

MOSFET REXFET-1

Middle voltage product technology development

Preface

This document provides a summary about Renesas's Electronic product technology development of middle voltage automotive power MOSFETs.

Target Device

Latest REXFET-1 wafer process products covering TOLL/TOLG Power MOSFET packages.

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1. Introduction

The new 48V technology has been normalized in electric motors system to reduce emissions in electric vehicles (EVs). It replaces the conventional 12V system for providing additional higher-voltage batteries to meet the increased power requirements. Besides electric motor and battery packs of powertrain, 48V system also has an advantage for other direct operations such as heating and air conditioning application. This technology increases power capability, which can be used for heavier loads, such as the air conditioner and catalytic converter at start up. This has consequently spurred the advancement of local DC-DC converters and passive components, including capacitors and inductors, that are appropriate for 48V configurations. Such developments may lead to the widespread adoption of this technology in fully battery-electric systems, facilitating the conversion of the battery pack's 400 or 800 V output to 48 V for distribution throughout the vehicle.

To enhance vehicle performance, the 48V system is capable of powering a hybrid motor, facilitating quicker and smoother acceleration while simultaneously conserving fuel. The implementation of DC-DC converters that supply 48V enables a significant reduction in the size and weight of the cable harness, as a 48V cable has a diameter that is half that of a 12V cable. This transition supports the current designs of 48V DC-DC converters that will operate 12V subsystems and paves the way for point-of-load (PoL) designs to accommodate the growing power demands of electronic control units (ECUs) responsible for advanced driver-assistance systems (ADAS) and the central controllers for fully electric autonomous vehicles.

In all the above-mentioned applications, power MOSFET plays an important role in being part of main components delivering power-efficiency systems. To meet this need, Renesas, as one of the leading manufacturers of automotive power semiconductors, provides a new range of high power MOSFETs to fulfill the requirements.

2. Technology Driving REXFET-1 series

The 48V electrical systems are beginning to be used by EV manufacturers. For automotive, the 48V system application is giving middle voltage MOSFET a promising market not only for HEV but also BEV. Compared with 24V, only half as much current is required to get the same power. The newest specialty in EV will use parts with more power, higher torque and automation with smart engineering. The intriguing prospective uses of 48V represent a significant advancement in automobile design. Specialized EVs can benefit from this higher voltage system without having to compromise on weight or size.

48V's limited range of 30-60V has led to its re-emergence. The reason this range is effective, regardless of capping voltages below a 60V cut-off, is because they meet Safety-Extra Low-Voltage (SELV) requirements. 48V can distribute power to your commercial EV components, minimizing copper losses without causing unsafe SELV issues. The output can reach 57.6V before the power supply shuts down and protects your downstream circuitry from damage.

48V system trend perspective, BEV has no heat source, needs to drive more heavy loads (Heater, HVAC, de-icer). The power capacity of 48V is 4 times that of the classic 12V system, which can supply big power for a big load or realize a small current under the same power. Therefore, a smaller cable cross section is required. This would also reduce cost and weight to the harness. The 48V system needs only 25% of the current with a smaller cross section of the cable for the same application. 48V system realizes weight saving of wire harnesses (Wire harnesses: 20~50kg/car).

De-centralized Merit of 48V system. The spare battery for the BEV is currently 12V, but the low voltage makes the current increase and becomes physically heavier harness to maneuver. Distribute 48V in the car and install a DC/DC converter in front of the application to support various applications and reduce the overall weight of the internal system. 48V system Merit: power capability by 4x due to reducing current (1/4) compared with 12V system □ lighter-weight harness around the vehicle

Battery costs are rapidly reducing, which signals a wider EV adoption. 48V uses smaller batteries, yet competently caters to increased e-power requirements for connectivity and autonomy. The good part is they cost less than high voltage systems. If battery prices drop low enough, however, designers might opt for fully electrifying. For now, the 48V architectures provide the optimal trade-off of meeting regulations, performance, weight and cost.

3. REXFET-1 Principle

The most crucial feature of power MOSFETs used in car electronics to regulate high-current drives in hot conditions is low ON-resistance. The importance of switching characteristics has increased recently due to the growth of PWM and power supply applications. Renesas is creating high-performance processes that combine low gate capacitance and ultra-low on-resistance based on these technical advancements. To solve this difficulty, the latest release wafer process is the new REXFET-1 process technology.

In the previous ANM1 and ANM2 process technology, Renesas applied Super Junction technique which concentrating on P column implementation. At this point it has already achieved Ron index of 0.36.

With the aim to become worldwide top-class low Ron, high power in small package, high reliability of 10~ppm level, new REXFET-1 wafer process technology with split gate technique was applied for improving Ron index to as low as 0.24. By having this new achievement, it will help to further decrease heat dissipation and loss in the application system.

We provide a range of devices that meet automotive criteria by utilizing cutting-edge trench technology for wafer processing and multi-wire/clip bonding for packaging. These products have low resistance and high-speed switching capabilities.

Furthermore, we use a sturdy design that integrates years of experience to ensure that our products are very reliable and durable, allowing users to use them with confidence. We have developed the REXFET-1 series (80-100V products) for 48V systems used in electric vehicles (HEV).

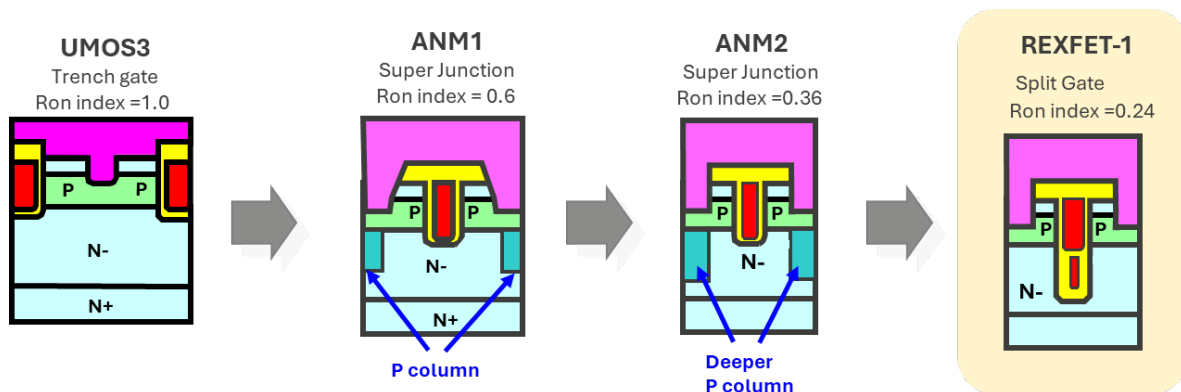


Figure 3-1 Renesas technology has the outstanding performance based on low Rsp & FOM*

* Note: Rsp: Specific on resistant
FOM: Figure of Merit

4. Package Technology

High current automotive applications like power steering, brushless DC drives, battery management, and battery safety switches are best suited for the TO-Leadless (TOLL) (HSOF) package. For high power applications that demand the best thermal behavior, exceptional EMI behavior, and maximum efficiency combined with space reduction, TOLL is the ideal answer.

Further, to be competitive in package variant Renesas has introduced its first TOLX series package family products. Besides TOLL features as mentioned above, TO Leaded with gullwing (TOLG) package with same TOLL pin compatibility has a gullwing lead to improve PBS reliability 2xTCoB performance for some applications. Furthermore, for improving the thermal improvement, a new top side cooling solution is the best for using TOLT package. TOLT is still under development, however the prototype sample is ready for evaluation.

There are 3 package line up to meet current application demand. Expand product line-up with high current/small size/better heat dissipation packages. Package trend

- Smaller inductance for Fast switching via lead-less concept, clip-bonding
- High power density with Top-side cool, Dual side cool, many pins count
- Outstanding package & soldering reliability with Wettable-Flank, clip-bonding technology
- Package size downsizing including height for system size and cost reduction

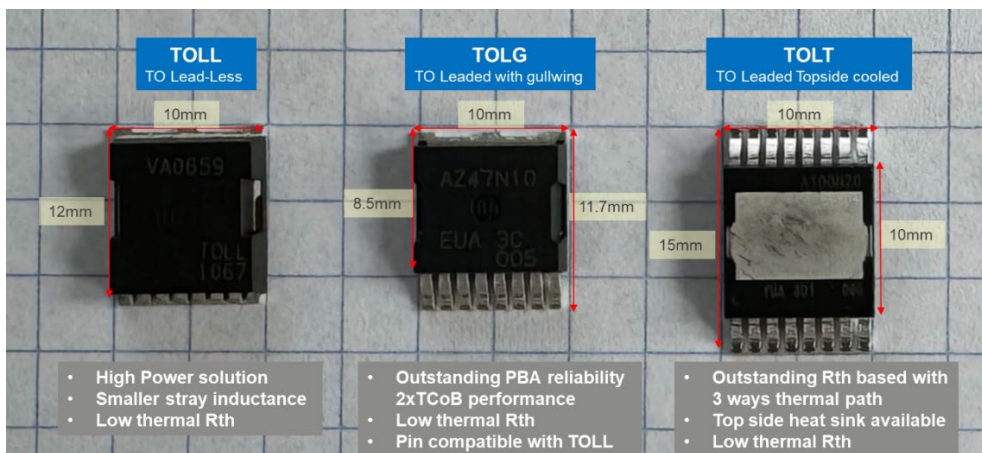


Figure 4-1 TOLX Family Package

Renesas is looking forward to further introducing the latest packages for compact and smaller footprints to follow the latest trend design for future needs.

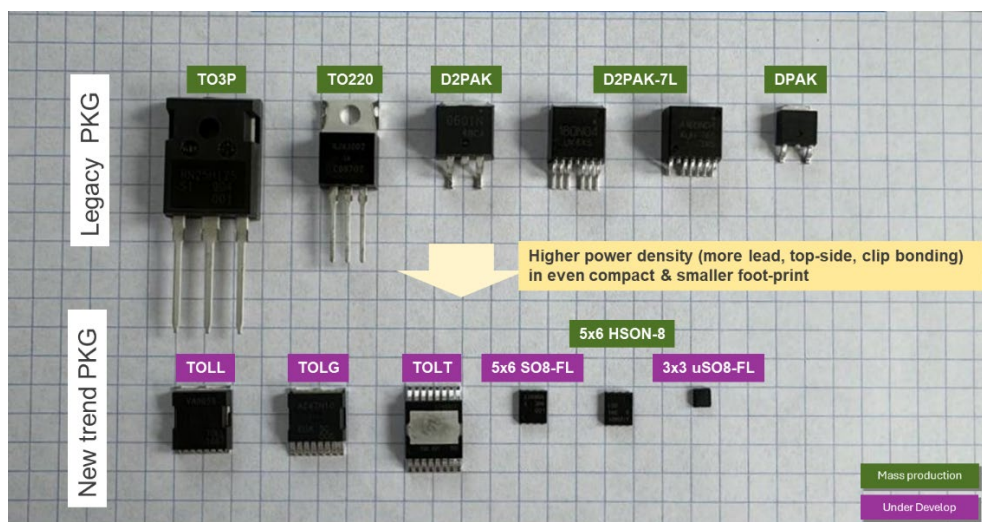


Figure 4-2 Renesas's today package technology

5. REXFET-1 Feature & Performance

Renesas TOLL/TOLG product design is an innovative package type designed for high current applications and lowest RDS (on) in the available market. It offers a compact design, reducing both footprint and height.

Benefit of TOLL package is to provide the solution on the power density, thermal performance and the design budget control. TOLL MOSFET as a large solder pad on the back side and removes the extra lead. large metal pad for better thermal performance, Thinness design with 50% of package reduction, Eliminate extra lead for space & cost saving.

The TOLL MOSFET Package design has a huge improvement compared to TO-263-7P. It is 60% reduction in overall size, 30% reduction in footprint and 50% reduction in height

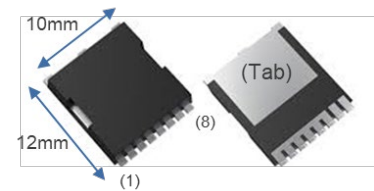
Features

- Super Low Rds(on) to minimizing conduction loss
- Low input capacitance & Stable switching capability
- The best-in-class RDS x Qg figure-of-merit (FOM)
- Outstanding solderability with Wettable flank lead type
- 300A high-current support with package
- AEC-Q101 Qualified product & PPAP capable
- PB-Free, RoHS Compliant
- -40~175°C operating temperature

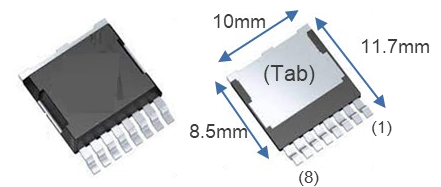
Benefits

- Easy to design for noise suppression
- High Efficiency, High Power and Low heat dissipation cost
- Simplification of driver circuit
- Easy to choose the best-fit for system needs

Package outline



TOLL: TO Lead-Less



TOLG: TO Leaded with gullwing

Key product specifications are written in the table below.

Table 1: Key Product Specifications

Part Name [Package]	RBA300N10EANS-3UA02 [TOLL]	RBA300N10EHPF-5UA02 [TOLG]	Unit
VDSS	100	←	V
VGSS	±20	←	V
ID	340	←	A
RDS(on) (Max.)	1.5	←	mΩ
RDS(on) (Typ.)	1.3	←	mΩ
VGS(th)	2.0~4.0	←	V
Ciss	13000	←	pF
Coss	3300	←	pF
Crss	80	←	pF
Qg	170	←	nC
Rth(ch-c)	0.32	←	°C/W

6. Conclusion

Understanding that the 48V system in automotive becomes important for EV business, Renesas started to evolve in development of middle voltage power MOSFET and released the TOLL and TOLG packages products as shown in figure below. Renesas will continue to develop new products packaging and will be aligned with 48V system needs such as advanced packaging (TOLT, 5x6 SO8-FL, 3x3 uSO8-FL) for space saving, miniature for compact application design and thermal improvements.

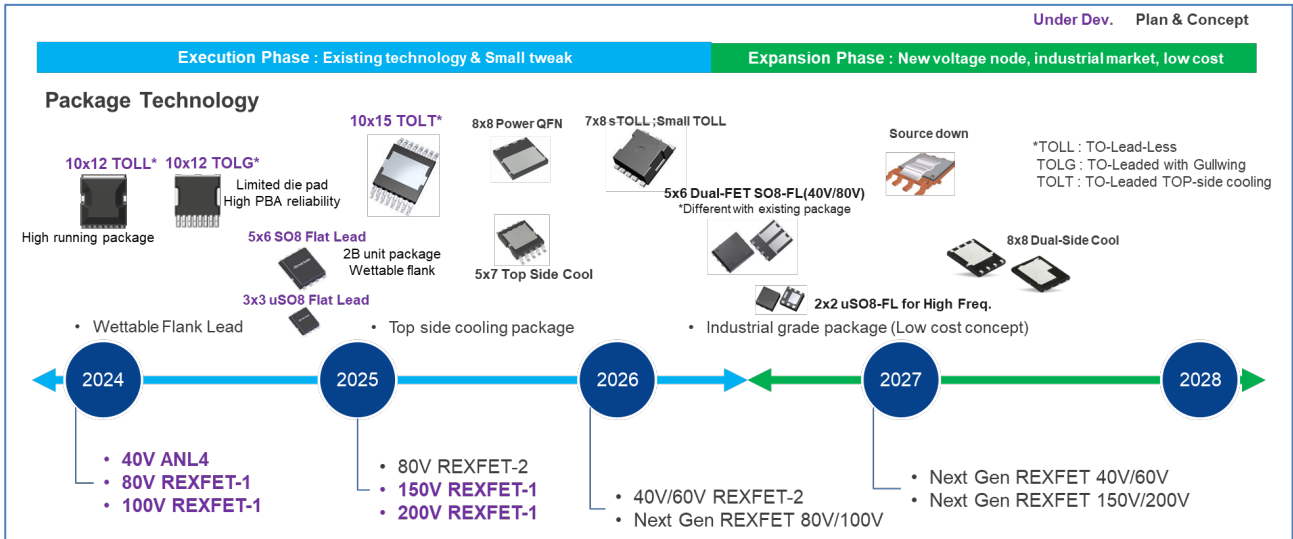


Figure 6-1 Renesas Power MOSFET technology roadmap

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2024.11.13	-	First edition

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