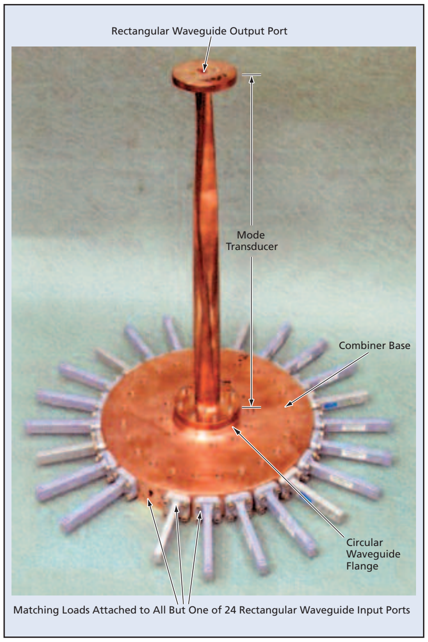
24-Way Radial Power Combiner/Divider for 31 to 36 GHz

A unique design affords high bandwidth with high order of combining.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure shows a prototype radial power-combining waveguide structure, capable of operation at frequencies from 31 to 36 GHz, that features an unusually large number ($N = 24$) of combining (input) ports. The combination of wide-band operation and large N is achieved by incorporating several enhancements over a basic radial power-combiner design. In addition, the structure can be operated as a power divider by reversing the roles of the input and output ports.



This **Power Combiner** contains 24 internal reduced-height radial waveguides with impedance-transforming height and width steps, plus an internal central matching post.

In this structure, full-height waveguides at the combining ports are matched in impedance to reduced-height radial waveguides inside the combiner base. This match is effected by impedance-transforming stepped waveguide sections. This matching scheme is essential to achievement of large N because N is limited by the height of the waveguides in the base.

Power is coupled from the 24 reduced-height radial waveguides into the TE_{01} mode of a circular waveguide in the base with the help of a matching post at the bottom of the base. ("TE" signifies "transverse electric," the first subscript is the azimuthal mode number, and the second subscript is the radial mode number.) More specifically, the matching post matches the reflections from the walls of the 24 reduced-height waveguides and enables the base design to exceed the bandwidth requirement.

After propagating along the circular waveguide, the combined power is coupled, via a mode transducer, to a rectangular waveguide output port. The mode transducer is divided into three sections, each sized and shaped as part of an overall design to satisfy the mode-conversion and output-coupling requirements while enabling the circular waveguide to be wide enough for combining the 24 inputs over the frequency range of 31 to 36 GHz. During the design process, it was found that two different rectangular waveguide outputs could be accommodated through modification of only the first section of the mode converter, thereby enabling operation in multiple frequency ranges.

This work was done by Larry Epp, Daniel Hoppe, Abdur Khan, and Daniel Kelley of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Three-Stage InP Submillimeter-Wave MMIC Amplifier

Submillimeter-wave amplifiers can enable more sensitive receivers for earth science, planetary remote sensing, and astrophysics telescopes.

NASA's Jet Propulsion Laboratory, Pasadena, California

A submillimeter-wave monolithic integrated-circuit (S-MMIC) amplifier has been designed and fabricated using an indium phosphide (InP) 35-nm gate-length high electron mobility transistor (HEMT) device, developed at Northrop Grumman Corporation. The HEMT device employs two fingers each 15 micrometers wide. The HEMT wafers are grown by molecular beam epitaxy (MBE) and make use of a pseudomorphic $In_{0.75}Ga_{0.25}As$ channel, a silicon delta-doping layer as the electron supply, an $In_{0.52}Al_{0.48}As$ buffer layer, and an InP substrate. The three-stage design uses coplanar waveguide topology with a very narrow ground-to-ground spacing of 14 micrometers. Quarter-wave matching transmission lines, on-chip metal-insulator-metal shunt capacitors, series thin-film resistors, and matching stubs were used in the design. Series resistors in the shunt branch arm provide the basic circuit stabilization. The S-MMIC amplifier was measured for S-parameters and found to be centered at 320 GHz with 13–15-dB gain from 300–345 GHz.

This chip was developed as part of the DARPA Submillimeter Wave Imaging Focal Plane Technology (SWIFT) program (see figure). Submillimeter-wave amplifiers could enable more sensitive receivers for earth science, planetary remote sensing, and astrophysics telescopes, particularly in radio astronomy, both from the ground and in space. A small atmospheric window at 340 GHz exists and could enable ground-based observations. However, the submillimeter-wave regime (above 300 GHz) is best used for space telescopes as Earth's atmosphere attenuates most of the signal through water and oxygen absorption. Future radio