CHRIS DEMARTINO | Technology Editor

At Qorvo, Big Expectations for GaN

Qorvo systems engineer Bror Peterson discusses several topics in regard to 5G communications, such as gallium-nitride technology and more.

When talking about 5G, what role do you expect gallium-nitride (GaN) technology to have?

Peterson: The primary role for GaN, or more specifically, GaN-on-silicon-carbide (GaN-on-SiC), is high-efficiency final stage power amplifiers (PAs) for both traditional high-power macro, as well as emerging massive MIMO base station platforms. Widespread market adoption for GaN-on-SiC power amplifiers has been driven by the demand for wider-bandwidth multi-carrier and multi-band systems. Systems that once covered a single 20-MHz bandwidth now need 10x the power and 20x bandwidth to handle various intraband and interband carrier aggregation combinations.

It is generally accepted that GaN-on-SiC Doherty PAs achieve higher power-added efficiency (PAE) at higher frequencies and over larger bandwidth compared to incumbent LDMOS technology. At a unit-cell level, GaN devices are fundamentally more efficient and inherently have higher output impedance, along with lower parasitic capacitance. This allows easier wideband matching and scaling to very large output powers. In addition, GaN-on-SiC is more reliable at high channel temperatures. The bottom line is that GaN is a fundamentally better semiconductor (high breakdown voltage and saturation velocity) that allows new system level trades to improve size, weight, power, and cost.

As we move toward 5G, significantly wider component carrier bandwidths (up to 200 MHz) and new frequency bands covering 3.3 to 4.9 GHz and beyond are being standardized, requiring the use of GaN. In addition to the sub-6-GHz enhancements, 5G will also introduce new millimeter-wave bands between 24-30 and 37-43 GHz. These millimeter-wave hybrid beamformed base stations will need very compact, fully-integrated front-end-modules. GaN's high power density and low noise figure is particularly well suited for this application and will be key to achieving the effective isotropic radiated power (EIRP) and antenna gain to noise temperature (G/T) needed to close the link to mobile user equipment.

What do you expect to see in terms of module integration?

Peterson: The level of integration really depends on the platform. For traditional macro base stations, the final PA stage will integrate the main and peaker amplifier with pre-matching and harmonic traps into a single compact dual-path package. For massive MIMO platforms with up to 128 transmit and receive paths, a much higher level of integration is needed. Initially, the driver plus fully matched Doherty PA will be integrated into a single package.

On the receive side, dual-channel switch low-noise amplifiers (LNAs) with multiple stages of variable gain are already mainstream. Over time, a single fully-integrated 2T2R or 4T4R module will directly interface to the antenna and transceiver, and may include the isolators and filters. This module would also provide a separate feedback path for closed loop pre-distortion and a digital interface for control and biasing.

At millimeter-wave frequencies, the antenna array element spacing is extremely small (3.75 mm at 39 GHz). It will be necessary to integrate at least the PA, TR Switch, and LNA into a single module. Further integration with a core-beamformer RFIC is expected, but may be delayed due to export compliance considerations that limit output power when integrated with phase and amplitude controls.

Can you tell us a little about the filter requirements and solutions that you expect to be associated with 5G?

Peterson: There are several significant trends impacting filter requirements for 5G. First, most of the new bands for 5G are unpaired and use time-division duplexing. Unlike paired-spectrum where the uplink and downlink frequencies can be closely spaced and require complex duplexing filters, unpaired spectrum typically allows simpler band filters. Second, the shift to full-dimensional beamforming and massive MIMO base stations gives additional freedom to null potential out-of-band interferers. In addition, massive MIMO base stations require as many as 128 filters, so a compact form factor and lower cost will be critical.

Bror Peterson