

# The Technology Revolution in Solid State Switching Relays



Figure 1: Ultra Small Solid State Relay

Modern Relay technology has been around since the 1960's and its main function has been to provide automation with electrical isolation for many applications. All Relays have two separate circuitries: input and output. The main purpose for a Relay is to control a hazardous load voltage and current by employing a small signal to the input side which consists of milliamps at millivolt levels. Relays in general can be considered a very broad technology that is used across an endless number of applications in almost every area of electronics. They come in many shapes and sizes, but are generally divided to two main categories, which are Electromechanical and Solid State Relays.

Electromechanical Relays can be sub-categorized based on the Relay's load current and load characteristic. For example, Relays that are capable of switching a load current of 2A or less are called Signal Relays. Relays that switch high frequency signals are called High Frequency (RF) Relays. Power Relays usually switch high load current. And certain types of Relays with a Din rail mount would be grouped under Control Panel Relays.

Developed later than Electromechanical, Solid State Relays are categorized based on their output chip. These consist of: Photo-Triacs (for AC output), Photo-Transistors (for DC output) and MOSFET Relays (for AC and/or DC output). With no moving parts, Solid State Relays can avoid mechanical failure modes associated with traditional Electromechanical Relays, such as contact sticking or permanent welding. They also tend to offer more desirable characteristics and

design advantages such as low power consumption, stable on-resistance over lifetime, long life, small size, fast switching speeds, shock and vibration resistance, and elimination of mechanical contact chatter.

When comparing performance advantages of Solid State Relay technology (SSR), one quickly realizes that these devices are not created equal. Optical MOSFET-based Relays such as PhotoMOS<sup>®</sup> have highly linear input and output characteristics that outshine alternatives such as Triacs or Optocouplers. These SSR with MOSFET output chips can also control small analog signals without distortion. SSR that use output chips such as Triacs or Bipolar Transistors have offset voltages that distort and clip signals. This characteristic is very important for precise test equipment and measurement devices. A number of manufacturers offer Solid State Relays that employ two MOSFETs inside one package, which makes it possible to control both AC polarities or allow for separate DC loads in the same device. This ability to control both AC and DC signals in this manner is not available when using Triacs and Phototransistors.

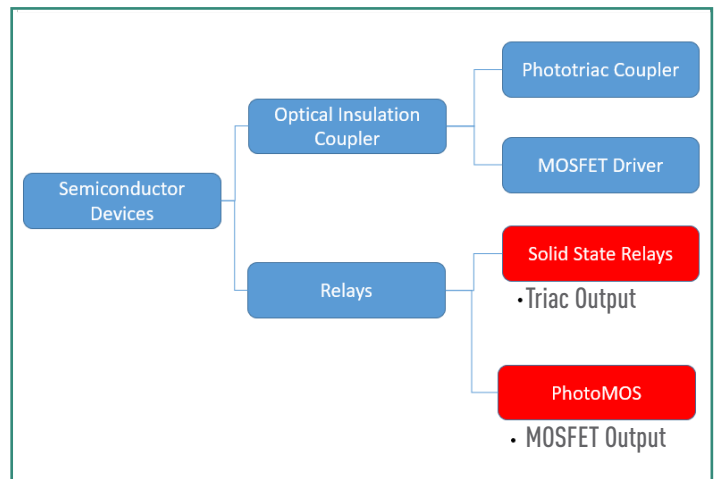
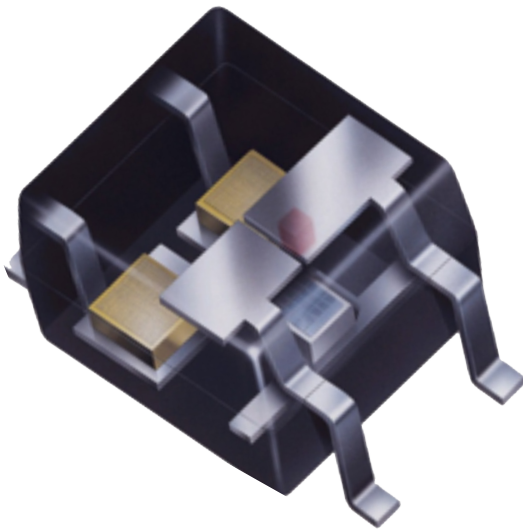


Figure 2: Classification of Semiconductor Devices



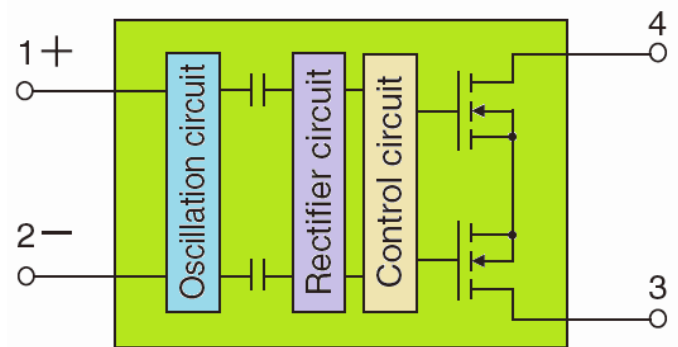
**Figure 3: Internal Structure of Conventional MOSFET Relay (PhotoMOS)**

MOSFET Relay technology is significant even with just a basic understanding of how the conventional LED driven MOSFET output Relay operates. MOSFET Relays typically consist of an LED and photo array that is molded in a translucent resin which allows light to pass through while providing a dielectric barrier between the input and output. To turn on the Relay, first a current is applied to the LED on the input side which will illuminate. The light is then absorbed by the photoelectric element which converts the light to electric power similar to a solar cell. This electrical current then passes through a control circuit and charges the gates of the 2 MOSFETs on the output side. When the gate voltage of the 2 MOSFETs reaches its set threshold, the MOSFETs begin to conduct, allowing the load to pass through the terminals. When the LED is turned off, the control circuit rapidly discharges the gate which will force the MOSFETs to stop conducting and turn off the load.

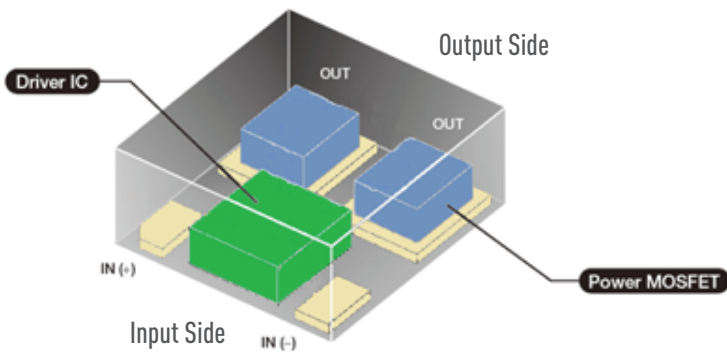
Taking this technology one step further is a Capacitive Coupled Relay, such as the Panasonic CC TSON, which employs a control method that differs from the long-established LED operated MOSFET Relays. In this device, the LED from the input side has been replaced with a Capacitive Coupling Driver IC; this allows the Relay to be voltage-driven rather than current-driven. When a DC voltage signal is applied to the input terminals, the circuit in the driver IC begins to oscillate the signal at high speed. This oscillated signal is then

passed through a Capacitor which provides isolation between input and output. Afterwards, the signal is then converted to a DC voltage by a rectifier circuit. A control circuit takes this rectified DC signal and charges the MOSFET gate on the output side. Once the gate voltage of the MOSFET supplied from the driver IC reaches a preset voltage value, the MOSFET begins to conduct and turns on the load.

Removing the LED from the input side relieves some of the design limitations previously encountered by MOSFET Relays. The LED takes up a lot of space. Without it, the mounting area is approximately 46% smaller than the previous SON type package making this a very small size Relay in the industry (Category is using MOSFET on the output side). Also, since the capacitive coupled control circuit is voltage driven, there is no need for any external current limiting Resistor to be placed on the input side. The capacitive controlled input has extremely low current consumption with an input current draw of 0.2mA or less which is significantly lower than the LED current draw of previous MOSFET Relays. Since temperature has a direct impact on the LED character, one advantage of removing the LED from the Relay is the ability to withstand industrial ambient operating temperatures. The Capacitive Coupled Relay (CC TSON) can reliably operate at temperatures up to 105°C, which is 20°C higher than ambient operating temperatures for LED controlled Relays.



**Figure 4: Internal Schematic Diagram of Capacitive Coupled Relay (CC TSON)**



**Figure 5: Internal Structure of New Capacitive Coupled Relay (CC TSON)**

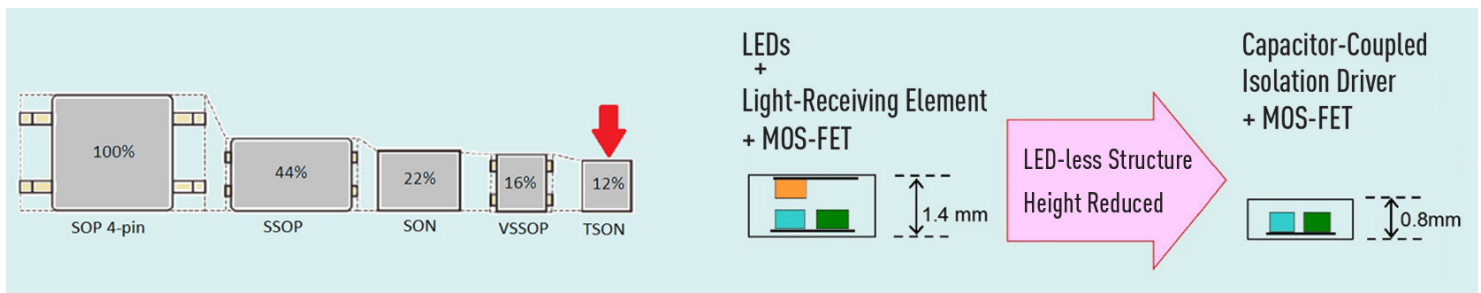
The CCD IC has some limitations. One constraint is the amount of isolation that can be provided between input and output. This Relay is currently constrained to 200V maximum isolation between input and output. Since the size of the internal MOSFETs is very small, the Relay is still limited to 30V and 40V (AC-peak or DC) load voltages and 300mA or 750mA load current, depending on the specific variation.

The benefits of Capacitive Coupled Relays (CC TSON) can be advantageous to several markets. These may include, but are certainly not limited to, automatic test equipment, security equipment and telecommunications. Applications such as IC testers, probe cards and board testers require high density mounting. The small size of this type of Relay is allowing these designs to push the limits of how many probes can be added to a single test card.

For Battery powered security equipment such as cameras, fire alarms, smoke detectors and handheld radios, extending the life of the replaceable Battery is a major interest. The low power demand to operate the Capacitive Coupled Relay can be very appealing in these applications.

In I/O modules for safety PLC devices, the ability to withstand high industrial temperature and small size can be crucial. These factors make the Capacitive Coupled Relay (CC TSON) a great solution when providing functional isolation for analog-to-digital conversion is desirable. Furthermore, the low current 0.2mA current consumption allows the switch to be operated directly by the micro-controller without the assistance of a Transistor amplifier circuit.

As long as there is a necessity in circuit design to automate switching with electrical isolation, Relays will continue to remain integral components. The evolution of Relays has gone from their origins of using magnetic coil actuators, to LEDs that are used to drive Triacs or MOSFETS, and to the most recent development of the capacitive coupled isolation method. With such a wide number of various benefits and limitations of each type, none of these technologies will be obsolete in the near future. What can be said now is that with this newest generation of Relays, the industry can hope to see more options that are smaller and can be energized using much lower power than ever before.



**Figure 6: Evolution of Miniaturization for PhotoMOS**



By Jeffrey Katz, Senior Product Engineer, Panasonic Industrial Devices Sales Company of America and an accredited Mechanical Engineer. Jeff is a product specialist in both Solid State and Electromechanical Relays, as well as Passive Infrared Sensors, Fine Pitched Connectors and Miniature Electromechanical Switches (Light Touch and Snap Action).