Complementary Paired G₄FETs as Voltage-Controlled NDR Device

G₄FET-based NDR circuits are more versatile than their predecessors.

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It is possible to synthesize a voltage-controlled negative-differential-resistance (NDR) device or circuit by use of a pair of complementary G₄FETs (four-gate field-effect transistors). For more information about G₄FETs, 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 G₄FETs for the JFETs and connecting both JFET gates of each G₄FET together. The front gate terminals of each G₄FET are connected to the same voltage. This creates a negative-resistance circuit or device that can be used as a phase shifter or other RF device.

Figure 1. A Lambda Diode is a negative-resistance circuit or device, previously made from JFETs, and now made from G₄FETs.

Figure 2. This LC Oscillator and Schmitt Trigger are examples of enhanced NDR circuits that can be made by use of G₄FETs.

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.
of the G_{4}FETs 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_{4}FET NDR devices like that of Figure 1. In the Schmitt trigger shown here, the G_{4}FET NDR is loaded with an ordinary inversion-mode, p-channel, metal-oxide-semiconductor field-effect transistor (inversion-mode PMOSFET), the $V_{T}$ terminal of the G_{4}FET NDR device is used as an input terminal, and the input terminals of the PMOSFET and the G_{4}FET 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_{4}FET and thereby adjusting the trigger-voltage window.

In the oscillator, a G_{4}FET 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_{4}FET 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.

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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.

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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 dB of gain at 120–200 GHz.

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