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A LOW-POWER CMOS LOW NOISE AMPLIFIER FOR SPACE-BASED LOW-FREQUENCY RADIO ASTRONOMY

Abstract

In modern radio astronomy, new science drivers have recently emerged for observation of low-frequency radio waves, below 30 MHz. Due to the atmospheric opacity and man-made interferers, exploring this frequency band requires a space-based radio telescope with a very large aperture that is impossible to realize in a monolithic fashion. Therefore, a distributed system consisting of a swarm of 50 or more nanosatellites is proposed in the OLFAR (orbiting low-frequency antennas for radio astronomy) project to realize such an instrument. Each of the OLFAR satellites will contain at least a single science antenna and subsequently the OLFAR array will comprise of a large number of receivers. In conventional radio telescopes, which typically consist of only a few receivers, expensive GaAs or InP cryogenically cooled HEMT transistors are used to implement the low-noise amplifier (LNA). HEMT transistors are capable of achieving excellent noise figures and have dominated the field of radio astronomy. However, due to the large number of nanosatellites used in OLFAR, less expensive, integrated nanometer CMOS technologies are more attractive to be used in LNAs implementations. Although there exist many critical design challenges at low-frequencies which must be carefully considered such as the required signal-to-noise ratio (SNR), noise figure, linearity and area to be used in cube-satellites. In this paper, a novel CMOS-based integrated LNA is designed, analyzed and implemented to be used in the OLFAR project. The amplifier has 0.45 dB noise figure while consuming 45mW of power from a 1.8-V supply voltage and achieves output P1dB of -5.5dBm and output IP3 of 7dBm with the gain (S21) ranging from 21dB to 16.1dB across the OLFAR band (i.e., 0.3MHz-30MHz). The LNA represents one of the first CMOS designs that satisfies the very demanding requirements of low-frequency radio telescopes.