Isolation Device Solution for Intelligent Power Module (IPM) Drive to realize high-accuracy industrial equipment in high noise environment

Yasufumi Kakihana, Senior Staff Engineer, IoT & Infrastructure Business Unit, Renesas Electronics Corp.

Michinari Asai, Senior Manager, IoT & Infrastructure Business Unit, Renesas Electronics Corp.

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Abstract

As efforts to protect the environment have advanced, the use of inverters in industrial applications and green energy systems have continued to grow rapidly as a way to achieve low-power motor control and reduce power conversion loss. In recent years, this demand has been increasing more and more in relation to Sustainable Development Goals (SDGs). Further improvement in accuracy and downsizing of equipment are required. This white paper focuses on the new Renesas Photocoupler RV1S9x61A and RV1S9x62A for IPM drive which resolve these market demands. These products make it possible to reduce the dead time of the inverter, and are isolation devices with optimum characteristics for driving high-speed power devices which reduce switching loss.

Introduction

The inverter is used in many industrial instruments such as AC servo drives in robot controllers, machine tools, semiconductor production devices and electronic parts mounting devices, general-purpose inverters, and green energy systems like solar inverters, wind inverters and battery systems. And the Intelligent Power Module (IPM) used in the inverter is a high-performance module that combines power devices, drive circuits, and protection functions into a single package. In recent years, many of these industrial devices are required to have high accuracy, low power consumption, and reduced size, and IPM products using high-speed power devices such as high-speed IGBTs and SiC MOS FETs are being developed.

Issues for Isolation Device Selection

The inverter circuit with power devices such as IGBTs and SiC MOSFETs is used in industrial automation equipment and green energy systems, which use high voltage, because of the low-power motor control and reduced power conversion loss. An IPM is high-performance module which highly integrates these power devices (Figure 1). The IPM drivers are used to transmit the inverter control signal (PWM) from the MCU to the power devices. At this time, the main circuit of the high voltage section and the control circuit of the low voltage must be electrically isolated, so an isolation device is used for this IPM driver.

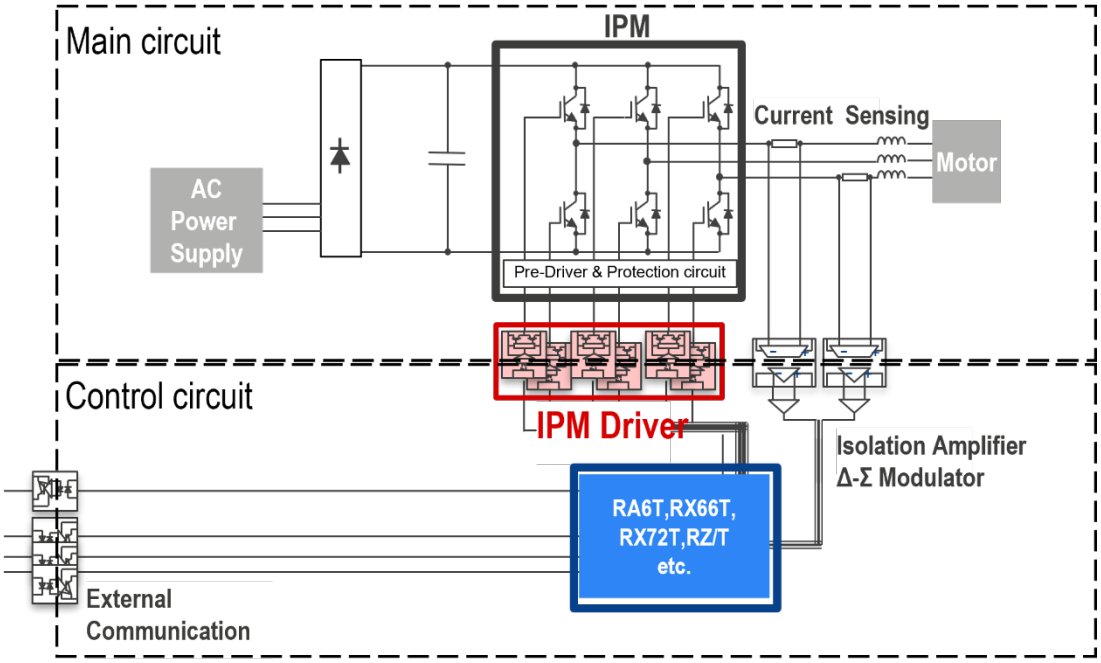


Figure 1. Inverter Circuit of the General-purpose Inverter

Below is a description of requirements for isolation devices and selection issues.

High Accuracy

The inverter has a configuration in which the power devices of the upper arm and the lower arm are connected in series to the DC power supply, and power is converted from direct current to alternating current by switching ON / OFF of the upper and lower power devices at high speed while changing the duty ratio. However, there is an operation delay in the power device and its drive circuit, and if the turn-off is delayed from the turn-on when trying to switch ON / OFF the upper arm and the lower arm at the same time, that is, when the upper arm and the lower arm are ON at the same time, both upper and lower arm devices can cause a DC short circuit and destroy the circuit. To prevent this, a dead time is inserted as a period during which both devices are turned off at the same time when the upper arm and lower arm are switched on / off. But this causes distortion in the output voltage, and high-accuracy control is especially difficult at low speeds. Therefore, in order to reduce the dead time, it is necessary to have a power device with a small operation delay, and at the same time, an isolating device that drives the power device and has a high speed and a small variation in the delay time.

Low Power Consumption

About 50% of the world's electricity consumption is said to be from motor equipment, and this power reduction is a consistent end-user request. In addition, improvement of conversion efficiency in green energy systems such as solar and wind power inverters and electricity storage equipment are essential to the adoption of green and renewable energy. In order to reduce this power consumption, it is important to reduce the switching loss of the power device in the inverter. But for that purpose, it is necessary to switch the power device ON/OFF at high speed, so the dV/dt between the collector and the emitter of the power device output becomes large. When this dV/dt becomes large, the ground potential of the circuit that drives the power device on the upper arm side fluctuates rapidly. Therefore, insolation devices with high noise rejection (high Common mode rejection (CMR)) are required, especially when using high-speed IGBTs or SiC MOSFETs.

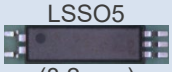
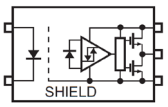
Downsizing

With the improvement of factory floor efficiency and the increase in the number of robot axes, there is a demand for reducing the size of motor drive devices and controllers. In addition, the size reduction of solar inverters and storage devices is also necessary to improve the flexibility of installation locations. On the other hand, there is a concern that the internal temperature will rise due to more compact designs. For this reason, it is necessary to select devices in a small-size package that supports high temperature operation.

Renesas Coupler for IPM Drive - RV1S9x61A, RV1S9x62A

Renesas' RV1S9x61A RV1s9x62A are IPM drivers which have small Propagation Delay Difference Between Any Two Parts (PDD), high noise rejection to meet the needs of the customers mentioned above. RV1S9x61A, RV1S9x62A are active high, active low output respectively, support Vcc 15V IPM input and Vcc 24V I / O. Package variations are also available to adapt downsizing and safety standards. Table 1 shows the outline of the package and characteristics.

Table 1. RV1S9x61A, RV1S9x62A Package and Characteristics Outline

Part Number	**RV1S9161A / RV1S9162A**	**RV1S9261A / RV1S9262A**	**RV1S9061A / RV1S9062A**
Package (Creepage Distance)	SO5  (4.2 mm)	LSSO5  (8.2 mm)	LSO5  (8 mm)
Pin Connection			
Output type	Active High / Active Low		
Isolation Voltage BV	3750 Vrms	5000 Vrms	5000 Vrms
CTI	400		
Temperature (max.) Ta	125 ℃		
Supply Voltage Vcc	4.5 V ～ 30 V		
Threshold Input Current (max.) IFLH / IFHL	3 mA / 3 mA	4 mA / 4 mA	4.5 mA / 4.1 mA
Supply Current (max.) IccL, IccH	3 mA		
Propagation Delay (max.) tpHL/LH	60 ns		
Pulse Width Distortion (max.) PWD	20 ns		
Propagation Delay Difference Between Any Two Parts (max.) PDD	25 ns		
Common Mode Rejection (min.) CMR	100 kV/us		

High Accuracy and Low Power Consumption

The internal block of RV1S9x61A, RV1S9x62A is shown in Figure 2. These are IPM drivers of totem pole output type with an AlGaAs LED on the photocoupler input side, and a photo detector IC in which a photodiode and a signal processing circuit are configured on the same chip on the photocoupler output side. Since the RV1S9x61A, RV1S9x62A use a miniaturized wafer process and optimizes circuit constants for this photo detector IC and use speed-up capacitor for the input side (Figure 3), they make it possible to reduce the dead time by reducing the variation in the propagation delay time, including temperature changes. Figure 4 shows the temperature dependence and speed-up capacitor dependence of tpLH and tpHL in RV1S9261A.

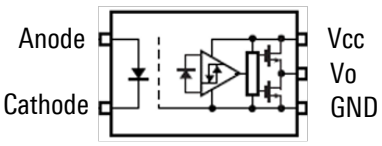


Figure 2. Internal Block of the RV1S9x61A, RV1S9x62A

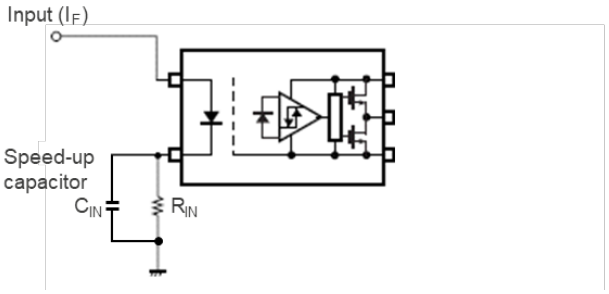


Figure 3. Example of Using Speed-up Capacitor

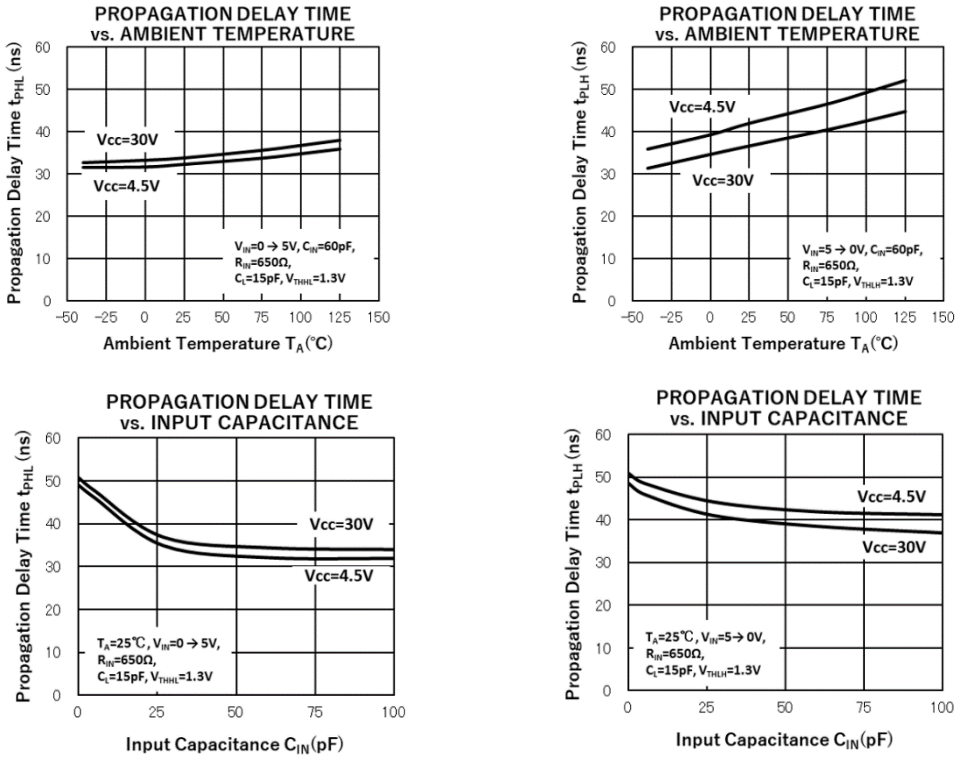


Figure 4. Temperature Dependence and Speed-up Capacitor Dependence of tpLH and tpHL in RV1S9261A

In addition, RV1S9x61A, RV1S9x62A achieve a high CMR (high noise rejection) that prevents malfunctions caused by the steep dV / dt of high-speed power devices in order to reduce equipment switching loss.

For example, RV1S9061A achieves a 75% reduction in PDD and double the CMR value compared to our conventional product PS9009 (Figure 5).

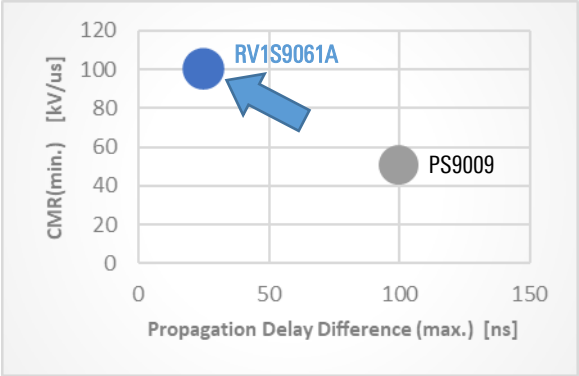


Figure 5. Comparison of RV1S9061A with our Conventional PS9009

Various Packages

The cross-sectional structure of RV1S9x61A, RV1S9x62A are shown in Figure 6. The double mold structure is adopted, and the LED and the photo detector IC are facing to ensure an insulation distance of 150 um. This structure is different from the on-chip structure with an insulation distance of about 10um like digital isolators, and the distance between input and output is longer. Also, when considering the end of life, the insulating part of the photocoupler is in the open mode due to the decrease in the brightness of the LED, while the digital isolator is in the short mode due to oxide film or polyimide film breakage, which may cause an electric shock accident. Photocouplers have been used in many sets as an isolation device for over 40 years and contribute to the improvement of system safety.

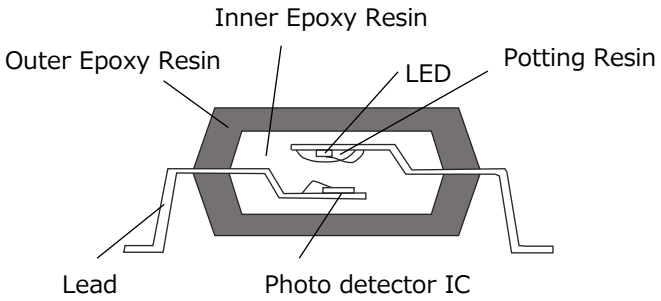


Figure 6. Cross Section View of RV1S9x61A, R1S9x62A

As shown in Table 1, three types of packages SO5, LSO5 and LSSO5 are prepared, and can be selected according to safety standards and the size of the board. Since it is one channel type package, the coupler can be arranged according to the IPM input pin arrangement. SO5 (RV1S9161A, RV1S9162A) has 4.2mm creepage, and can be used not only for IPM drive but also as 200V reinforced insulation for I / O due to its CTI 400.

LSSO5 (RV1S9161A, RV1S9162A) is small packages with creepage 8.2mm, the mounting area can be reduced by 35% compared to the conventional 8mm creepage LSO5. It is useful for downsizing the equipment and improving the layout flexibility for equipment such as AC400V AC servo (Figure 7).

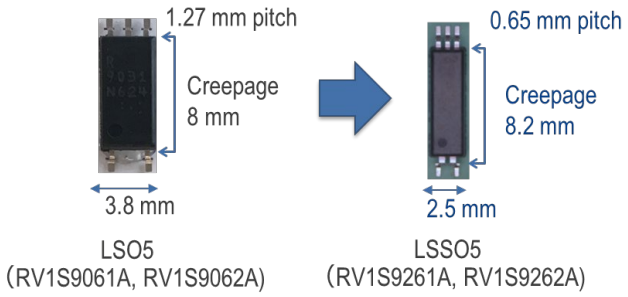


Figure 7. Comparison of Conventional Package LSO5 and LSSO5

Conclusion

For inverters using IPM in industrial equipment and green energy systems, the IPM driver RV1S9x61A and RV1S9x62A from Renesas provide the optimum solution for high accuracy, low power consumption, and downsizing of equipment.

Additional Resources

Renesas Electronics photocoupler web site：
https://www.renesas.com/us/en/products/interface-connectivity/optoelectronics

Renesas Electronics photocoupler catalog：
https://www.renesas.com/us/en/document/bro/photocouplers-brochure

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan
https://www.renesas.com

Contact Information

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