

Solid Statements: Three-Phase Motor-Reversing Solid-State Relays



Three-phase motors are used in many industrial applications to control loads such as pumps, compressors, valves, conveyors, and many other motor-driven devices. They are relatively simple in design, efficient, and have a high starting torque compared to single-phase motors. They are smaller and less expensive than single-phase motors with comparable ratings, and also tend to last longer than single-phase motors with the same power rating.

Many loads driven by a three-phase motor simply require the motor to turn on and off in order for them to perform their required function (as depicted on Fig 1). One such load would be an industrial fan, which only needs the motor to rotate in one direction in order for air to circulate. A compressor is another example of a three-phase load where the motor simply needs a connection to a three-phase AC network in order to perform its desired function.

These applications typically use a simple [three-phase solid-state relay](#), contactor, or motor starter to switch power to and from the motor.

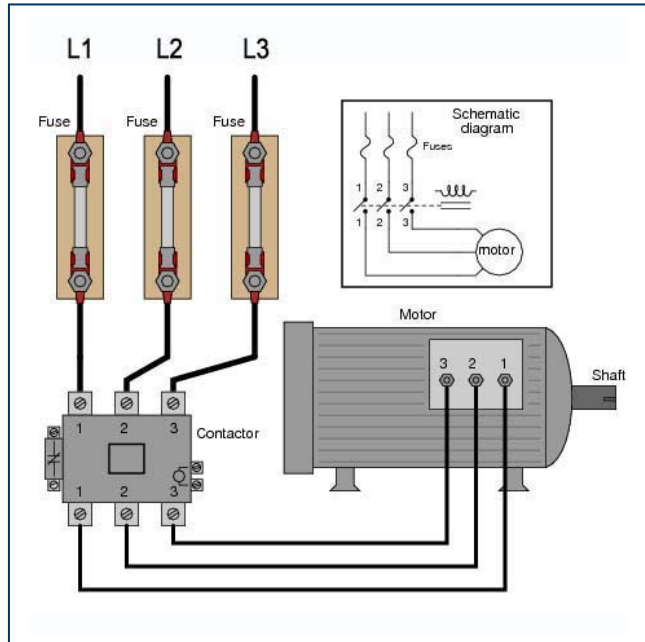


Fig. 1: Simple three-phase motor circuit (courtesy of www.allaboutcircuits.com)

However, some applications are not as straight forward and require a bit more than simply turning the motor on and off. Sun tracking solar panel systems, for example, utilize motors to move the panels throughout the day so that they can follow the path of the sun across the sky. However, at the end of the day they must return to their original position in order to greet the sun on the following morning. This requires a controller that can not only energise the

motor, but also reverse its direction when needed.

Reversing a Three-Phase Motor:

Figure 1 above shows a simple wiring diagram for controlling a three-phase motor with a contactor. When the contactor is energised, it switches the three phases of the AC mains to the motor and it begins to rotate accordingly. It will continue to rotate at a constant speed and direction for as long as the contacts remain closed. However, if you change the connection of any two phases of the AC mains to the contactor (connect L1 to terminal #2 and L2 to terminal #1, for example), the direction of the motor will reverse when it is re-energised.



Electric actuators automate industrial valves in the energy, chemical, waste water, and other industries

Of course, physically changing the connection on the contactor every time you want to change the direction of the motor is a bit impractical. Therefore, a device is needed that can do this automatically when a “direction” command is provided by a controller. Traditionally this was accomplished by

using discrete components, multiple mechanical relays or, more conveniently, a three-phase motor-reversing contactor. However, as we’ve discussed in previous issues, the mechanical solutions have the same drawbacks associated with any electromechanical device. The most significant of these drawbacks is life expectancy, especially in applications where the motor is “bumped” or “inched” in order to achieve a specific position.

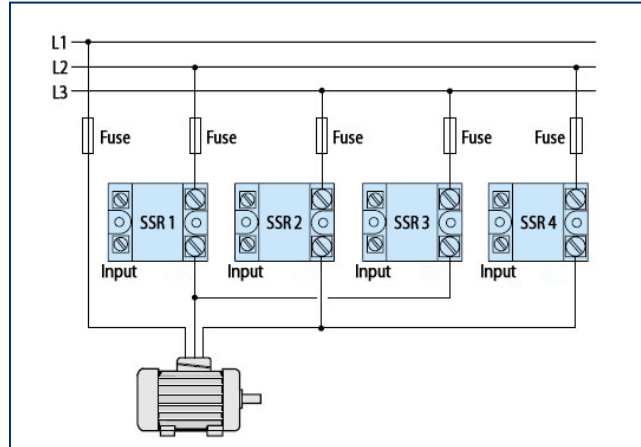


Fig. 2: 4x SSR motor-reversing circuit, with direct connection of the third phase to the motor.

One possible motor-reversing solution that addresses the problems associated with mechanical devices is the utilisation of multiple single-phase solid-state relays. As seen in Figure 2, L1 of the AC mains is connected directly to the motor. SSR #1 and SSR #3 connects either L2 or L3 to the second leg of the motor, and SSR #2 and SSR #4 connects either L2 and L3 to the third leg of the motor. When SSRs #1 & #2

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are energised, the motor will rotate in one direction. To reverse the direction, SSRs #1 & #2 are de-energised, and SSRs #3 & #4 are energised, effectively swapping the connection of L2 and L3 to the motor.

***A few important notes with regards to using multiple SSRs in a motor-reversing application:**

- 1) The system controlling the SSRs must have an interlock circuit that prevents the “forward” and “reverse” relays from turning on simultaneously! Failure to comply with this requirement may result in a phase-to-phase short through the relays.... a very dramatic and unwanted effect.
- 2) Relays with internal overvoltage protection must not be used in motor-reversing applications. An internal TVS may switch on the output of the SSR when subjected to an electrical transient, effectively creating a phase-to-phase short. A Metal Oxide Varistor (MOV) may be placed across the output of each SSR to provide protection from transients.
- 3) A fifth SSR can be used to switch the third phase of the motor if this is required by the application. It is not necessary for this relay to be part of the interlock circuit, but it must be energised at the same time as the “forward” or “reverse” relays to prevent the motor from being damaged.

Motor-Reversing Solid-State Relays!

Yet another, and often more preferred solution for many applications is to utilise a motor-reversing solid-state relay. The Crouzet brand **GNO** series

motor-reversing SSR offers two significant advantages over the methods just discussed. These are 1) all four SSRs are contained in one industry-standard three-phase SSR package, and 2) the interlock circuit is already built into the relay.

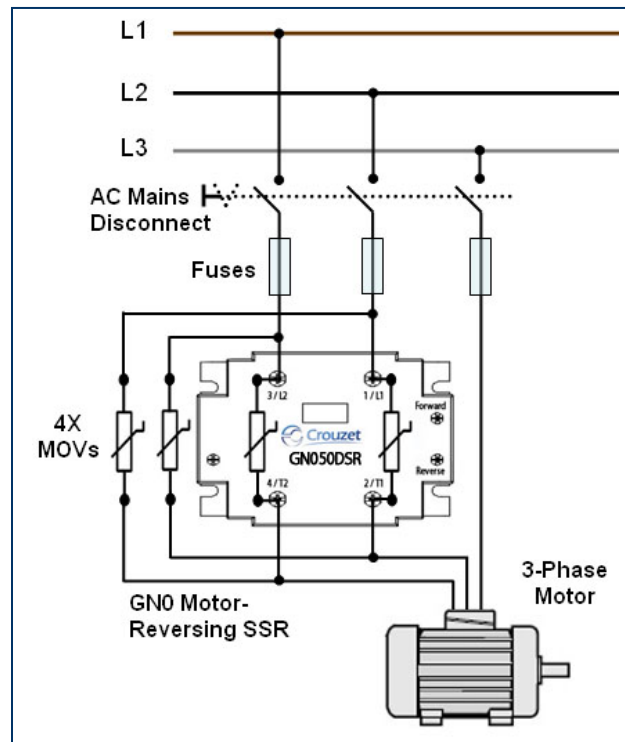


Fig. 3: Simplified GNO Motor-Reversing SSR wiring diagram

As can be seen from figure 3 above, two of the three phases are wired through the GNO and the third phase is connected directly to the motor. When a logic signal is applied to the “forward” terminal, the GNO switches L1 and L2 directly to the motor. When the signal is removed from the “forward” terminal and

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applied to the “reverse” terminal, the GN0 switches the connection of L1 and L2, effectively reversing the direction of the motor. If a logic signal is simultaneously placed on the “forward” and “reverse” terminals, the relay will shut off.

GN0 Input-Output Status		Control Signal Applied To:		
		A1 (Forward)	A1 & B1	B1 (Reverse)
Load Terminals	L1-T1	Closed	Open	Open
	L2-T2	Closed	Open	Open
	L1-T2	Open	Open	Closed
	L2-T1	Open	Open	Closed

Fig. 4: Load-current path through the GN0 outputs for a given input condition

External MOVs can be added to the circuit to provide additional protection from overvoltage conditions. As with figure 2, the GN0 has 4 separate output circuits to provide the motor-reversing function (2 for forward, and 2 for reverse), so 4 MOVs would be required. Also, as with any electrical circuit, proper fusing and a suitable disconnect from the AC mains is required.

Motor-Reversing Applications!

GN0 Motor-Reversing SSRs are an ideal solution in many three-phase applications. A growing trend is in renewable energy systems, as well as electronic valve control. However, there are many more potential applications for these relays.

- **Electric Actuators / Valves**
- **Solar Panel Tracking Systems**

- **Baggage / Material Handling Equipment**
- **Industrial Hoists**
- **Packaging / Strapping Machines**
- **Satellite Systems**
- **Pipe Bending**
- **Security / Access Control Systems**
- **Industrial Grinders**

The GN0 is ideally suited for many applications using three-phase induction motors up to

- 10HP@600V
- 7.5HP@480V
- 3HP@240V



Solar panel tracking systems create an increasing demand for motor-reversing solid-state relays.

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