Power semiconductors form the heart of many applications, whose efficiency depends on the availability of new technologies. During the last few years MOSFET technology has made enormous progress, and these devices have gained acceptance by many users. However, when switching power circuits safety concerns are met by galvanically isolating control and power circuits, which is realized with optocouplers in most cases.

Panasonic Electric Works now offers a photovoltaic MOSFET driver that provides galvanic isolation while saving parts and an extra power supply. Essentially this part is an isolated voltage source powered by an input LED. The input side of the photovoltaic MOSFET driver consists of an LED. Current flow causes the LED to emit light, which passes through a transparent silicon resin, providing galvanic isolation of input and output circuits. The photons are directed to an array of solar cells, where they produce an electron-hole pair in the solar cell. Due to the p-n junction and its difference in potential, the electron-hole pair is separated and there is a voltage drop across the solar cells. A load circuit can be powered with the voltage, but maximum current is determined by the number of electron-hole pairs created by the photons. If too much current is drawn out of the solar cells, the photovoltage will drop to zero. Due to this behaviour, solar cells have a nonlinear I-V characteristic. Significant points are V_{OC} (open circuit voltage, zero load current) and I_{SC} (short circuit current, zero voltage).

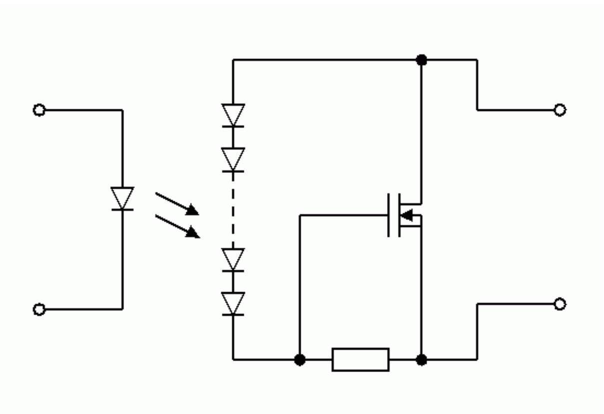

Figure 1: Electrical circuit of Photovoltaic MOSFET driver

If the device's output is used as a power supply for electrical circuits, connecting the solar cells to the load circuit may be sufficient. When using the device for switching capacitive loads, a connection for discharging the load circuit must be supplied if fast turn off times are required. This is achieved by the normally closed MOSFET in the driver (Figure 1). At first this MOSFET is conductible and the generated current flows via its drain to the source. Since the current flows through the resistor, this results in a gate-source voltage drop and causes the MOSFET to proceed into an off-state. After it has proceeded to the off-state, the generated photovoltage and current are available at the output pins of the device. If no more current is produced from the solar cells, a capacitive load will start discharging itself through the driver, and current through the driver is reversed. This forces a positive gate-source voltage and the internal MOSFET becomes conductible, thus providing a path for discharging the load, which results in fast turn off times.

This behaviour is extremely practical, when power MOSFETs are involved in the load circuit. Switching characteristics of power MOSFETs are determined by the capacitors formed between the structures of gate, source and drain. This can be seen in the cross section of a power MOSFET's cell in Figure 2. Many of these cells are connected in parallel to carry higher currents. Parallel connection can be realized quite easy since source and drain connection are on the top or bottom side of the wafer.

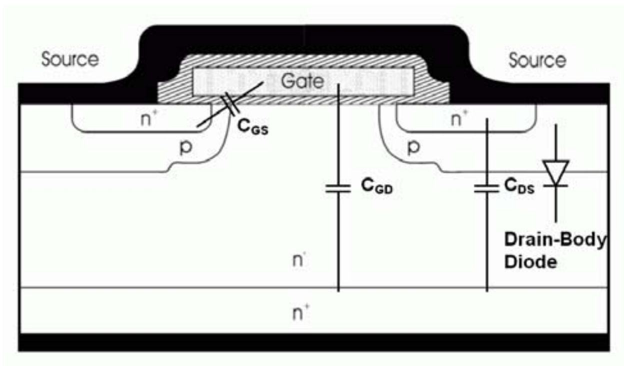

Figure 2: Cross section of the power MOSFET's cell showing intrinsic parts

The gate source capacitance C_{GS} needs to be charged to a treshold voltage level V_{th} before any drain current is allowed to flow. When the treshold voltage V_{th} is reached at t_1, the drain current i_D of the power MOSFET increases to a full load current.

However, the MOSFET has not turned on yet since the drain-source voltage V_{DS} is still at a load voltage level caused by the intrinsic capacitors. Most of the drive current is now needed since the gate-drain capacity C_{GD} has to be discharged in order to reach the V_{DSon} value. The value of the gate-drain capacity, often referred as Miller capacity, is voltage dependent and contributes most to the switching speed of the MOSFET. After C_{GD} is discharged to V_{DSon} and full load current is reached, the MOSFET is in an on-state. Figure 3 shows the graph of the signals during turn on.

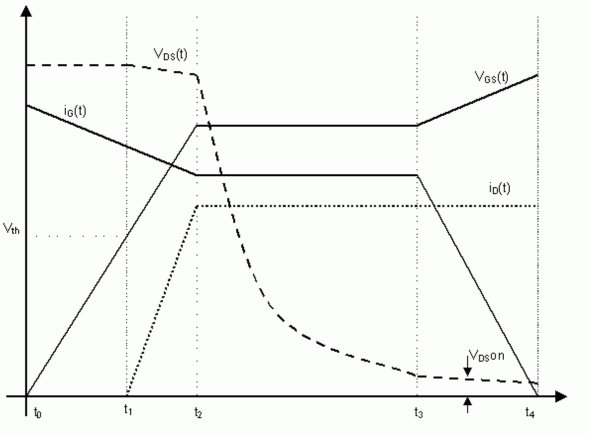

Figure 3: MOSFET turn on sequence

On-resistance of a power MOSFET is determined by the length of the n^- drift region (see Figure 2). If a high breakdown voltage has to be realized, the n^- drift region needs to be increased, hence on-resistance will be increased. On the other hand, reducing the on-resistance requires a short n^- drift region. This will reduce breakdown voltage and, because of $C = \varepsilon \cdot A/d$, the intrinsic capacitors will increase. This leads to a relationship between load voltage, on-resistance and capacities of the power MOSFET.

As described above, the MOSFET's switching speed is determined by its capacities and the drivers capability of charging / discharging them. As can be seen from the datasheet of the photovoltaic MOSFET driver, the short circuit output current I_{SC} of the APV1121S is typically 14 μA for an input current I_F of 10 mA. Due to the limited output energy of the driver, charging load capacities takes some time (T_{on} = 0.4 ms with C_L = 1000 pF) compared to a typical switching speed of approximately 50 ns for power MOSFETs. One advantage in applications where fast turn off times are required is the control circuit inside the MOSFET driver; it provides typical turn off times T_{off} of 0.1 ms.

The photovoltaic MOSFET driver is a good choice for switching load MOSFETs when galvanic isolation of input and load circuit is required. The driver minimizes the need of additional parts and power supplies and it is available in different package sizes, including the industry's smallest SSOP package (APV2111V) with a size of only 4.45 x 2.65 x 1.8 mm (LxWxH).