SURFACE PRESSURE SENSING RADAR USING V-BAND (65-70 GHZ)

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Program: FY21 R&TD Topics **Strategic Focus Area: Atmospheric composition and dynamics**

Objectives: Surface pressure is the main quantity that relates to the instability of the atmosphere and the main factor in prediction of storm formation and intensification. Despite its importance, remote sensing measurements of pressure are currently of limited availability and quality. The objective of this proposal is to develop a differential absorption radar instrument in a compact package that will enable the estimation of surface pressure anywhere, under any conditions for enhanced weather forecasting modeling, and be ready to integrate it on an airborne platform in two years.

Measurement Principle: Radar echo power has a strong gradient with frequencies as a result of absorption of atmospheric O_2 around 60 GHz. This technique makes measurements of two radar channels with similar water vapor and liquid water characteristics; - one sufficiently far into the O_2 band and the other on the wing of the band. The ratio of these measurements, or the differential absorption, is a measure of the O_2 column abundance, which is an accepted proxy for air density and in turn surface pressure.

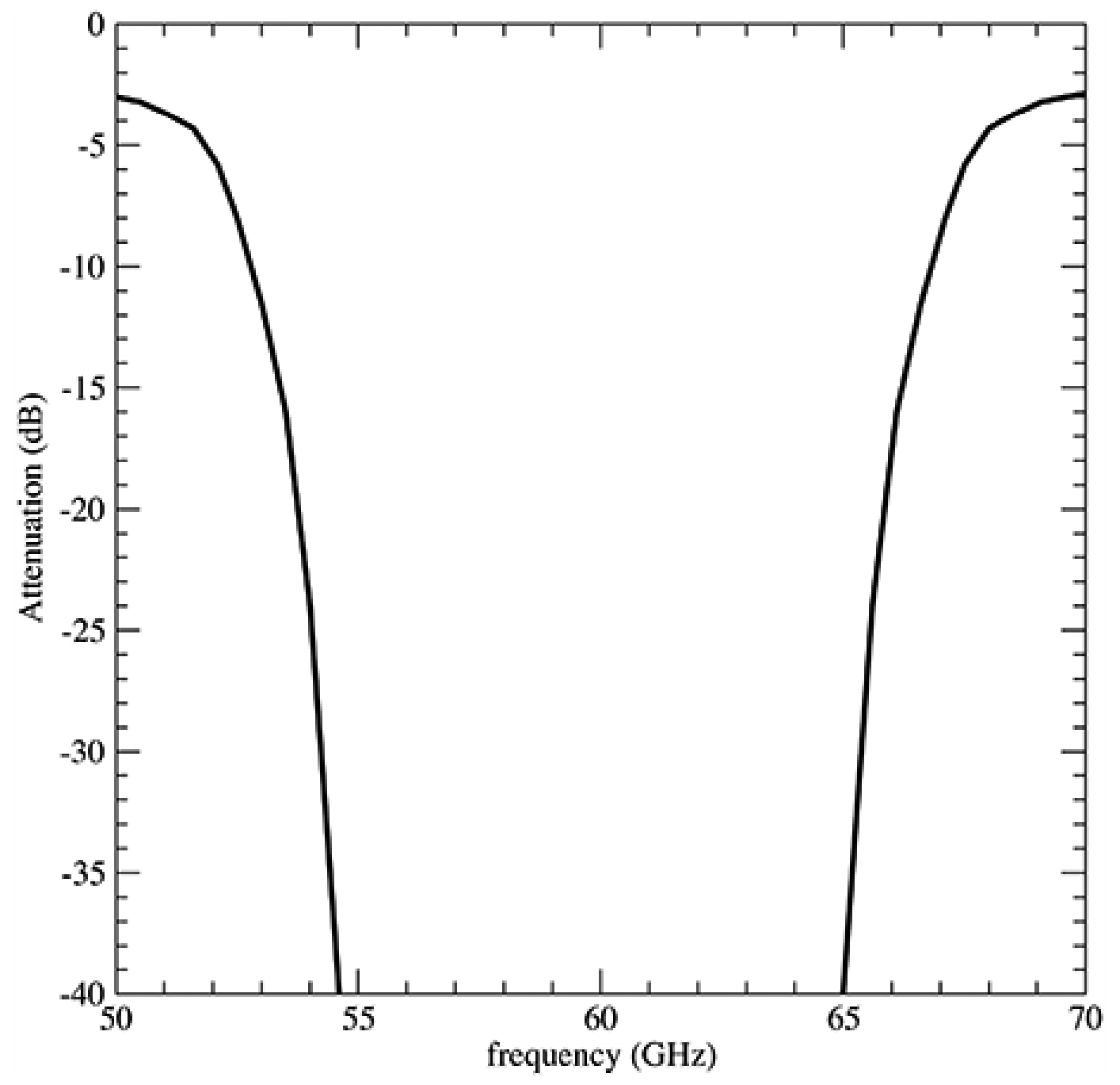


Figure 1: Oxygen absorption line shows significant frequency dependence

Background: Surface pressure is the force per unit area due to the weight of the column of air in the atmosphere above the Earth's surface. Surface pressure is the main driver behind atmospheric dynamics and is important for studying weather forecasting, prediction of strength and path of storms, dry tropospheric delays, which affect radar range measurements for missions like NISAR and SWOT, as well as GPS accuracy. It is the main quantity that relates to the instability of the atmosphere and the main factor in prediction of storm formation and intensification. Surface pressure is one of the most important prognostic variables in meteorology because falling pressure implies that there is an approaching (or developing) storm that will arrive (or intensify) within the immediate future, generally over the next 24 hours. The farther the pressure drops, the stronger the storm. Despite its importance, remote sensing measurements of surface pressure are currently of limited availability and quality. Existing passive techniques to measure surface pressure remotely cannot penetrate clouds and are therefore not useful precisely where this intelligence is needed. The radar presented here will allow the estimation of surface pressure anywhere, under any conditions using differential absorption method.

Approach and Results: Figure 2 shows the system level block diagram. We have characterized all the subassemblies and integrated all the blocks with digital bench top equipment as shown in figure 3. For the lab demonstration and radar validation, we used FODL to simulate a target. Figure 4 (a) shows the reference chirp generated by AWG and figure 4 (b) shows the echo chirp received after propagation through the FODL. Figure 4 (c) shows a peak at 5.2km confirming that the FODL length is 10.4km.In parallel, we have started the development of a RainCube style digital system and a power supply design. Digital system uses a commercial FPGA and a custom designed I/O board that provides ADC, DAC, telemetry, control and communication operations. The additional funding received in the last quarter allowed us to continue the work on the digital system and as a result, we were able to finish the assembly of the I/O board as well as perform preliminary simulations for the FPGA code. Figure 5 shows the custom I/O board.

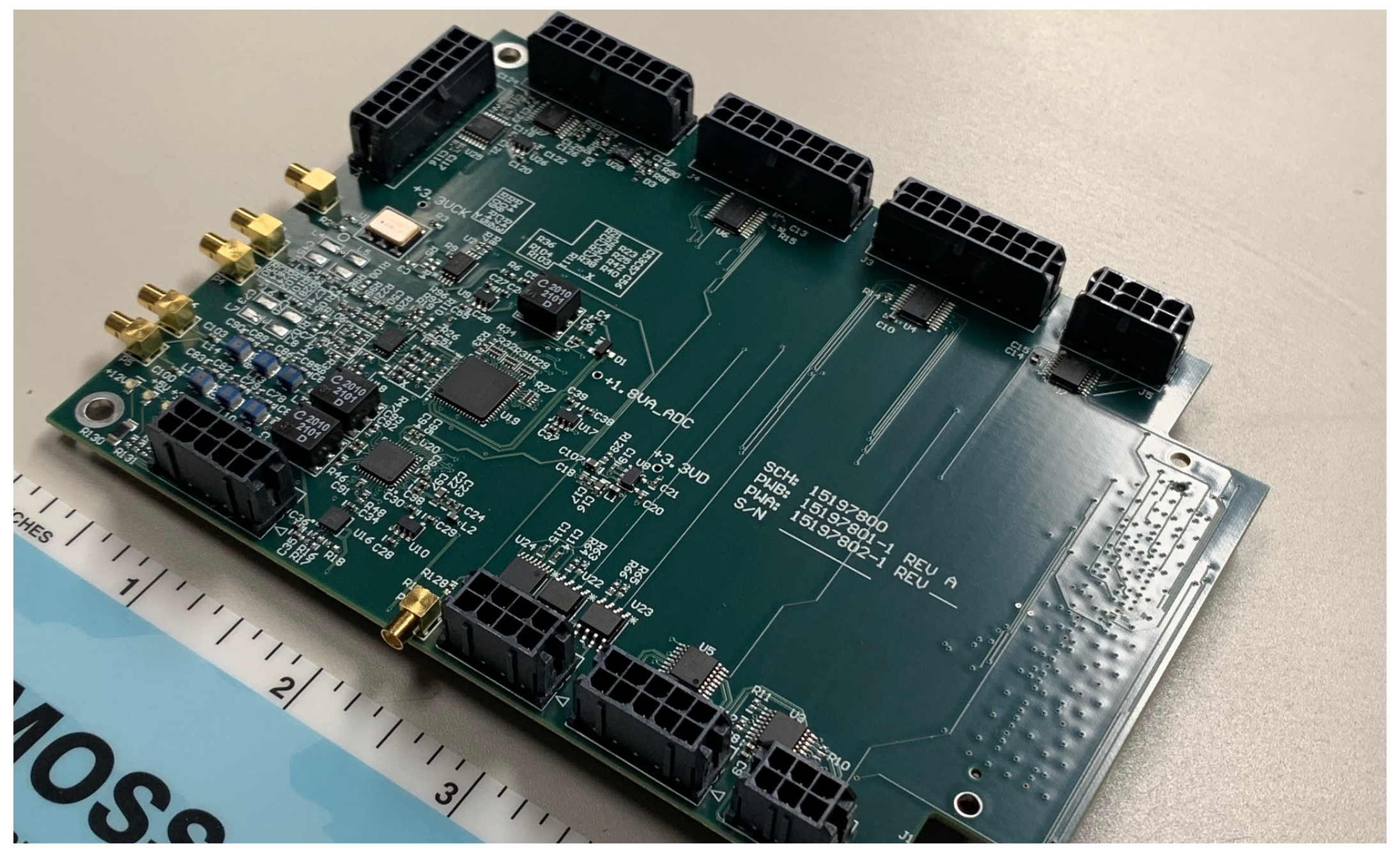


Figure 5: Custom digital I/O board

Significance/Benefits to JPL and NASA: This work positions JPL as the leader in the advanced technology for a new measurement concept making it a disruptive innovation. This work could complement existing and planned cloud and precipitation missions. The inherent low mass and volume architecture of the proposed instrumentation provides many possible avenues to space including future InVEST and Earth Ventures calls. We proposed to the NASA Instrument Incubator program (IIP 2021) to develop the design and technology for a spaceborne instrument that measures surface pressure using an oxygen differential absorption radar named DABAV (Differential Absorption Atmospheric V-band pressure radar), which means pressure in Hindi. DABAV is based on the work presented in this poster and operates over a wide bandwidth (65-70GHz) using a compact architecture that reduces mass, power, size and development time. DABAV, if successful, will do a full design of the instrument, identify and develop key technologies, develop, test an airborne instrument for demonstrating technology and measurement concept, and test the integrated instrument in a relevant environment to achieve TRL 6.

Publications: R. Gawande, Z. Haddad, M. Michalik, M. Taylor, M. Tsai, "Surface pressure sensing radar using V-band", European Microwave Conference, Feb 2022, London, UK (accepted)

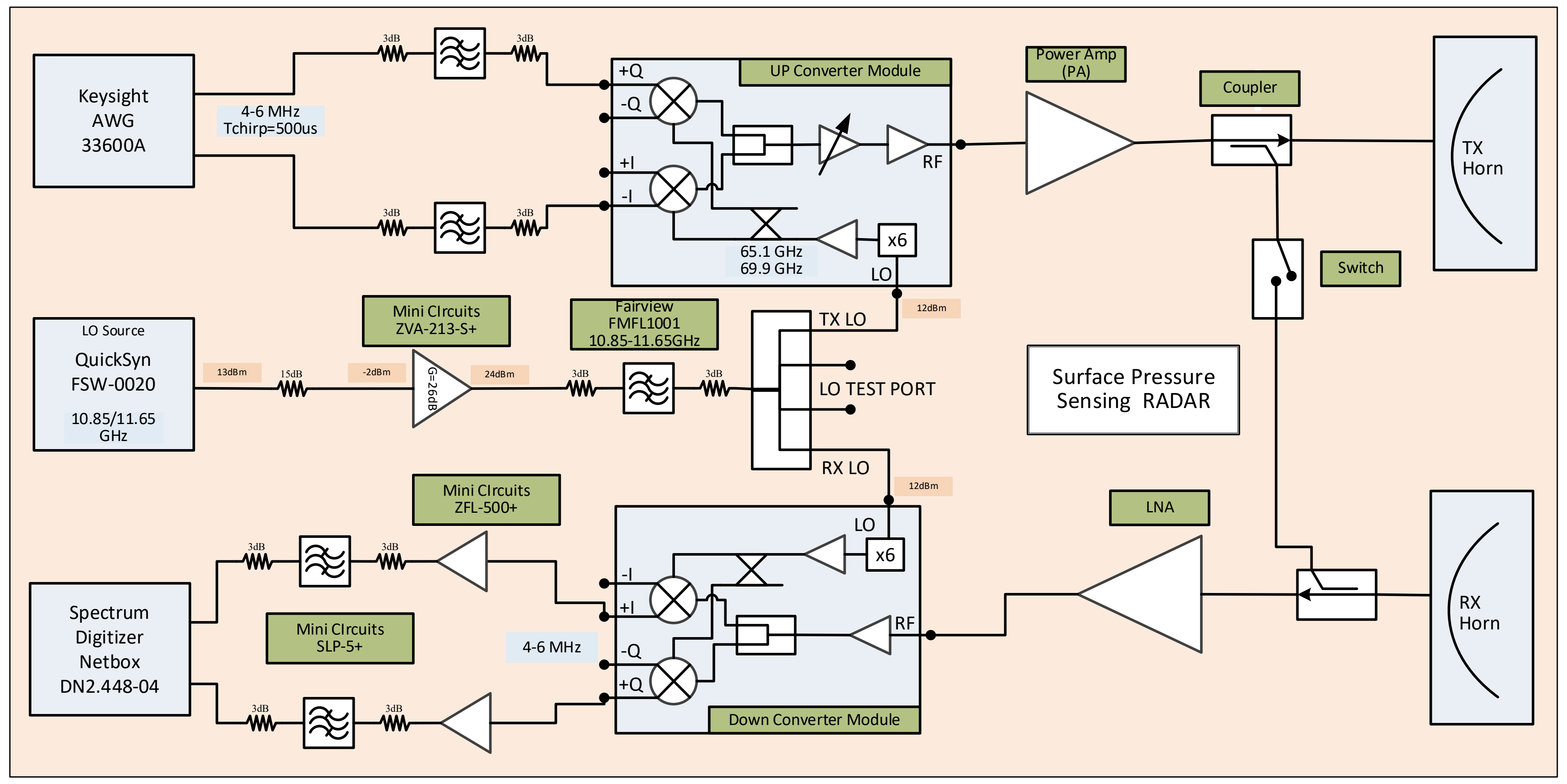


Figure 2: Simplified block diagram showing the V-band radar with bench top digital equipment and single stage up and down conversion

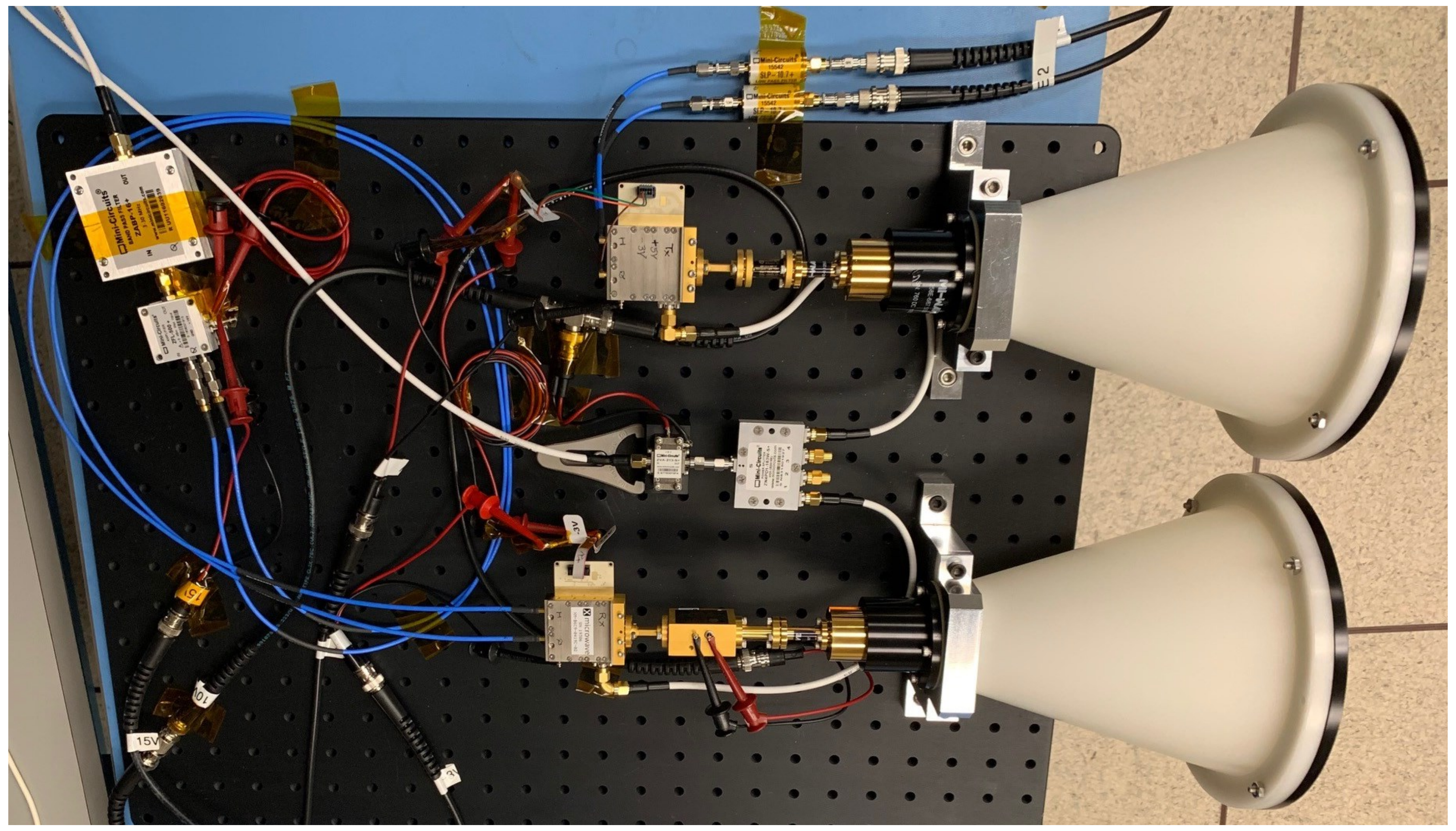
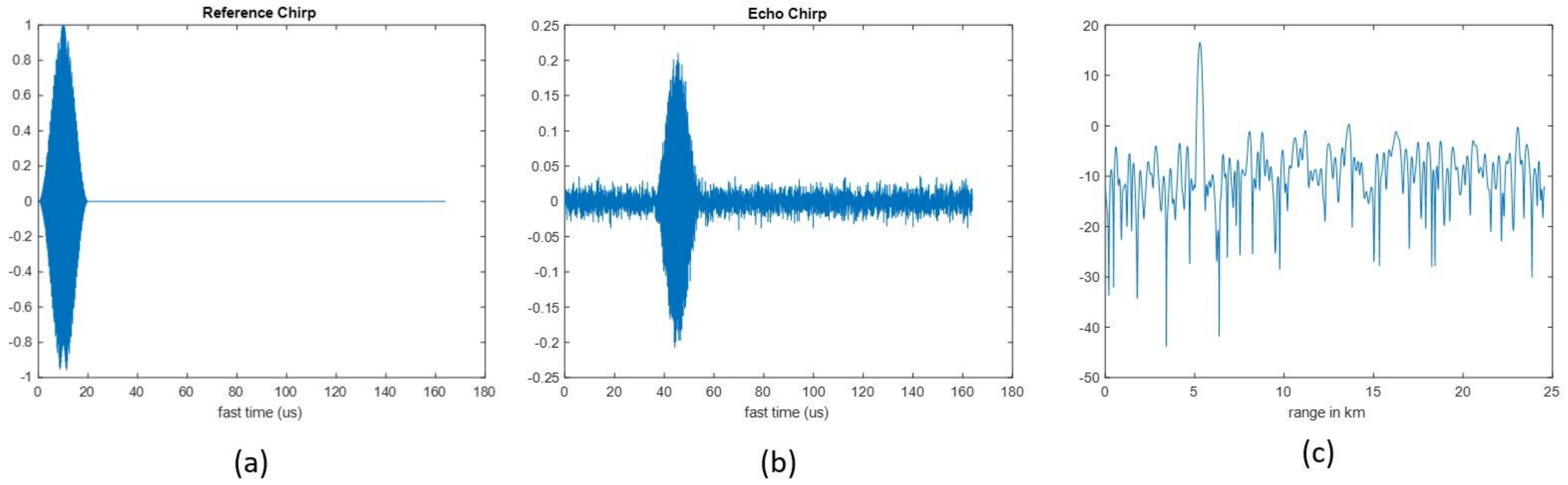


Figure 3: Integration of V-band pressure radar in laboratory setup.



(a) (b) (c)

Figure 4: (a) Reference chirp generated by AWG with Hanning window, (b) Echo chirp received after propagating through the FODL, (c) Compressed pulse shows a range of 5.2km for 10.4km long FODL.

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