Throw out complex bias sequencers along with the negative voltage supply

In modern telecommunication systems, the range of parameters an engineer must consider while optimizing a design is staggering. Not only must electrical specifications be achieved, but physical and thermal constraints must be given special attention and significant design effort, especially since they are often at odds with overall system requirements. As a result, any design technique that aids in reducing system complexity—without reducing performance—can eliminate costs, failure modes, and waste in the design cycle. The use of enhancement mode pseudomorphic high-electron-mobility-transistors (E-pHEMTs) in monolithic microwave integrated circuits (MMICs) is one such promising technique, for it may directly address a well-known design challenge, Specifically, that of sequencing in amplifier biasing, as demonstrated in figure 1.

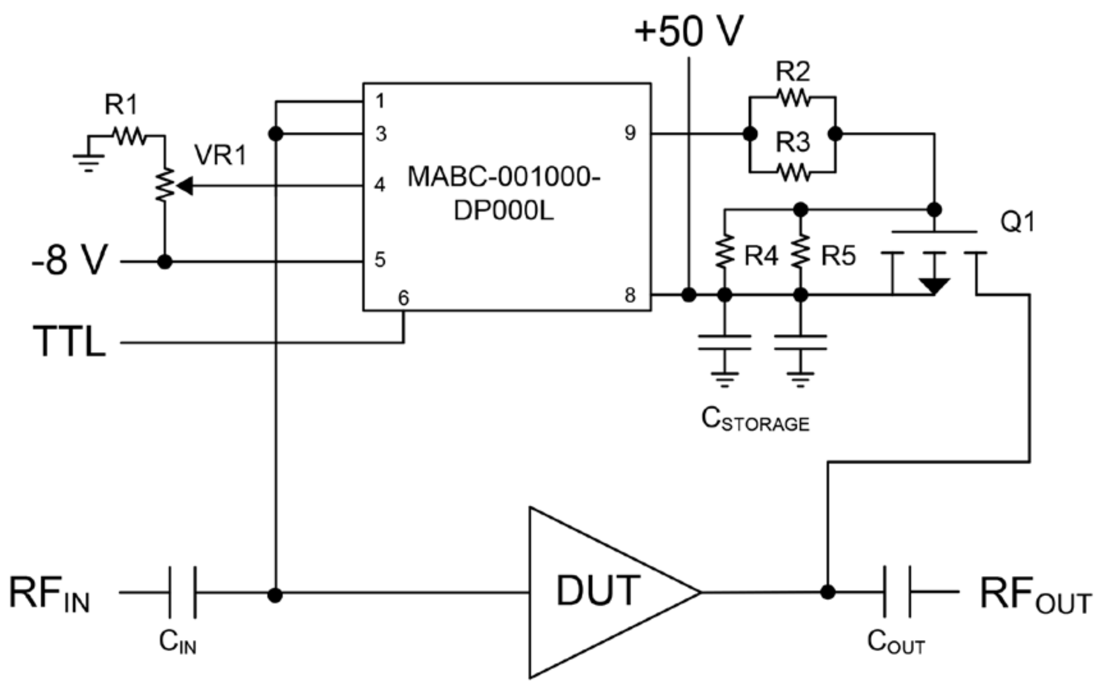

FIGURE 1.
Amplifier Bias Controllers/Sequencer Modules are generally complex and expensive circuitry to purchase or develop for dual bias amplifiers.

Traditionally, amplifiers constructed from depletion mode pHEMTs (D-pHEMTs) and HEMTs require sequencing circuits to ensure the bias voltages are energizing the transistors in the proper order. A typical bias timing scheme is shown below in Figure 2.

Failure to bias such an amplifier in the correct manner, often results in transistor damage. For instance, the device channel is normally conductive and will sink large levels of current, if not first biased into pinch-off mode. A depletion mode device also requires that RF power to be applied after the device has entered the appropriate portion of the sequence, and must also be powered down with the exact reverse sequence. Any deviations in the timing sequence could induce damage to the amplifier.

The timing problem becomes even more complicated when the microwave system contains multiple depletion mode amplifiers, such as phased array radars. Not only does the sequencer have to control hundreds, if not thousands, of amplifiers in parallel, but any delays or offsets in the bias scheme could have profound impact on the overall sensitivity of the radar.

A solution to this vexing problem can be found in physics. Many MMIC processes now offer both depletion D-pHEMT transistors and enhancement E-pHEMT devices on the same substrate. In terms of RF performance, these transistors are comparable—and in some instances, E-pHEMTS can outperform their D-pHEMT cousins in maximum gain, noise figure,

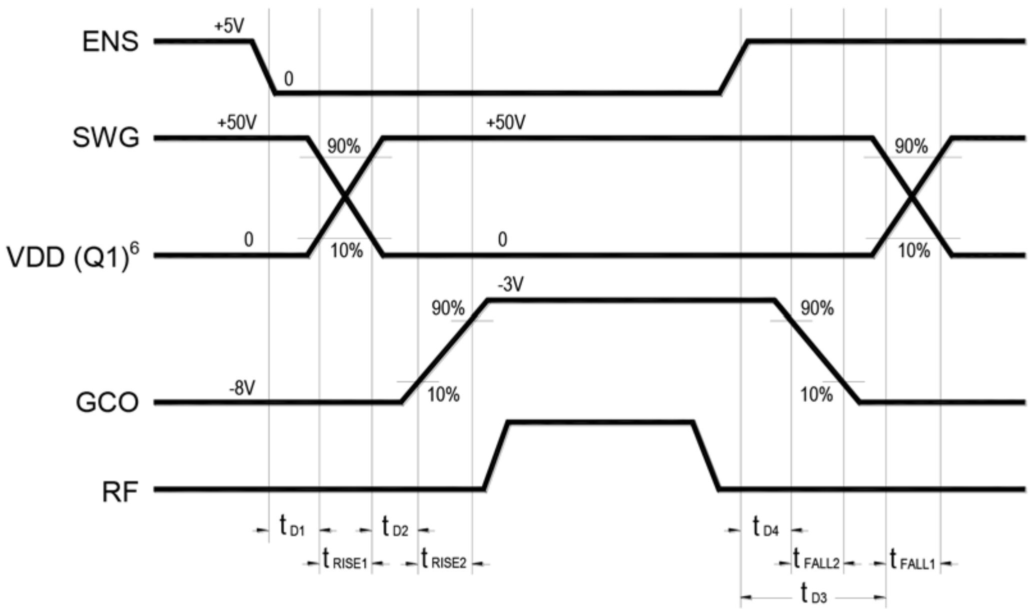

FIGURE 2.
As dual bias amplifiers require a precise sequence before energizing each port, timing diagrams and activation sequences require digital controllers to prevent damage from improper sequencing.

and linearity. Unlike depletion mode devices, however, E-pHEMT transistors are normally non-conductive, and will only sink current when both the drain and the gate are biased, regardless of sequence. As a result, the sequencer circuit can be eliminated altogether.

The savings generated by removing the sequencer can be enormous. For example, positive bias techniques enable a reduced bill of materials, a simplification of the circuitry, and a reduction the number of extraneous noise sources. These eliminations allows the designer to focus on more important aspects of the system, such as optimizing the RF signal chain.

The use of E-pHEMT devices by designers of power amplifiers (PAs) and low noise amplifiers (LNAs) is in its infancy, as such devices have only recently been made available from a number of semiconductor manufacturers. However, Custom MMIC has been a pioneer in this area and currently offers dozens of standard, off-the-shelf PA and LNA components built with E-PHEMT technology.

In many of these designs, the high gain and high linearity E-pHEMT amplifiers have matched—and even exceeded— similar depletion mode designs. Not only can E-pHEMT amplifiers reduce cost and complexity, they can also improve performance. By definition, this is a win-win situation.