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 are connected to the power supply, and the back gate terminals are connected to the control signal. The output signal is taken from the source terminal of the G₄FET.

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.
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 $V_G$ 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. $V_T$ 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 ($V_G$ 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 150 GHz and 10 dB at 200 GHz.

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