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SYSTEM ARCHITECTURE FOR A COMPACT, LOW-COST 56-92 GHZ SPACE BASED SOLAR EVENT OBSERVATION INSTRUMENT

Abstract

This paper presents a comparison of two different system architectures, from the receiver antennas to digitisation, for a compact, space based, low cost, mm wave sun observation instrument. A space based instrument reduces the atmospheric attenuation and mm-wave signal scattering challenges faced by ground based observatories, increases the instrument's time on target, and allow for wider field of view exposure to the sun.

Double down-conversion and single down-conversion superheterodyne receivers are evaluated based on system dynamic range, receiver sensitivity and system noise figure. Simulation models are constructed using the performance parameters of commercial off-the-shelf (COTS) components, as well as state of the-art (SOTA) components in literature where suitable commercial components are not available. Furthermore, to meet CubeSat requirements of light weight and low cost, only surface mountable components suitable for hybrid system integration on commercial soft substrates are considered, ruling out conventional machined waveguide components.

Detailed system simulation results that take into account contributions of phase noise, nonlinear harmonics and intermodulation products, and thermal noise are presented. Consequently, it is indicated that a continuous front-end bandwidth of 56 to 92 GHz is feasible using COTS and SOTA components, if divided into four down-conversion channels i.e. 56-65, 65-74 74-83 and 83-92 GHz, with the first stage down-conversion IF bands at 7-16, 16-25, 25-34 and 34-43 GHz and a common second down-conversion IF band of 200 MHz around 5 GHz. The system incorporates a 2-38 GHz frequency synthesizer to select 72 frequency points over 36 GHz signal bandwidth with frequency resolution of 0.5 GHz. Average power over the 200 MHz band is determined through log detection, and the subsequent DC output signal is digitized continuously at a symbol rate of 148 Mbaud.

The double conversion architecture has an average dynamic range of 42 dB in each channel, as opposed to 31 dB for single down-conversion system where the 7-43 GHz down-conversion stage is omitted. The latter also exhibits saturation in some of the channel above -40 dBm input power. Furthermore, the double down-conversion system has a lower sensitivity threshold of is $5.34\text{x}10^{-4}$ mW/m^2 opposed to $5.34\text{x}10^{-6}$ mW/m^2 for the single down-conversion system. The average system noise temperature of single down-conversion is 769°K which is 90.9°K less than double down-conversion's noise temperature at 5 GHz.

Index Terms—noise figure, baseband, dynamic range, millimetre waves, flares, sun spot, solar wind, corona mass ejection, acceleration of particles.