

## Solid-State Relays Frequently Asked Questions (FAQs)

### 1. Q: WHAT IS A “SOLID-STATE RELAY” (SSR)?

**A:** A solid-state relay is an electronic switching device in semiconductor technology. An SSR is capable of switching AC loads where both of the output MOSFETs are required as well as DC loads where one MOSFET or two in parallel can be used.

### 2. Q: WHAT ARE THE ADVANTAGES OF SSRs?

**A:** SSRs provide longer lifetimes, bounce free operation, no contact burning, immunity to RFI (radio frequency interference) and EMI (electromagnetic interference), higher switching speeds, low level control signals, small package size, and multi-functional integration.

### 3. Q: IN WHICH APPLICATIONS CAN SSRs BE USED?

**A:** They are used in industrial, automotive, telecommunication, as well as security and instrumentation applications; all in all everywhere where galvanic isolation is necessary, high reliability, and switching times are important and space is limited.

### 4. Q: HOW DOES AN SSR FUNCTION?

**A:** An infrared LED on the input side, galvanically isolated from the output side, emits light onto a stack of photodiodes (PV stack) which acts as a “solar cell” for the MOSFET switches. Enough voltage is generated by the PV stack to switch the MOSFET pair on.

### 5. Q: HOW DO THE AC/DC AND ONLY DC ONLY CONFIGURATIONS LOOK LIKE?

**A:** In AC/DC configuration the load is connected across pins 4 and 6. This option makes both AC and DC switching possible. In DC only configuration, the two internal MOSFET switches are paralleled by tying pins 4 and 6 together. Pins 4 and 6 become the positive output of the SSR, and pin 5 becomes the negative output.

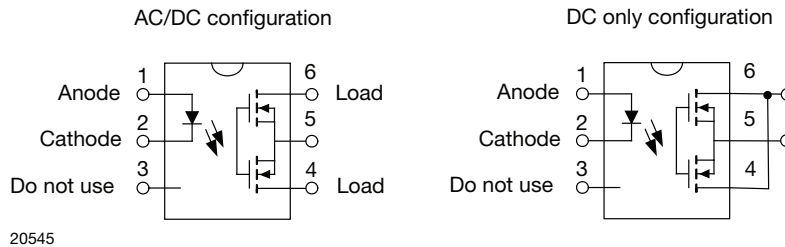


Fig. 1 - AC and DC Configuration with SSRs

### 6. Q: WHAT ARE THE ADVANTAGES OF DC ONLY CONFIGURATION? (pins 4 and 6 jumpered)

**A:** In the DC only configuration MOSFETs can be arranged back to back to lower the on-resistance ( $R_{on}$ ) and increase the current handling capabilities. However in this configuration the switch will operate only in one direction due to the parasitic substrate diode in the MOSFETs.

### 7. Q: WHAT IS THE DIFFERENCE BETWEEN NORMALLY OPEN (1 FORM A) AND NORMALLY CLOSED (1 FORM B) SSRs?

**A:** In case of normally open MOSFETs (Fig. 2), the switch is in the open circuit mode when there is no actuating LED current. For normally closed MOSFETs (Fig. 3), the output is conducting without the control signal and is open when there is an actuating LED current.

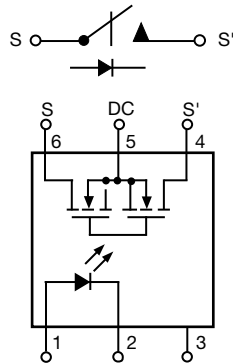


Fig. 2 - 1 Form A SSR

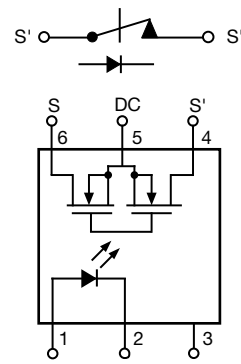


Fig. 3 - 1 Form B SSR

### 8. Q: WHAT IS THE FUNCTION OF THE CURRENT-LIMITING CIRCUITRY?

**A:** In order to protect MOSFETs from overcurrent transients by limiting the peak current through the switched circuit, the current-limit circuitry reduces the peak current from the PV stack and drops the voltage available for the gates of the MOSFET switches.

Without current limiting circuitry SSR current is only limited by series and load resistances as well as its own on-resistance ( $R_{on}$ ). Due to extensive power dissipation and heating, secondary breakdown can occur and an excessive current flows until the fault distinguishes.

With current limiting circuitry SSR only draws a short pulse of current and goes into an active state where the on-resistance ( $R_{on}$ ) is increased and the current is held at its limit value. The SSR resumes its normal operation when the excessive current is removed. This is not a continuous operation mode but a basic protection against overcurrent transients.

For more information see the application note: [www.vishay.com/doc?83860](http://www.vishay.com/doc?83860)

### 9. Q: WHAT ARE POSSIBLE PREVENTION METHODS AGAINST OVERVOLTAGE EXTREMES?

**A:** Overvoltage suppression devices such as Zener diodes, metal oxide varistors (MOVs), gas discharge tubes, or semiconductor suppressors are possible solutions for protecting the outputs of the SSRs.

### 10. Q: HOW SHOULD THE MAXIMUM AND MINIMUM VALUES FOR THE INPUT RESISTOR IN A SPECIFIC APPLICATION BE DETERMINED?

**A:** An input resistor is necessary to limit the current through the infrared LED to a recommended value when using logic drive. The resistor should be dimensioned to ensure enough forward current under worst case conditions to keep the output working further. Therefore “Absolute Maximum Ratings” should be considered.

For more information see the application note: [www.vishay.com/doc?83861](http://www.vishay.com/doc?83861)

### 11. Q: HOW CAN FASTER TURN-ON TIMES WITH FORM A SSRs AND FASTER TURN-OFF TIMES WITH FORM B SSRs BE ACHIEVED?

**A:** It can be realized by using a current peaking circuit such as an RC network parallel with the LED current limiting resistor. This will provide a current spike and improve the turn-on and turn-off times.

For more information see the application note: [www.vishay.com/doc?83861](http://www.vishay.com/doc?83861)

### 12. Q: HOW CAN HIGHER SWITCHING VOLTAGES BE ACHIEVED USING SSRs?

**A:** Stacking SSRs in series enables higher switching voltages. The total load voltage becomes the sum of the individual load voltages and maximum load current becomes the lowest rated load current of the SSRs in series. In order to prevent the voltage on terminal exceeding the maximum rating, the output must be clamped.

For overvoltage suppression methods, refer to the application note: [www.vishay.com/doc?83859](http://www.vishay.com/doc?83859)

### 13. Q: HOW CAN AVALANCHE BREAKDOWN BE PREVENTED IN CASE OF STACKED SSRs?

**A:** An RC snubber network on the output will create a discharge path and prevent avalanching as well as a metal oxide varistor (MOV) will keep the relay from exceeding the avalanche breakdown.

For more information on preventions against avalanche breakdown, refer to the application note:

[www.vishay.com/doc?83602](http://www.vishay.com/doc?83602)

### 14. Q: HOW IS SWITCHING SPEED RELATED TO THE LED DRIVE CURRENT?

**A:** For some battery powered applications and telecom applications, low turn-on current and slow speed are sufficient. Moderate speed performances are required where power consumption is critical. When every second is essential like in instrumentation applications, high-speed performance as a result of high turn-on current is necessary (Fig. 4). This can be achieved by higher control currents which will speed up the charging of the MOSFET gates.

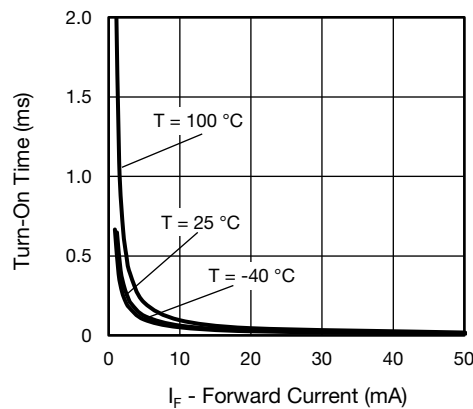


Fig. 4 - Dependency of Turn-On Times on LED Forward Current

### 15. Q: HOW CAN AN SSR BE USED TO DRIVE EXTERNAL POWER MOSFETs?

**A:** The LED emits light onto a PV stack which acts as a power source for the MOSFET switches. In case of fully integrated SSRs, the part already consists of a pair of integrated MOSFETs on the output.

Vishay also offers stand-alone MOSFET drivers to allow the designer to build up a customized SSR module with external power MOSFETs. The MOSFET driver provides the energy to switch the external MOSFETs and also the galvanic isolation between the input and the output side.

In case of motor drive controls, IGBT predrivers and AC/DC power inverters, LH1262, VO1263, and VOM1271 are available, which can also be customized to build your own SSR. VOM1271 also contains an integrated turn-off circuit to improve the switch-off time.

Customized SSRs can be designed with DC or AC relay outputs. A DC MOSFET relay can be designed with a single MOSFET driver on the output. An AC MOSFET relay can be realized with an additional MOSFET on the output by combining the outputs.

To achieve faster turn-on characteristics, MOSFET drivers can be stacked to drive the same output MOSFET with higher drive currents.

Faster turn-off function is achieved with an additional JFET which discharges the gate to source capacitance when the PV stack is turned off.

For more information see the application note: [www.vishay.com/doc?81225](http://www.vishay.com/doc?81225)



## **16. Q: WHAT ARE THE ADVANTAGES OF MOSFET RELAY APPLICATIONS COMPARED TO TRADITIONAL THYRISTOR SWITCHES?**

**A:** Lower on-resistance ( $R_{on}$ ) losses (depending on the voltage drop), higher switching frequencies and AC/DC capability are some of the advantages of the MOSFET relays.

They can switch off independent of a zero crossing and are fully controllable independent of the phase angle. They do not have a specification of maximum on state voltage but the voltage drop depends on the load current.:

For more information see the application note: [www.vishay.com/doc?81225](http://www.vishay.com/doc?81225)

## **17. Q: HOW CAN THE TURN-ON TIME BE IMPROVED FOR MOSFET DRIVERS?**

**A:** The fast turn-off circuit using a JFET limits the turn-on time because of the presence of a resistor with the JFET and the gate capacitance  $C_G$  of the MOSFET. The solution would be to prevent the effect of the resistor until the threshold voltage of the output MOSFET is reached. A Zener diode in parallel with the resistor helps solve this problem. An additional solution would be to connect more MOSFET drives in parallel to drive one MOSFET on the output and increase the drive current for this output MOSFET.

For more information see the application note: [www.vishay.com/doc?81225](http://www.vishay.com/doc?81225)

## **18. Q: HOW CAN THE TURN-OFF TIME BE IMPROVED FOR MOSFET DRIVERS?**

**A:** In order to decrease turn-off times, the gate of the output MOSFET needs to be discharged. One solution is a resistance parallel to the gate, however this will permanently consume current. The second and better solution is to apply a JFET or a depletion MOSFET. Until output MOSFET has a certain gate voltage, the JFET is in its conduction mode. At this point of the certain gate voltage, the JFET is turned off and the gate starts charging. When PV stack is turned off, the JFET produces the faster turn-off time by discharging the gate to source capacitance.

For more information see the application note: [www.vishay.com/doc?81225](http://www.vishay.com/doc?81225)

## **19. Q: HOW CAN THE AMOUNT OF CURRENT DRIVE IN CASE OF MOSFET DRIVERS BE INCREASED?**

**A:** By applying a pulsed current to the LED or placing the PV stacks in parallel to double the current driving capability of MOSFET driver.