

Diode series

Advantages of YQ Series: Compact and Highly Power Conversion Efficiency Schottky Barrier Diodes for Automotive

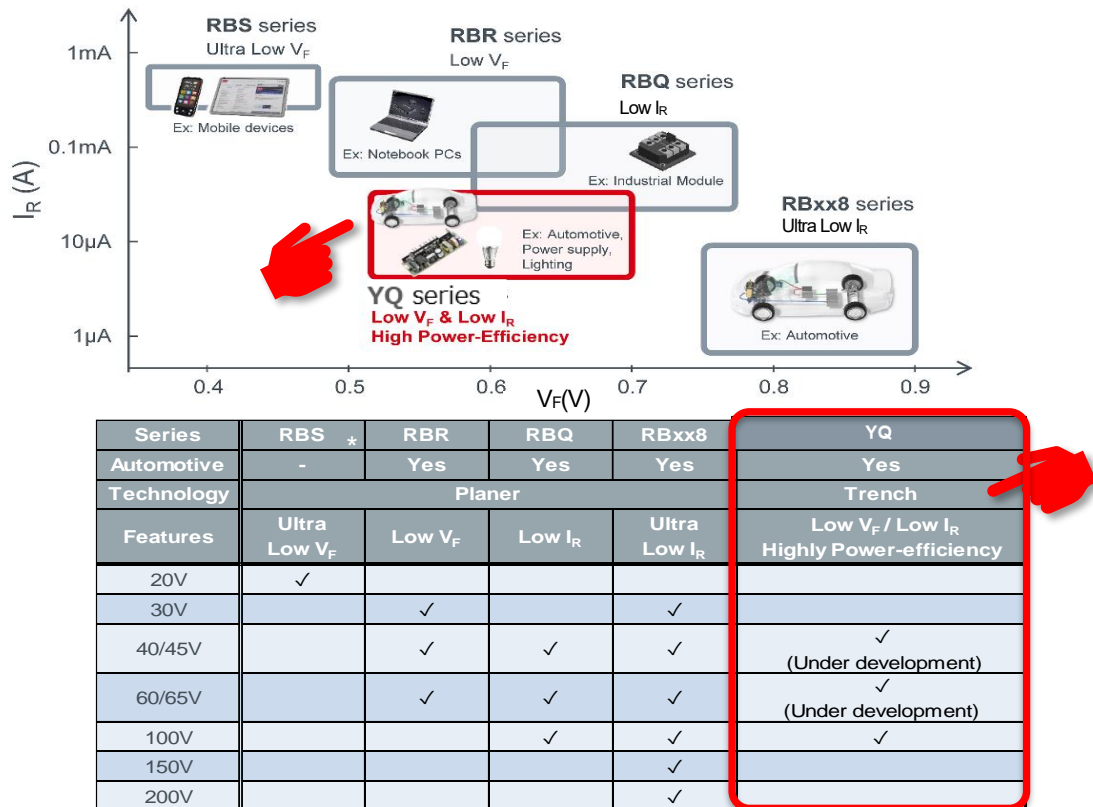
Schottky barrier diodes (SBDs) are semiconductor devices that feature low forward voltage (V_F) and low recovery loss compared with common PN junction diodes. They have significantly contributed to the improvement in power conversion efficiency of various power circuits, including PFC circuits and boost and buck converters, as well as reverse current protection circuits. Furthermore, demand for various automotive equipment including automotive LED lamps, in-vehicle infotainment, and ECU, solar power generation systems, and compact mobile devices represented by USB battery chargers has greatly increased in recent years.

To meet this demand, ROHM has developed the “YQ Series” as an addition to the previous RBS, RBR, RBQ, and RBxx8 series. Employing the latest Schottky process enables industry-leading low V_F and low capacitance characteristics, contributing to the improvement in power conversion efficiency of circuits. Furthermore, listing the compact and thin TO-277 package with high heat dissipation in its product lineup, the YQ series is also ideal for automotive equipment and compact mobile devices that have strict requirements for heat generation and mounting space.

This application note provides an easy-to-understand explanation about the advantages of the YQ series with respect to its characteristics based on comparison with common competing products. It also explains its advantages in actual circuits based on results of comparative evaluation using an LED driver.

1. ROHM SBD roadmap

Figure 1 shows the SBD selection map developed by ROHM. The trade-off between V_F and I_R (reverse current) is significantly improved in the new products of the YQ series (red frame) compared with the previous RBS, RBR, RBQ, and RBxx8 series. While V_F is kept equivalent, I_R is reduced to approximately 1/10 compared with the previous series. Therefore, the new products can be conveniently applied and achieve a lower loss especially in the automotive equipment under a harsh temperature environment. Although the breakdown voltage V_{RM} setting is currently only 100 V, other settings will be added gradually.



* Automotive grade is unavailable for RBS series.

Figure 1. SBD selection map developed by ROHM

2. Application example using the YQ series (automotive LED headlamp)

As an application example using the YQ series, Figure 2 shows peripheral circuits of an automotive LED headlamp. SBDs (red frame) are generally used for rectification of the boost block.

Since these circuits are generally energized under a sealed condition for automotive LED headlamps, the temperature can be very high. Furthermore, with the increase in the number of bulbs in a headlamp and downsizing of circuit boards in recent years, the operating condition is increasingly harsher with respect to heat generation. Therefore, as the characteristics required for SBD, in addition to low V_F (low conduction loss), the low I_R characteristics and the heat dissipation performance of packages are very important in terms of reduction in the thermal runaway risk. Since the trade-off between V_F and I_R is significantly improved in the YQ series as described in Chapter 1, it has a huge advantage with respect to these points (when comparing products with similar V_F , I_R can be significantly reduced from the previous series). Furthermore, a wide range of packages with superior heat dissipation performance, including TO-252 and TO-277, is listed in its lineup (the lineup is described in detail in Chapter 5). This allows for flexible applications to various usages and mounting spaces.

In addition, since a recovery loss occurs if the boost circuit is operated in the continuous mode, the recovery characteristics of SBD also becomes very important. Since this recovery loss is superimposed over the switching cycle, it is more important at a higher operation frequency.

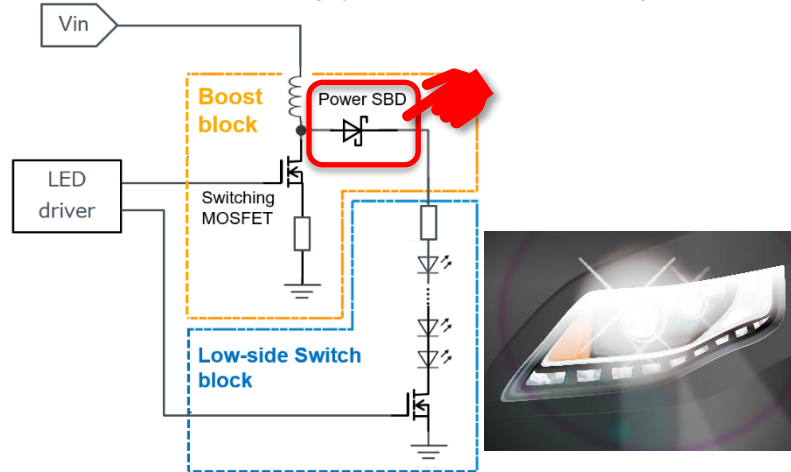


Figure 2. Peripheral circuits of automotive LED headlamps

3. Comparison of device characteristics with products from other companies

Figures 3 and 4 show the comparison results of the I_F - V_F and capacitance- V_R characteristics for the TO-277 package products in the 100 V/10 A class from other companies. ROHM YQ10RSM10SD [1] has one of the lowest V_F characteristics, nearly equivalent to the Company-A product. Therefore, it can be predicted that ROHM YQ10RSM10SD and the Company-A product have the lowest conduction loss when they are used in an actual circuit. In contrast, V_F of Companies-B and C products are higher by approximately 10 to 20%. Therefore, it can be expected that their conduction losses are higher compared with those of ROHM YQ10RSM10SD and the Company-A product. Furthermore, based on the capacitance- V_R characteristics, it can be predicted that ROHM YQ10RSM10SD has the lowest switching loss, because its capacitance is the smallest (approximately a half) compared with the competing products.

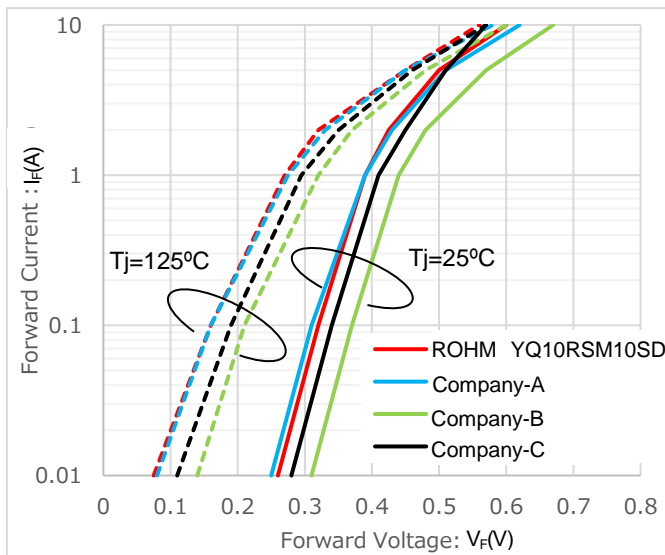


Figure 3. I_F - V_F characteristics

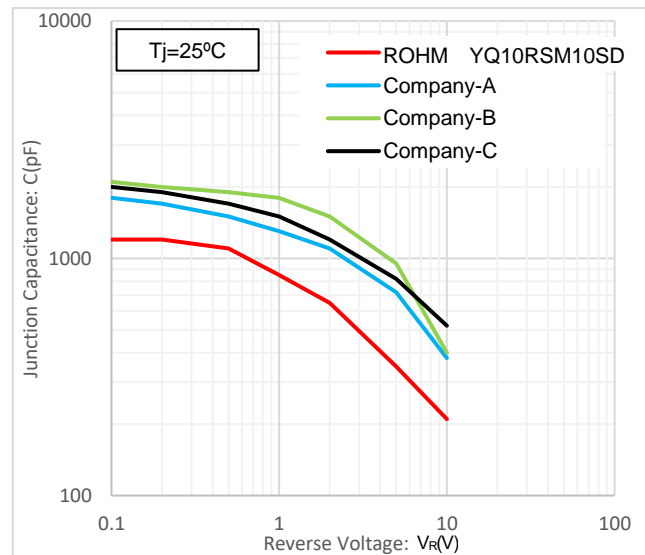


Figure 4. Capacitance- V_R characteristics

4. Comparative evaluation of competing products in actual equipment

Using ROHM automotive LED driver BD18353EFV-M [2] and its evaluation board, we compared the power conversion efficiency and heat generation of ROHM YQ10RSM10SD (100V/10A/TO-277) with similar products from other companies.

4-1. Evaluation board and circuit diagram

Figure 5 shows a full view of the evaluation board and its circuit diagram.

In this evaluation, a comparative evaluation was performed by exchanging the rectifier diode (red frame) in the boost block. For the switching MOSFET (blue frame), ROHM RD3P100SNFRA (100V/10A/TO-252) was used.

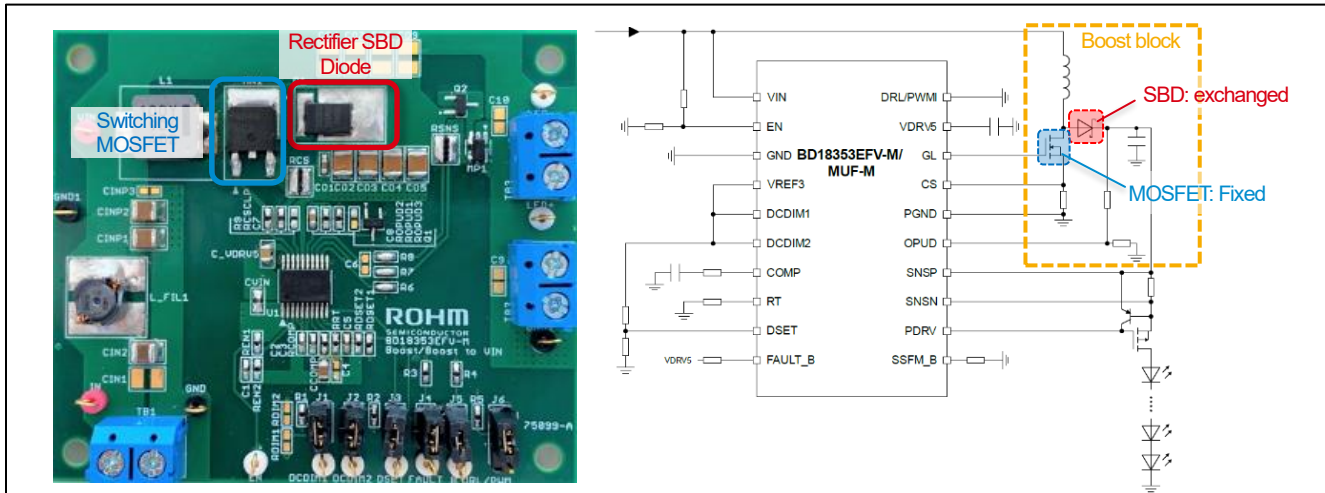


Figure 5. Picture of board and circuit diagram

4-2. Evaluation results

Figure 6 shows the comparison results of the efficiency and package surface temperature Tc.

As shown, it is confirmed that YQ10RSM10SD with superior characteristics of both V_F and capacitance has the highest power conversion efficiency and can keep T_c the lowest even with the same package. The efficiency of products from Companies-B and C are specifically lower and their T_c is higher. This is because of their high V_F as described in Chapter 3. Furthermore, although the Company-A product has the V_F characteristics equivalent to ROHM YQ10RSM10SD, its efficiency is lower and T_c is higher because its switching loss is higher.

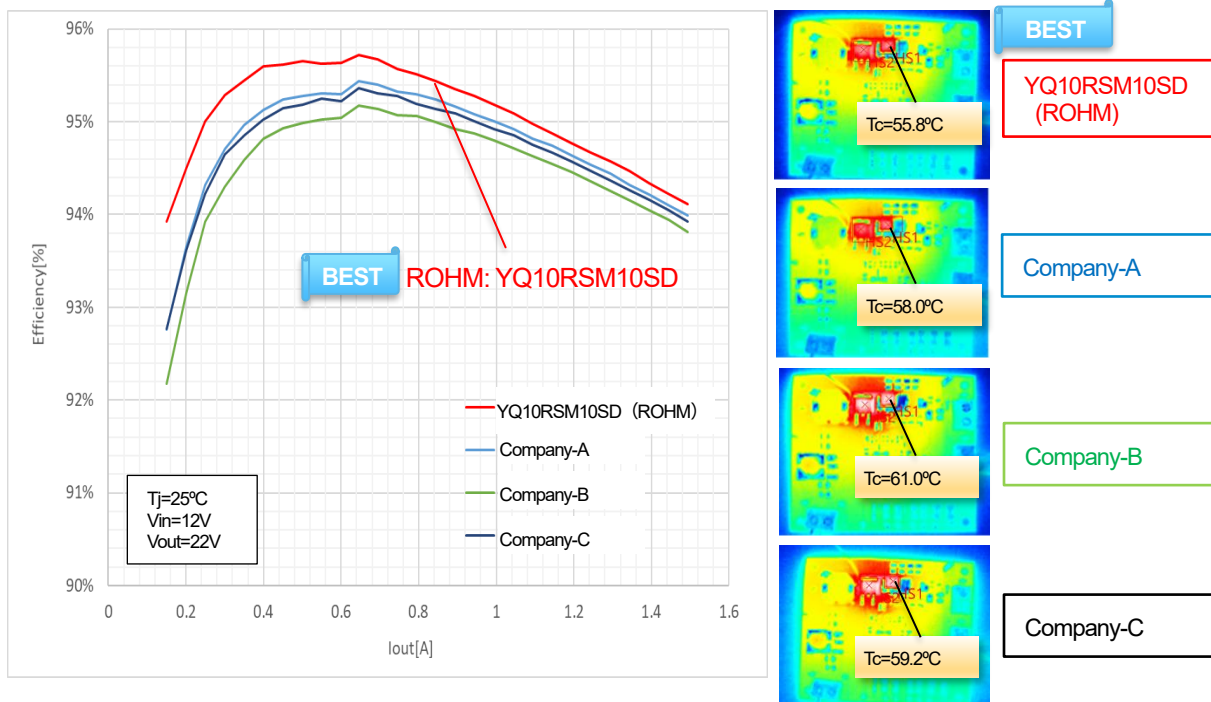








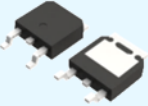

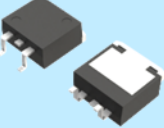



Figure 6. Comparison results of the efficiency and package surface temperature

5. Lineup

Figure 7 shows the lineup of the YQ series. A wide product lineup is prepared for various applications, including YQ10RSM10SD which was used for the evaluation of the LED driver described above. Products other than the following will be gradually added to the product lineup. Please feel free to contact us.

Package	I_o (A)	V_{RM} (V)	$T_j \text{ max}$ ($^{\circ}\text{C}$)	
PMDE 2.5×1.3×0.95mm 	1A 2A 	100	175	
SOD-123FL (PMDU) 3.5×1.6×0.8mm 	2A 3A 			
SOD-128 (PMDTM) 4.7×2.5×0.95mm 	2A 5A 			
TO-277A 6.5×4.6×1.1mm 	3A 15A 			
TO-252AA 10.0×6.6×2.2mm 	20A 			150
TO-263S 13.1×10.1×4.5mm 	20A 60A 			

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Figure 7. YQ series lineup

6. Summary

- The products of the YQ series have lower V_F and lower I_R simultaneously compared with the previous RBS, RBR, RBQ, and RBxx8 series. Therefore, they can contribute to improved power conversion efficiency in various applications.
- The TO-252 and TO-277 packages with superior heat dissipation performance are also listed in the product lineup. Combination with low I_R dies can significantly contribute to reduction in the thermal runaway risk compared with previous products. This means they are especially useful for automotive equipment under harsh temperature environment.
- Compared with products in the same class from other companies, the YQ series has superior characteristics of V_F and capacitance. Therefore, it can be considered that it has a great advantage with respect to improvement in the power conversion efficiency and reduction in heat generation when it is used in an actual circuit such as automotive LED headlamps.

7. References

- [1] Trench MOS Barrier Structure, 100V, 10A, TO-277A, Highly Efficient SBD for Automotive, YQ10RSM10SDTF
Data sheet (Rev.001) ROHM Co., Ltd., April 2023.
- [2] 1ch High Current LED Controller for Automotive, BD18353EFV-M, BD18353MUF-M
Data sheet (No. T SZ02201-0T1T0B400330-1-1 Rev.002) ROHM Co., Ltd., February 2021.

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