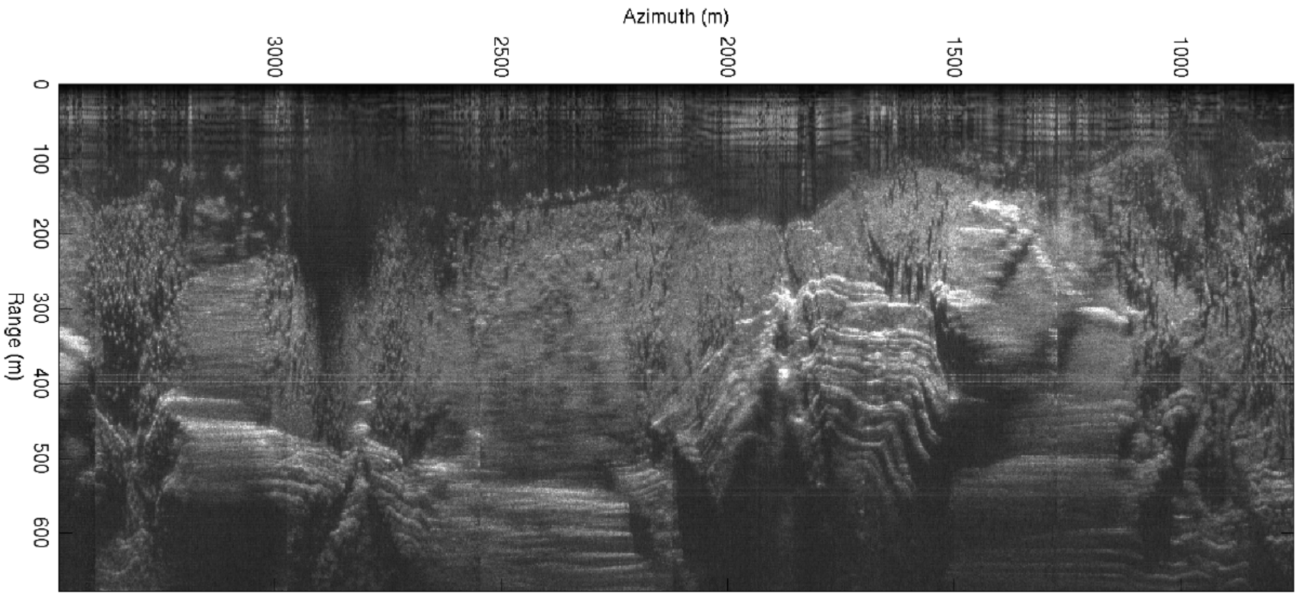

Figure 7. Example microSAR image from car-SAR driving up Provo Canyon, UT. Blurred sections result from the curving highway up the canyon. The canyon walls are naturally terraced and appear layered in the image.

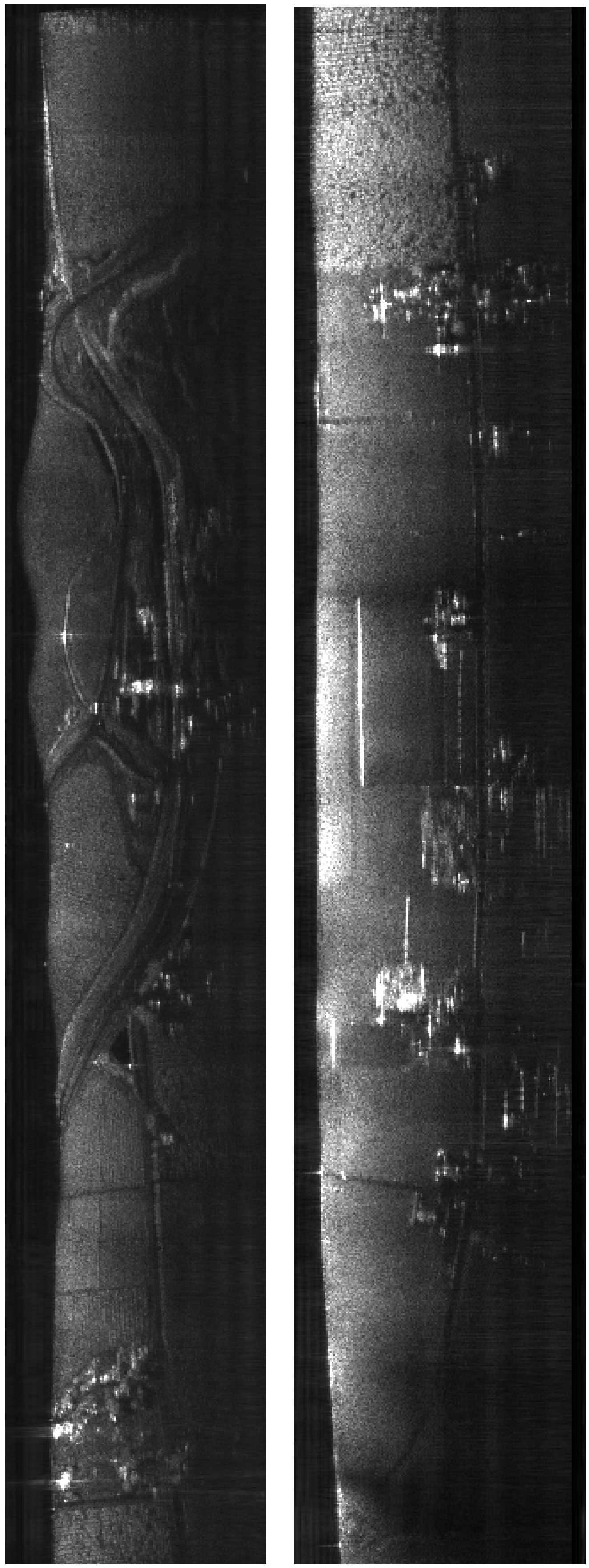

Figure 8. Example microSAR images collected from a small manned aircraft near Benjamin, UT.