evant MIL-STD-1553 specifications, including those that pertain to response times and data formats. The bus network extender can also insert simulated or table-driven data addressed to any bus controller (BC) or remote-terminal (RT)/support-area (SA) network combination.

In a system under test, subsystems connected at a local site are connected to the bus network extender. After the connection is made, the output of a remote bus controller mimics the activity of the bus controller at the local site and can be configured to operate with multiple remote sites. The entire bus network is then controlled by a workstation coupled at the local site. The configuration of the bus network extender is controlled by a single text file that is created by the user and that can be modified at the local site.

In order to extend a network, the bus network extender effects a logical sequence of events. The BC (either simulated or hardware in the loop) first sends a MIL-STD-1553 message to the RT. The RT passes the message to a central processing unit (CPU). A master CPU reads the message and transmits an Ethernet (or equivalent) MIL-STD-1553 message to a slave CPU, which receives the message and begins building a MIL-STD-1553 BC message chain. The slave CPU then sends the MIL-STD-1553 message to the RT via BC hardware, a response to the message is received by the BC hardware, and the CPU is notified. After notification, a slave CPU returns the MIL-STD-1553 message response to the master CPU over the Internet. If the message is a "transmit" message, the master CPU fills the destination RT data buffer with response data. Finally, new data become available to the hardware-in-the-loop or simulated BC.

The bus network extender also provides the following:

- An RT/SA address can be mapped to a different RT/SA on the remote RT to avoid having to change jumpers or reprogram an address.
- The system can be set to respond to some SAs by simulating other SAs. This capability enables testing even when some sensors or devices on a remote unit under test are unavailable.
- Multiple MIL-STD-1553 buses can operate simultaneously.
- Common configuration files can be used to control and document the interfaces to the bus-network-extender interfaces.
- Responses to MIL-STD-1553 messages can be generated in real time.
- It is possible to perform byte swapping for computers or firmware controllers that are based on different processor architectures.

Performance depends on the type of communication channel used to connect local and remote sites. In a compromise, commands are buffered by the bus network extender and appear, at least to the BC, to satisfy response-time requirements. However, data supplied by the bus network extender to the BC are transmitted from one or more frame times in the past. The system thus operates correctly with respect to protocol and timing but is subject to a delay in data content ranging from tens of milliseconds to seconds. Such delays result from finite signal-propagation speed and are unavoidable. Notwithstanding such delays, the bus network extender is well suited for protocol and interface integration testing, even on slower links. On faster links, some systems equipped with the extender can cycle MIL-STD-1553 frames at full speed, subject to only inevitable data delays. Some systems equipped with bus network extenders may seem to operate in real time on high-speed links.

The bus network extender is equipped with utility software that, upon command, displays the status of all BCs, remote transmission queues, and RT message queues. The software also provides a configuration file for all connected systems to provide error-free configuration at all locations, a configuration file that contains an entire system interface control document, and an input file that performs extensive error checking. Since slave BCs are configured automatically, remote configuration data are totally eliminated when remote simulations are not required. Should a slave network server be unreachable, the extender attempts to reestablish network connections automatically while maintaining adherence to real-time-response requirements for all MIL-STD-1553 messages.

This work was done by Julius Marcus and T. David Hanson of GeoControl Systems, Inc., for **Johnson Space Center**. *For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*

MSC-22741

MMIC HEMT Power Amplifier for 140 to 170 GHz

Circuits like this one could be useful in radiometers for probing the atmosphere.

NASA's Jet Propulsion Laboratory, Pasadena, California

Figure 1 shows a three-stage monolithic microwave integrated circuit (MMIC) power amplifier that features high-electron-mobility transistors (HEMTs) as gain elements. This amplifier is designed to operate in the frequency range of 140 to 170 GHz, which contains spectral lines of several atmospheric molecular species plus subharmonics of other such spectral lines. Hence, this amplifier could serve as a prototype of amplifiers to be incorporated into heterodyne radiometers used in atmospheric science. The original intended purpose served by this amplifier is to boost the signal generated by a previously developed 164-GHz MMIC HEMT doubler [which was described in "164-GHz MMIC HEMT Frequency Doubler" (NPO-21197), *NASA Tech Briefs*, Vol. 27, No. 9 (September 2003), page 48.] and drive a 164-to-328-GHz doubler to provide a few milliwatts of power at 328 GHz.

The first two stages of the amplifier contain one HEMT each; the third (output) stage contains two HEMTs to maximize output power. Each HEMT is characterized by gate-periphery dimensions of 4 by 37 µm. Grounded coplanar waveguides are used as impedance-matching input, output, and interstage-coupling transmission lines.

The small-signal *S* parameters and the output power (for an input power of about 5 dBm) of this amplifier were measured as functions of frequency. For the small-signal gain measurements, the amplifier circuit was biased at a drain potential of 2.5 V, drain current of 240 mA, and gate potential of 0 V. As shown in

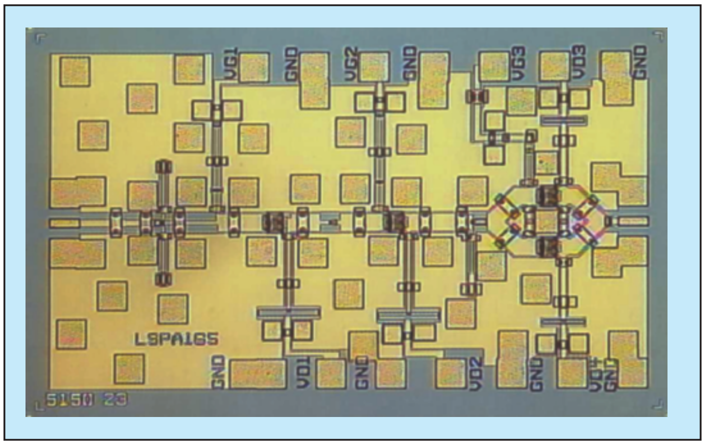


Figure 1. This **Three-Stage MMIC HEMT Amplifier** occupies a chip area with dimensions of 1.1 by 1.9 mm.

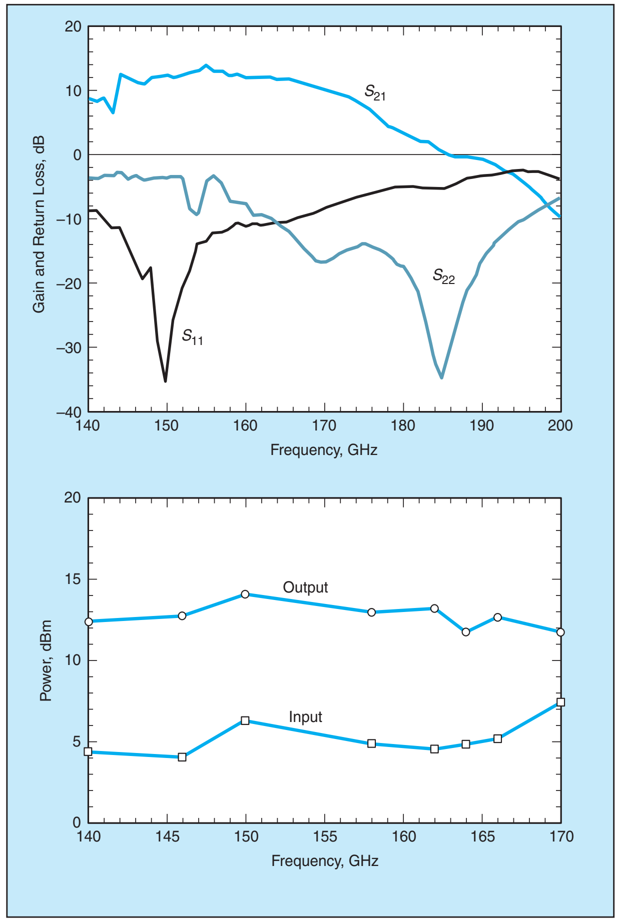


Figure 2. The **Small-Signal *S* Parameters and Power Output** of the amplifier were measured over its design frequency range.

the upper part of Figure 2, the small-signal gain (S_{21}), was found to be >10 dB from 144 to 170 GHz, while input and output return losses (S_{11} and S_{22}) are both approximately 10 dB at 165 GHz.

For the power measurements, the amplifier circuit was biased at a drain potential of 2.1 V, a drain current of 250 mA, and gate potential of 0 V (these biases were chosen to optimize the output power). As shown in the lower part of Figure 2, the output power ranged from a low of about 11.8 dBm (≈15 mW) to a high of about 14 dBm (≈25 mW). The peak power output of about 14 dBm was achieved at 150 GHz at an input power of 6.3 mW, yielding a large-signal gain of slightly less than 8 dBm.

This work was done by Lorene Samoska of **NASA's Jet Propulsion Laboratory**, *and Vesna Radisic, Catherine Ngo, Paul Janke, Ming Hu, and Miro Micovic of HRL Laboratories, LLC. Further information is contained in a TSP (see page 1). NPO-30127*

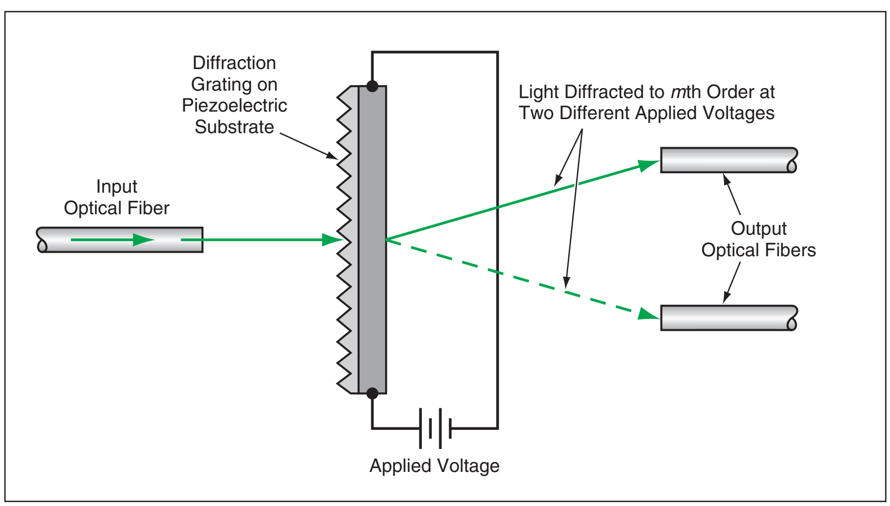
Piezoelectric Diffraction-Based Optical Switches

Switching times can be short enough for demanding applications.

Ames Research Center, Moffett Field, California

Piezoelectric diffraction-based optoelectronic devices have been invented to satisfy requirements for switching signals quickly among alternative optical paths in optical communication networks. These devices are capable of operating with switching times as short as microseconds or even nanoseconds in some cases.

The basic principle of this invention can be illustrated with reference to a simple optical switch shown schematically in the figure. Light of wavelength λ is introduced via an input optical fiber. After emerging from the tip of the input optical fiber, the light passes through a uniform planar diffraction grating that is either made of a piezoelectric material or is made of a non-piezoelectric material bonded tightly to a piezoelectric substrate. A voltage can be applied to



The **Period of the Diffraction Grating Is Varied** between two values by switching between two values of voltage applied to the piezoelectric substrate, thereby switching between two different angles of *m*th-order diffraction. Output optical fibers are positioned to intercept the diffracted light at the two angles.