Laser Driver Reference Design with GaN HEMT for High-Resolution LiDAR

White Paper

Introduction

While it has been discussed for a long time in the automotive industry, the light detection and ranging (LiDAR) function, which accurately measures the distance of objects for autonomous driving and specifies space, is rapidly expanding to other fields. It is being employed in sensors for detecting obstacles and implementing algorithms for avoiding them in applications such as robot vacuum cleaners, automated guided vehicles (AGVs). Services for understanding highway traffic volumes and promoting route avoidance have also begun, as have services for providing map data through 3D mapping. Furthermore, using real-time point cloud data obtained by LiDAR, research on object cognition and behavior estimation algorithms is progressing in conjunction with AI (*1), and the importance and need for high-accuracy data that can be obtained with LiDAR is increasing. Further improvement of LiDAR characteristics is expected to lead to innovations that create new services, not just in the automotive market.

Through the development of electronic devices, ROHM will contribute to improving the characteristics of LiDAR applications, to solving social problems, and to the creation of innovations that generate new services. In this white paper, we describe the laser diodes, GaN HEMT (EcoGaN™ (* 2)), and GaN gate drivers that greatly contribute to improving the characteristics of LiDAR applications, and report that we have started to publish a reference design that provides them as solutions.

High-precision high-power laser diode that provides high-resolution images

For LiDAR and object detection, a high-definition, high-power beam light source is essential to improve the accuracy of object positioning, stretch object detection distances, enhance object detection images, and improve the accuracy of object detection algorithms. With its proprietary patented technology, ROHM has successfully developed a high-power laser diode that enables high-definition image acquisition, and has already established a mass production system.

The 75 W product, RLD90QZW3, achieves a narrow light emission width for the laser diode. The range is 22% narrower at 225 μm, compared to 290 μm for competitors, allowing for a higher resolution and wider sensing range with higher beam sharpness, narrower emissivity, and higher optical density. In addition, the temperature dependence of the laser wavelength is 40% better at 0.15 nm/ºC compared to competitor's 0.25 nm/ºC, which allows the use of narrow wavelength bandpass filters and allows systems to be designed with a narrow wavelength range. This means that the signal-to-noise ratio (S/N ratio) improves, making it possible to accurately measure objects at a farther distance. In addition, thanks to ROHM's proprietary technology, the power-optical conversion efficiency (PCE) also boasts an industry-leading 21% while achieving a narrow emission width, and the increase in power consumption has been kept to a minimum.

Table 1: RLD90QZW3 characteristics comparison * October 2022 ROHM data

	Competitors /Traditional products	ROHM product	Summary
Product name	(RLD90QZW3 equivalent product)	RLD90QZW3	
Laser emission width	290 μm	225 μm	**22% reduction**, can emit light with a sharp beam
Laser wavelength and temperature dependence	0.25 nm/°C	0.15 nm/°C	**40% reduction**, improved S/N ratio due to temperature dependence
Conversion efficiency	-	21%	Industry-leading value

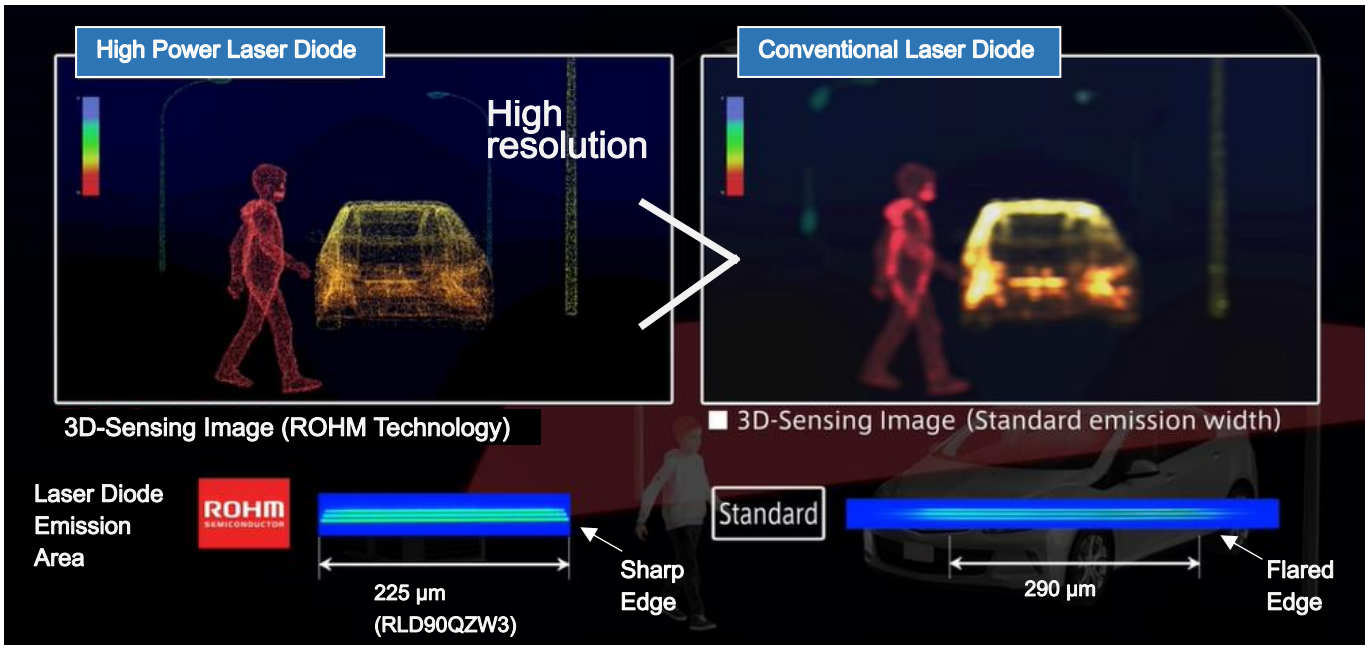


Figure 1: Illustration of using a ROHM laser diode

With these advanced technologies, ROHM is expanding its lineup of laser diodes for LiDAR, and is leading the way in the high-power market. In addition to starting to provide samples for a further high-power product, the 120 W RLD90QZW8, ROHM can supply not only packaged products, but also chips, which can be applied by the user in the development of multi-element enclosed modules, allowing distinctive LiDAR systems to be designed.

Table 2: High-power laser diode product lineup

Note: Contact your sales representative for the latest lineup and availability

Product name	Wavelength	Light output	If (max)	Luminescent area (W x L)	Package
RLD90QZW5	905 nm	25 W	11 A	70 µm x 10 µm	ø5.6 mm CAN
RLD90QZW3		75 W	27 A	225 µm x 10 µm	
RLD90QZW8		120 W	50 A	270 µm x 10 µm	

GaN HEMT (EcoGaN™) and GaN gate drivers deliver high-speed switching

As one of the most prominent wideband gap semiconductors along with SiC devices (*3), GaN devices can significantly reduce the on-resistance per unit area compared to traditional Si semiconductors. In the same on-resistance product, the chip size can be reduced and the switching loss can be significantly reduced (about 65% less compared to Si). SiC devices continue to evolve towards higher voltage and high-power applications, while GaN devices are moving towards higher-frequency driving and the usage of the two technologies is diverging. In LiDAR applications, the use of GaN devices that can be driven at high frequencies is optimal, and market introduction has begun since the technology allows systems to be built that can transmit narrow pulse signals and obtain higher-definition images. ROHM has already established a mass production system for GaN devices. Compared to competing products, GaN devices also improve the gate-source voltage resistance up to 8 V and improves the margin for overshoot failure during switching operations by about 30%, facilitating simpler circuit design. Furthermore, it adopts a high heat dissipation surface-mounted package, which makes the product easy to mount. A structure is used that reduces parasitic inductance from packaging by 55% compared to conventional packages and reduces characteristic degradation.

Table 3: GaN HEMT (EcoGaN™) Lineup

Note: Contact your sales representative for the latest lineup and availability.

Product No.	V_{DSS} [V]	V_{GSS} [V]	I_D [A]	$R_{DS(on)}$ [mΩ]	Qg [nC]	Package
GNE1040TB	150	8	10	40	2.0	DFN5060 5 mm x 6 mm x 1.0 mm
GNE1015TB			55	15	4.9	
GNE1007TB			80	7	10.2	

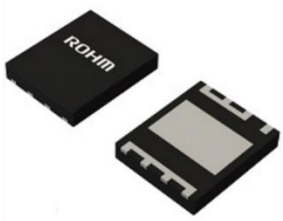


Figure 2: Illustration of EcoGaN™ package for ROHM's GaN HEMT products (DFN5060)

The gate driver that drives the high-speed drivable GaN HEMT must also be high-speed. ROHM has already begun providing samples of the high-speed gate driver IC (BD2311NVX-C), which is ideal for driving GaN HEMT. The BD2311NVX-C is a high-speed 1-channel gate driver optimized for GaN HEMT driving with a reduced output delay of 3.4 ns (Turn-on)/3.0 ns (Turn-off) on the input signal. As with EcoGaN™, it is an easy-to-mount product due to the adoption of a surface-mounted package.

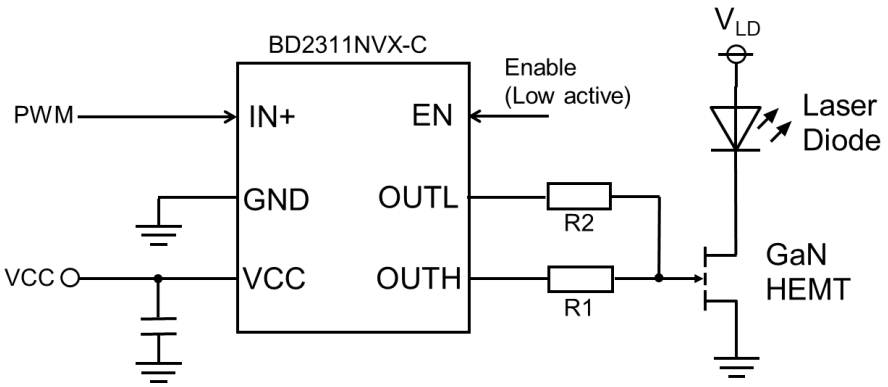


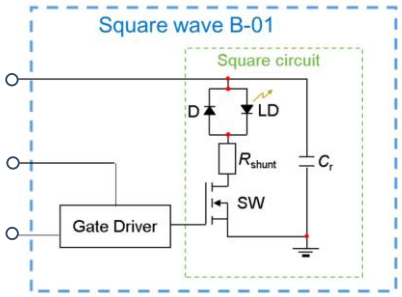
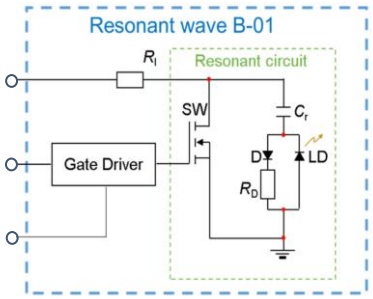
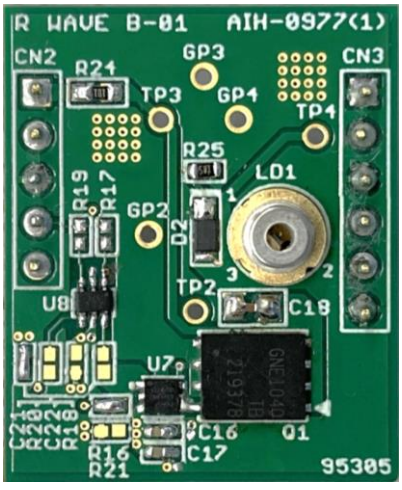
Figure 3: Gate driver for GaN HEMT (BD2311NVX-C) circuit diagram example

Gate driver solutions for GaN HEMT and GaN HEMT drives enable high-frequency driving, a feature of GaN HEMT. In addition to laser driving for LiDAR, they can also be applied to high-frequency DC/DC converters that utilize the features of GaN devices.

Laser driven reference design

Laser diodes, GaN HEMT (EcoGaN™) and GaN gate drivers are described in the previous chapter, but ROHM has also developed a reference design that combines each of these devices that are key to laser driving and discloses the design information. (Laser Driver Reference Design with GaN HEMT for High-Resolution LiDAR [REFLD002])

Table 4: Laser Driver Reference Design with GaN HEMT for High-Resolution LiDAR summary

Reference design name		REFLD002-1	REFLD002-2
Board name		S WAVE B-01	R WAVE B-01
Circuit type		Square Wave Circuit	Resonant Wave Circuit
Main mounted device	Laser diode	RLD90QZW8	RLD90QZW3
	GaN HEMT	GNE1040TB	GNE1040TB
	Gate driver	BD2311NVX-C	BD2311NVX-C
Block diagram			
Board photo			

Generally, GaN HEMT, which can be switched on and off at high speed, is used to drive LiDAR laser diodes, and is configured in a square wave or resonant wave circuit. The square wave circuit turns the switch connected in series to the laser diode connected to the power source on and off, but the rise/fall time is limited by the speed of the semiconductor switch and the loop inductance formed in the circuit. Although resonant wave circuits are common for high-frequency driving circuits, knowledge of high-frequency is required to design the circuit constants. At ROHM, we

have developed and published a reference design for both circuits. The board designs and basic operation evaluations are carried out at ROHM, and design data (circuit diagrams, PCB Gerber, BOM) and evaluation data are published, so users can refer to and alter the reference designs freely under their own responsibility. In addition, since the simulation circuit is published on the ROHM Solution Simulator (*4), which is a free simulator available on the web, users can easily simulate both circuits. Since changes in waveform when the circuit constants are changed can be immediately confirmed, the simulator can be used for initial design studies.

In addition to the reference design data, application notes, simulation models (SPICE models, Ray data), and PCB library data for individual products are also available on the web. By utilizing the reference designs, reference design circuit simulations, and product data, design and evaluation man-hours can be drastically reduced, and the process of introducing products to the market can be speeded up.

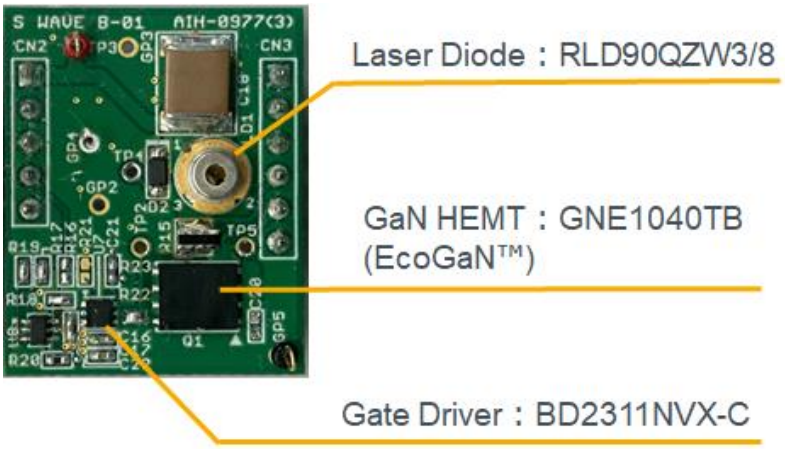


Figure 4: Reference design for LiDAR [REFLD002]

Summary

In response to the increasing market for LiDAR applications, ROHM provides laser diodes, GaN HEMT (EcoGaN™), and GaN gate drivers, which are key parts for improving LiDAR characteristics, as solutions. By offering reference designs, ROHM hopes to speed up the market introduction process for users, thereby solving social problems through its products and contributing to innovation created by new services.

Terminology, Reference Materials

(*1) AI: Artificial intelligence artificial intelligence)
(*2) EcoGaN™: A ROHM GaN device that contributes to energy efficiency and miniaturization by simultaneously achieving lower application power consumption, smaller peripheral components, and reduced design man-hours and parts count by maximizing GaN's low on-resistance and high-speed switching performance. EcoGaN™ is a trademark or registered trademark of ROHM Co., Ltd.
(*3) SiC device: Wide-gap semiconductor silicon carbide
(*4) ROHM Solution Simulator: A free simulation tool provided by ROHM on the web

Application Note: Semiconductor Laser Application Note

Reference Websites

Applications

LiDAR
Robot Vacuum Cleaner
Automated Guided Vehicle (AGV)

Related News

ROHM's 75W High Optical Output Laser Diode for LiDAR
ROHM starts Production of 150V GaN HEMTs: Featuring Breakthrough 8V Withstand Gate Voltage

Products

High-Power Laser Diode
GaN HEMT
Laser Driver Reference Design with GaN HEMT for High-Resolution LiDAR

Simulation circuit (ROHM Solution Simulator)

* MY ROHM registration is required to access the ROHM Solution Simulator.
Square wave circuit
Resonant wave circuit

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Catalog No. 65WP004E Rev.001