formance — specifically, gain and phase (see figure). The automated test system uses the LabVIEW software to control the test equipment, collect the data, and write it to a file. The input to the LabVIEW program is either user-input for systematic variation, or is provided in a file containing specific test values that should be fed to the VMUT. The output file contains both the control signals and the measured data.

The second step is to post-process the file to determine the correction functions as needed. The result of the entire process is a tabular representation, which allows translation of a desired I/Q value to the required analog control signals to produce a particular RF behavior. In some applications, "corrected" performance is needed only for a limited range. If the vector modulator is being used as a phase shifter, there is only a need to correct I and Q values that represent points on a circle, not the entire plane.

This innovation has been used to calibrate 2-GHz MMIC (monolithic microwave integrated circuit) vector modulators in the High EIRP Cluster Array project (EIRP is high effective isotropic radiated power). These calibrations were then used to create correction tables to allow the commanding of the phase shift in each of four channels used as a phased array for beam steering of a Ka-band (32-GHz) signal.

The system also was the basis of a breadboard electronic beam steering system. In this breadboard, the goal was not to make systematic measurements of the properties of a vector modulator, but to drive the breadboard with a series of test patterns varying in phase and amplitude. This is essentially the same calibration process, but with the difference that the data collection process is oriented toward collecting breadboard performance, rather than the measurement of output from a network analyzer.

This work was done by James Lux, Amy Boas, and Samuel Li of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44518.

Complementary Paired G^{4}FETs as Voltage-Controlled NDR Device

G^{4}FET-based NDR circuits are more versatile than their predecessors.

NASA's Jet Propulsion Laboratory, Pasadena, California

It is possible to synthesize a voltage-controlled negative-differential-resistance (NDR) device or circuit by use of a pair of complementary G^{4}FETs (four-gate field-effect transistors). [For more information about G^{4}FETs, please see the immediately preceding article.] As shown in Figure 1, the present voltage-controlled NDR device or circuit is an updated version of a prior NDR device or circuit, known as a lambda diode, that contains a pair of complementary junction field-effect transistors (JFETs). (The lambda diode is so named because its current-versus-voltage plot bears some resemblance to an upper-case lambda.) The present version can be derived from the prior version by substituting G^{4}FETs for the JFETs and connecting both JFET gates of each G^{4}FET together. The front gate terminals

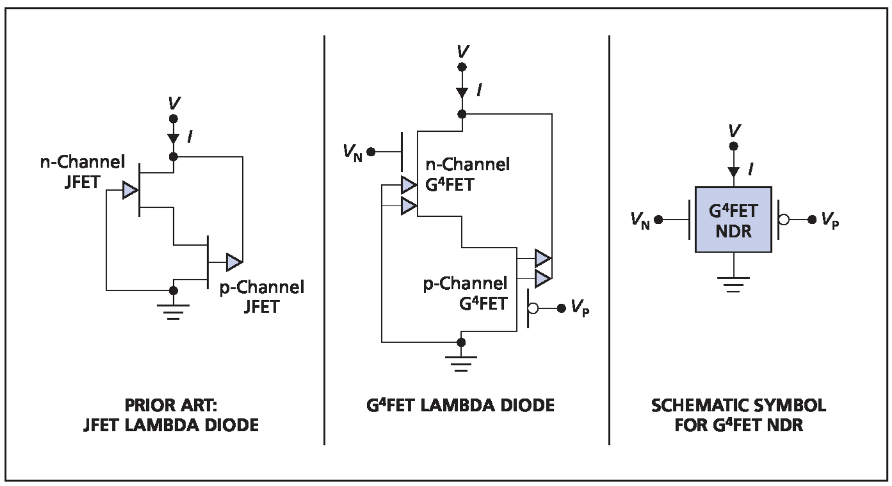

Figure 1. A **Lambda Diode** is a negative-resistance circuit or device, previously made from JFETs, and now made from G^{4}FETs.

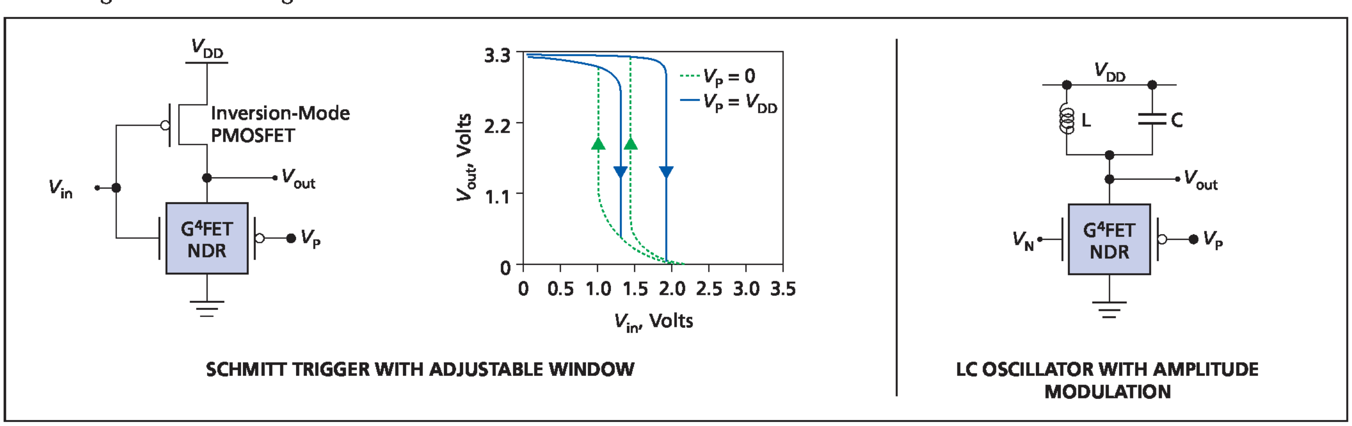

Figure 2. **This LC Oscillator and Schmitt Trigger** are examples of enhanced NDR circuits that can be made by use of G^{4}FETs.

of the G^4FETs constitute additional terminals (that is, terminals not available in the older JFET version) to which one can apply control voltages V_N and V_P.

Circuits in which NDR devices have been used include (1) Schmitt triggers and (2) oscillators containing inductance/capacitance (LC) resonant circuits. Figure 2 depicts such circuits containing G^4FET NDR devices like that of Figure 1. In the Schmitt trigger shown here, the G^4FET NDR is loaded with an ordinary inversion-mode, p-channel, metal oxide/semiconductor field-effect transistor (inversion-mode PMOSFET), the V_N terminal of the G^4FET NDR device is used as an input terminal, and the input terminals of the PMOSFET and the G^4FET NDR device are connected. V_P can be used as an extra control voltage (that is, a control voltage not available in a typical prior Schmitt trigger) for adjusting the pinch-off voltage of the p-channel G^4FET and thereby adjusting the trigger-voltage window.

In the oscillator, a G^4FET NDR device is loaded with a conventional LC tank circuit. As in other LC NDR oscillators, oscillation occurs because the NDR counteracts the resistance in the tank circuit. The advantage of this G^4FET-NDR LC oscillator over a conventional LC NDR oscillator is that one can apply a time-varying signal to one of the extra control input terminals (V_N or V_P) to modulate the conductance of the NDR device and thereby amplitude-modulate the output signal.

This work was done by Mohammad Mojarradi of Caltech; Suheng Chen, Ben Blalock, Chuck Britton, Ben Prothro, and James Vandersand of the University of Tennessee; Ron Schrimph of Vanderbilt University; and Sorin Cristoloveanu, Kerem Akarvardar, and P. Gentil of Grenoble University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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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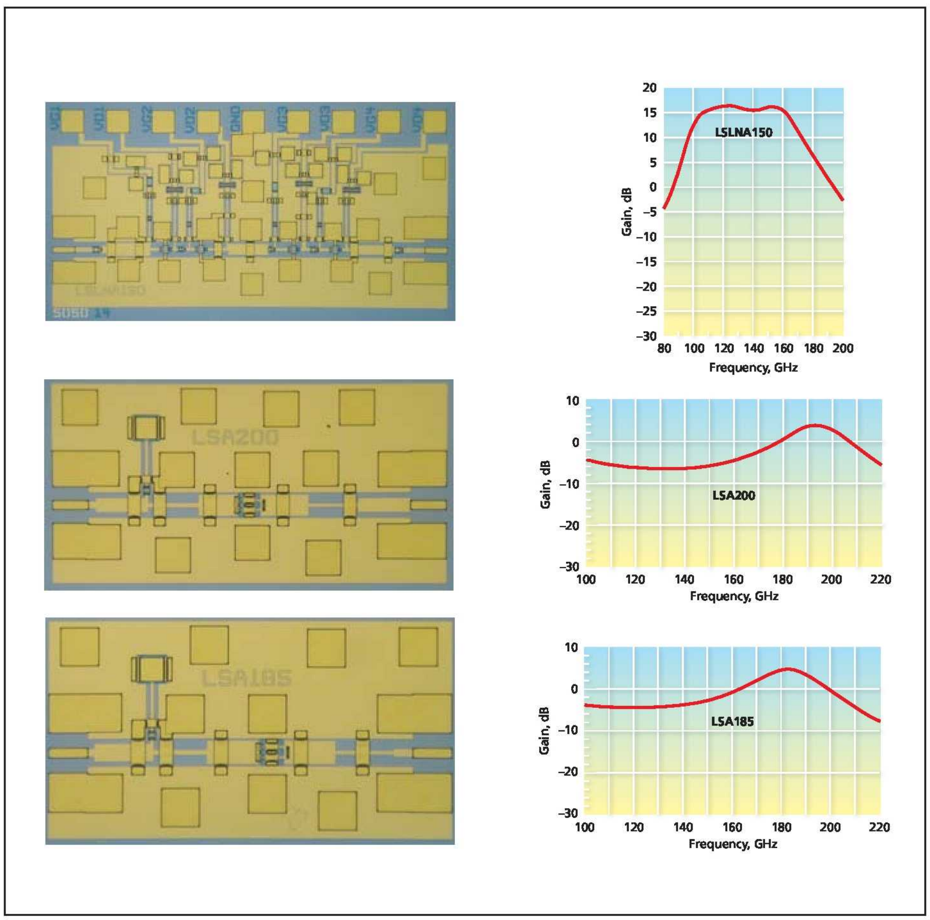
Three MMIC Amplifiers for the 120-to-200 GHz Frequency Band

These would complement previously reported MMIC amplifiers designed for overlapping frequency bands.

NASA's Jet Propulsion Laboratory, Pasadena, California

Closely following the development reported in the immediately preceding article, three new monolithic microwave integrated circuit (MMIC) amplifiers that would operate in the 120-to-200-GHz frequency band have been designed and are under construction at this writing. The active devices in these amplifiers are InP high-electron-mobility transistors (HEMTs). These amplifiers (see figure) are denoted the LSLNA150, the LSA200, and the LSA185, respectively.

Like the amplifiers reported in the immediately preceding article, the LSLNA150 (1) is intended to be a prototype of low-noise amplifiers (LNAs) to be incorporated into spaceborne instruments for sensing cosmic microwave background radiation and (2) has potential for terrestrial use in electronic test equipment, passive millimeter-wave imaging systems, radar receivers, communication receivers, and systems for detecting hidden weapons. The HEMTs in this amplifier were fabricated according to 0.08-μm design rules of a commercial product line of InP HEMT MMICs at HRL Laboratories, LLC, with a gate geometry of 2 fingers, each 15 μm wide. On the basis of computational simulations, this amplifier is designed to afford at least 15



These Three MMIC Amplifiers have been designed to be suitable for a variety of applications at frequencies up to about 200 GHz.