

## About High Frequency Relays for High-speed Differential Transmission Signal Switching

### Overview

In recent years, various devices have been generating and processing large amounts of data, such as high quality images, movies from digital cameras and smart phones transmitting through internet, television, etc.

There are several standards for digital transmission such as HDMI, USB, MIPI, DDR, Thunderbolt, PCI Express and SATA (Serial ATA), so high speed signals exceeding the bandwidth of several Gbps are often required even for general use. **(Figure 1)**

This high speed signal is widely used not only for communication between devices but also for processing equipment internal circuits, communication between built-in

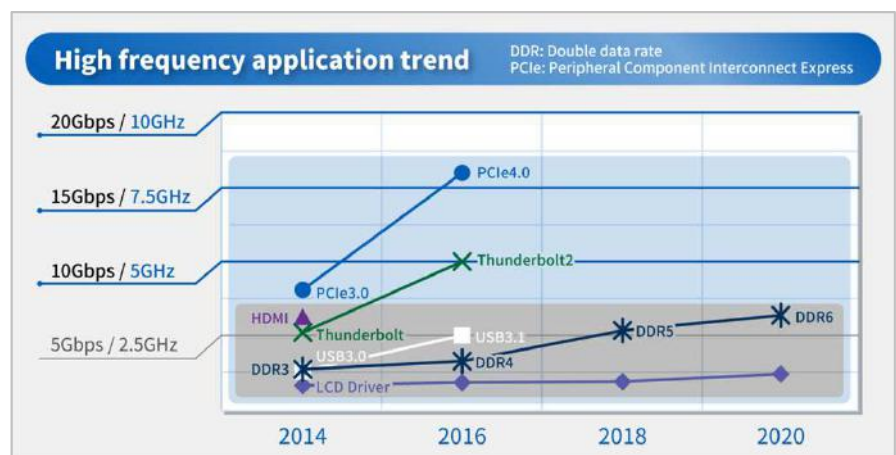


Figure 1

parts as well as for the inspection machine at the manufacturing stage of equipment and parts.

Mechanical relays are built in the main bodies of production and inspection equipment and final products, and are used for switching signal connection.

In the case of transmission and switching of high speed signals by means of mechanical relays, change and deterioration of the signal waveform due to the transmission characteristic (frequency characteristic) of the relay used affects the signal quality, so that a relay having better transmission characteristics is required.



This product is a relay with excellent transmission quality developed for high speed signals, especially for high speed differential transmission signals.

### On High Speed Differential Transmission Systems

The differences between differential transmission system used for high speed signal transmission and single end system used in conventional signal are:

In the single-end system, a signal is transmitted with one line, and the magnitude of the signal is determined by the potential difference with the ground.

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On the other hand, in the differential transmission method, opposite phase signals are transmitted to the two lines, respectively, and the magnitude of the signal is determined by the potential difference between the two lines. **(Figure 2)**

In the single-end method, since a single signal line transmits a signal, there is the advantage that the number of signal lines is small, but it is susceptible to the influence of external noise and there is a limit in speed.

Therefore, in order to transmit a large amount of signals quickly, it is necessary to increase the number of signal lines and to perform parallel transmission as well as to consider synchronism between parallel signals, which is rarely used for high-speed signal applications.

On the other hand, in the differential transmission method, the greatest advantage is that it is resistant to noise in order to see the potential difference between the two signal lines. Normally, since external noise is similarly applied to two signal lines, noise is cancelled out when viewed by a potential difference at the time of reception. **(Figure 3)**

Also, being resistant to noise means that the voltage amplitude of the signal can be kept low, so it is possible to shorten the rise/fall time of the signal and to increase the speed. **(Figure 4)**

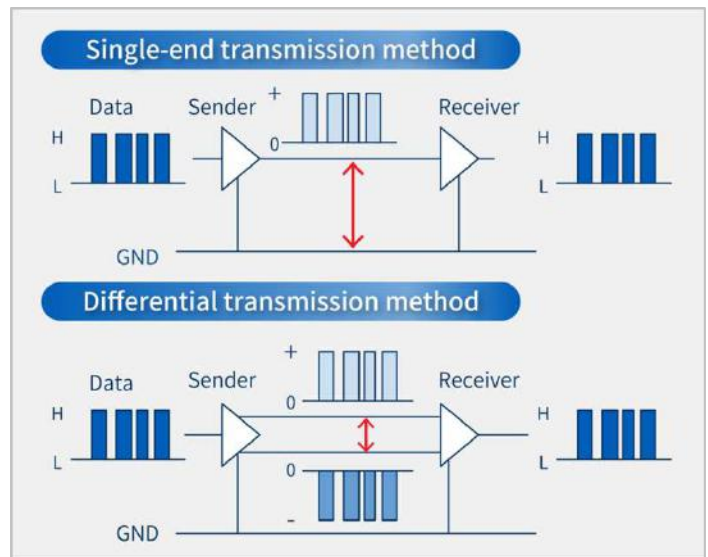


Figure 2

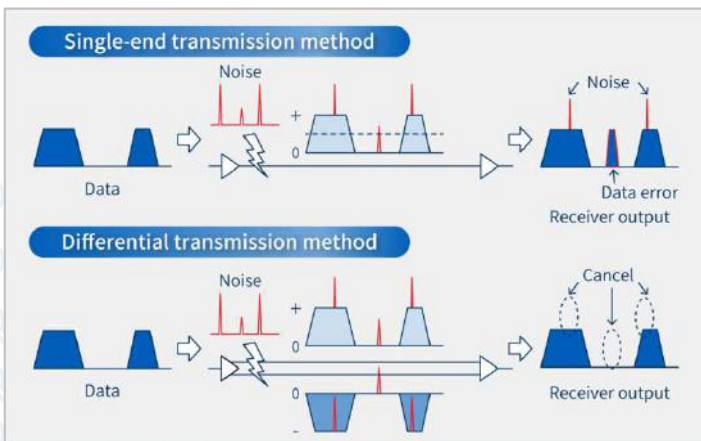


Figure 3

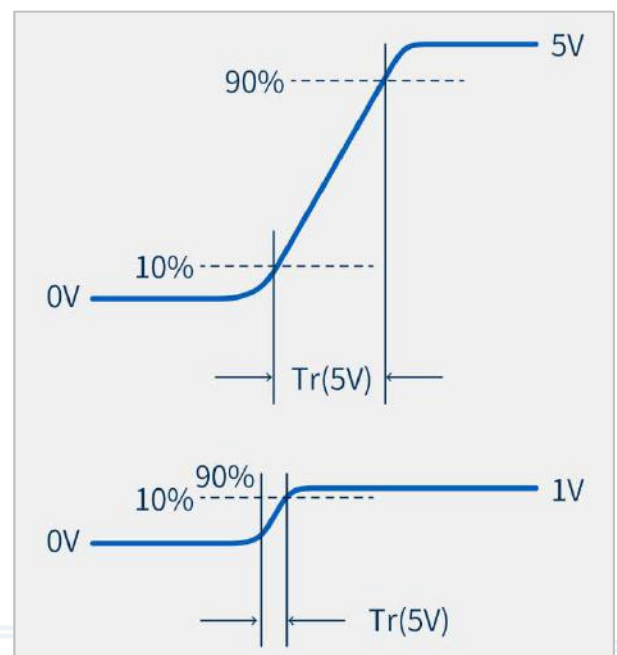


Figure 4

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In the high-speed differential transmission system, the specification required for the mechanical relay is a two-pole contact type for transmitting signals on two lines. A signal is transmitted by a potential difference between the two signal lines, so that a one-pole contact side and the transmission characteristics on the 2 pole contact side are equivalent. In circuit switching applications, it is also said that the transmission characteristics on the N.O contact side and the N.C contact side are equivalent.

### Representative Circuit Example of Relay

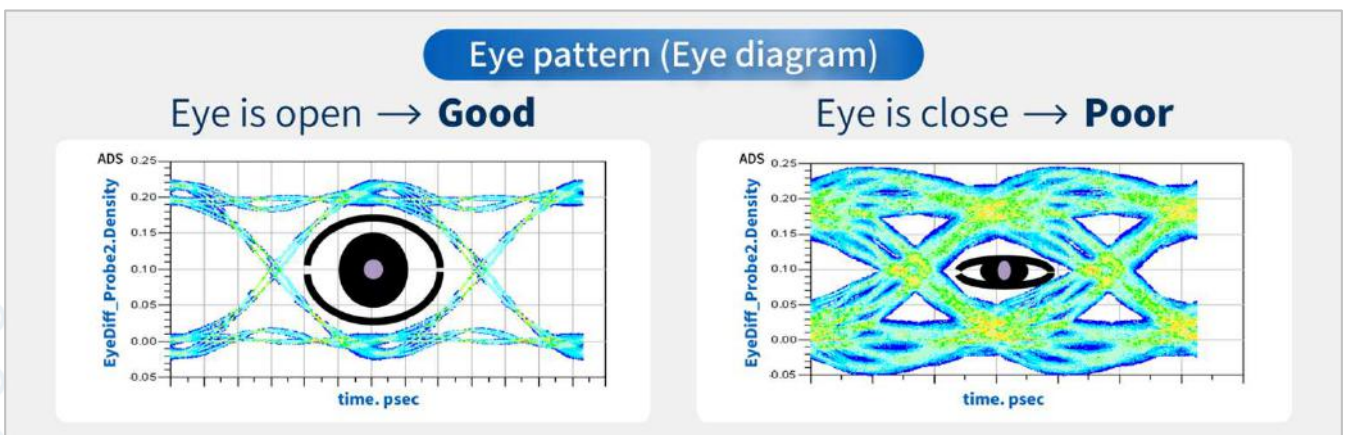
Main applications of relays used in semiconductor inspection apparatus include signal switching between the main body of the inspection apparatus and the inspection object and switching of input/output channels of the apparatus. Specific circuit examples are shown below:

- Input and switch different signals to the inspection object.
- Switch inputs and outputs of signals to a plurality of inspection objects and inspection device channels.
- Switching between signal from inspection equipment and loopback test.

### Evaluation of High-Speed Differential Transmission Signal

In digital signals, "1" and "0" change in a complicated manner, so it is not possible to evaluate the quality of the waveform from a single frequency signal.

For that reason, what is commonly referred to as "eye pattern/eye diagram" (obtained by sampling a signal waveform in a relatively long time or displaying a prescribed pattern signal, such as a random signal) in superimposition is generally used. It is called an eye pattern because the image on which the waveform is superimposed looks like an eye. **(Figure 5)**



**Figure 5**

The vertical axis of the eye pattern image represents voltage amplitude and the horizontal axis represents time.

When the voltage amplitude varies, the upper and lower lines are thick, and in the case of attenuation, the upper and lower widths become narrow.

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When there is variation in the time axis direction, the width of the line that transits from the top to the bottom or from the bottom to the top increases.

When the opening (the part where the eye is open) is wide, it can be said that the signal quality is good because the signal can be read correctly. If it is narrow, the signal can not be read correctly or an error occurs and the signal quality deteriorates.

Eye pattern characteristics are important for relays used for differential transmission signals, as such, relay characteristics have to be closely aligned with the application.

Items for consideration during evaluation of customer application and clearance of final system include: Transmission / reception unit, characteristics of the whole transmission path, such as cable, connector, device) and interface standard (USB, HDMI, MIPI, etc). It is common practice to ensure that specifications of relays match load requirements.

### Product Structure Outline (Principle of Structural Characteristics)

The existing G6K-RF series has the basic structure of a signal relay with good frequency characteristics shielded with a metal case.

By shielding with a metal case and grounding, high frequency characteristics are improved by configuring a microstrip line structure in which a space between a metal case, a resin case and a signal terminal are used for a high frequency transmission line.

However, in this structure, there are restrictions such as the thickness of the resin case inside the signal relay, the spacing between the signal terminals and the metal case, and there is also a limit to making ideal transmission path characteristics.

In the most recent products, by making the shape and dimensions of the metal case aiming at the optimum impedance characteristic for each part of the signal terminal of the built-in relay, it was possible to achieve excellent frequency characteristic. **(Figure 6)**

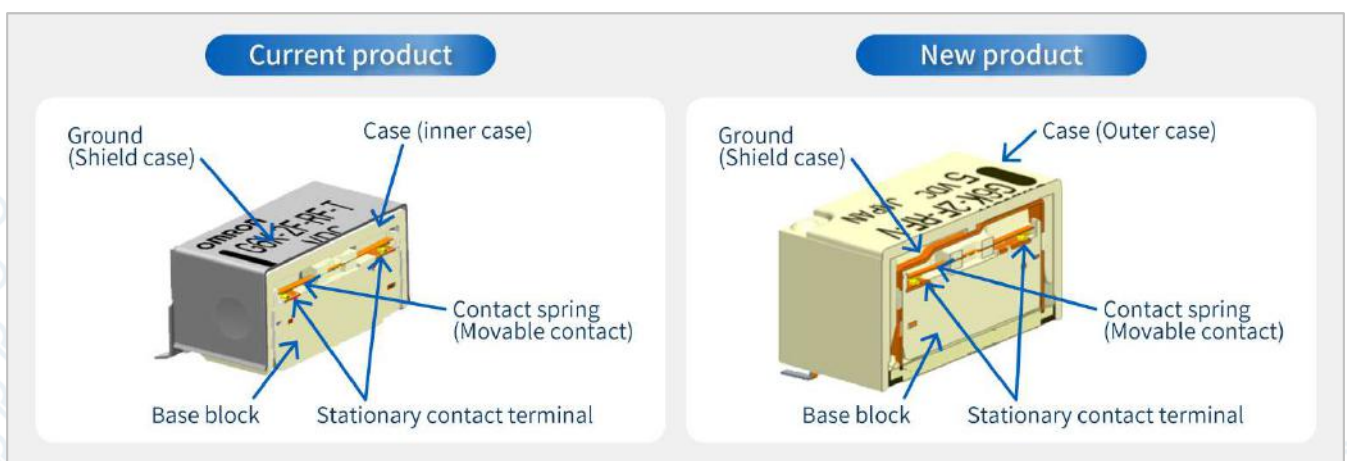


Figure 6

## About High Frequency Relays for High-speed Differential Transmission Signal Switching

### Feature 1: High-Speed Transmission Signal Related Characteristics

Offering stable linearity high insertion loss characteristic at 3 dB or less from DC to 8 GHz. **(Figure 7)**

This enables stable signal transmission in a wide frequency band.

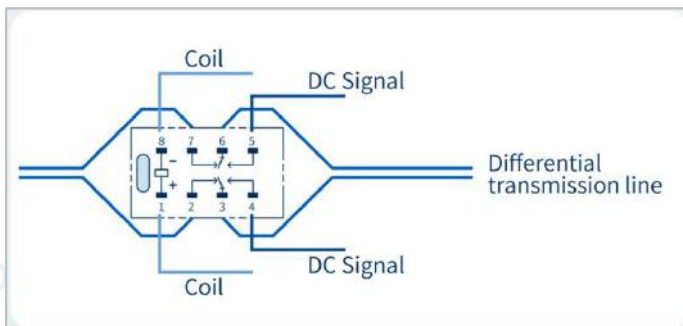
It also supports DC signals, so it can also be used to switch between conduction check and DC inspection signal.

### Feature 2: Others

- Allows for pattern wiring underneath relay.

In existing high frequency relays, there are some points of connection on the board with the bottom of the relay such as GND, and some patterns can not be placed underneath the relay because they interfere with the signal line inside the relay.

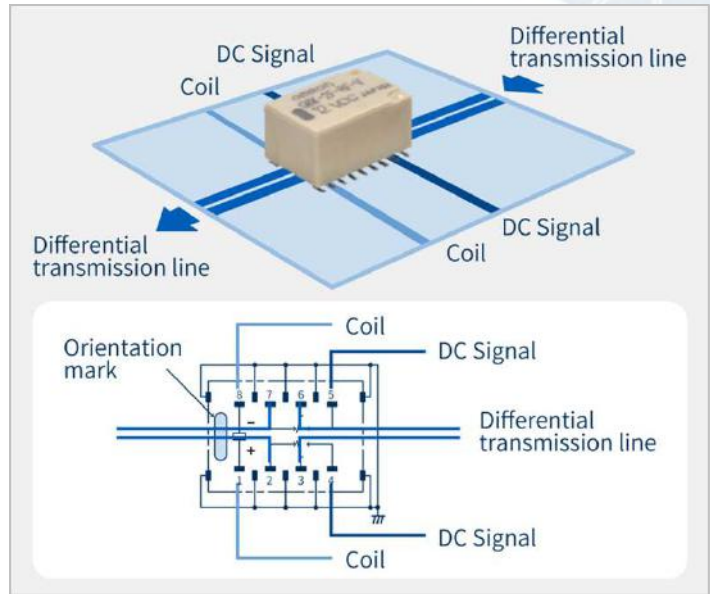
In order to avoid this, it was necessary to design complicated wirings using multilayer boards and sacrificing differential transmission characteristics in circuit design. However, with this product, since it allows for pattern underneath the relay, it contributes to a simpler circuit design with good high frequency characteristics. **(Figure 8)**



**Figure 8**

- Outside L-shaped surface mount terminal

By making the terminal shape in an Outside L shape and the same dimensions, we have achieved excellent solderability and improved visibility of the soldered state at the appearance inspection.



**Figure 7**

- Plastic case does not interfere with PCB board traces

Many existing high-frequency relay models utilize metallic exterior cases, but this product was developed with resin case.

With metal cases, there is an issue where the probe pins short-circuit through the metal case during inspection of the relay mounting board and both the board and parts are damaged, but this new product can prevent this problem.

## About High Frequency Relays for High-speed Differential Transmission Signal Switching

- Main ratings, characteristics, specifications

Item	Value	Note
Contact resistance	100mΩMax. (Initial)	10mA at 1VDC with voltage drop method
Operate voltage	80%Max.	
Release voltage	10%Min.	
Operate time	3msMax.	
Release time	3msMax.	
Coil power consumption	Approx. 100mw	
Dielectric strength	350VAC, 50/60Hz 1min	Between coil and contacts, Between contacts of different polarity, Between contacts of the same polarity, Between ground and coil/contacts
Insulation resistance	500MΩMin.	
Rated load (resistance)	10mA / 10VDC 1A / 30VDC 0.3A / 125VAC 1W at 8GHz	
Max. switching voltage	125VAC, 60VDC	
Max. switching current	1A	
Max. carry power	1W	at 8GHz, Impedance50Ω, V.SWR 1.2Max at load.
Max. switching power	1W	at 8GHz, Impedance50Ω, V.SWR 1.2Max at load.
Mechanical endurance	50,000,000ops. Min.	
Electrical endurance	1,000,000ops. Min.	Load condition 10mA/DC10V
	100,000ops. Min.	Other rated load condition
Ambient temperature	-40°C~+70°C	with no icing or condensation

### Afterword

The use of high-speed transmission signals is expected to further increase the demand for higher speed and signal transmission quality in the future due to the expansion of applications and fields such as digitization of various equipment and household appliances and increasing the amount of signal information and IoT.

We believe that this relay can be widely deployed in semiconductor inspection equipment, manufacturing equipment and related equipment used in these devices.

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