Isolation Device Solution for Factory Footprint Reduction & Industrial Automation Ease of Design

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Abstract

Recently, there has been a growing demand for devices that reduce part count and size to achieve downsizing in building management, HVAC systems, power supplies, and industrial equipment. Furthermore, optimizing the design of the optocouplers' input current and extending their lifespan in insulated parts of the equipment is desirable.

This article focuses on transistor output couplers that meet these market needs, featuring ultra-low input current and a high optical transmission coefficient, i.e. high current transfer ratio (CTR).

Introduction

Industrial automation equipment including robot controllers, AC servos, and general-purpose inverters, as well as building management and HVAC systems, require a reduced equipment footprint in order to enhance floor efficiency in factories and buildings, accelerate transportation and installation, lower transportation costs, and make it compatible with workers and manual labor. Additionally, as the shortage of analog design engineers worsens, end equipment design is becoming more complex due to increasing demands for increased functionality, better accuracy and extended equipment lifespan.

Issues for Isolation Device Selection

Background of Factory Equipment Footprint Reduction Trends

In industrial automation equipment or building management / HVAC systems, reduced equipment footprint is essential for improving productivity and reducing energy consumption. Reduced factory footprints can be achieved through:

1. **Space-saving:** Increase productivity per floor area by reducing occupied space, minimizing factory building investments, shortening process work time, improving TAT (Turn Around Time) by reducing transport time in the factory, and increasing the number of management facilities per worker by reducing the distance between facilities. Additionally, achieve higher functionality within the same footprint, such as increasing the number of robot axes.

2. **Flexible production lines:** Creating adaptable factory layouts that can be easily modified in response to demand fluctuations and improvement activities, allowing for easier installation, transportation and configuration.
3. **Eco-friendliness:** Reducing material use (casing, board, wiring, etc.), lowering energy consumption for factory-wide utilities like air conditioning and lighting, and decreasing transport energy per equipment (truck, ship, aircraft, etc.)

These demands have led not only to the reduced size of equipment like robot controllers, AC servos, and inverters but also to the integration of connected devices, such as servo drives and motors.

For home solar inverters, the shift towards zero-energy houses (ZEH) will increase installation demand. However, limited space on north-facing exterior walls or within homes poses challenges. Downsizing these components not only addresses space constraints but also eases transportation and construction work, reducing overall costs.

Background to Design Ease

Industrial equipment is becoming increasingly compact and precise, but these systems are not just composed of digital integrated circuits, which can be relatively easily optimized. They also handle analog functions like power supplies, some communications and A/D conversion, etc. making the design process significantly more complex. Additionally, analog circuit design requires skills and intuition gained from many years of experience, leading to a shortage of skilled analog design engineers in recent years. As a result, there is a pressing need to simplify the design of analog circuits.

Renesas Transistor Output Coupler Driving by Ultra-Low Input Current - RV1S2x51A and RV1S2x55A

The Renesas RV1S2x51A and RV1S2x55A are DC-input and AC-input types, respectively, and are ultra-low input current drive transistor output couplers to meet the needs of customers with the aforementioned problems.

Figure 1 shows the relationship between the current transfer ratio CTR and the input forward current I_F. Conventional transistor output couplers have a large I_F dependence on CTR, but the new ultra-low input current drive transistor output coupler has a very low I_F dependence of CTR on the low I_F side.

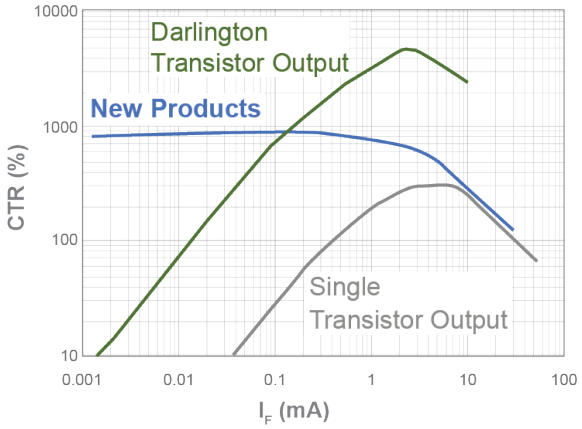
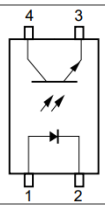
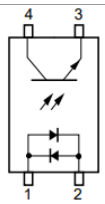
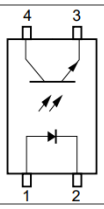
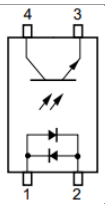
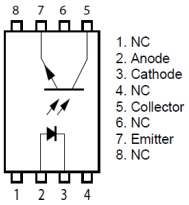


Figure 1. Relationship between CTR and I_F

Table 1 shows the package types and main electrical characteristics of the new products. CTR is specified at I_F = 0.05 mA and 1 mA.

Table 1. RV1S2x51A and RV1S2x55A package and characteristics outline

	RV1S2951A	RV1S2955A	RV1S2251A	RV1S2255A	RV1S2451A
Package	FLAT LEAD 		LSSOP 		LSDIP8 
Pin pitch	1.27 mm		1.3 mm		1.27 mm
Creepage distance	4 mm		8.2 mm		15 mm
Isolation Voltage	2500 Vr.m.s.		5000 Vr.m.s.		7500 Vr.m.s.
Input Type	DC	AC	DC	AC	DC
Pin connection	    DC Input: 1. Anode, 2. Cathode, 3. Emitter, 4. Collector AC Input: 1. Anode, Cathode, 2. Cathode, Anode, 3. Emitter, 4. Collector				 1. NC 2. Anode 3. Cathode 4. NC 5. Collector 6. NC 7. Emitter 8. NC
Operating Ambient Temperature (T_A)	-40 ~ +115 ℃				
Forward Voltage	1.22 ~ 1.52V (I_F=0.1 mA, T_A=25℃)				
Collector to Emitter Dark Current	50 nA (I_F =0 mA, V_{CE}=40V, T_A=25℃)				
CTR	300 ~ 800 % (I_F =0.05, 1 mA, V_{CE}=5 V T_A=25℃)		300 ~ 1000 % (I_F =0.05, 1 mA, V_{CE}=5 V, T_A=25℃)		
Rise Time / Fall Time	5 μs / 6 μs (V_{CC}=5 V, I_C=2 mA, RL=100 Ω, T_A=25℃)				

For Factory Equipment Footprint Reduction

Figure 2 shows the circuit diagram around the optocoupler. The input section of the optocoupler has a buffer that amplifies the sink current of the MCU or IPM and a limiting resistor Rs that adjusts the input current, but the large size of these parts, including the optocoupler, makes it difficult for customers to reduce their equipment footprint.

The new RV1S2x51A and RV1S2x55A are ultra-low input current drive transistor output couplers that enable equipment footprint reduction by reducing the size of the

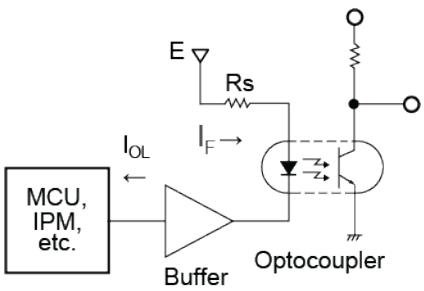


Figure 2. Optocoupler peripheral circuit diagram

optocoupler itself, elimination of buffers by low-IF drive, and reducing the size of the current limiting resistor.

First, as shown in Table 1, we offer FLAT LEAD, LSSOP, and LSDIP8 packages for 4mm, 8mm, and 15mm class creepage packages, respectively, to reduce the size of the optocoupler itself. Each is the world's smallest equivalent creepage package.

For reference, Figure 3 shows a comparison of the dimensions of FLAT LEAD and LSSOP for SSOP and LSOP, which are our conventional packages (equivalent to competing products) in the 4 mm creepage class and 8 mm creepage distance class, respectively. They reduce the footprint by 30% and 35%, respectively.

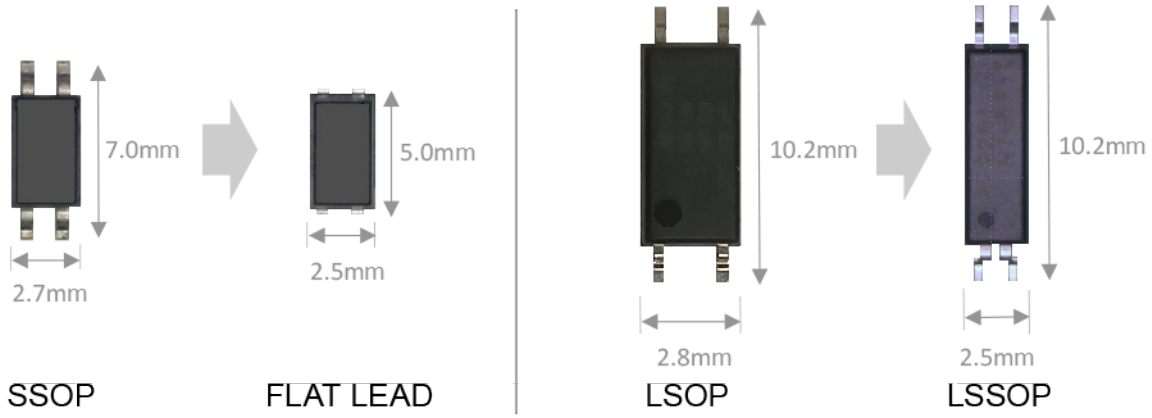


Figure 3. Package Dimension Comparison

In addition, if the current I_F driving the optocoupler is large, it is necessary to amplify it with a buffer if the maximum allowable current of the I/O such as an MCU or IPM is small, but if the current I_F driving the optocoupler is small, the buffer is not required.

Furthermore, when driving an optocoupler with a low I_F, the power P (= $I_F{}^2 \times Rs$) at the limiting resistor Rs is reduced, and the rated power of the limiting resistor Rs can be reduced, thereby reducing the size of the chip resistor.

The downsizing of optocouplers, the reduction of buffers, and the size of chip resistors not only contribute to the downsizing of equipment, but also to the improvement of freedom in board layout design.

For ease of design

Conventional single-transistor output couplers and Darlington transistor output couplers have the following equipment design challenges.

- As shown in Figure 1, since CTR is highly dependent on I_F, it is necessary to check the effects of I_F fluctuations due to input current limiting resistors and optocoupler forward voltages, as well as I_F fluctuations due to ambient temperature, etc.
- It is necessary to confirm the effect of CTR reduction due to the energization of the optocoupler on the set

As shown in Figure 1, the new RV1S2x51A and RV1S2x55A have a smaller I_F dependence on CTR and a smaller effect of I_F variation on the instrument. In addition, the new product has been changed to an LED with a longer life than the conventional product, and since it can be driven with a lower input current, the reduction in CTR due to energization is much smaller.

Figure 4 shows the estimated life of the CTR due to LED degradation when the conventional single-transistor output coupler (driven by I_F = 2.5 mA) and the new product (driven by I_F = 0.5 mA) are energized at an ambient temperature of 100°C and DUTY100%. The time for the CTR to decrease by 50% is about 10 years for the conventional product, but is about 200 years for the new product, and the life of the new product is about 20 times that of the conventional product.

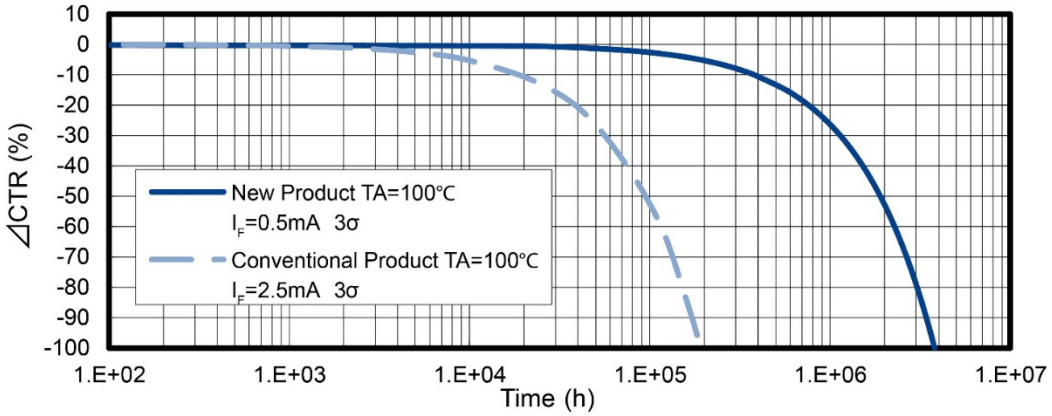


Figure 4. Estimated life

Therefore, the aforementioned confirmation is facilitated.

Conclusion

Renesas Electronics' ultra-low input current drive transistor output couplers RV1S2x51A and RV1S2x55A provide solutions for reducing equipment size and simplifying device design for industrial automation systems including robot controllers, AC servos, and general-purpose inverters, as well as building management and HVAC systems.

Additional Resources

Renesas Electronics optocoupler web site：

https://www.renesas.com/us/en/products/interface-connectivity/optoelectronics

Renesas Electronics optocoupler catalog：

https://www.renesas.com/us/en/document/bro/optocouplers-brochure

Renesas Electronics transistor output coupler driving by ultra-low input current RV1S2x51A、RV1S2x55A：

https://www.renesas.com/us/en/products/interface/optocouplers-optocouplers/optocouplers-optocouplers-transistor-output/low-input-current/product-selector?field-if-at-ctr-ma=0.05%2C0.05

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