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GaN-Based Inverter Reference Design Raises Performance For AC Servo Drives

Texas Instruments has introduced a three-phase, gallium nitride (GaN)-based inverter reference design that helps engineers build 200-V, 2-kW AC servo motor drives and next-generation industrial robotics with fast current-loop control, higher efficiency, and more accurate speed and torque control. The design (see Fig. 1), aimed at 20-Vac circuits, is the company's second GaN inverter reference design. The first one was aimed at 48-Vac circuits.

The three-phase, high-frequency GaN inverter reference design features TI's newest LMG3410 600-V, 12-A GaN power module with an integrated FET, gate driver and protection. The GaN module allows the design to switch up to 5x faster than silicon FETs, while achieving efficiency levels greater than 98% at 100 kHz and greater than 99% at a 24-kHz PWM frequency. With GaN, designers can optimize switch performance to reduce power loss in the motor, and downsize the heat sink to save board space. Operating the inverter at 100 kHz significantly helps improve torque ripple when used with low-inductance motors.

According to TI, silicon-based inverters do not work at 100 kHz, and will dramatically lose efficiency when operated even at 50 kHz. The GaN inverter power stage easily interfaces with microcontrollers (MCUs), including TI's TMS320F28379D drive control system-on-chip to help dynamically adjust voltage frequency and achieve ultra-fast current loop control.

TI has also introduced its new DesignDRIVE Fast Current Loop software with innovative sub-cycle PWM update techniques that help push current-loop performance in servo drives to less than 1 µs, potentially tripling motor torque response. The Fast Current Loop software outperforms traditional MCU-based current-loop solutions, and is available for free with controlSUITE software.

Sub-cycle PWM update in FCL is different from conventional methods. In short, most PWM current loops perform the FOC calculations through a majority of the PWM carrier period, and therefore, do not update the PWMs until a full PWM cycle after the sample was taken. The DesignDrive FCL uses a special mode in the C2000 MCH PWM known as the immediate mode. In this mode, the PWM output can change as soon as a register value changes, thus avoiding the >100-µs delay updating the inverter.

FCL techniques leverage the cycle-scavenging architecture and peripherals of the C2000 MCU to minimize the sample conversion time and the field oriented control processing. As a result, the PWM can be updated in as little as 910 ns on 200-MHz MCUs. Relative to the full PWM period, this is less than 1%. So, the inverter is adjusted to the current situation sooner and the PWM modulation index is still quite high at 98%.

In addition to the GaN module, the reference design relies on TI's AMC1306 isolated delta-sigma modulators with current sensing to increase motor control performance. TI's ISO7831 digital isolator also provides reinforced isolation between the MCU and the design's six PWMs.

The reference design can be downloaded here, and information on the LMG3410 is available here. For more information on FCL and how the differentiated C2000 architecture can achieve these results, see the Fast Current Loop FCL Whitepaper.

—contributed by Spencer Chin

Fig. 1. TI's three-phase, gallium nitride-based inverter reference design helps engineers build 200-V, 2-kW ac servo motor drives and next-generation industrial robotics. The design is based on the company's LMG3410 600-V, 12-A GaN power module.

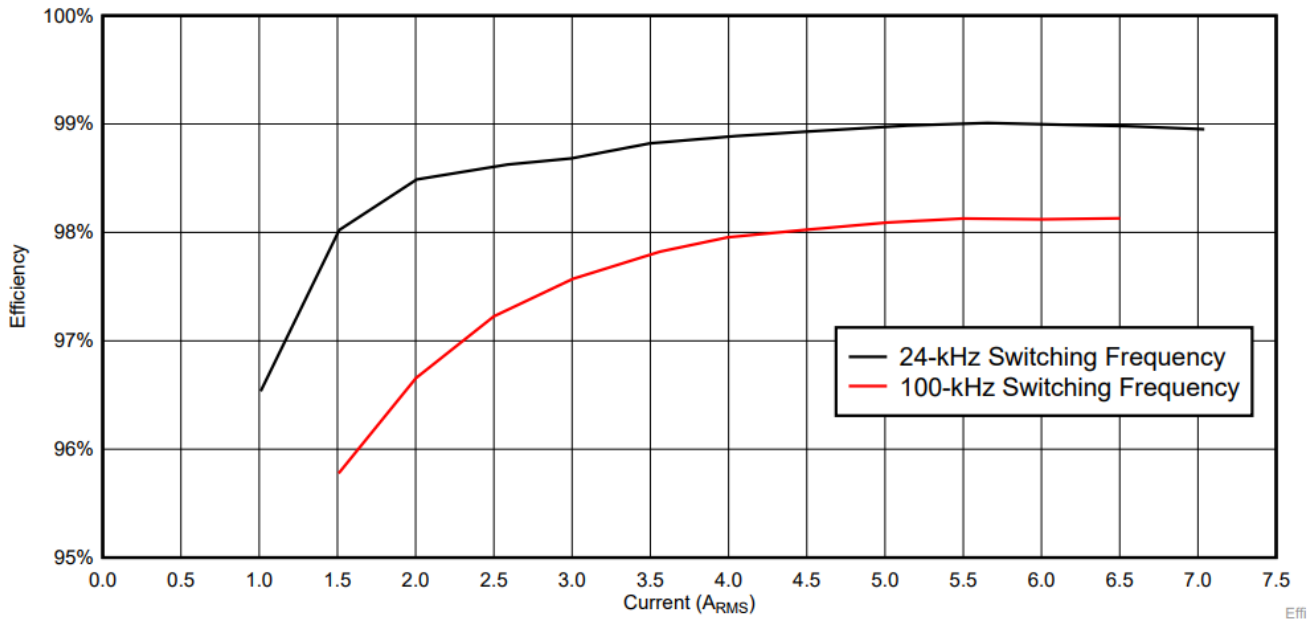

Fig. 2. TI's GaN power module enables the inverter reference design to switch up to 5x faster than silicon FETs, while achieving efficiency levels greater than 98% at 100 kHz and greater than 99% at a 24-kHz PWM frequency. A silicon-based inverter would suffer dramatic reductions in efficiency just going to 50 kHz.

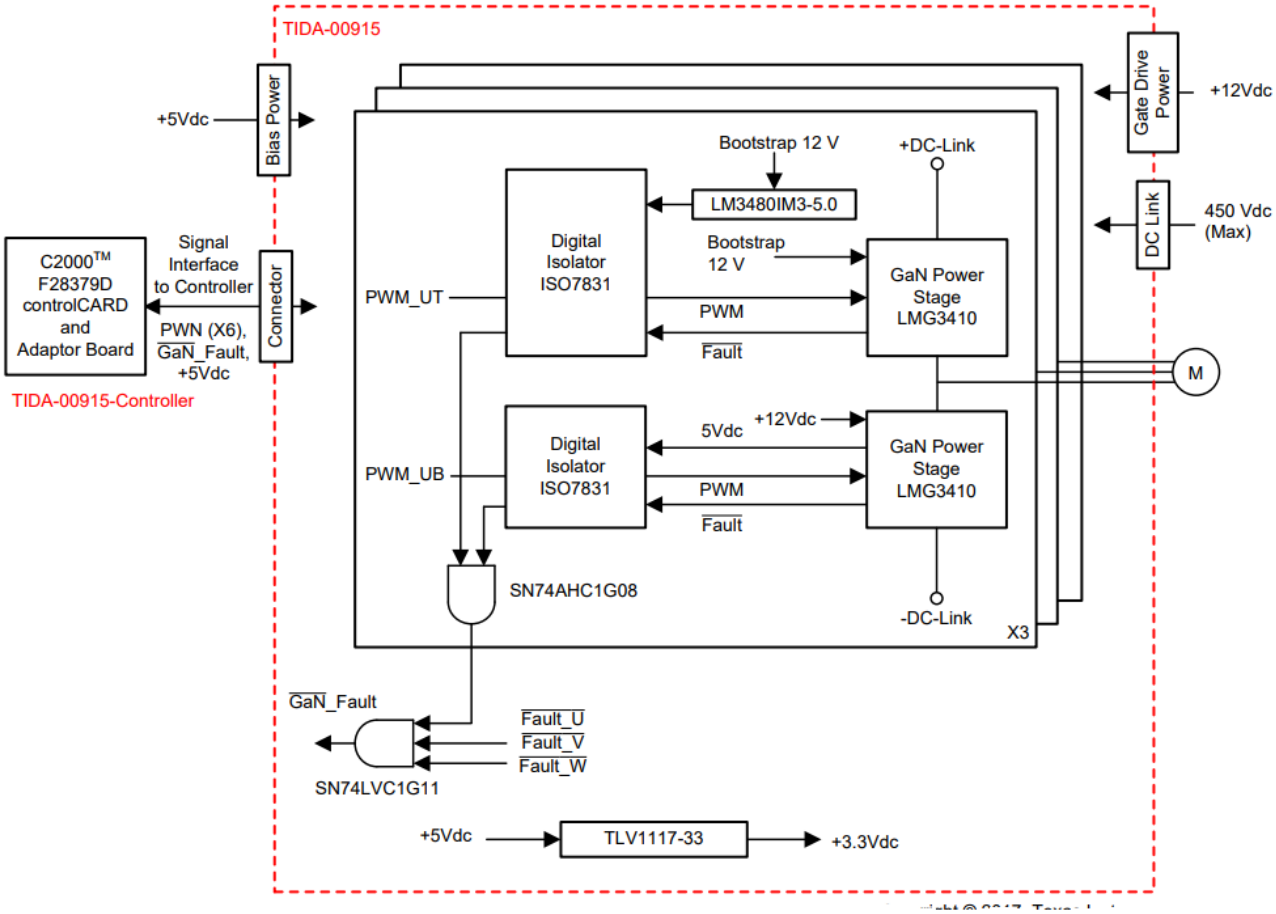

Fig. 3. Application block diagram. The high-frequency GaN inverter reference design features TI's LMG3410 GaN power module with an integrated FET, gate driver and protection. The inverter power stage easily interfaces with MCUs such as TI's TMS320F28379D drive control system-on-chip to help dynamically adjust voltage frequency and achieve ultra-fast current loop control. This design also uses the company's AMC1306 isolated delta-sigma modulators with current sensing to increase motor control performance and the ISO7831 digital isolator, which provides reinforced isolation between the MCU and the six PWMs.