Ultra Low Noise S-Band LNA for Deep Space Communication

Andrew W. Janzen(1)
(1) Jet Propulsion Laboratory, Pasadena, CA, 91106

Deep space communication requires the use of very low noise amplifying devices. To achieve these low noise temperatures, front end electronics are usually cooled cryogenically to below 20K physical temperature. Silicon Germanium (SiGe) transistors have been shown to operate reliably in this temperature range and can have competitive noise performance with HEMT transistors for operation below 10 GHz. (J. Bardin, Phd Thesis; S. Weinreb, et al., IEEE Vol 55, No 11). Much of the work on silicon germanium cryogenic amplifiers has been pioneered at Caltech in the Microwave Research Group (E. Bryerton, et al. Ultra Low Noise Cryogenic Amplifiers for Radio Astronomy) and further work is in progress at JPL to develop a SiGe amplifier with a goal of achieving 2 K noise temperature at 2.2-2.3 GHz. Simulation results in Microwave Office indicate that the amplifier should be able to achieve 2 K at .5 GHz and 2.3 K at 2.3 GHz. The design under consideration is comprised of a two-stage SiGe amplifier, with the first stage utilizing ST Microelectronics 55nm transistors and the second stage utilizing commercial SiGe transistors from NXP Semiconductors. Both transistor types have shown excellent noise performance below 20 Kelvin physical temperature.

The circuit design draws on circuit techniques utilized in amplifiers at Caltech (S. Weinreb et al. Matched wideband low-noise amplifiers for radio astronomy), a circuit design utilized by Joe Bardin in his Thesis (Bardin PhD Thesis, p155), and an application note from Philips Semiconductors (Philips Semiconductor, 2.4 GHz low noise amplifier with the BFG480W). All of these designs utilize resistive feedback from the collector to the base, which effectively biases the transistor at a near optimal bias regardless of operating temperature. There is a tradeoff when choosing the value of this feedback resistance, as lower resistance values improve input matching, but also degrade noise performance. Simulation results indicate that to achieve lowest noise performance either gain flatness or matching at the input and output is sacrificed. Results presented will include test results on a measured S-band amplifier and a discussion of relevant noise measurement methods for extremely low noise amplifiers. It is believed that this amplifier may find other applications in quantum computing and radio astronomy.