Measurement	Input Stage	Driver Stage	Final Stage
Input Voltage Standing-Wave Ratio	1.0023:1	1.9:1	33:1
Gain, dB	13.3	8.8	9.6
DC-to-RF Efficiency, Percent	54.2	42.6	58.6
Power-Added Efficiency, Percent	51.7	36.9	52.2

Several Measurements were made on each amplifier stage to characterize its performance.

amplifiers are less likely to go into oscillation.

In order to design this amplifier, it was necessary to derive mathematical models of microwave power transistors for incorporation into a larger mathematical model for computational simulation of the operation of a class-D microwave amplifier. The design incorporates state-of-the-art switching techniques applicable only in the microwave frequency range. Another major novel feature is a transmission-line power splitter/combiner designed with the help of phasing techniques to enable an approximation of a square-wave signal (which is inherently a wideband signal) to propagate through what would, if designed in a more traditional manner, behave as a more severely band-limited device (see figure).

The amplifier includes an input, a driver, and a final stage. Each stage contains a pair of GaAs-based field-effect transistors biased in class D. The input signal can range from –10 to +10 dBm into a 50-ohm load. The table summarizes the performances of the three stages.

This work was done by William H. Sims of **Marshall Space Flight Center.**

This invention has been patented by NASA (U.S. Patent No.6,388,512). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at (256) 544-5226 or sammy.a.nabors@nasa.gov. Refer to MFS-31455.

Improvements of ModalMax High-Fidelity Piezoelectric Audio Device

Langley Research Center, Hampton, Virginia

ModalMax audio speakers have been enhanced by innovative means of tailoring the vibration response of thin piezoelectric plates to produce a high-fidelity audio response. The ModalMax audio speakers are 1 mm in thickness. The device completely supplants the need to have a separate driver and speaker cone. ModalMax speakers can perform the same applications of cone speakers, but unlike cone speakers, ModalMax speakers can function in harsh environments such as high humidity or extreme wetness. New design features allow the speakers to be completely submersed in salt water, making them well suited for maritime applications. The sound produced from the ModalMax audio speakers has sound spatial resolution that is readily discernable for headset users. [The ModalMax product line was described in "High-Fidelity Piezoelectric Audio Device" (LAR-15959), *NASA Tech Briefs*, Vol. 27, No. 8 (August 2003), page 36.] Other improvements of the ModalMax audio speakers include methods to reduce size, reduce power demand, and increase audio fidelity by increasing vibrational responses at the low and high ends of the audio frequency range.

This work was done by Stanley E. Woodard of **Langley Research Center**. *Further information is contained in a TSP (see page 1).*
LAR-16321-1

Alumina or Semiconductor Ribbon Waveguides at 30 to 1,000 GHz

The waveguides would be configured to exploit low-loss electromagnetic modes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Ribbon waveguides made of alumina or of semiconductors (Si, InP, or GaAs) have been proposed as low-loss transmission lines for coupling electronic components and circuits that operate at frequencies from 30 to 1,000 GHz. In addition to low losses (and a concomitant ability to withstand power levels higher than would otherwise be possible), the proposed ribbon waveguides would offer the advantage of compatibility with the materials and structures now commonly incorporated into integrated circuits.

Heretofore, low-loss transmission lines for this frequency range have been unknown, making it necessary to resort to designs that, variously, place circuits and components to be coupled in proximity of each other and/or provide for coupling via free space through bulky