1.9 THz 4-Pixel Heterodyne Array Receiver

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We are developing a 16-pixel 1.9 THz superconducting receiver module for future balloon and aircraft instruments. Towards achieving this goal, we have developed a 4x1-pixel heterodyne receiver system. This array uses a 4x1-pixel multiplier chain for the local oscillator (LO) and a matching 4x1-pixel feedhorn array with hot electron bolometer (HEB) mixers, coupled weakly through a free-standing wire-grid. Simultaneous pumping of mixers is verified through I-V curves with sensitivities of ~850 K. This design can be extended into larger arrays, ultimately 4x4 or possibly larger by stacking the 4x1 LO and mixer modules, and the approach can be scaled in size to create arrays at other THz frequencies.

The receiver consists of a 4x1-pixel multiplier chain and a corresponding 4x1-pixel feedhorn focal plane unit (FPU) housing the HEB mixers. In the laboratory setup, the 4x1-pixel LO [1] is injected quasioptically via a polarizer grid and reimaged with two parabolic mirrors onto the FPU. The first mirror sits outside a liquid cryostat and the second mirror is bolted to the 4 K plate inside the cryostat. The HEB mixer block is also bolted to the 4 K plate and connected to low noise amplifiers (LNAs) via semi-rigid coax with GPO connectors. The first stage low-noise amplifiers are also in thermal contact with the 4 K plate. Each HEB is constructed from a niobium nitrate (NbN) bridge and a bowtie antenna on a silicon-on-insulator (SOI) chip [2]. These chips are inserted into individual waveguide circuit and then placed into the 4x1-pixel mixer block.

The local oscillator [1] takes input from a Ka-band synthesizer and through a series of amplification and frequency multiplication stages ultimately produces power from four output horns at 1.9 THz. Each LO pixel is designed to output a minimum of 10 μW of power, which provides sufficient power to pump each of the 4 HEB mixers with a 10% beam splitter. The output power from each output can be controlled electronically by using the diode bias.

The backend electronics have a 1-2 GHz IF passband and fed to digital spectrometers and microwave detectors, which are used to complete Y-factor measurements. A computer-controlled bias system scheme has the capability to both set the bias voltages on the LO and HEBs and read back the bias voltages and currents from the HEBs, thus enabling active local oscillator level trimming for each pixel critical to the operation of stable HEB-based receivers.

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