PLSCX Wideband Spectrometer

Team Neon Falcon: Y. Alenezi, N. Golding, S. Lockhart, A. Macanip, R. McConvey M. Munoz
Advisor: Prof. Albin J. Gasiewski
University of Colorado Boulder – Dept. of ECEE

BACKGROUND

The SCX frequency bands are gaining increasing attention, especially from wireless communications companies who are seeking to use 7.125-8.4 GHz in 6G communications. SCX-band frequencies do not penetrate materials as deeply as other traditional radiometry ranges, making these bands useful for obtaining moisture readings from crop or vegetation canopies. As dense deployments in these bands continue to develop, it is desirable to explore within which frequencies radiometry is feasible.

DESIGN OVERVIEW

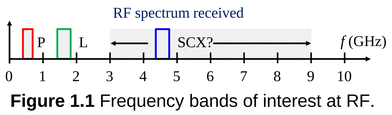

Figure 1.1 Frequency bands of interest at RF.

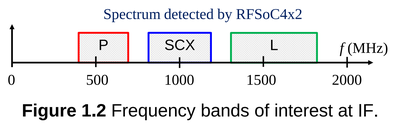

Figure 1.2 Frequency bands of interest at IF.

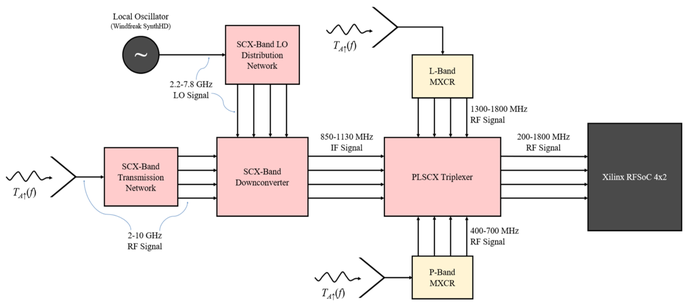

Figure 2 PLSCX Radiometer System Design Block Diagram.

The PLSCX-Band Radiometer is a combination of three MXCR radiometers, each detecting brightness temperature spectra across different bands (Fig 1.1). Each band contains information on the radiation field observed from an associated antenna along with two temperature references. These signals are combined in the ***transmission network*** prior to amplification.

The ***downconverter*** and ***local oscillator distribution board*** amplify, filter and frequency shift the SCX-band signal to the sampling frequency range of the RFSoC. Additional P- and L-band spectra are interleaved (Fig 1.2) using a ***triplexer***. The ***triplexer*** combines all three bands into a single set of four paths. The paths are fed into the ***RFSoC*** where digital signal processing continuously calibrates and estimates radiometric data.

TRANSMISSION NETWORK

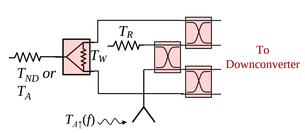

Figure 3. Transmission Network Schematic

The transmission network combines reference temperatures and the antenna temperature with specific phase shifts for use in continuous radiometer calibration. Here two reference signals are used, one being split into two paths.

DOWNCONVERTER

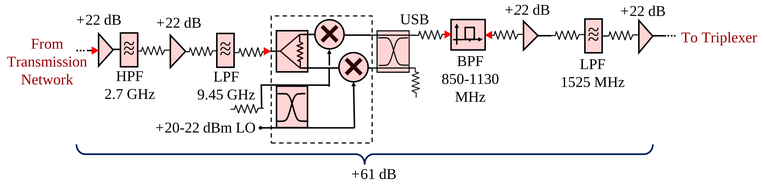

Figure 4. A single SCX downconverter path schematic.

Each downconverter path amplifies, filters, and downconverts the SCX signal prior to combination with the P- and L-band implementations. A series of LNAs amplify the signal in RF, and appropriate filters limit the band to 2.7-9.45 GHz. A coplanar microstrip waveguide routing topology is used to match impedance with component footprints. Attenuators are placed between amplifiers to reduce oscillations and improve match. The signal is tuned with an IQ mixer, and the lower side band (LSB) is rejected via a quad-hybrid and 50 Ω termination with a nominal sideband rejection ratio of -30 dB. The signal is further amplified and filtered in the IF. High gain (+61 dB) is required to amplify the ultraquiet radiometric power levels to detectable levels.

LO DISTRIBUTION

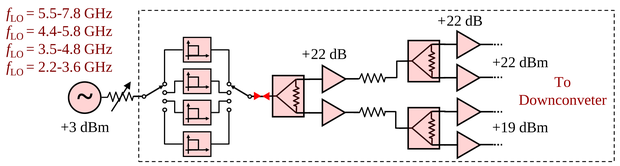

Figure 5. LO Distribution Schematic

The local oscillator signal is split into four paths and amplified to drive the IQ mixers. A switched filter bank is implemented with RF PIN diodes to eliminate higher order harmonics which measured ~15 dB above a given frequency.

TRIPLEXER

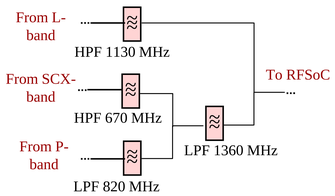

Figure 5. A single triplexer path, combining P- L- and SCX- bands

The triplexer combines the four outputs of the P-, L-, and SCX- front ends using passive elliptical filtering. The output of the triplexer contains information from all three frequency bands from DC to 2 GHz, and is sampled by the RFSoC ADC at the Nyquist rate (Fig 1.2).

MXCR BACKGROUND

Prof. Gasiewski's multi-path cross-correlation radiometry (MXCR) technology is a novel radiometer architecture. Traditional radiometers need to spend time calibrating to estimate unknown receiver gain and offsets, which limits the scene observation time. Through complex cross-correlations between the multiple paths, it is possible to cancel out the unknown receiver path gains in order to solve for the antenna temperature in terms of the reference temperatures. With the MXCR architecture, the calibration is continuously performed with the antenna temperature measurements.

WHAT'S NEXT?

In future revisions, the PLSCX-band radiometer prototype will be consolidated to a single board and flown on an airborne mission within ***NASA's Frontline Of Rapidly Transforming Ecosystems (FORTE)*** to study the artic coastline of Alaska.

ACKNOWLEDGEMENTS

We would like to thank Professor Bogatin, Professor Gasiewski, Mohit Bhat, Aravind Venkitasubramony, Michael Marques, and all previous and current CET researchers who made our work possible.

Additionally, we would like to acknowledge Mini-Circuits and Analog Devices for providing complimentary components, and Sierra Circuits for providing complimentary PCB fabrication and assembly.