Physical Sciences

Laser-Ranging Transponders for Science Investigations of the Moon and Mars

NASA's Jet Propulsion Laboratory, Pasadena, California

An active laser was developed ranging in real-time with two terminals, emulating interplanetary distances, and with submillimeter accuracy. In order to overcome the limitations to ranging accuracy from jitters and delay drifts within the transponders, architecture was proposed based on asynchronous paired one-way ranging with local references. A portion of the transmitted light is directed, via a reference path, to the local detector. This allows for compensation of any jitter in the timing of the emitted laser pulse. The same detector is used to measure the time of the received pulses emitted from the remote terminal. This approach removes any change in the delay caused by the detector or its electronics.

Two separate terminals using commercial off-the-shelf hardware were built to emulate active laser ranging over interplanetary distances. The communication link for the command to start recording pulse arrival times and data transfer from one terminal to the other was achieved using a standard wireless link, emulating free space laser communication. The deviation is well below the goal of 1-mm precision. This leaves enough margin to achieve 1-mm precision when including the fluctuations due to atmospheric turbulence while ranging to Mars through the Earth's atmosphere. The two terminals are mounted on translation stages, which can be moved freely on rails to yield a wide range of distances with fine adjustment. The two terminals were separated by approximately 16 meters.

This work was done by Hamid Hemmati, Yijiang Chen, and Kevin Birnbaum of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48125

Ka-Band Waveguide Three-Way Serial Combiner for MMIC Amplifiers

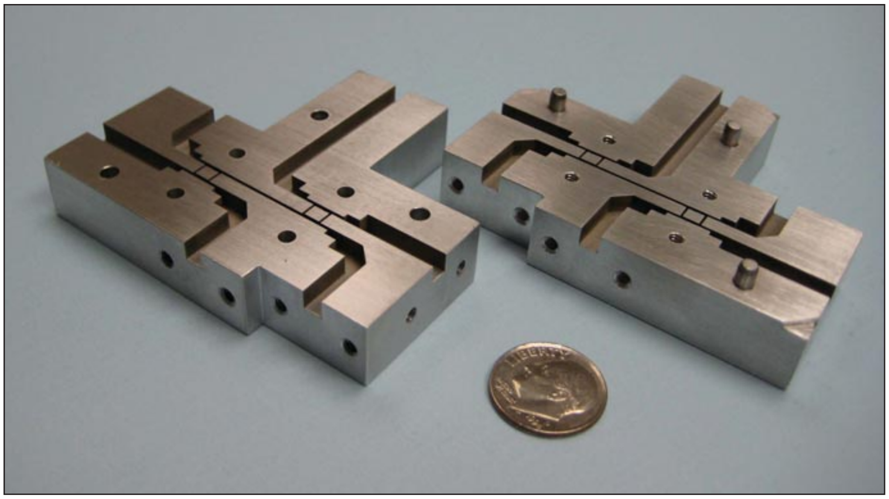
This device is a power combiner that can be used for a solid-state power amplifier.

John H. Glenn Research Center, Cleveland, Ohio

In this innovation, the three-way combiner consists internally of two branch-line hybrids that are connected in series by a short length of waveguide. Each branch-line hybrid is designed to combine input signals that are in phase with an amplitude ratio of two. The combiner is constructed in an E-plane split-block arrangement and is precision machined from blocks of aluminum with standard WR-28 waveguide ports. The port impedances of the combiner are matched to that of a standard WR-28 waveguide. The component parts include the power combiner and the MMIC (monolithic microwave integrated circuit) power amplifiers (PAs). The three-way series power combiner is a six-port device. For basic operation, power that enters ports 3, 5, and 6 is combined in phase and appears at port 1. Ports 2 and 4 are isolated ports. The application of the three-way combiner for combining three PAs with unequal output powers was demonstrated.

NASA requires narrow-band solid-state power amplifiers (SSPAs) at Ka-band frequencies with output power in the range of 3 to 5 W for radio or gravity science experiments. In addition, NASA also requires wideband, high-efficiency SSPAs at Ka-band frequencies with output power in the range of 5 to 15 W for high-data-rate communications from deep space to Earth. The three-way power combiner is designed to operate over the frequency band of 31.8 to 32.3 GHz, which is NASA's deep-space frequency band.

For the proof-of-concept demonstration of this innovation, three available PAs were selected with output powers of 0.1, 0.2, and 0.6 W to meet the ampli-



This photo of the fabricated **Serial Combiner** shows the split-block construction arrangement.