3   ULTRAWIDEBAND MICROWAVE RADAR INSTRUMENTATION

The second radar to be provided is an ultrawideband microwave radar operating over the frequency range of 2-18 GHz with quad-polarization capability. The radar is for mapping near-surface internal layers with very fine resolution and measuring the thickness of snow over sea ice. The system is designed to operate in Frequency-Modulated and Continuous Wave (FM-CW) mode for low-altitude measurements—500-1000 m—and stretch mode for high-altitude measurements—2500 m and above.

Figure 3-1 shows the simplified system block diagram and Table 3-1 lists system parameters of the ultrawideband microwave radar. It consists of four main sections: chirp or transmit and local oscillator (LO) signal generators; a transmitter; two identical receivers; and a digital section. Figure 3-2 shows the transmit chirp signal and LO signal generators. It consists of two identical Direct Digital Synthesizers operating over the frequency range of 1.375-2.375 GHz and with the same clock signal. The outputs from the synthesizers are frequency multiplied by a factor of 16 to obtain 22-38 GHz. Each multiplier stage consists of a filter, amplifier and attenuators. The filter is used to reduce out-of-band spurious signals and reduce undesired harmonics. The amplifier increases the signal level to that required to drive the next-stage multiplier in the chain. The signal from the final multiplier stage is amplified, filtered, and supplied to the input of the down-converter. The down-converter is supplied with a 20-GHz LO signal to generate the 2-18 GHz chirp signal. The LO signal generator is identical to the transmit signal generator, except the LO signal is delayed to keep the beat-frequency signals within the bandwidth of the IF filter.
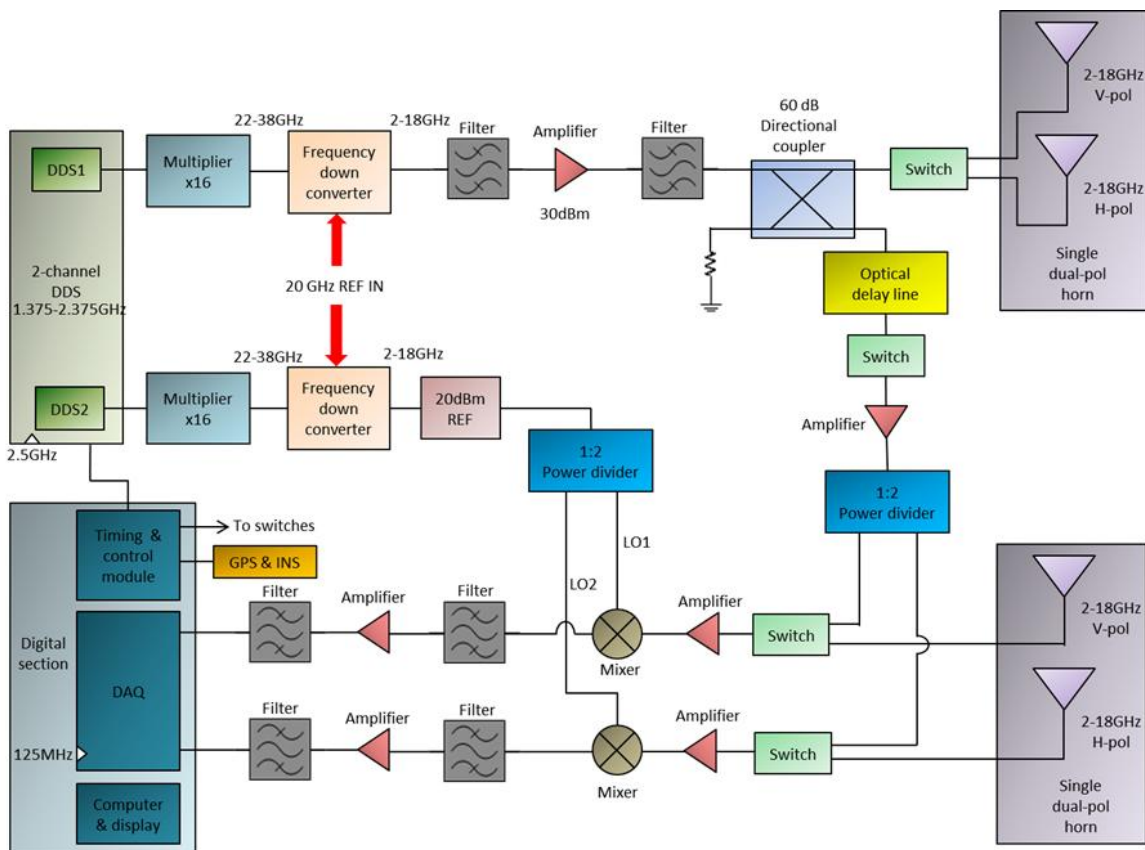

Fig. 3-1: Simplified system block diagram of the ultrawideband microwave radar.
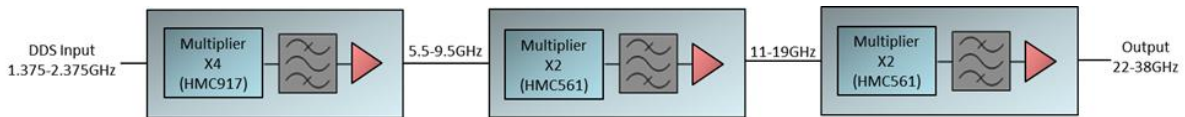
Fig. 3-2 Frequency multiplier unit.

Table 3-1: System Parameters

Parameter	Value
Operating Frequency*	2-18 GHz
Num of Transmit Channels	2 (H-pol. and V-pol.)
Transmit Power	200 mW
Num of Receive Channels	2 (H-pol. and V-pol.)
Receiver Sampling Rate	250 MHz
Digitizer	12-bit A/Ds
Antenna	Dual-pol. Horn or Vivaldi array

The transmitter consists of a bandpass filter, variable-gain amplifier (VGA), driver and power amplifiers, and a Single-Pole Double-Through (SPDT) switch. The bandpass filter is used to reduce out-of-hand signals; VGA is used to shape the amplitude of the transmit waveform to reduce range sidelobes; and drive and power amplifiers are used to increase the transmitter signal level to about 30 or 40 dBm. The high-power signal of about 40 dBm is needed for high-altitude operation of the radar. The SPDT switch is utilized to polarize the transmit signal. Each receiver consists of a SPDT switch, a low-noise amplifier (LNA) with high-reverse isolation, a mixer, a bandpass filter, and an Intermediate Frequency (IF) amplifier. One of the SPDT switches selects receive signal polarization and the other injects a delayed sample of the transmit signal for calibration; the LNA boosts the received signal and reduces LO leakage signal being coupled to the receive antennas; and the mixer multiplies the received signal with the LO signal to generate a beat signal whose frequency is proportional to range. The multiplication in the mixer generates sum and difference frequencies, and the bandpass filter allows only difference frequencies to pass through to the IF amplifier. The beat-frequency signals are amplified and further filtered with anti-aliasing filters before being supplied to the digitizer. We will generate all the clocks from a 10-MHz Rubidium clock, including a 250-MHz clock for the ADC and DAC, 2.5 GHz for the chirp-DAC, and 20 GHz for the LO down conversion in the chirp generator.

The digital section consists of hardware required to generate timing signals to control the radar and set up the delay of the LO signal generator. This keeps the IF signal frequency range nearly constant while operating at different altitudes. It also consists of hardware required to digitize signals from two receive channels.

4   COST AND WORK BREAKDOWN

The total proposed costs for the hardware and supporting documentation described herein for this fixed price contract are $2,190,000 USD. This cost reflects the actual costs to duplicate the hardware and all digital and RF systems and is consistent with the cooperative agreement between the University of Kansas and the Alfred Wegener Institute. The necessary software is provided at no additional cost. The project will begin upon receipt of initial payment according to the following schedule: