Normally closed PhotoMOS relay

The solid-state relay market is steadily growing to meet the demand for parts with reduced size and weight, low power consumption, longer lifetime, and higher reliability. However the conventional semiconductor relay technologies utilizing Phototriacs or Photocouplers have been unable to implement normally closed switching elements. To develop a Form-B type semiconductor relay Panasonic Electric Works is employing its PhotoMOS technology.

Emergency cut-off applications are typical for Form-B type switching devices. During normal operation no input signal is supplied and the switch is conductible. Only in case of a malfunction will the relay be activated and the load side interrupted until the fault is cleared. Below the development of a normally closed semiconductor relay is described.

A PhotoMOS relay consists of a light emitting diode (LED), an array of solar cells with a control circuit and two Power MOSFETs. The LED is optically coupled with the solar cells but electrically isolated by silicon gel. The LED on the input side of the relay starts emitting light when a drive signal is applied. With the help of the photovoltage from the solar cells, the Power MOSFET is operated. This basic configuration (Figure 1) is valid for every PhotoMOS relay.

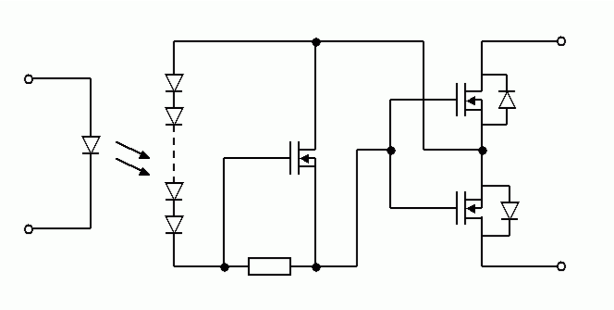

Figure 1: Schematic of a PhotoMOS relay

To develop a normally closed PhotoMOS relay, a depletion mode MOSFET is used. The gate of the MOSFET is operated with the help of the control circuit by optimizing turn on and turn off time. Figure 2 shows the response of the load current to the input current.

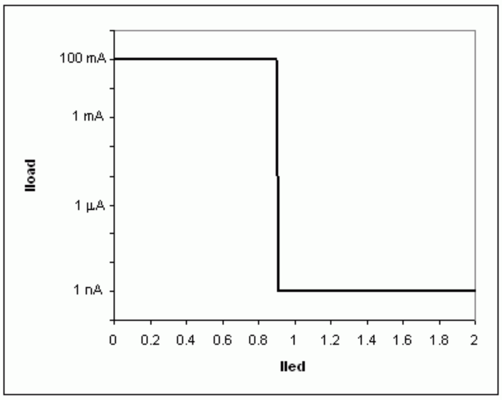

Figure 2: Load current vs. input current

Load current in Figure 2 is choosen as 100 mA. After applying a typical current of 0.9 mA to the LED, the MOSFET begins to switch off the output side. Due to the behaviour of the MOSFETs, a typical leakage current of 1 nA for the AQZ404 continues to flow.

The normally closed PhotoMOS relay employs an array of solar cells with a control circuit to apply a voltage between the gate and source of the output transistors. The gate voltage is negative in reference to the source pins of the coupled transistors. Activation time depends on the time required to charge the MOSFET's gate capacity. Therefore the operation time depends on the LED current supplied (see Figure 3).

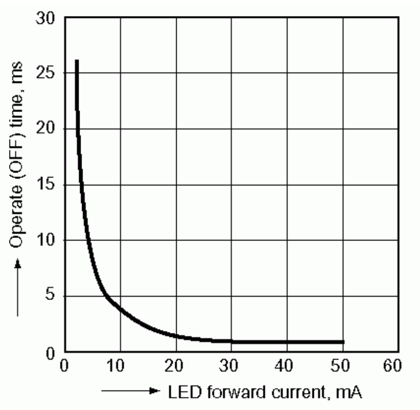

Figure 3: Operate time vs. LED current

The operation time is valid for the AQZ404 PhotoMOS relay. It has a load voltage of 400 V and an on-resistance of 2.8 Ω. Figure 4 shows the cross section of a transistor cell used for the Power MOSFET.

The cells are built using the DSD (double-diffusion and selective doping) process.

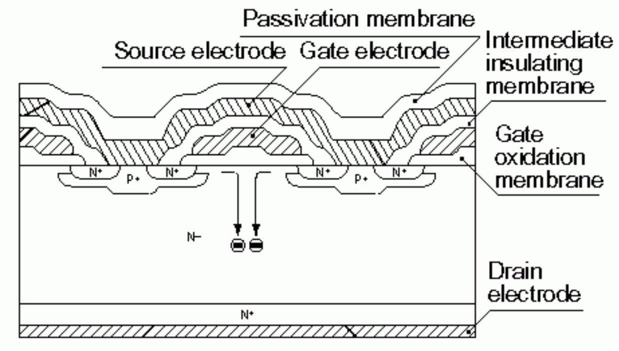

Figure 4: Cross section of depletion mode transistor cell

By connecting transistor cells in parallel the MOSFET's on-resistance can be reduced. The cell's parallel connection results in a larger area, hence in higher capacities, which increase the operation times. To achieve faster operation times the LED current must be increased as shown in Figure 3.

In order to switch higher currents of up to 0.5 A, the power dissipation, caused by the on-resistance of the depletion mode MOSFET used in the AQZ404 must be reduced. This is achieved by connecting many small transistor cells in parallel. This increases the area of the MOSFET chip and requires a certain package size. But in addition to mounting space, there is a second reason for using larger packages.

The load current results in a power loss due to the on-resistance of the semiconductor relays. The resulting heat must be dissipated. This can be achieved by increasing the surface of the package. For this reason Panasonic Electric Works offers various package type, e.g.:

- SSOP (Shrink small outline package)
- SOP (Small outline package)
- DIP (Dual In-line package)
- Power DIP (Power Dual In-line package)
- SIL (Single In-line package)

Because of the different heat transfer characteristics, the package determines the maximum allowable power dissipation. The values range from 300 mW for the SSOP package to 1.6 W for the SIL package. The variety of different package types combined with different load voltages and other parameters results in various PhotoMOS relay types. Panasonic Electric Works offers the widest range of semiconductor relays worldwide and is a technology leader. Please convince yourself by visiting our homepage: http://www.panasonic-electric-works.com

Examples of PhotoMOS Form B types:

Electrical characteristics (room temperature, typical values)			
Part number	AQV412EH	AQY410S	AQZ 404
Package	DIP6	SOP4	SIL
Load voltage	60 V	350 V	400 V
Continuous load current	0.55 A	0.12 A	0.5 A
Power dissipation	550 mW	350 mW	1.6 W
On-resistance	1 Ω	18 Ω	2.8 Ω
Off state leakage current	200 nA	0.1 nA	1 nA
Switching Speed, Operate OFF time	3 ms	0.52 ms	3.9 ms
Switching Speed, Reverse ON time	0.3 ms	0.23 ms	0.8 ms
LED operate current	1.9 mA	0.9 mA	1.0 mA