Power-Amplifier Module for 145 to 165 GHz

This module represents the highest frequency solid-state power amplifier to date.

NASA's Jet Propulsion Laboratory, Pasadena, California

A power-amplifier module that operates in the frequency range of 145 to 165 GHz has been designed and constructed as a combination of (1) a previously developed monolithic microwave integrated circuit (MMIC) power amplifier and (2) a waveguide module. The amplifier chip was needed for driving a high-electron-mobility-transistor (HEMT) frequency doubler. While it was feasible to connect the amplifier and frequency-doubler chips by use of wire bonds, it was found to be much more convenient to test the amplifier and doubler chips separately. To facilitate separate testing, it was decided to package the amplifier and doubler chips in separate waveguide modules. Figure 1 shows the resulting amplifier module.

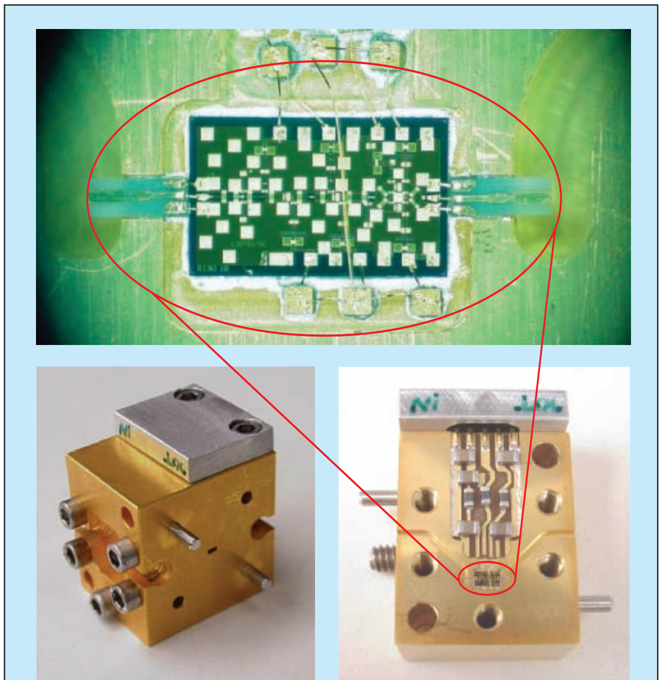

Figure 1. The **Amplifier Is Packaged** in a WR5 waveguide module, with electric-field-plane alumina probes to interface the chip to the waveguide, and bypass capacitors to suppress low-frequency oscillations. The module is compact and can easily be integrated into a test system or with wafer probes.

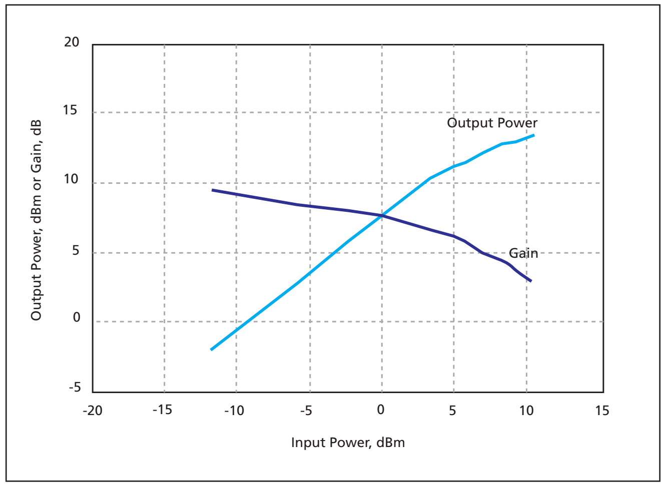

Figure 2. **Output Power and Gain** at 150 GHz were measured as functions of input power. The output power exhibited saturation at 13 dBm.

The amplifier chip was described in "MMIC HEMT Power Amplifier for 140 to 170 GHz" (NPO-30127), *NASA Tech Briefs*, Vol. 27, No. 11, (November 2003), page 49. To recapitulate: This is a three-stage MMIC power amplifier that utilizes HEMTs as gain elements. The amplifier was originally designed to operate in the frequency range of 140 to 170 GHz. The waveguide module is based on a previously developed lower frequency module, redesigned to support operation in the frequency range of 140 to 220 GHz.

Figure 2 presents results of one of several tests of the amplifier module — measurements of output power and gain as functions of input power at an output frequency of 150 GHz. Such an amplifier module has many applications to test equipment for power sources above 100 GHz.

This work was done by Lorene Samoska and Alejandro Peralta of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).NPO-40260*

Aerial Videography From Locally Launched Rockets

Images of an event or scene are rapidly collected, processed, and displayed.

Stennis Space Center, Mississippi

A method of quickly collecting digital imagery of ground areas from video cameras carried aboard locally launched rockets has been developed. The method can be used, for example, to record rare or episodic events or to gather image data to guide decisions regarding treatment of agricultural fields or fighting wildfires.

The method involves acquisition and digitization of a video frame at a known time along with information on the position and orientation of the rocket and camera at that time. The position and orientation data are obtained by use of a Global Positioning System receiver and a digital magnetic compass carried aboard the rocket. These data are radioed to a ground station, where they are processed, by a real-time algorithm, into georeferenced position and orientation data. The algorithm also generates a file of transformation parameters that account for the variation of image magnification and distortion associated with the position and orientation of the camera relative to the ground scene depicted in the image. As the altitude, horizontal position, and orientation of the rocket change between image frames, the algorithm calculates the corresponding new georeferenced position and orientation data and the associated transformation parameters.

The output imagery can be rendered in any of a variety of formats. The figure presents an example of one such format.

This work was done by Stacey D. Lyle of Conrad Blucher Institute for Surveying and Science at Texas A&M University—Corpus Christi for **Stennis Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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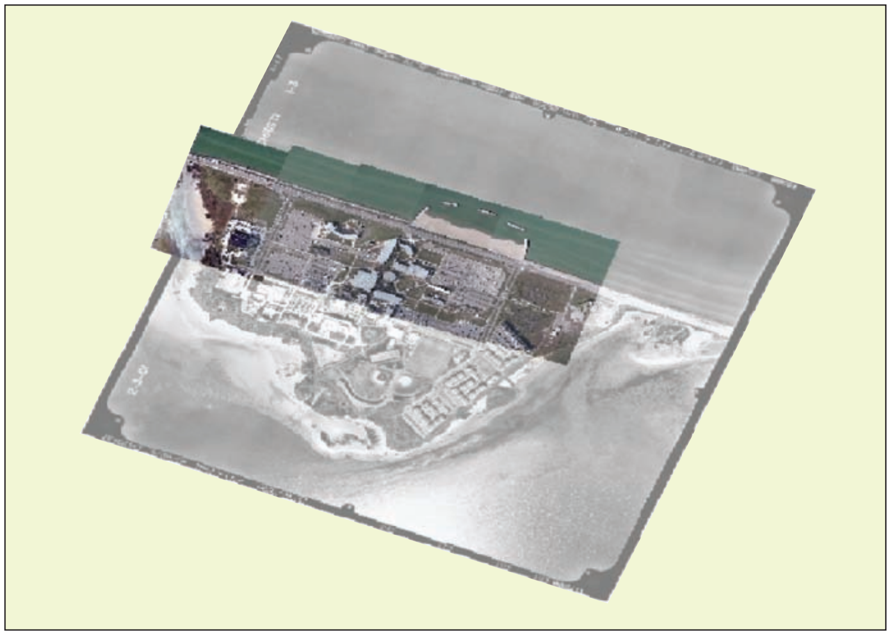
Refer to SSC-00214-1, volume and number of this NASA Tech Briefs *issue, and the page number.*



A **Digitized, Transformed Image** acquired from a video camera aboard a rocket was superimposed on a scan of an aerial image of a larger area that contains most of the video-image scene.

SiC Multi-Chip Power Modules as Power-System Building Blocks

Fault-tolerant power-supply systems could be constructed and expanded relatively inexpensively.

John H. Glenn Research Center, Cleveland, Ohio

The term "SiC MCPMs" (wherein "MCPM" signifies "multi-chip power module") denotes electronic power-supply modules containing multiple silicon carbide power devices and silicon-on-insulator (SOI) control integrated-circuit chips. SiC MCPMs are being developed as building blocks of advanced expandable, reconfigurable, fault-tolerant power-supply systems. Exploiting the ability of SiC semiconductor devices to operate at temperatures, breakdown voltages, and current densities significantly greater than those of conventional Si devices, the designs of SiC MCPMs and of systems comprising multiple SiC MCPMs are expected to afford a greater degree of miniaturization through stacking of modules with reduced requirements for heat sinking. Moreover, the higher-temperature capabilities of SiC MCPMs could enable operation in environments hotter than Si-based power systems can withstand.

The stacked SiC MCPMs in a given system can be electrically connected in series, parallel, or a series/parallel combination to increase the overall power-handling capability of the system. In addition to power connections, the modules have communication connections. The SOI controllers in the modules communicate with each other as nodes of a decentralized control network, in which no single controller exerts overall command of the system. Control functions effected via the network include synchronization of switching of power devices and rapid reconfiguration of power connections to enable the power system to continue to supply power to a load in the event of failure of one of the modules.

In addition to serving as building blocks of reliable power-supply systems, SiC MCPMs could be augmented with external control circuitry to make them perform additional power-handling functions as needed for specific applications: typical functions could include regulating voltages, storing energy, and driving motors. Because identical SiC MCPM building blocks could be utilized in a variety of ways, the cost and difficulty of designing new, highly reliable power systems would be reduced considerably.

Several prototype DC-to-DC power-converter modules containing SiC power-switching devices were designed and built to demonstrate the feasibility of the SiC MCPM concept. In anticipation of a future need for operation at high temperature, the circuitry in the modules includes high-temperature inductors and capacitors. These modules were designed to be stacked to construct a system of four modules electrically connected in series and/or parallel.

The packaging of the modules is designed to satisfy requirements for series and parallel interconnection among modules, high power density, high thermal efficiency, small size, and light weight. Each module includes four output power connectors — two for serial and two for parallel output power connections among the modules. Each module also includes two signal connectors, electrically isolated from the power connectors, that afford four zones for signal interconnections among the SOI controllers. Finally, each module includes two input power connectors, through which it receives power from an in-line power bus. This design feature is included in anticipation of a custom-designed power bus incorporating sockets compatible with "snap-on" type connectors to enable rapid replacement of failed modules.

The distributed control hardware and software enable power conversion to continue uninterrupted when as many as two