

White Paper

Isolation Device Solution for Downsizing of Industrial Automation and Solar Inverter

Yasufumi Kakihana, Senior Staff Engineer, Industrial Analog & Power Business Div., Renesas Electronics Corp.

Michinari Asai, Principal Engineer, Industrial Analog & Power Business Div., Renesas Electronics Corp.

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Abstract

Industrial automation and solar inverter equipment are under intense pressure for size reduction to extract cost savings, while, at the same time, new safety standards are requiring longer creepage and clearance distances in the electrical isolation components, making it difficult for Engineers to meet both goals with existing isolation components. This white paper examines some of the reasons behind these industry trends and introduces the new Renesas RV1S92xxA and RV1S22xxA family of products which were specifically designed to help engineers meet both competing requirements. These new products can reduce board space by 35% in a typical MCU to Inverter isolation interface of a general-purpose inverter circuit, while simultaneously providing creepage and clearance distances required under new safety standards.

Introduction

In industrial automation equipment such as robot controllers, AC servos, and general-purpose inverters, downsizing is required to improve factory floor use efficiency, but longer creepage distance is needed due to stricter safety standards. Similarly, green energy systems like solar inverters and battery systems require downsizing due to the size limitations in installation locations, but creepage distance cannot be changed. From this situation, the isolation device has issues for equipment downsizing. This white paper will explain the selection of isolation devices for downsizing, focusing on the Renesas RV1S92xxA and RV1S22xxA photocouplers which combine the world's smallest package with long creepage distances required for these applications.



Issues for Downsizing

The generic inverter circuit in Figure 1 is often used in high voltage industrial automation equipment and green energy systems which require a low-power motor control circuit and reduced power conversion loss.

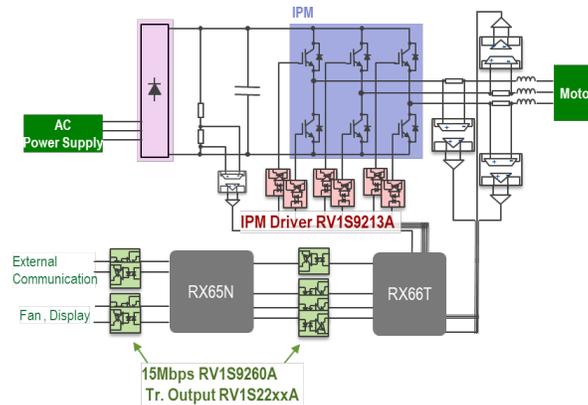


Figure 1. General-purpose inverter circuit

There are various photocouplers in an inverter circuit. IGBT drivers and IPM drivers are used for communication between the inverter control signal (PWM) from the MCU, to power devices such as IGBTs. Isolation amplifiers and delta-sigma modulators are used for the bus line voltage monitor and the motor current sensing. The inverter circuit may have two MCUs for an inverter control for motor drive in the high voltage block, and for communication and display control in the low voltage block. Communication couplers are used for communication between MCUs and I/O.

The following describes the background of downsizing requirements and the issues of selecting an isolation device.

Background of Downsizing

In industrial automation equipment, downsizing is required to achieve both productivity improvement and energy reduction. Downsizing can be described by:

- 1) Space saving: Increase productivity per floor area by reducing occupied space, reducing factory building investment, reducing process work time, improving TAT (Turn Around Time) by reducing transport time in the factory, increasing the number of management facilities per worker by reducing the distance between facilities, and higher functionality of equipment (increasing the number of robot axes, etc.) within the same footprint
- 2) Building a flexible production line: Easily changed factory layout in response to demand fluctuations and improvement activities (Easy installation, transportation and configuration)
- 3) Eco friendly: Reduction of materials (casing, board, wiring, etc.), reduction of electric power such as air conditioning and lighting in the whole factory, reduction of transport energy per equipment (truck, ship, aircraft, etc.)

In fact, these demands have seen not only downsizing of equipment such as robot controllers, AC servos, and inverters, but also integration with connected devices, such as servo drives and motors.

As for home solar inverters, the trend towards the zero-energy house (ZEH) will require more installations in the future however, there is limited space for installations such as the north outer wall or inside the house. Downsizing these components also reduces the burden of transportation and construction work, leading to a total cost reduction.

Stricter Safety Standards

Since the motor drive equipment standard was changed from UL508C to UL61800-5-1, AC200V equipment that requires reinforced insulation must use a longer creepage isolation device. In addition, the change from UL508 to UL61010-2-201, which is the standard for control devices such as PLCs (Programmable Logic Controllers), also requires longer creepage distances and the replacement of isolation devices for AC200V reinforced insulation applications. The longer creepage requirements contradict the previously mentioned demand for downsizing of industrial automation equipment, and the conflicts between both demands must be solved.

Furthermore, there is also a recent requirement from functional safety standard IEC61508 that in multi-channel communication, it is necessary to verify whether the destruction or failure of one channel affects other channels. To support this, it is necessary to select an isolation device that can ensure independence for each channel.

High Temperature Operation

Lastly, there is the possibility of temperature rise inside the equipment due to downsizing. Therefore, it is necessary to select a small, high-temperature isolation device.

Downsizing Summary

Many future inverter and automation equipment applications will require isolation devices that combine:

- Small size
- Long creepage distance
- High temperature tolerance

Renesas Photocoupler – RV1S92xxA, RV1S22xxA

Renesas' RV1S92xxA and RV1S22xxA are the industry's smallest, long creepage photocouplers with a reduced lead pitch while maintaining a creepage/clearance distance of 8.2 mm as shown in Figure 2. To meet the needs of customers with the issues described in the previous section, we offer products with various features. Table 1 shows the RV1S92xxA lineup of IC output couplers, and Table 2 shows the transistor output RV1S22xxA lineup.

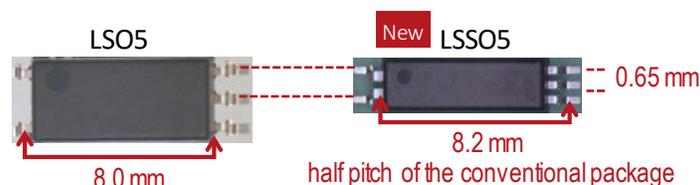


Figure 2. Comparison of conventional package LSO5 and new LSSO5

Function	Part No.	Output Logic	Pin Connection	VDD	IFHL (max.)	IDDH /IDDL (max.)	tPHL, tPLH (max.)	PWD (max.)	CMH, CML (min.)	ABSOLUTE MAXIMUM RATINGS	
				V	mA	mA	ns	ns	TA	BV	
				°C	V						
High-Speed Communication (15Mbps)	RV1S9260A	Active Low		2.7 ~ 5.5	2.6	2	60	20	50	-40 ~ 125	5,000
IPM Drive	RV1S9213A	Active Low		4.5 ~ 25	5	1.3	500 / 750	650	50	-40 ~ 125	5,000

Table 1. RV1S92xxA line up

Function	Part No.	Pin Connection	CTR			ABSOLUTE MAXIMUM RATINGS		
			%	@IF	@VCE	VCEO	TA	BV
				mA	V	V	°C	V
DC Input	RV1S2281A		50 ~ 400	5	5	80	-40 ~ 115	5,000
DC Input (Low input current)	RV1S2211A		100 ~ 400	1	1	40	-40 ~ 115	5,000
AC Input	RV1S2285A		50 ~ 400	5	5	80	-40 ~ 115	5,000

Table 2. RV1S22xxA line up

Key Features

The cross-sectional structure of RV1S92xxA and RV1S22xxA is shown in Figure 3. A double mold structure is adopted, and the LED and the photo detector IC are positioned to ensure an insulation distance of 150 μm . This is different from the on-chip structure of digital isolators which typically have an insulation distance of about 10 μm and a longer distance between input and output.

Also, when considering the end of life, a photocoupler will be in the open mode due to the decrease in the brightness of the LED, while the digital isolator will be in the short mode due to oxide or polyimide film break down which may cause an electric shock accident. Photocouplers have been used as isolation devices for over 40 years in many applications and contribute to an improvement of the system safety.

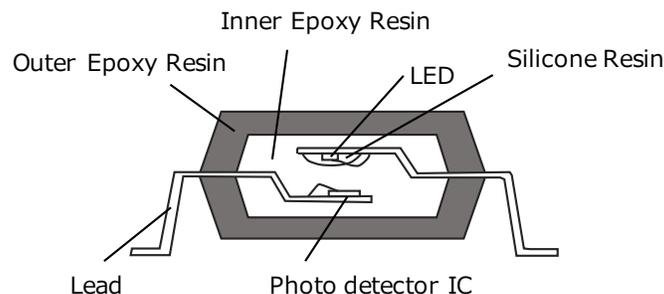


Figure 3. Cross section view s of RV1S92xxA, RV1S22xxA

In the communication interface between the MCU and ASIC of the inverter circuit example shown previously, by using the 15Mbps RV1S9260A and the transistor output RV1S2281A, the mounting area can be reduced by 35% compared to the conventional 8mm creepage LSO5, LSOP as shown in Figure 4. In addition, the power device IPM (intelligent power module) has been downsized, but the area of isolation between the IPM and MCU can be reduced by using the IPM driver RV1S9213A for PWM signal and the transistor output RV1S2281A for feedback of the fault signal. Since each is a single channel product, the layout of the isolation device (photocoupler layout) according to the IPM pin connection is possible.

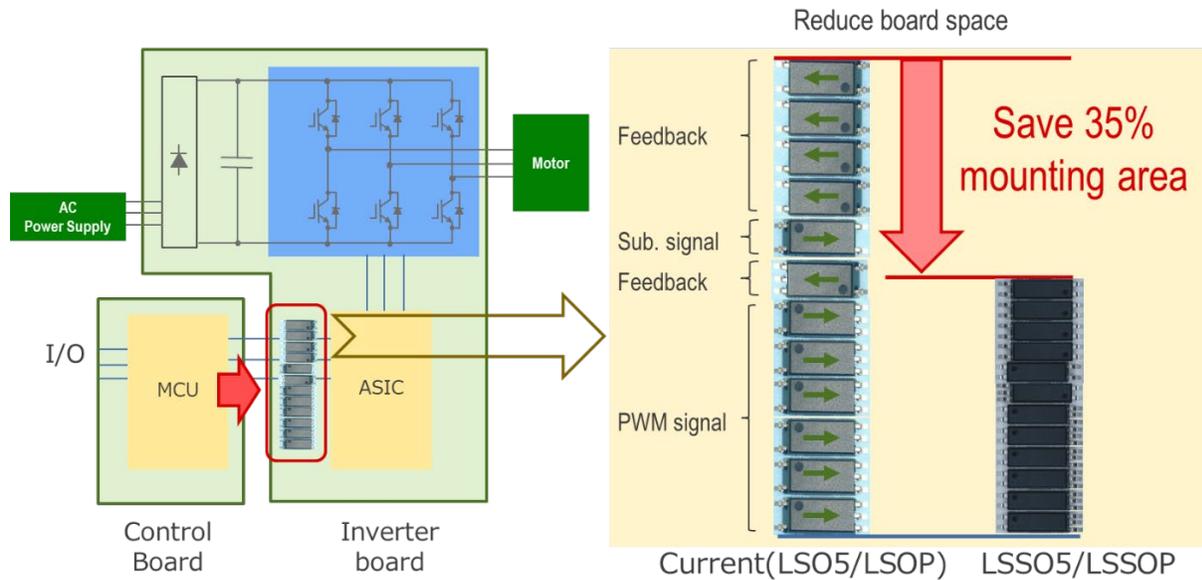


Figure 4. Mounting area comparison of LSO5/LSOP and LSSO5/LSSOP

Stricter Safety Standards

Since the motor drive equipment standard was changed from UL508C to UL61800-5-1, creepage/clearance distance of 5.5mm is required for reinforced insulation of AC200V equipment. Therefore, SSOP/SO5 devices with creepage/clearance distances of 4.2 to 5mm can no longer be used. The RV1S92xxA in LSSO5 and RV1S22xxA in LSSOP shown in Fig. 5 have a reduced length in the pin pitch direction, and a creepage/clearance distance of 8.2mm is ensured. As shown in Fig. 4, the equipment can be downsized while still meeting the new safety requirements.

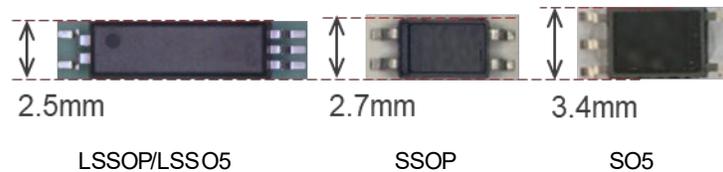


Figure 5. Comparison of LSSO5/LSSOP, SSOP and SO5

In addition, regarding the change from UL508 to UL61010-2-201, which is the standard for control devices such as PLCs (Programmable Logic Controllers), the isolation devices to need be changed to ones with 6mm creepage for AC200V reinforced insulation applications. This requirement can also be supported with RV1S92xxA of LSSO5 and RV1S22xxA of LSSOP.

Since these are single channel products, it is possible to minimize the verification of this isolation portion to meet functional safety IEC61508 requirements.

High Temperature Operation

The RV1S92xxA supports the industry's highest level of 125° C operating temperature, and the RV1S22xxA also supports a high operating temperature of 115° C, making them ideal for use on power boards near the IPM.

Conclusion

In industrial automation equipment and solar inverters, the world's smallest creepage photocouplers RV1S92xxA and RV1S22xxA from Renesas provide solutions to the conflicting issues of downsizing equipment and stricter safety standards.

Additional Resources

Renesas Electronics photocoupler web site:

<https://www.renesas.com/products/optoelectronics.html>

Renesas Electronics photocoupler catalog:

<https://www.renesas.com/doc/products/others/r08cp0001>

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