Electronic Design

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Turning on the Lights: GaN Power FETs for LiDAR Sensors

Learn more about the role of GaN power FETs and the gate drivers behind them in LiDAR sensors.

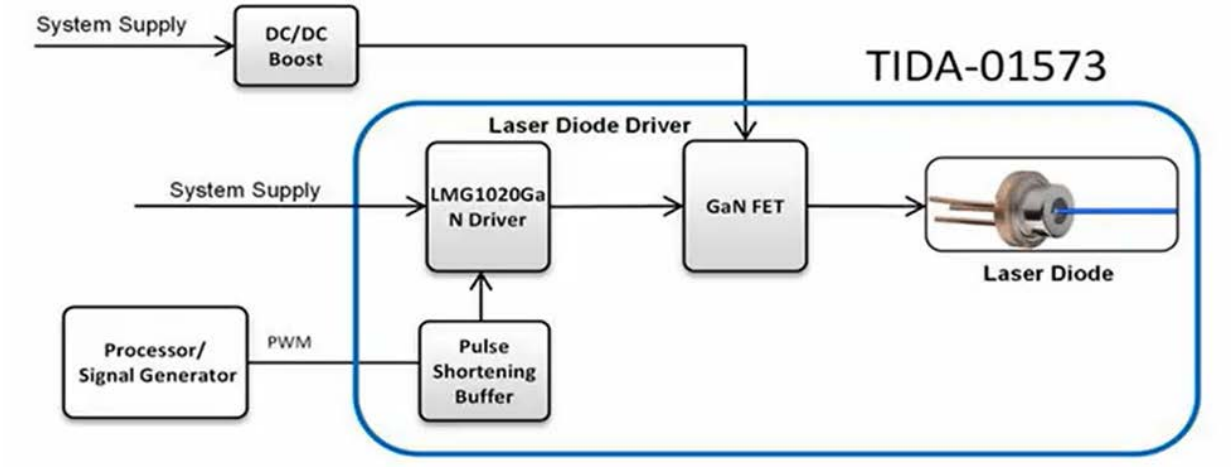
Gallium-nitride (GaN) power devices are becoming one of the core building blocks in LiDAR sensors thanks to their ultra-fast switching speeds and limited parasitics, which enable high peak currents in conjunction with high bus voltages and narrow pulse widths.

To usher in the future of self-driving cars, more advanced sensors must be used within the vehicle's system. One of the more widely used sensors to detect the presence of objects surrounding a self-driving vehicle is LiDAR—short for light detection and ranging—which shoots out light from a laser and measures the reflections in the scene, sort of like light-based radar. The vehicle's onboard computer can use the data to interpret the car's relation to its surroundings and the presence of other cars and objects on the road.

The LiDAR sensor must be based on a very fast switch that generates a voltage pulse for the laser diode. The duration of the voltage may only be a couple of nanoseconds. The pulse frequency of LiDAR is generally able to range between 500 kHz to 1 MHz. Thus, a power switching device with a very short rise and fall time is required. GaN power HEMT technology tends to have very fast turn-on and turn-off speeds and a high pulse current capability. These power-handling capabilities are ideal for LiDAR sensors.

These GaN power FETs must be paired with gate drivers to drive them. For instance, the LMG1020 from Texas Instruments is a low-side driver designed to control GaN FETs and logic-level MOSFETs for high-speed systems, including LiDAR and other time-of-flight (ToF) sensors used in facial recognition. They also work in virtually any type of power converter requiring low-side drivers.

The *figure* shows how the GaN power FETs and gate-driver ICs fit into the LiDAR sensor. The reference design includes a low-side GaN gate driver (the LMG1020 or the LMG1025-Q1), which can drive the GaN power FET in a way that will deliver a 0.5-ns laser optical pulse at more than 100 W, with a short propagation delay.



Block diagram of a LiDAR sensor's driver stage.

The Fundamentals of LiDAR Sensors

LiDAR sensors use light in the form of a pulsed laser to detect the presence of objects surrounding a vehicle and precisely map the distances to them. The onboard computer will be able to interpret the vehicle's relation to its surroundings.

The principle of LiDAR is to point the laser at a surface, then sending out a short laser pulse and measuring the time it takes the light to return to its sensor, calculating the distance using the formula: Distance = (Speed of light × Time elapsed)/2. LiDAR is becoming one of the most important sensors for the future of self-driving cars due to its ability to capture distance and depth information with millimeter-level accuracy and at long range.

While its future is in autonomous driving, it's also used in other applications, including:

- **Environmental monitoring**: LiDAR sensors can be used in topographical mapping, monitoring air quality, and forest canopy analysis, among other uses.
- **Aerospace**: LiDAR can also be used in terrain mapping, detecting obstacles, and altimetry in all kinds of aircraft, especially drones.
- **Archaeology**: LiDAR has also been used to assist archaeologists in uncovering hidden structures and landscapes using large-scale scanning.

Key advantages of LiDAR include:

- **Higher accuracy**: This is essential for applications needing detailed spatial data, meaning any information about the physical location and shape of objects.
- **Higher frame rates**: This is valuable for cars driving on busy roads or other dynamic environments.
- **Robustness and reliability**: LiDAR sensors are also ideal for navigating harsh environmental conditions where cameras can struggle, such as heavy fog, dust, or rain.
- **Higher lateral resolution**: This is useful in detailed 3D mapping.

GaN: Gaining Ground in LiDAR Sensors

When using LiDAR sensors to capture distance and depth information, a shorter pulse width (PW) will enable a better resolution. However, when using a higher pulse amplitude, this will increase the detection range.

Integrating GaN power FETs and ultra-fast gate-driver ICs will increase switching speed and reduce power loss, opening the door to more advanced LiDAR sensors. GaN power FETs take advantage of all figures of merit (FOM) of the latest GaN-on-Si process technologies, while the gate drivers are specifically designed for slew-rate augmentation, which is also a boon to the sensor's performance.

By combining these power components and optimizing the PCB layout for them, one can achieve higher laser power along with less ringing for improved EMI and thermals. These improved specifications play into higher resolution and detection range.