White Paper

Isolation Device Selection for Industrial Automation

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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. These inverters comprise high-voltage circuit blocks and low-voltage circuit blocks of control. Electric isolation is needed between these two circuit blocks. This document outlines issues of isolation device selection and correspondence. It will also discuss the latest photocouplers from Renesas with an introduction of the RV1S9x60A as an example.

Introduction

Industrial Automation equipment such as AC servos, general-purpose inverters and robot controllers, and green energy systems like solar inverters, wind inverters and battery systems require lower power consumption and higher speed communication due to increased data volume needed for control. On the other hand, the noise environment is more severe because the power devices like IGBTs and SiC MOSFETs provide higher speed switching. In addition, it is necessary to meet safety and size requirements. These situations make it difficult to select isolation devices.

This document will discuss the isolation requirements of industrial automation equipment and green energy systems, and introduce the RV1S9x60A from Renesas, which is used for communication between microcontrollers (MCUs) and I/O.

Issues for Isolation Device Selection

The inverter circuit in Figure 1 is used in industrial automation equipment and green energy systems, which use high voltage, because of low-power motor control and reduced power conversion loss.

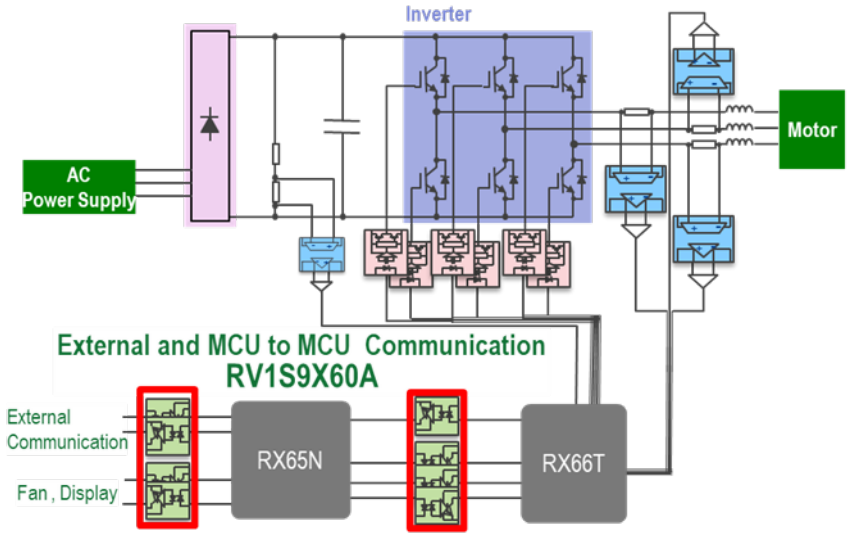


Figure 1. *Inverter circuit of the general-purpose inverter.*

There are various photocouplers in an inverter circuit. IGBT drivers and IPM drivers are used for communication of 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 high voltage block and for communication and display control in low voltage block. Communication couplers are used for communication between MCUs and I/O. Below is a description of requirements for isolation device and selection issues.

Eco friendly ~ Low power consumption, high speed, high noise rejection

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. Therefore, it is necessary to select a low power consumption solution. In addition, it is necessary to speed up the communication of the isolation block in response to the increase in the amount of control data accompanying the improved system functionality. On the other hand, the noise environment is becoming severe as the speed of power devices such as IGBTs and SiC MOSFETs increases.

A selection of low-power, high-speed, high-noise rejection-balanced isolation devices is required.

High-voltage system

Increasing system voltage is implemented as part of environmental considerations. This leads to a reduction in current loss due to the increase in voltage and a reduction in the amount of wiring material (copper (Cu)) due to the reduction in current. In fact, the lineup of the 690V type general-purpose inverter and the 1000V type solar power controller has been expanded. Such high-voltage equipment requires a package with long creepage/clearance distance.

Stricter safety standards

UL508C, which is a standard for motor drive equipment, has been changed to UL61800-5-1, and it is necessary to extend the creepage distance for reinforced insulation of AC200V equipment. Furthermore, UL508, which is a standard of control devices such as PLC (Programmable Logic Controller), is changing to UL61010-2-201. It is necessary to extend the creepage distance in response to the reinforced insulation requirements of AC200V systems, and the newer isolation devices that support these requirements are needed for new developments.

Recently, due to the requirements of the functional safety IEC 61508 in multi-channel communication, it is necessary to verify whether destruction or failure of one channel affects other channels. This requires selecting a device which can ensure independence for each channel.

Size reduction and high temperature operation

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.

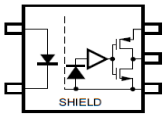
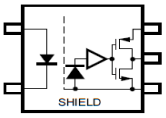
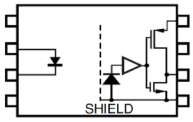
Shortening development period

There are concerns that the measures required to manage the rise in internal temperature and the deterioration of the noise environment due to the use of new power devices (high-speed IGBT, SiC) will increase the development time and costs of these systems.

Renesas High-Speed Coupler – RV1S9x60A

Renesas' RV1S9x60A is a 15Mbps communication photocoupler that can operate at low input current while maintaining high noise rejection. Package variations are also available to meet the needs of the customers mentioned above. Table 1 shows the outline of the package and characteristics.

Table 1. *RV1S9x60A package and characteristics outline*

Part Number	**RV1S9060A**	**RV1S9160A**	**RV1S9960A**
Package (Creepage Distance)	LSO5  (8.0mm)	SO5  (4.2mm)	LSDIP8  (14.5mm)
Pin Connection			
Supply Voltage (VDD)	2.7 V to 5.5 V	2.7 V to 5.5 V	2.7 V to 5.5 V
Isolation Voltage (BV)	5 000 Vrms	3 750 Vrms	7 500 Vrms
Temperature (max.) (Ta)	125 °C	125 °C	110 °C
Threshold Input Current (max.) (IFHL)	2.2 mA	2.0mA	3.8 mA
Supply Current (max.) (IDDL/H)	2.0 mA	2.0mA	2.0 mA
Propagation Delay (max.) (tpHL/LH)	60 ns	60 ns	60 ns
Pulse Width Distortion (max.) (PWD)	20 ns	20 ns	20 ns
Propagation Delay Skew (max.) (tpsk)	25 ns	25 ns	25 ns
Common Mode Rejection (min.)	50 kV/us	50 kV/us	50 kV/us

Eco friendly ~ Low power consumption, high speed, high noise rejection

The internal block of RV1S9x60A is shown in Figure 2. On the photocoupler input side, an AlGaAs LED as a light emitting element is mounted, and on the output side, a photo detector IC in which a CMOS IC and a photodiode are integrated is mounted.

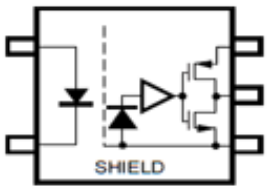


Figure 2. *Internal block of the RV1S9x60*

The RV1S9x60A uses a miniaturized wafer process and optimizes circuit constants for this photo detector IC and achieves a 60% reduction in power consumption compared to our conventional product, PS9151. The threshold input current IFHL achieves the industry's best-in-class 2.0 mA (RV1S9160A) and photo detector IC circuit current 2.0 mA max at high-speed communication of 15 Mbps. In addition, the RV1S9x60A CMR (Common Mode Rejection) achieves 50kV / us min, the industry's best-in-class, which is 3.3 times higher than our conventional products, as shown in Figure 3.

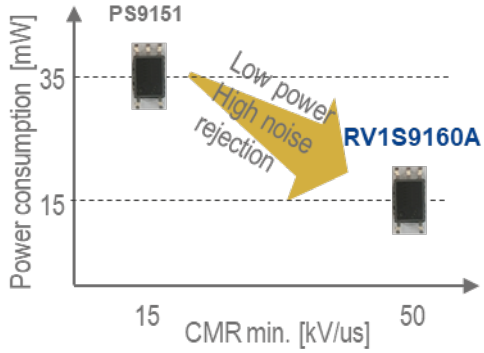


Figure 3. *Comparison of RV1S9160A with our conventional 15Mbps product*

With faraday shielding on the photodiode inside the photocoupler, layout design, and circuit optimization, and LED input with divided resistors (Ra, Rk) as shown in Figure 4, the influence of the parasitic capacitance inside the photocoupler of common mode noise can be suppressed, and high CMR is achieved.

The RV1S9x60A balances low power consumption, high speed and high noise resistance.

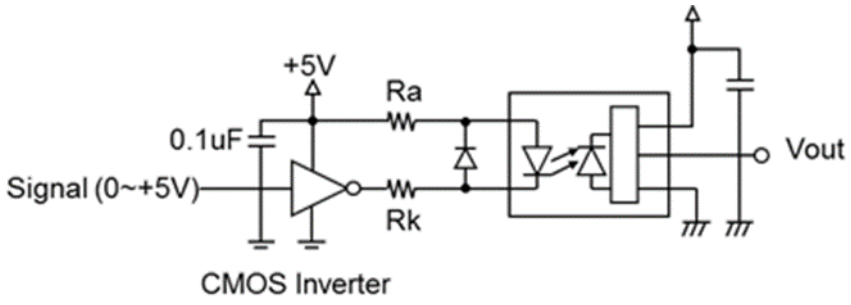


Figure 4. *Divided resistor input to improve CMR*

High Voltage System

The cross-sectional structure of RV1S9x60A is shown in Figure 5. The double mold structure is adopted, and the LED and the photo detector IC are facing to ensure an insulation distance of 100-400 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.

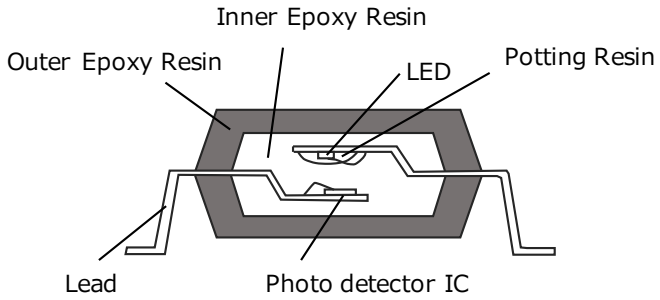


Figure 5. *Cross section views of RV1S9x60*

For the 690V industrial inverter and the 1000V power conditioner, which are high voltage equipment, RV1S9960A of LSDIP, which has 0.4mm insulation distance and 14.5mm creepage distance / clearance distance, secures safety.

With the change from UL508C to UL61800-5-1, the standard for motor drive equipment, a long creepage/clearance distance of 5.5mm is required for reinforced insulation of AC200V equipment. The RV1S9060 of LSO5 has a creepage/clearance distance of 8mm to meet this requirement.

Also, for transitioning from UL508 to UL61010-2-201, which is the standard of control equipment such as PLC (Programmable Logic Controller) for equipment connected to a power supply of less than 300V AC, a 6mm creepage distance is required when a CTI*=175 isolation device is used as reinforced insulation.

Since the RV1S9160A of SO5 has a CTI of 400, the creepage distance can be reduced to 4.2mm, and a more compact design of this part is possible.

*CTI (Comparative Tracking Index)

Downsizing, high-temperature operation

As shown in Figure 6, the RV1S9x60A prepares three types of packages that contribute to downsizing for each application.

The SO-5 RV1S9160A is suitable for PLC, I/O, and RS485 / 232 with a creepage distance of 4.2mm. Since CTI is 400 as mentioned above, it is possible to support 200V AC with the same 100V foot pattern as conventional (UL508) in PLC.

The LSO5 RV1S9060A can be used for communication between MCUs of 200V and 400V AC servos and inverters, and 750 VDC storage batteries with a creepage distance of 8mm. Compared to general SDIP with 8mm creepage distance products, the package height is reduced by 30% and the mounting area is reduced by 25%, contributing to the downsizing of the set.

The LSDIP RV1S9960A is suitable for 690V industrial inverters and 1000V solar power conditioner applications with a creepage distance of 14.5mm.

The RV1S9060A and RV1S9160A support the industry's highest operating temperature of 125 degrees Celsius; the RV1S9960A also supports the highest operating temperature of 110 degrees Celsius as a long creeping (14.5mm) coupler; and the RV1S9x60A is low power consumption, so higher density mounting becomes possible.

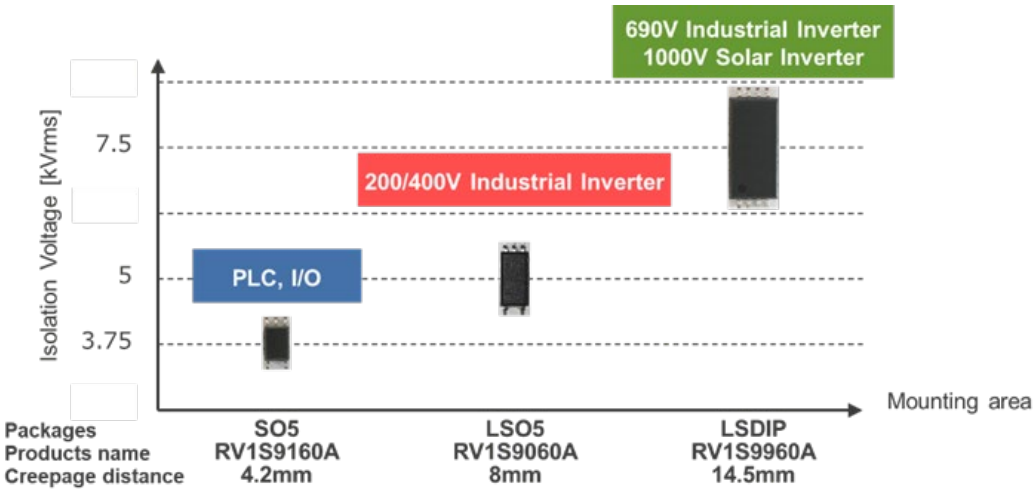


Figure 6. *Package variation and isolation voltage*

Shortening development period

As explained above, the high temperature operation and high noise rejection of the RV1S9x60A contribute to the improvement of the flexibility of layout, the control of temperature and noise problems, and the reduction of the countermeasure time.

Conclusion

The various issues in the selection of isolation devices are solved by using Renesas photocoupler RV1S9x60 which has low power consumption, high speed, high noise resistance and the package variation.

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/r08cp0001ej0150-photocoupler.pdf