

Microwave Receiver Prototype Development for the Hyperspectral Microwave Atmospheric Sounder (HyMAS)¹

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Recent technology advances have significantly changed the landscape of modern radiometry by enabling miniaturized, low-power, and low-noise radio-frequency receivers operating at frequencies up to 200 GHz. These advances enable the practical use of receiver arrays to multiplex multiple broad frequency bands into many spectral channels. We use the term “hyperspectral microwave” to refer generically to microwave sounding systems with approximately 50 spectral channels or more. We present the design and analysis of the receiver subsystem for the Hyperspectral Microwave Atmospheric Sounder (HyMAS), with focus on the ultra compact Intermediate Frequency (IF) processor module. HyMAS comprises multiple receivers operating near the oxygen absorption line at 118.75GHz and the water vapor absorption line at 183.31GHz. The hyperspectral microwave receiver system will be integrated into a scanhead compatible with the NASA GSFC Conical Scanning Microwave Imaging Radiometer (CoSMIR) airborne system to facilitate demonstration and performance characterization. HyMAS is designed to have a 52-channel hyperspectral microwave receiver subsystem with four temperature sounding bands (two antennas) near 118.75GHz and two moisture sounding bands (one antenna) near 183.31GHz. Both polarizations are measured (although at slightly different IF passbands) to increase the total channel count. Subharmonic mixers will be pumped by phase-locked oscillators, and single-sideband operation will be achieved by waveguide filtering of the lower sideband. Size/volume constraints on the receiver subsystem led to a relatively high IF frequency (18 – 29GHz) to facilitate miniaturization of the IF processor module. Broadband operation over such a relatively high intermediate frequency range is a technical challenge for the front-end receiver systems, and a receiver temperature of approximately 2000-3000K is expected over the receiver bandwidth. The IF channel filters are designed using substrate integrated waveguides (SIW), and are fabricated with low-temperature co-fired ceramic (LTCC) technology. This process allows for a stackable filter design with multiple metal levels and embedded passive components. The SIW filter design was compared to an interdigital filter design, and the SIW filter showed better filter rejection, insertion loss, and shape factor (sharper skirts) at the desired frequency bands. The substrate dielectric constant is relatively high, thus reducing the feature size to facilitate a more compact envelope. In this discourse, we also present measured data for a prototype 9-channel subset of the 52 channel receiver subsystem, which has been fabricated to validate simulation results. The ultra-compact IF processor module is being developed by MIT Lincoln Laboratory and the receiver front-end modules being developed by NASA GSFC.

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