**GaN Power ICs Integrate Power FET With Gate Drive And Logic**

**Navitas Semiconductor** has announced what it describes as the world’s first, commercially available GaN power ICs, using its proprietary AllGaN monolithically-integrated 650-V platform. According to the vendor, combining GaN power FETs with GaN logic and drive circuits enables 10x to 100x higher switching frequencies than existing silicon circuits, making power electronics smaller, lighter and lower cost (Fig. 1.) Both the GaN power ICs and the company’s AllGaN platform were introduced during CTO & COO Dan Kinzer’s recent APEC plenary talk “Breaking Speed Limits with GaN Power ICs.” Navitas is currently sampling its GaN power ICs to beta customers.

With this introduction, a new generation of high-frequency, energy-efficient converters is being enabled for smartphone and laptop chargers, OLED TVs, LED lighting, solar inverters, wireless charging devices and datacenters. The applications targeted by Navitas’ initial offerings of GaN power ICs will be in the 20-W to 200-W range.

“GaN has tremendous potential to displace silicon in the power electronics market given its inherent high-speed, high-efficiency capabilities as a power FET,” says Kinzer. “Previously, that potential was limited by the lack of equally high performance circuits to drive the GaN FETs quickly and cost effectively. Navitas has solved this remaining challenge to unlock the full potential of the power GaN market. With monolithic integration of GaN drive and logic circuits with GaN power FETs, the industry now has a path to cost-effective, easy-to-use, high-frequency power system designs.”

CEO Gene Sheridan added, “The last time power electronics experienced a dramatic improvement in density, efficiency and cost was in the late 70s when silicon MOSFETs replaced bipolar transistors, enabling a transition from linear regulators to switching regulators. A 10x improvement in density, 3x reduction in power losses and 3x lower cost resulted a short time thereafter. A similar market disruption is about to occur in which GaN power ICs will enable low-frequency, silicon-based power systems to be replaced by high-frequency GaN with dramatic improvements in density, efficiency and cost. This is an exciting time for the industry.”

The new GaN Power ICs are said to enable switching at up to 40 MHz, resulting in up to 4X higher power density and 20% lower system cost. This capability is illustrated by a two-phase inverter demonstrated by Navitas and Stanford (Fig 2.) In this demo, the GaN device overcomes limitations of existing GaN FETs. For example, when a GaN switch is a depletion-mode device, it requires an extra (silicon) FET, extra passives, isolation, and complex packaging in order to make the device into a normally off cascode device. Meanwhile, early enhancement-mode GaN devices require many added circuits. Note that Navitas’ chips employ enhancement-mode transistors.

However, achieving the higher performance promised by Navitas’ new parts will require some design changes on the customers’ part. In order to achieve both higher-frequency switching and higher efficiency, designs using the GaN power ICs will need to move from hard switching to soft switching. The following equations identify the specific losses that are reduced by applying soft switching to the power switch.
In addition, optimization of magnetics will be required to hit the performance goals at high frequency. According to Navitas, core losses associated with existing, mass-produced ferrite materials currently limit switching frequencies, so further work is required.

While achieving switching frequencies in the tens of megahertz may be a long term goal, a more immediate benefit may be cleaner switching of GaN FETs versus existing transisors as the integration of gate driver and FET minimizes overshoot and undershoot (Fig 3).

For more information, email Stephen Oliver at stephen.oliver@navitassemi.com.

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**Fig. 1.** With their monolithic integration of a 650-V FET, matched gate driver and logic in GaN, Navitas’ new power ICs achieve 20x lower drive loss than silicon, shorter propagation delay than silicon (10 ns), a zero-inductance turn-off loop, a rail-to-rail output, and remove layout sensitivity. Logic circuitry includes hysteretic digital inputs, voltage regulation, and ESD protection. Achieving a monolithic integration of driver and logic circuits in a GaN process required a major redesign by Navitas of familiar drive circuitry to account for the lack of a PMOS transistor.
Fig. 2. A two-phase inverter prototype using one of Navitas’ 650-V GaN power ICs operates with high efficiency at switching frequencies of 27 MHz and 40 MHz.

Fig. 3. Monolithic integration of the gate driver and FET eliminates gate overshoot and undershoot, improving turn-on and turn-off performance versus GaN FETs driven by a discrete gate driver.