Panasonic Electric Works offers a wide range of PhotoMOS relays for use in telecommunication, measurement, security devices and industrial control. Obviously the PhotoMOS relay differs from the conventional electromechanical relay, but it also distinguishes itself from other switching solutions that utilize optocouplers and semiconductors.

The construction of the PhotoMOS relay is illustrated by Figure 1. The input pins are connected to a light emitting diode. This LED is located on the upper part of the relay and if a current flows through it, it starts emitting infrared light. Below the LED there is an array of solar cells integrated into an optoelectronic device, located at least 0.4 mm from the LED.

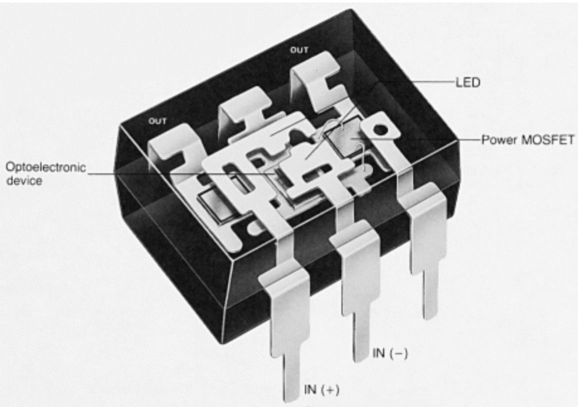

*Figure 1: Internal construction of a PhotoMOS relay*

The light emitter and detector are moulded in a translucent resin that allows light to pass, thus providing a dielectric barrier between the input and output side. The optoelectronic device serves as control circuit for switching two power MOSFETs and therefore the load circuit. These DMOS transistors are source coupled, thus providing bidirectional switching capabilities.

Therefore we will take a closer look at the DMOSFET output transistor which significantly differs from standard MOSFETs used in integrated circuits. It has a vertical channel structure, source and drain are placed opposite the wafer as shown in Figure 2.

As a result, more space for the source and drain region is available and the current rating can be increased.

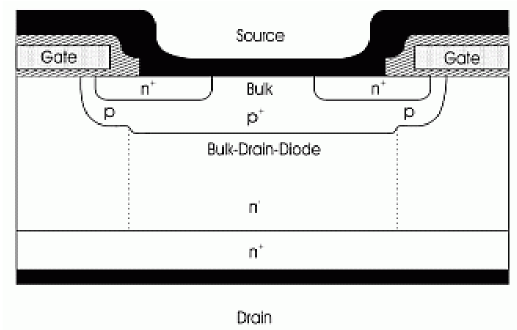

*Figure 2: DMOSFET structure*

Even though the DMOSFET features a greater current rating compared to standard MOSFETs, both types are susceptible to voltage spikes. These spikes can be caused by lightning or by switching inductive loads. In order to protect the PhotoMOS from such overvoltage, adding a protective device to the circuit may be necessary. This application note describes one possible method by utilizing a metal oxide varistor (MOV).

Varistors (Variable Resistors) are voltage-dependent resistors with a symmetrical V-I characteristic curve (Figure 3) whose resistance decreases with increasing voltage. Connected in parallel with an electronic device or circuit, they form a low-resistance shunt when voltage increases, thereby preventing a further rise of the overvoltage.

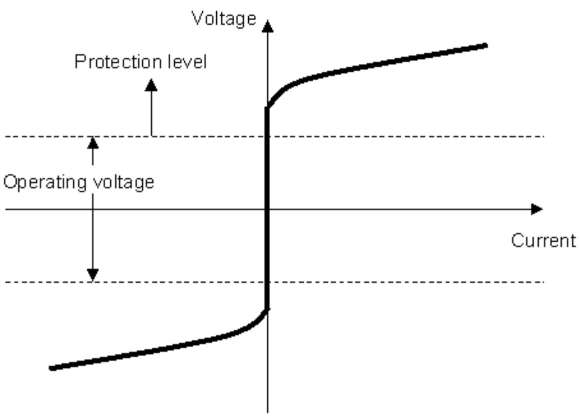


*Figure 3: V-I characteristic of varistor*

Switching off inductive loads

When switching off inductive loads, high voltages may be produced that harm the inductor itself and in particular the switch. To reduce this voltage peak, a varistor can be connected in parallel to the inductive load or the switch.
At first, the varistor's operating voltage will be determined according to the following example:

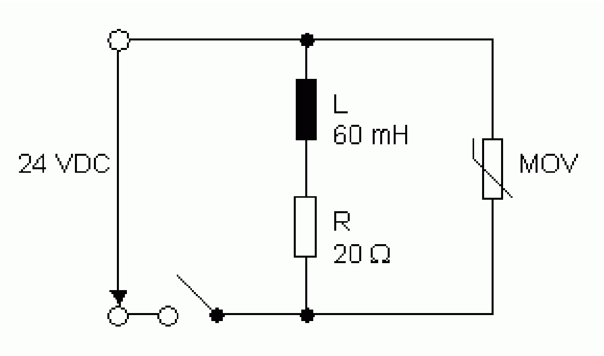


*Figure 4: Switching off inductive loads*

The operating voltage is 24 VDC. Assuming a 10% tolerance, the varistor's DC operating voltage must be higher than 26.4 VDC. Since the current through the inductor cannot change abruptly, the load current of 1.2 A will flow through the varistor after switching off. Because of the varistor's V-I characteristics, a certain voltage drop across the varistor is the consequence (for example 60 V).

Based on this voltage drop, the dynamic resistance of the varistor can be calculated:

$$R_{Var} = \frac{60V}{1.2A} = 50\Omega$$

Taking this resistance and the load resistance in account, the time constant $\tau$ for the duration of the protection can be determined:

$$\tau = \frac{L}{R} = \frac{60mH}{50\Omega + 20\Omega} = 0.86ms$$

After these parameters have been determined, the maximum varistor ratings have to be checked. With the time duration, the max. allowable current is determined from the derating curve and compared to the 1.2 A from the application.
The maximum energy absorption of the varistor must be higher than the energy from the inductor:

$$W = \frac{1}{2} \cdot L \cdot I^2 = 0.5 \cdot 60mH \cdot 1.2A^2 = 0.043J$$

Moreover, the protection level of the varistor must satisfy the max. voltage ratings of the switch and of the inductor in order to offer adequate protection.

Surge voltage protection

Another typical application for a varistor is to protect the switch and load against surge voltages that may result from lightning or electrostatic discharge. First select the varistor's operating voltage as described before. The voltage class of the varistor must be higher than the maximum load voltage.

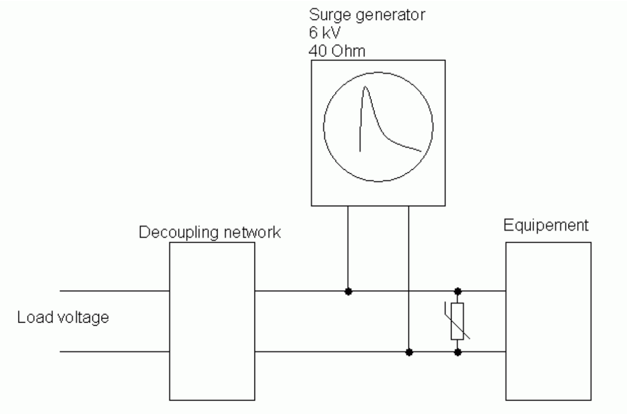


*Figure 4: Surge voltage protection*

In the next step, the surge current is determined. For the first iteration, the surge current is the peak value of overvoltage divided by the internal impedance of the voltage source.

$$I_{Peak} = \frac{6kV}{40\Omega} = 150A$$

With this surge current, the varistor voltage can be determined from the V-I characteristics (for example 320 V for a varistor with voltage class of 95 V). Pay attention to the tolerance of the varistor and consider the lowest voltage drop possible. In the next iteration, the surge current is determined again by taking the peak value for the surge voltage, reducing it by the voltage drop across the protection element and dividing the result by the internal impedance of the surge voltage source.

$$I_{Max} = \frac{6kV - 320V}{40\Omega} = 142A$$

Afterwards the varistor's derating curve has to be considered by using maximum current and pulse duration. The maximum permissible power dissipation is checked by the energy of the pulse, its duration and the number of repetitions (here one per 60 sec):

$$P = \frac{W}{T} = \frac{n \cdot V \cdot I \cdot t}{T} = \frac{1 \cdot 320V \cdot 142A \cdot 50\mu s}{60s} = 37mW$$

If all these criteria are met and if the protection level is sufficient for the electrical circuit, the optimal varistor is determined. Afterwards the application can be tested in order to verify whether the protection level is sufficient.

As these examples illustrate, one can see that protecting semiconductor switches is essential. Thereby one has to mind a certain margin between load voltage and maximum voltage of the switch. When choosing a PhotoMOS relay, consider the load current first, then add a maximum margin to the load voltage to find the PhotoMOS relay most suitable for you. If you need assistance in choosing a PhotoMOS relay or if you have any technical questions, please feel free to contact us: info-eu@euro.de.mew.com