Technical Bulletin November 2007

Compressor Motor Types and Start Relays

A brief summary of motor types, and the starting components that some of these motors require.

1. **Single phase compressor motor type**

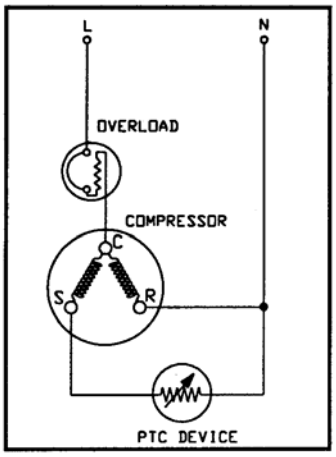
A. RSIR Motor (Resistance Start – Induction Run)

This is the simplest motor used in hermetic compressors. It has a main (or run) winding, and also a start winding. The start winding is required only during start-up. The motor requires no capacitors. A relay is needed only to isolate the start winding when the compressor reaches a speed at which the main winding alone can function properly

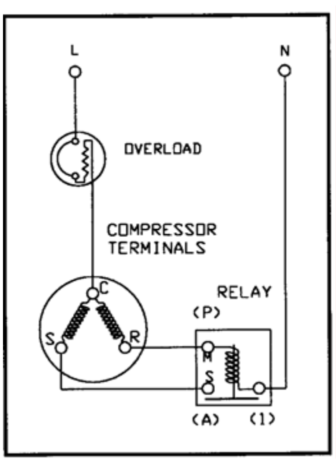
An RSIR motor is normally used on balanced pressure start applications, where a high motor starting torque is not required. Domestic refrigerators often utilise RSIR compressors.

The most widely used relay on Kulthorn RSIR compressors is a PTC (Positive Temperature Coefficient) solid state device. This device is installed in series with the start winding. A PTC experiences a ‘step’ increase in resistance as a result of an electric current passing through it. The PTC is matched to a motor design so that, coinciding with the compressor reaching the required switching speed, the sharp increase in the PTC resistance effectively prevents any current passing through the start winding. This is a simple device, with no moving parts.

On some compressors, the PTC device is a combined start relay and motor protector.



RSIR Motor Diagram with PTC Relay

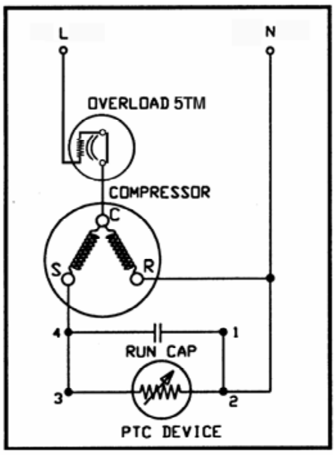


RSIR Motor Diagram with Current Relay

B. RSCR (Resistance Start – Capacitor Run)

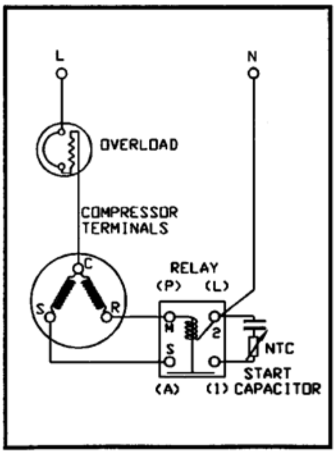
When low starting torque is adequate, but improved operating efficiency is required, the addition of a run capacitor in series with the start winding can produce the required result. This may again be on a domestic refrigerator application, but one where a small increase in cost is justified by the higher efficiency that is needed to satisfy market demands or regulatory requirements.

Again a PTC or current relay is used, but in this case it does not isolate the start winding, which remains active whenever the compressor runs. The relay allows current to bypass the run capacitor during run-up, producing the necessary starting characteristics. When the PTC resistance increases or the current relay opens, the effect is to bring the run capacitor into series with the start winding.



RSCR Motor Diagram with PTC Relay

C. CSIR Motor (Capacitor Start – Induction Run)



CSIR Motor Diagram with Current Relay

When a compressor is required to start against unbalanced pressures, as is the case when a TX valve is used as the system's expansion device, a CSIR motor may be the appropriate choice.

We may think of the CSIR motor as being an RSIR motor that has been upgraded by the addition of a start capacitor in series with a suitably modified start winding. The result is that, instead of switching only the start winding, the relay now isolates the start winding and the start capacitor. As with the RSIR motor, the CSIR motor, once up to speed, runs on the main winding only.

D. CSR Motor (Capacitor Start and Run, sometimes identified as CSCR)

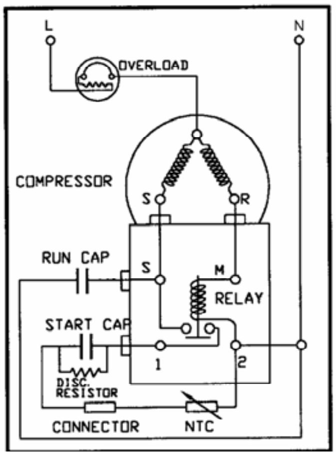
This motor offers the improved starting characteristics that a start capacitor provides, plus the increased running efficiency that results from the use of a run capacitor. This motor is widely used on larger commercial refrigeration applications.

In this design, the run capacitor is again in series with the start winding, these components being active whenever the compressor is running. There is an additional capacitor (the start capacitor) in parallel with the run capacitor during the run-up. It must be isolated when the compressor reaches a speed where the start capacitor is no longer required.

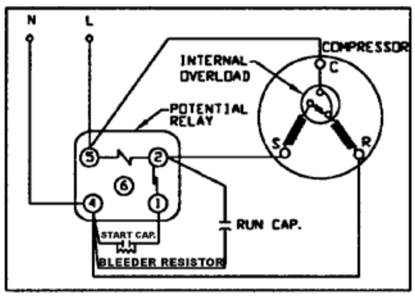
While some smaller CSR compressors are supplied with current relays, the relays specified for larger CSR compressors are usually potential relays.

A possible disadvantage of a current relay on a CSR system is that it is a normally open (NO) device. At the instant that power is applied to the compressor, the main winding and the run capacitor are live, and the run capacitor starts to charge. When the contacts of the current relay begin to close, there is the likelihood that the run capacitor will discharge across those contacts, resulting in possible burning of the contacts and, in extreme cases, the contacts may weld together.

Welded contacts prevent the relay from opening, and the start capacitor will remain in circuit. Start capacitors are designed only for intermittent and brief use. If a relay does not open, the start capacitor will, in turn, fail.



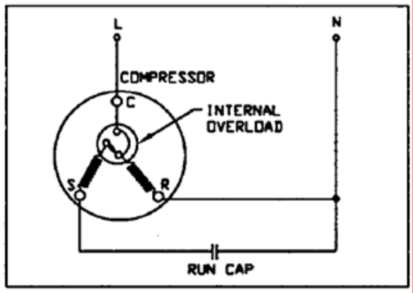
CSR Motor Diagram with Current Relay



CSR Motor Diagram with Potential Relay

E. PSC Motor (Permanent Split Capacitor)

This type of motor offers optimum efficiency due to its use of a run capacitor. It does not normally use a start relay or a start capacitor, resulting in low starting torque but also a cost saving. Room air conditioners (RAC) are the most common application for PSC compressors. Such units are typically designed with capillary tubes, and thus achieve balanced pressures prior to start-up. The compressor's reduced starting ability is thus not a problem, and the total unit cost benefits from the elimination of a relay and a start capacitor. The excellent efficiency of a PSC motor is another obvious benefit in the design of high volume RACs.



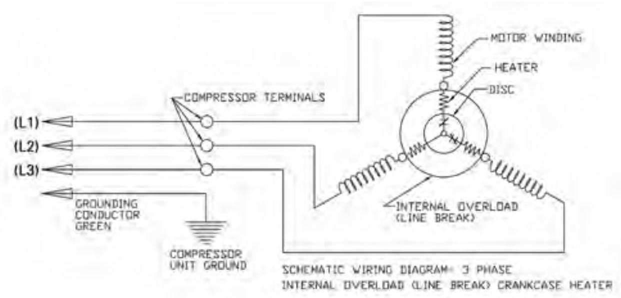
PSC Motor Diagram

It is only when system pressures fail to balance, or the supply voltage to the compressor terminals is very low, that the need for enhanced starting ability may be an issue. There is more than one way to achieve this, but the use of a start kit (potential relay and start capacitor) is one option. Other aftermarket service devices, wired across the run capacitor, may also offer acceptable solutions.

2. Three Phase Motors

Since we have mentioned all the single phase motor types found in Kulthorn compressors, we should mention also the other widely used motor type. More appropriate for larger compressors, a three phase motor has the obvious need for three supply phases. If three phase supply is not already available, this can add significantly to the installation cost. On the other hand, benefits include

- excellent starting torque
- a wide operating voltage range
- no ancillary starting devices (relays, capacitors)
- Reduced starting load on any individual phase, and minimal impact on nearby lighting, etc.



Three Phase Motor Wiring Diagram

The use of a three phase compressor may be essential to comply with local regulations relating to starting current limits.

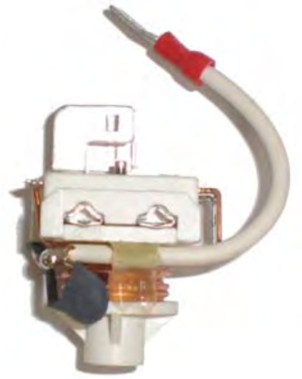
A suitable contactor, preferably incorporating thermal protection, is necessary to switch a three phase compressor.

A three phase reciprocating compressor is designed to run in either direction, therefore phase connections can be made in any sequence

3. Compressor Motor Starting Relays

A. Current Type Relay

A current relay is a normally open (NO) switch. When power is applied to a compressor, the main winding current flows through an armature in the relay. The magnetic effect of the armature closes the contacts. As the compressor speed increases, the main winding current drops until the point is reached where the reducing magnetic field can no longer support the contact assembly, and the relay opens.



Current Type Relay

B. PTC Type Relay

PTC (Positive Temperature Coefficient) is a solid state device. This device is installed in series with the start winding. A PTC experiences a 'step' increase in resistance as a result of an electric current passing through it. The PTC is matched to a motor design so that, coinciding with the compressor reaching the required switching speed, the sharp increase in the PTC resistance effectively prevents any current passing through the start winding. This is a simple device, with no moving parts.

PTC Type Relay

C. Potential Type Relay

A potential relay is a normally closed (NC) device, and this overcomes the problem of contacts arcing on start-up.

A potential relay incorporates a coil that senses start winding voltage. As the compressor speed increases, the start winding voltage also increases. When this voltage reaches the relay's pick-up value, the contacts open. While the compressor continues to run, the start winding voltage will remain sufficiently high to hold the relay open. When the compressor is switched off, the relay contacts close.

Potential Type Relay

Some Practical Considerations

When replacing a relay, always use the component specified by the manufacturer.

Where a current or potential relay is used, it has been carefully selected to match the compressor design. Relays may be identical physically, but have different electrical characteristics. Do not use a different relay simply because it looks the same or because it is used on another compressor of a similar size. It may operate when first installed, but fail to work when load conditions or the supply voltage change.

The same considerations apply to PTC relays. A PTC is carefully matched to a compressor motor. If a PTC relay is used with a motor larger than the one for which it is intended, the device will switch sooner than it should, possibly before the compressor has reached a running speed that the main winding alone can sustain. If a smaller motor is matched to the same PTC, its lower current will result in a longer delay than normal before the start winding is effectively isolated. In some circumstances this can cause the motor protector to open and stop the compressor.

The correct PTC is designed to function satisfactorily over the full range of loads and supply voltages. It is very important that no PTC relay should be fitted to a compressor other than the one specified by Kulthorn Kirby.

When replacing any of the above types of relays, it is important to remember that components are constantly upgraded, and Kulthorn may specify a part number that differs from the original. That part will, however, offer the correct electrical characteristics for the specific compressor.

If a start capacitor fails, do not replace only the capacitor.

Start capacitors are reliable devices. In most cases of start capacitor failure, they result from the capacitor being in circuit for more than the normal start-up time. This in turn suggests the possibility of a faulty relay. It is good practice, when replacing a failed start capacitor, to also replace the start relay.

Why are some start capacitors fitted with discharge resistors?

A start capacitor that is used in conjunction with a run capacitor and a potential relay (on a CSR motor) will retain an electrical charge when the relay contacts open and the start capacitor is isolated. When the compressor stops, and the potential relay contacts close, there is the likelihood that the start capacitor will discharge across the relay contacts, causing them to weld. This can subsequently result in damage to the start capacitor and/or the compressor motor.

This situation is avoided by the use of a discharge resistor that is fitted across the terminals of the start capacitor. When the relay opens, the charge in the start capacitor is safely dissipated through the resistor. Its resistance is sufficiently high (typically 15,000 ohms) that it does not affect the performance of the capacitor.

When replacing the start capacitor on a CSR compressor, the replacement capacitor should be one that is fitted with a discharge resistor.

Always mount a potential relay in the correct position.

A potential relay will operate in any position, but it is only in the correct orientation that it will offer the specified electrical characteristics. In other positions, the pick-up voltage may differ from specification.

Referring to the manufacturer's code of potential relays supplied with Kulthorn compressors, the mounting position is indicated by the second last digit in the part number. As an example, an RVA8R6D relay has mounting position code '6', indicating that the relay should be installed with the mounting tab at the bottom.

Starting Problems Due to Low Voltages

The starting ability of a compressor reduces as the supply voltage is reduced. Low voltage may result from a supply problem, but this is not always the case.

The effective starting voltage is the voltage supplied to the compressor terminals at the instant of starting. This is the voltage, measured at the compressor terminals, at the moment when the compressor is drawing its starting current or locked rotor current (LRA). If the wiring to the compressor is of excessive length, and/or the cables are not large enough to carry the high starting current, there will be a significant voltage drop at the compressor terminals. This is the voltage that the compressor sees, and this voltage may be below the approved starting range of the compressor. In such a case, the fault does not belong with the supply authority, nor with the compressor. Consideration should be given to upgrading the electrical wiring to the compressor.