Chapter 8

Use of Solid State Relays (SSRs)

8.1 General description

8.1.1 What is a solid state relay (SSR)?

As devices in various industrial equipments and home appliances shift to electronic controls, there is an increasing need for higher performance and higher reliability in the components comprising the equipment.

Within this trend, relays which act as a control component are shifting from conventional contact-type electromagnetic relays to solid state relays (SSR).

An SSR is a device in which a load is controlled by supplying a fixed current, I_F, to the SSR input light emitting diode, which turns ON an output triac.

Functionally, there are also types with snubber circuits and zero-crossing circuit functions.

Applications cover a wide range, from home appliances to industrial equipment, and the SSR can be selected according to the load that requires control.

<Table 8-1> SSR features

	SSR		Electro-magnetic Relay
	Non-zero-cross type	Zero-cross type	
(1) Operating noise	No	No	Yes
(2) On time (ton)	Fast	—	Slow
(3) Zero-cross operation	No	Yes	No
(4) Service life	Long	Long	Short
(5) Drive current	Small	Small	Large
(6) Size	Small	Small	Large
(7) Phase control	Possible	—	Not possible

8.1.2 SSR features

Compared with an electromagnetic relay, an SSR has the features listed in Table 8-1.

8.1.3 SSR basic operation

● **SSR principle of operation**

As shown in Fig. 8-1 (a), an SSR is composed of a phototriac, a zero-cross circuit, a snubber circuit and a triac. The phototriac is turned ON by supplying a fixed current, I_F, to the SSR input infrared emitting diode, and the output triac controls the load by turning ON.

The zero-cross circuit acts to turn the triac ON near zero of the AC voltage, and the snubber circuit is for suppressing misoperation due to noise.

● **Zero-cross operation** (ref. 16)

There are SSR models available with an internally built-in zero-cross circuit. An SSR with a built-in zero-cross circuit is turned ON near zero of the AC voltage, and turned OFF when the load current drops below the holding current of the triac.

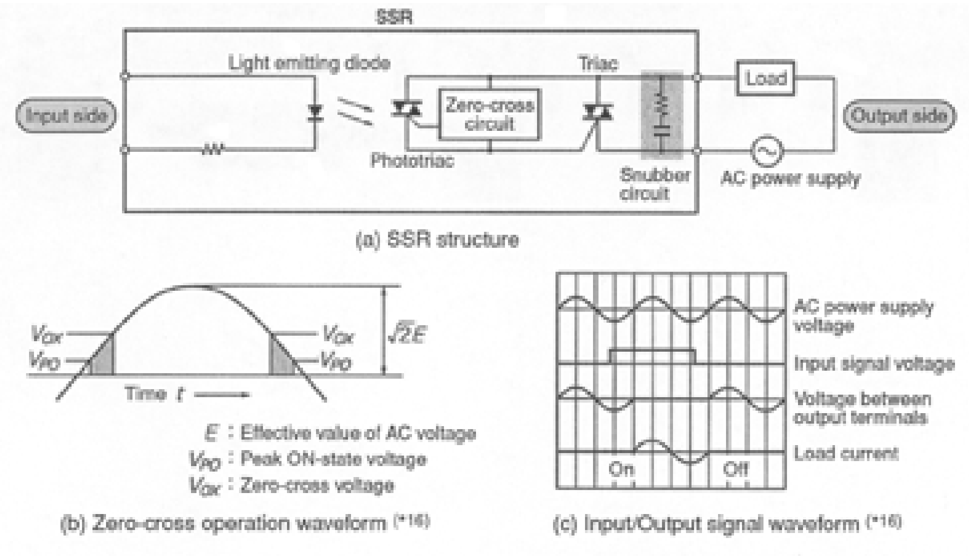
Fig. 8-1 (b) shows the zero-cross operation waveform.

If an input signal (DC) is applied to the SSR's input terminals while the SSR's output terminal (AC supply) voltage is between V_{PO} and V_{OX}, the SSR changes from the OFF-state to the ON-state, and load current flows. If the output terminal voltage is less than V_{PO}, or equal to or greater than V_{OX}, then the OFF-state is continued without the SSR turning ON, even with an input signal still applied.

The load is controlled by a triac, so after the input signal is removed, the SSR turns OFF when the load current drops below the triac holding current.

Fig. 8-1(c) shows the zero-cross operation waveform for a resistive load.

<Fig. 8-1> SSR mechanism and operation



In zero-cross operation, the turning ON of the load current while the AC voltage is at zero phase suppresses surge current and thereby reduces the generation of switching noise.

● **Snubber circuit** (ref. 16)

If a voltage at or above the rated value is applied to the device, it may either malfunction or be destroyed. Such phenomena as switching impulses generated during power supply switching, and oscillating surge caused by transformer inductance and the static capacitance between primary and secondary windings can be suppressed with a snubber circuit.

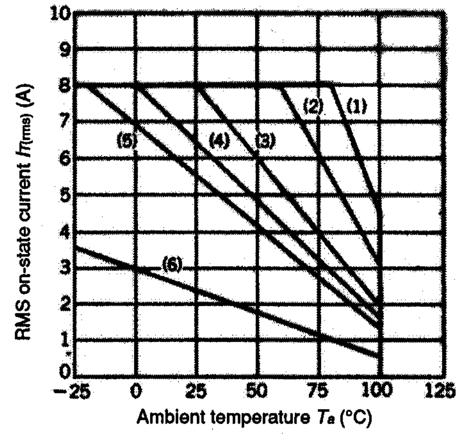
Normally, the snubber circuit consists of an *RC* network, and this is also effective for improving the critical rate of rise of OFF-state voltage (dV / dt).

8.1.4 Precautions for SSR use

The same as any other device, SSRs have electrical characteristics and ratings. If the device is used incorrectly, SSR reliability may be reduced, causing malfunction of the equipment into which it is incorporated. To maintain the electrical characteristics and reliability of an SSR, it must naturally be used within the designated ratings. However, in order to improve reliability, good heat radiation can be achieved by mounting it on a heat sink. Other measures, such as improving air convection also help. It is also important to use the device with a good understanding of the characteristics of the load, power supply, and the surrounding environment.

Precautions for using an SSR will now be described.

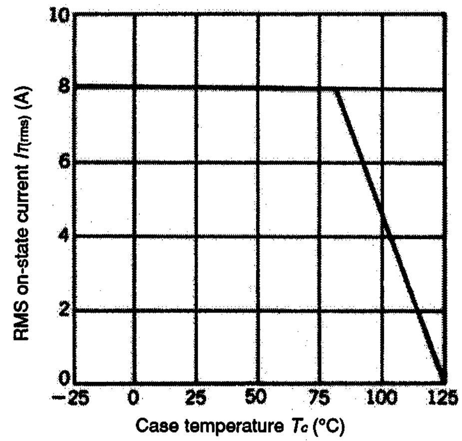
<Fig. 8-2> S102S01F RMS ON-state current derating curves (REF.16)



(1) With infinite heat sink
(2) With heat sink (200x200x2mm)
(3) With heat sink (100x100x2mm)
(4) With heat sink (75x75x2mm)
(5) With heat sink (50x50x2mm)
(6) Without heat sink

(Note) The Al plate is set up vertically, and the device is mounted at the center of the Al plate with a fastening torque of 4N-m. Heat-conducting silicone grease is applied to the heat radiating plate mounting surface. It is also assumed that there is no forced air cooling.

(a) RMS ON-state current vs. Ambient temperature characteristic



(b) RMS ON-state current vs. Case temperature characteristic

● Heat generation

Conventional relays have low contact resistance, so there is little heat generated when ON. (However, if switching sparks are generated frequently, the temperature of the contacts may rise.) Hence when using an electromagnetic relay, there is no particular need to consider heat dissipation.

However, when an SSR operates, an ON-state voltage $V_{T(rms)}$ of about 1.0 to 1.5 V is produced across the output terminals.

Therefore, there is a power loss of $P = I_T \times V_T$ (I_T is the RMS ON-state current) at the device, causing it to heat up.

For this reason, when using an SSR, it is necessary to provide heat dissipation to ensure that the junction temperature (T_j) of the components comprising the SSR stays lower than the rated junction temperature ($T_{j(MAX)}$).

For the load current value (RMS ON-state current (I_T)), it is necessary to determine the case temperature (T_c) of the SSR, and (when necessary) mount the SSR on an external heat sink so that the load current is within the range of the RMS ON-state current derating curve [example: Fig. 8-2 (b)].

For details of these and other methods of heat dissipation, consult product catalogs and the specifications of the SSR.

● Turn-on time

For SSRs, there are non-zero-cross types available, and models with built-in zero-cross circuits. Non-zero-cross type SSRs are generally turned ON within 1 ms or less (AC 50 Hz), and on removal of the input signal, turned OFF when the load current drops to or below the triac holding current.

SSRs with a built-in zero-cross circuit are turned ON near zero of the AC voltage, so the turn-on time (t_{ON}) may be delayed by at most a 1/2 cycle. (As with non-zero-cross types, they turn OFF when the load current drops to or below the triac holding current after the input signal is removed.) Therefore, when performing phase control, a non-zero-cross SSR must be used.

● Leakage current when open-circuit (OFF)

A slight leakage current flows through the SSR output even in the OFF-state. This current varies depending on the internal structure of the SSR and external circuit configuration.

If a snubber circuit (*RC* absorber) is built in or supplied externally, the leakage current increases when the circuit is open due to the capacitor. Therefore, if the load passes only a small current anyway (such as a neon tube, small solenoid etc.), the SSR may not turn OFF once the circuit is open due to this leakage current. An effective method of prevention is to add a shunt resistance in parallel with the load. This makes the current flowing to the load comparatively small by passing most of the SSR leakage current through the shunt resistance.

● Noise misoperation countermeasures

In general, when switching an inductive load (such as a motor or solenoid), a voltage is generated at either end of the inductance, and this may apply a voltage at or above the SSR rating. In this case the device may malfunction or be damaged. A snubber circuit should be incorporated to protect the SSR.

For details, see section 8.2.2.

● Surge current (ref. 26)

With a load such as a lamp, motor or solenoid, surge current flows into the SSR at the instant it turns on, and the value of this current may be 10 times normal. An SSR must be selected such that the surge current is at or below 70% of the one-cycle surge current of the SSR. An SSR with a built-in zero-cross circuit is also effective for reducing surge current.

● **Overcurrent** (ref. 26)

If the device is misconnected or the load is accidentally shorted, overcurrent will flow through the SSR and destroy it. To protect the SSR from this overcurrent, one method is to shut down the circuit using a quick-blowing fuse.

The quick-blowing fuse and SSR must be chosen with a balance for protecting against overcurrent, and the break down time vs current characteristics of the fuse must be within the SSR's surge current range. Therefore, comparing the results of the square of the fuse's rated break down current and time ($I^2{}_t$), and the SSR's squared current and time ($I_I{}^2t$), the value must be set such that the following holds:

(Fuse total break down I^2t) < (SSR's $I_I{}^2t$)

The $I_I{}^2t$ of the SSR is found as follows:

$$I_I{}^2t = \int_0^{tm} \left(\frac{I_{TSM}}{\sqrt{2}}\right)^2 dt$$

I_{TSM} : Peak one-cycle surge current

t_m : Half cycle time for the prescribed frequency

For example, if I_{TSM} = 160 A (60 Hz sine wave), then $I_I{}^2{}_t$ = 106 A^2s.

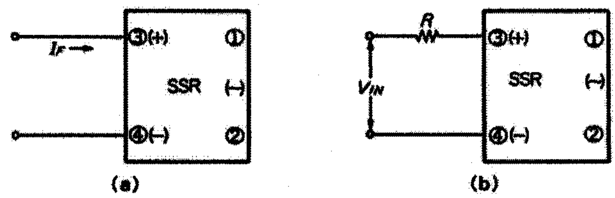
● **Commutation characteristics** (ref. 26)

With an inductive load, the phase of the load current is delayed relative to the circuit voltage, so it is necessary to consider the commutation characteristics of an SSR when it turns off. When the commutation condition exceeds the critical rate of rise of OFF-state voltage $(dV / dt)_c$ during SSR commutation, the SSR ON-state continues and control capability is lost. To prevent this, an RC absorber is connected in parallel with the SSR output to suppress the voltage rise rate during commutation.

● ***di / dt*** (ref. 26)

If the rise rate of the ON current which flows when the SSR is turned ON exceeds the SSR's critical rate of rise of OFF-state current di/dt, the SSR will be destroyed. The di/dt value increases as a pure resistive load is approached, but practical circuits always contain an inductive component, so the value is never as high as a purely resistive load. One method of reducing di/dt is to insert a coil to increase the inductive component of the circuit.

<Fig. 8-3> Basic input circuits



● **Latching current** (ref. 26)

With an inductive load, the output current will rise slowly when the SSR turns on. In particular, if the load is light and only a small current flows, the current rise is delayed relative to the triac latching current, and by the time the input pulse is removed, the triac latching current may not have been achieved, making it impossible for the triac to hold the ON-state.

Countermeasures for this are:

(i) Inserting a bleeder resistor in parallel with the load, thereby increasing the apparent load current.

(ii) Inserting an RC absorber in parallel with the SSR's output, thereby overlaying a capacitor discharge current on the load current.

The filter installed in (ii) also protects is against overvoltage and commutation characteristics.

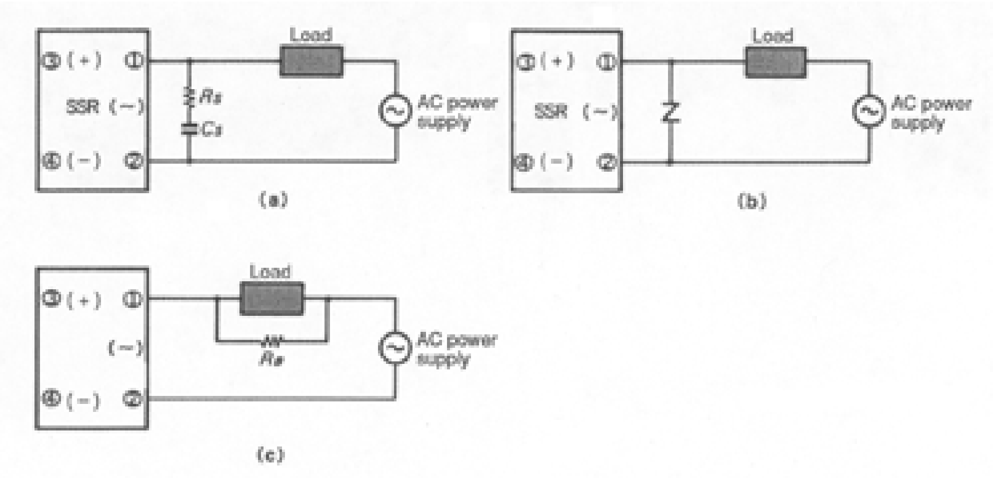
A good general rule is to design the circuit as follows: if the SSR is specified with the holding current I_H, apply a latching current of at least 1.5 times that holding current; if the SSR is specified with the minimum operating current, apply a latching current of at least the minimum operating current. For circuits with both resistive and inductive load conditions, design for the inductive load conditions.

8.2 Examples of basic application circuits

8.2.1 Example of basic input circuit

Fig. 8-3 shows examples of basic input circuits for a current driven SSR with no built-in input resistor. The circuit of Fig. 8-3 (a) uses a fixed current drive. The load can be controlled by applying a fixed forward current, I_F, at or above the minimum trigger current, I_{FT}, to the infrared emitting diode. Normally, the compound semiconductors used in infrared emitting elements exhibit degradation, so taking that into consideration, an overdrive of 2 to 2.5 times I_{FT} is applied. However, the input current must always be set so that

<Fig. 8-4> Basic output circuit



it is at or below the rated forward current.

Fig. 8-3 (b) is an input drive circuit using a fixed voltage. The current flowing to the infrared emitting diode is at or below the rated forward current. V_{IN} and R are set so that this is 2 to 2.5 times I_{FT}. In setting the value of that current, the forward voltage (V_F) of the light emitting diode should be taken into consideration as follows:

$$(V_{IN} - V_F) / I_{F(MAX)} < R < (V_{IN} - V_F) / (I_{FT} \times 2)$$

8.2.2 Example of basic output circuits

Fig. 8-4 shows examples of basic SSR output circuits. In Figs. 8-4 (a) and (b), a snubber circuit consisting of an RC absorber or varistor is added in parallel to an SSR output without a built-in snubber circuit, in order to further absorb and suppress noise. The external RC network is for absorbing and suppressing fast rising impulse noise.

In general, the following ranges are used for the RC absorber components:

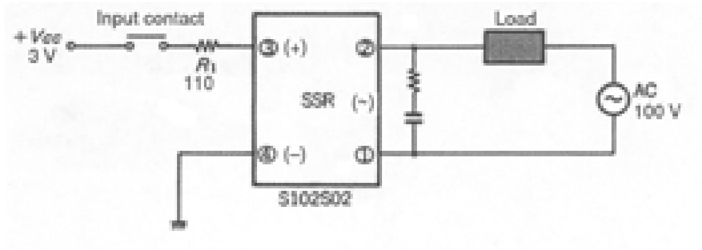
C_s = 0.022 to 0.1 μF

R_s = 20 to 100 Ω

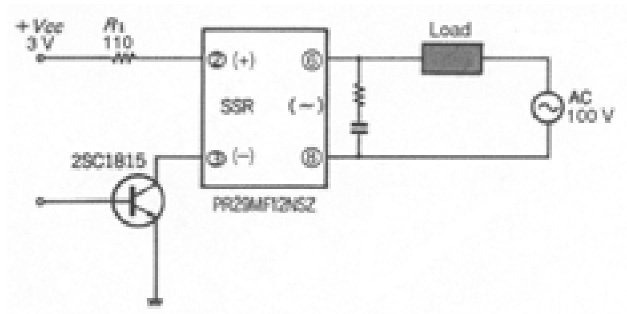
The varistor is used to protect the maximum voltage of the line against high energy noise such as lightning surge. Normally a varistor voltage of 200 to 300 V is used for a 100 VAC line, and a varistor voltage of 400 to 500 V is used for a 200 VAC line.

However, noise generation will vary depending on the load type and circuit conditions, so the snubber circuit constant is selected by checking in a practical circuit. In this situation, it is effective to use an RC absorber and varistor together.

<Fig. 8-5> Drive circuit using a contact switch



<Fig. 8-6> Drive circuit using an NPN transistor [1] (ref. 18)



The example in Fig. 8-4 (c) has a bleeder resistor inserted in parallel with the load. This method is effective with an inductive load when there is misoperation due to the load being light. The value of the resistor must be selected such that the current is at least the minimum operating current of the SSR.

8.3 Application circuit examples

8.3.1 Example of drive using a contact switch

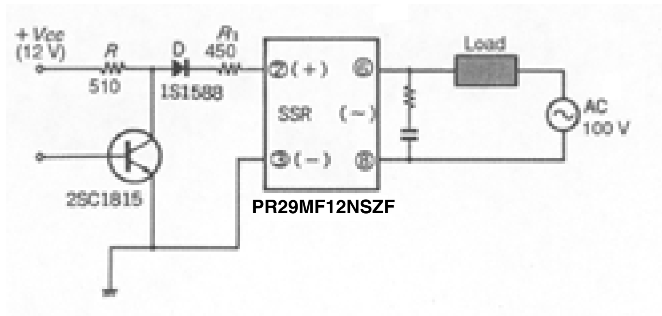
Fig. 8-5 shows an example of an SSR triggered with a switch, where the output changes between a conducting and shut down state when the switch is turned ON and OFF. The precaution here is to set V_{CC} and R_1 such that an input current of 2 to 2.5 times I_{FT} flows into the input of the SSR, as explained in section 8.2.1.

8.3.2 Example of drive using an NPN transistor

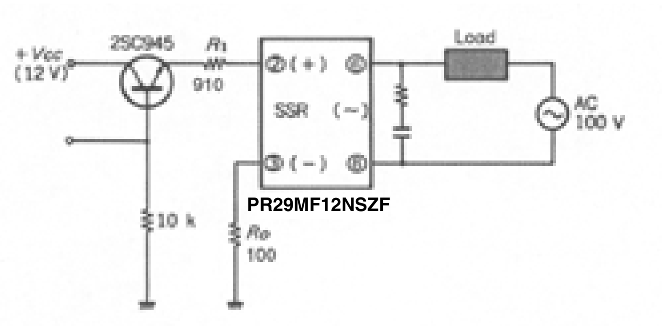
Fig. 8-6 shows an example where the SSR is driven using an NPN transistor. The base current of the transistor is determined while carefully considering V_{CC} and the impedance of the SSR input.

Fig. 8-7 shows a normally ON (active-on) type circuit which uses an NPN transistor in a similar manner. In this circuit, the SSR cond cts when the input is quiescent, and shuts down when the transistor is turned ON.

<Fig. 8-7> Drive circuit using an NPN transistor [2] (ref. 18)



<Fig. 8-8> Drive circuit using an NPN transistor [3] (ref. 18)



This type of use increases noise resistance, and thereby enables an improvement in system reliability.

Fig. 8-8 shows an example where the SSR is driven using an NPN transistor configured as an emitter-follower. The impedance, as seen from the input, is almost $h_{FE} \times (R_0 + R_1)$ (where h_{FE} is the DC current gain of the transistor), so high input impedance is achieved.

8.3.3 Example of drive using a PNP transistor

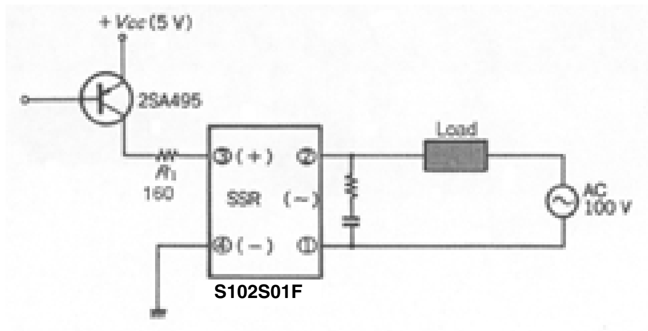
Fig. 8-9 shows a drive circuit using a PNP transistor. It is convenient to use this type of circuit in the following cases:

(1) When you wish to connect the SSR between the collector of the drive transistor and ground.

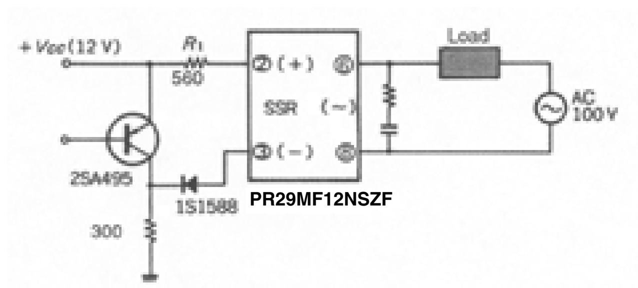
(2) When you wish to have the SSR conduct when the base terminal is low.

Fig. 8-10 shows an example where both the primary and secondary circuits are normally ON, and where both primary and secondary circuits switch OFF when the PNP transistor is turned ON. In that a PNP transistor is used, the circuit is the same as that of Fig. 8-9, but it is also similar to that shown in Fig. 8-7 in that it is normally ON, thereby improving

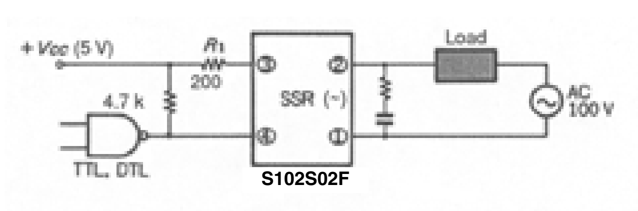
<Fig. 8-9> Drive circuit using a PNP transistor [1] (ref. 18)



<Fig. 8-10> Drive circuit using PNP transistor [2] (ref. 18)



<Fig. 8-11> Drive circuit using an IC (TTL, DTL) (ref. 18)



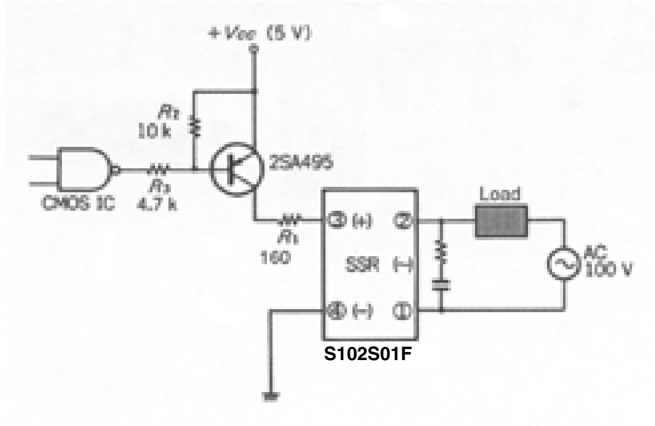
system reliability.

8.3.4 Example of drive using an IC

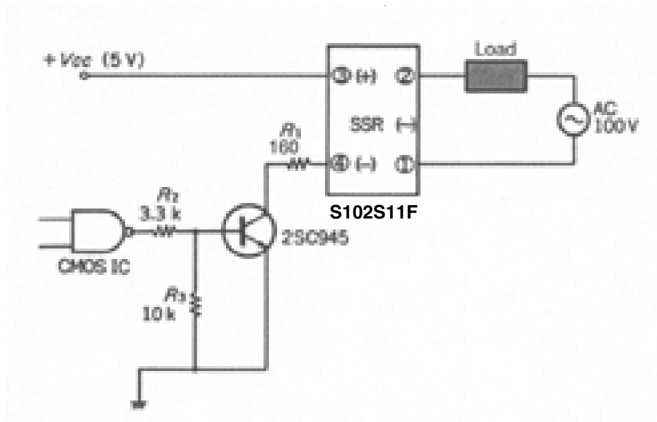
Fig. 8-11 shows an example where the primary circuit is directly driven using a TTL or DTL IC. The TTL or DTL devices respond at high speed, but for an SSR, the following point requires caution: in an SSR with a built-in zero-cross circuit, a maximum period of one half cycle of the secondary power supply is required from when the primary circuit infrared emitting diode is turned ON, until the secondary circuit of the SSR is actually switched ON.

In both Figs. 8-12 and 8-13, the SSR primary circuit cannot be driven directly by a C-MOS IC, so a transistor buffer is placed in between.

<Fig. 8-12> Drive circuit using a C-MOS IC [1] (ref. 18)



<Fig. 8-13> Drive circuit using a C-MOS IC [2] (ref. 18)



In the example of Fig. 8-12, a PNP transistor is used as the buffer, and overall the input circuit performs a logical AND function. For this example, care must also be taken regarding the point mentioned for Fig. 8-11.

Fig. 8-13, in contrast, shows an application example where the relay is driven by an NPN transistor.

8.3.5 Drive example using an AC bridge rectifier

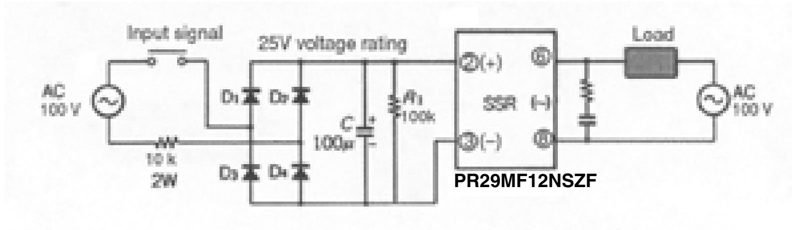
Fig. 8-14 shows an input drive circuit when the input signal is AC. Based on the AC power supply, the basic operation is as follows:

(1) When the switch is turned ON, the input is full-wave rectified by the rectification diodes D_1 to D_4.

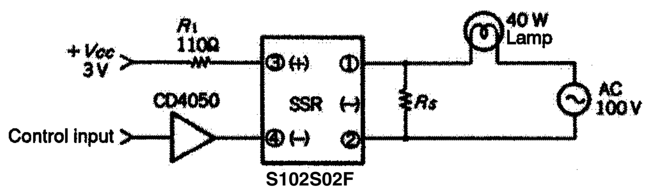
(2) The rectified waveform is then smoothed by C and R_1, and becomes a rough DC.

(3) The smoothed waveform is applied to the input terminals (② and ③) of the SSR, and DC current flows to the infrared emitting diode, triggering the SSR.

<Fig. 8-14> Drive circuit using an AC bridge rectifier [ref. 18]



<Fig. 8-15> ON-OFF control circuit for an incandescent bulb [ref. 18]



The voltage drop across the diode bridge needs to be considered when designing the circuit constant.

8.3.6 ON-OFF control circuit for an incandescent bulb

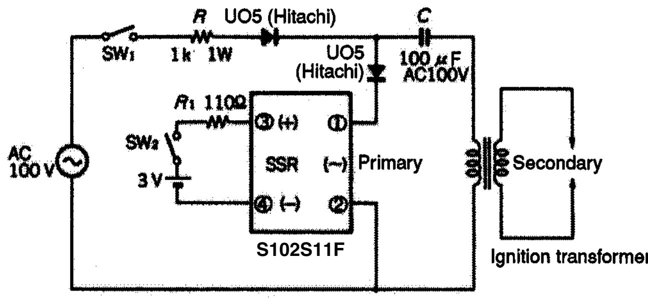
Fig. 8-15 shows an example of an ON-OFF control circuit for an incandescent bulb. The input is active low. Note that at the instant the incandescent bulb lights up, a surge current of 10 times the normal current flows, and this sudden load on the SSR must be reduced in some way. In this particular circuit, the surge current is reduced by providing a shunt resistor, R_S, in parallel with the SSR and constantly preheating the bulb to some extent. Setting the value of the resistance is critical. If the value is too low, there could be problems such as the bulb lighting up (regardless of whether the SSR is ON or OFF) or the resistor overheating. If the value is too high, the preheating effect is lost.

8.3.7 Gas ignition device

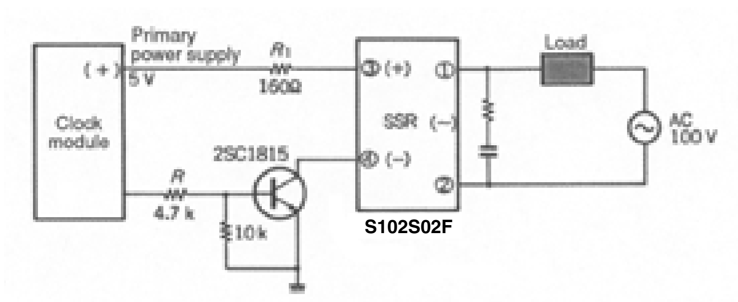
Fig. 8-16 shows a gas ignition device which generates an electrical spark. When SW_1 in the 100 V AC line is turned ON beforehand, the 100 V is rectified by the diode and the capacitor C is charged. Up to this point is preparatory operation.

SW_1 is turned OFF and when SW_2 is turned ON, a trigger is applied to the SSR, and the charge accumulated in the capacitor is discharged. This causes a current to flow in the primary of the transformer, and a high voltage corresponding to the winding ratio is gen

<Fig. 8-16> Ignition device [ref. 18]



<Fig. 8-17> Circuit combining timer and SSR [ref. 18]



erated at both ends of the secondary ignition circuit. This produces a spark which ignites the gas. The SSR used in this circuit is not equipped with a zero-cross function.

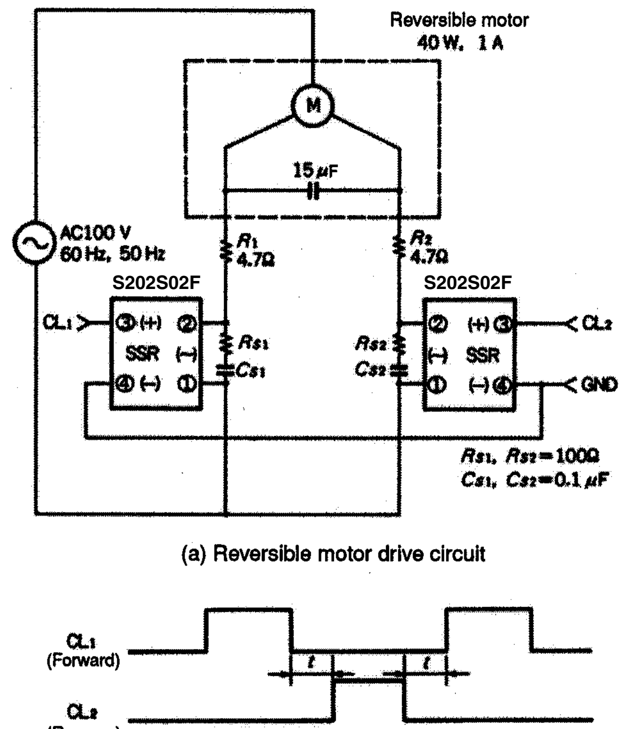
8.3.8 SSR control using timer

Fig. 8-17 shows an example where the SSR is triggered using a quartz clock module as a timer. This system is used in order to exploit the precision of quartz in the timer. (Naturally, timer and timer output are necessary as clock module functions.)

Terminal ③ of the SSR is common with the positive power supply terminal of the clock module. The timer output terminal (normal low, active high) is connected via an NPN transistor to terminal ④ of the SSR, as can be seen in the figure. The 100 V AC power supply and load are connected to the secondary side. When the set time arrives, the module output turns on and the SSR is triggered. After the set load time elapses, the module output turns off and operation of the load stops.

A load may be driven by the SSR in this way by setting a timer using a quartz clock module.

<Fig. 8-18> Reversible motor forward/reverse control circuit [ref. 18]



(a) Reversible motor drive circuit

(b) Timing chart

8.3.9 Reversible motor forward/reverse circuit

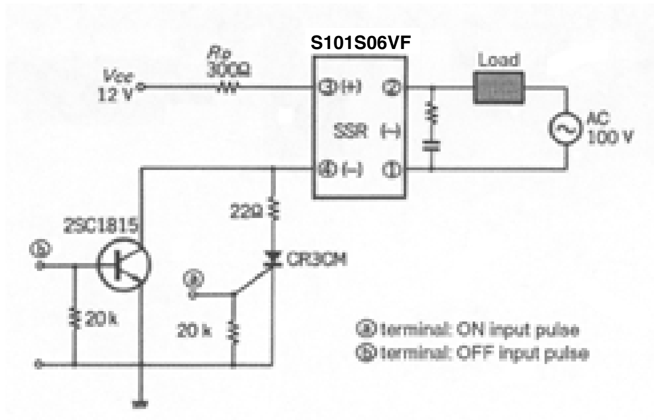
Fig. 8-18 shows an example where the forward/reverse rotation of a reversible motor is controlled using SSRs. Fig. 8-18 (a) shows the drive circuit and (b) the input signal timing chart.

During motor drive, the motor turns forward or in reverse when one of the two SSRs is triggered. The trigger is applied to either CL_1 or CL_2. The 100 V AC power supply is connected through the secondary side of one of the SSRs. As shown in the timing chart in Fig. 8-18 (b), when the trigger is applied with CL_1, the motor turns forward, and when the trigger is applied with CL_2, the motor turns in reverse.

Caution is needed here to ensure that the trigger is not applied to both SSRs at the same time. If the forward SSR and reverse SSR are turned ON at the same time, the motor will be stalled, and overcurrent may flow, destroying an SSR. Therefore, at least a 1/2 cycle of time (t) is necessary when switching between forward and reverse.

Also, a voltage two times the maximum power supply voltage is applied between the SSR output terminals. To prevent failure, it is necessary to use an SSR with at least a 200 V rating.

<Fig. 8-19> Hold circuit using an SSR (ref. 18)



8.3.10 Hold input switch and an SSR

In the design of Fig. 8-19, the SSR ON/OFF state is held by exploiting thyristor characteristics. If the SSR is in an OFF condition and the thyristor gate is pulsed once, the thyristor goes ON and holds that state. Thus the SSR remains triggered and a hold circuit is realized.

Conversely, if the SSR is ON and the transistor base is pulsed once, almost all of the current flowing through the primary side of the SSR flows into the transistor, and the thyristor and hence the SSR switch OFF. SSR latching ON/OFF control can be achieved in this way.

Finally, Tables 8-2 and 8-3 give a list of the characteristics of various sharp SSR models.

<Table 8-2> List of Sharp SSR characteristics for 100 V AC line

Model name	Absolute maximum rating					Electrical characteristics				Remarks	
	Forward current I_F [mA]	RMS ON-state current $I_{T(rms)}$ [A]	Repetitive peak off-state voltage V_{DRM} [V]	(*2) Isolation voltage $V_{iso(rms)}$ [V]	Operating temperature T_{opr} [°C]	Minimum trigger current		On-state voltage		Zero-cross	Snubber circuit
						I_{FT} [mA]	V_D [V]	V_T [V]	$I_{T(rms)}$ [A]		
PR31MA11NZF	50	0.1	400	5000	-25 to +80	10	6	2.5	0.06	×	×
PR26MF11NSZF	50	0.6	400	4000	-25 to +85	10	6	3.0	0.6	×	×
PR26MF12NSZF	50	0.6	400	4000	-25 to +85	5	6	3.0	0.6	×	×
PR26MF21NSZF	50	0.6	400	4000	-30 to +85	10	6	3.0	0.6	○	×
PR29MF11NSZF	50	0.9	400	4000	-25 to +85	10	6	3.0	0.9	×	×
PR29MF12NSZF	50	0.9	400	4000	-25 to +85	5	6	3.0	0.9	×	×
PR29MF21NSZF	50	0.9	400	4000	-30 to +85	10	6	3.0	0.9	○	×
S101D01F	50	1.2	400	4000	-25 to +85	10	6	1.7	1.2	×	×
S101D02F	50	1.2	400	4000	-25 to +85	10	6	1.7	1.2	○	×
S101DH1F	50	1.5	400	4000	-25 to +85	10	6	1.7	1.5	×	×
S101DH2F	50	1.5	400	4000	-25 to +85	10	6	1.7	1.5	○	×
S102T01F	50	2.0	400	3000	-25 to +100	8	12	1.7	2	×	×
S102T02F	50	2.0	400	3000	-25 to +100	8	6	1.7	2	○	×
S10105VF	50	(*1) 3	400	4000	-25 to +100	15	12	1.5	1.5	×	×
S10106VF	50	(*1) 3	400	4000	-25 to +100	15	6	1.5	1.5	○	×
S105T01F	50	(*1) 5	400	3000	-25 to +100	8	12	1.5	2	×	×
S105T02F	50	(*1) 5	400	3000	-25 to +100	8	6	1.5	2	○	×
S108T01F	50	(*1) 8	400	3000	-25 to +100	8	12	1.5	2	×	×
S108T02F	50	(*1) 8	400	3000	-25 to +100	8	6	1.5	2	○	×
S102S01F	50	(*1) 8	400	4000	-25 to +100	8	12	1.5	2	×	×
S102S02F	50	(*1) 8	400	4000	-25 to +100	8	6	1.5	2	○	×
S102S11F	50	(*1) 8	400	4000	-20 to +80	8	12	1.5	2	×	○
S102S12F	50	(*1) 8	400	4000	-20 to +80	8	6	1.5	2	○	○
S112S01F	50	(*1) 12	400	4000	-25 to +100	8	12	1.5	12	×	×
S112S02F	50	(*1) 12	400	4000	-25 to +100	8	6	1.5	12	○	×
S116S01F	50	(*1) 16	400	4000	-25 to +100	8	12	1.5	16	×	×
S116S02F	50	(*1) 16	400	4000	-25 to +100	8	6	1.5	16	○	×

(*1) with heat sink

(*2) 60 Hz AC, 1 minute, RH = 40 to 60%

Sine wave applied between input and output using a withstand voltage tester equipped with a zero-cross circuit (short between input terminals and between output terminals)

<Table 8-3> List of Sharp SSR characteristics for 200 V AC line

Model name	Absolute maximum rating: Forward current I_F [mA]	RMS ON-state current $I_{T(rms)}$ [A]	Repetitive peak off-state voltage V_{DRM} [V]	Isolation voltage(*2) $V_{iso(rms)}$ [V]	Operating temperature T_{opr} [°C]	Electrical characteristics: Minimum trigger current I_{FT} [mA]	V_D [V]	On-state voltage V_T [V]	$I_{T(rms)}$ [A]	Remarks: Zero-cross	Snubber circuit
PR31M11NTZF	50	0.1	600	5000	-25 to +80	10	6	2.5	0.06	×	×
PR36MF11NSZF	50	0.6	600	4000	-25 to +80	10	6	3.0	0.6	×	×
PR36MF22NSZF	50	0.6	600	4000	-25 to +80	10	6	3.0	0.6	○	×
PR36MF11NSZF	50	0.6	600	4000	-25 to +85	10	6	3.0	0.6	×	×
PR36MF12NSZF	50	0.6	600	4000	-25 to +85	5	6	3.0	0.6	×	×
PR36MF21NSZF	50	0.6	600	4000	-30 to +85	10	6	3.0	0.6	○	×
PR36MF22NSZF	50	0.6	600	4000	-30 to +85	5	6	3.0	0.6	○	×
PR39MF11NSZF	50	0.9	600	4000	-25 to +85	10	6	3.0	0.9	×	×
PR39MF12NSZF	50	0.9	600	4000	-25 to +85	5	6	3.0	0.9	×	×
PR39MF21NSZF	50	0.9	600	4000	-30 to +85	10	6	3.0	0.9	○	×
PR39MF22NSZF	50	0.9	600	4000	-30 to +85	5	6	3.0	0.9	○	×
S201D01F	50	1.2	600	4000	-25 to +85	10	6	1.7	1.2	×	×
S201D02F	50	1.2	600	4000	-25 to +85	10	6	1.7	1.2	○	×
S201DH1F	50	1.5	600	4000	-25 to +85	10	6	1.7	1.5	×	×
S201DH2F	50	1.5	600	4000	-25 to +85	10	6	1.7	1.5	○	×
S202T01F	50	2.0	600	3000	-25 to +100	8	12	1.7	2	×	×
S202T02F	50	2.0	600	3000	-25 to +100	8	6	1.7	2	○	×
S201S05VF	50	(*1) 3	600	4000	-25 to +100	15	12	1.5	1.5	×	×
S201S06VF	50	(*1) 3	600	4000	-25 to +100	15	6	1.5	1.5	○	×
S205T01F	50	(*1) 5	600	3000	-25 to +100	8	12	1.5	2	×	×
S205T02F	50	(*1) 5	600	3000	-25 to +100	8	6	1.5	2	○	×
S208T01F	50	(*1) 8	600	3000	-25 to +100	8	12	1.5	2	×	×
S208T02F	50	(*1) 8	600	3000	-25 to +100	8	6	1.5	2	○	×
S202S01F	50	(*1) 8	600	4000	-25 to +100	8	12	1.5	2	×	×
S202S02F	50	(*1) 8	600	4000	-25 to +100	8	6	1.5	2	○	×
S202SE1F(*3)	50	(*1) 8	600	3000	-25 to +100	8	12	1.5	2	×	×
S202SE2F(*3)	50	(*1) 8	600	3000	-25 to +100	8	6	1.5	2	○	×
S202S11F	50	(*1) 8	600	4000	-20 to +80	8	12	1.5	2	×	○
S202S12F	50	(*1) 8	600	4000	-20 to +80	8	6	1.5	2	○	○
S212S01F	50	(*1) 12	600	4000	-25 to +100	8	12	1.5	12	×	×
S212S02F	50	(*1) 12	600	4000	-25 to +100	8	6	1.5	12	○	×
S216S01F	50	(*1) 16	600	4000	-25 to +100	8	12	1.5	16	×	×
S216S02F	50	(*1) 16	600	4000	-25 to +100	8	6	1.5	16	○	×
S216SE1F(*3)	50	(*1) 16	600	3000	-25 to +100	8	12	1.5	16	×	×
S216SE2F(*3)	50	(*1) 16	600	3000	-25 to +100	8	6	1.5	16	○	×

(*1) with heat sink

(*2) 60 Hz AC, 1 minute, RH = 40 to 60%
Sine wave applied between input and output using a withstand voltage tester equipped with a zero-cross circuit (short between input terminals and between output terminals)

(*3) Between input and output: Reinforced insulation type

References Indicated by (ref.) in the text

(ref. 16) Sharp Semiconductor Data Book "Optical Semiconductor Volume 2", 1996, Sharp Corporation.

(ref. 18) Solid State Relay Application Manual, 1982, Sharp Corporation.

(ref. 26) Sharp Semiconductor Reliability Handbook, Optoelectronic Devices Volume, Sharp Corporation.

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