High Transmit Power and High Transmit/Receive Isolation in a 183 GHz FMCW Radar

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Improving the measurement of humidity inside upper-tropospheric ice clouds is an important science objective of the meteorological community because of the role these clouds play in the earth's water cycle and radiative balance. A differential radar operating near the strong 183 GHz water vapor absorption line is a promising technique for obtaining range-resolved humidity measurements inside ice clouds. By measuring the relative brightness of ice-particle reflectivity at different frequencies across few-GHz-wide absorption line, the absolute humidity content inside the clouds may be retrieved using the known relationship between atmospheric water vapor attenuation and frequency.

For this purpose we are developing a frequency-modulated continuous-wave (FMCW) radar operational over approximately the 183-193 GHz span that is the upper flank of the atmospheric water absorption line. The FMCW approach allows for high processing gain (i.e., long coherent integration time) to compensate for the lower peak transmit powers available using an all-solid-state radar transmitter, which has been chosen to accommodate small airborne observation platforms with small mass and power payloads.

One challenge of FMCW radar is that, because the transmitter and receiver are operating simultaneously, even low-level signal leakage from the transmitter to the receiver has the potential to carry noise with it that raises the radar's noise figure above its thermal-noise-limited value. Therefore, high-isolation transmit/receive (T/R) architectures are called for. To achieve this, we are developing a monostatic radar at 183 GHz based on our past work in short-range FMCW security radars at 340 and 680 GHz, with high T/R isolation realized through quasioptical circular polarization duplexing. Here we report on measurements of T/R isolation in a 183 GHz FMCW radar test bench, demonstrating extremely high isolation values in the 90±10 dB range. We also show experimentally how, even with these high isolation values, a phase-noise-cancelling RF circuit architecture is necessary to preserve the radar's sensitivity for continuous-wave transmit powers approaching the 1 Watt.

Watt-level CW power at these frequencies is now almost within reach by using state-of-the-art high-power 183 GHz GaAs Schottky diode frequency-multipliers pumped by III-V W-band power amplifiers. Using compact waveguide power-combining techniques, transmit powers exceeding 400 mW have been realized over 180-190 GHz. In this development, testing has revealed the primary importance of suppressing standing wave interactions between the multiple pathways in power-combining modules.