GENERAL INFORMATION

3ARR3 & 3ARR22 Potential Type Motor Starting Relays

General Description

GE Potential Relays are used for assisting in the initial function of capacitor start, induction run and capacitor start, capacitor run motors. The motors are the larger sized compressor motors for residential central air conditioning systems and larger pump motors (over 1/3 hp at 120 VAC and 3/4 hp at 240 VAC). Smaller motors used on residential refrigeration systems generally use current type starting relays or thermal/resistance devices such as PTCR's. In order to use a potential type starting relay, the motor must have a start capacitor, but it may or may not also have a run capacitor.

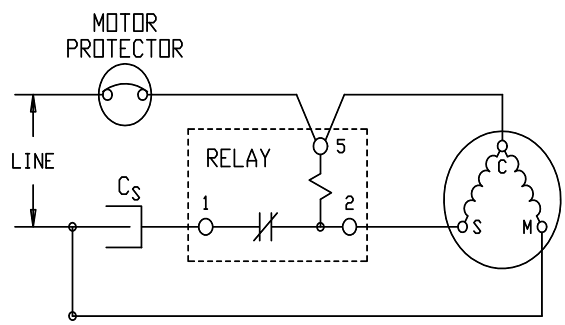
Operation

In a capacitor start, induction run or capacitor start, capacitor run motor, a voltage is generated in the start winding when the motor is running. This voltage results from the induced magnetic flux lines in the rotor cutting through the turns of the start winding. The voltage induced in the start winding is a function of the speed of the motor at any time and the number of turns in the start winding. The higher the speed of the rotor, for a given start winding, the higher the induced voltage in that start winding. When a motor is first energized, the voltage across the start winding is less than the supply voltage since the start winding is in series with the start capacitor. As the motor increases speed, the voltage across the start winding increases, and continues to increase until full motor speed is reached. At that point, the value of start winding voltage is called the continuous voltage rating required for relay coil design considerations. The start winding voltage can be significantly higher than the supply voltage.

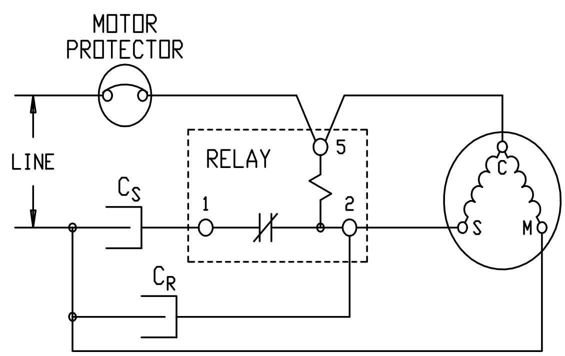
Since the coil of the relay is connected across the start winding of the motor, the relay responds to the increase in start winding voltage as the motor increases speed *(See Figs 1 & 2).* The normally closed relay contacts, in series with the start capacitor, are designed to open at a specific motor speed as the start winding voltage increases.

Note: The relay responds to the start winding voltage and not the supply voltage to the equipment.

CIRCUIT FOR POTENTIAL RELAY APPLICATIONS



CAPACITOR START - INDUCTION RUN
FIG 1



CAPACITOR START - CAPACITOR RUN
FIG 2

For a specific motor and load conditions, there is a correlation between the start winding voltage and the speed of the motor. The relay utilizes this correlation to “pick up” and open the relay contacts at a voltage which will ensure that the motor will pull up to normal running speed after the start capacitor is disconnected. The relay pickup voltage is determined from the voltage/ speed/torque characteristics of the specific motor in the application.

After disconnecting the start capacitor, the relay remains “picked up” during the run cycle of the motor. Therefore, the coil of the relay must be designed to be continuously energized at the value of the start winding voltage after the start capacitor is disconnected.

When the motor is de-energized, the relay “drops out”, closing the contacts, and the relay is ready for the next motor start function.

Note: The start capacitor must be discharged during the run cycle by a bleed resistor across the terminals to prevent a charged start capacitor from discharging through the relay contacts and welding them as the motor is de-energized and the relay contacts re-close. The equipment manufacturer should determine the required value and wattage rating based on the specific application. Normally, a start capacitor bleed resistor has a resistance value of approximately 15,000 ohms and 2 watt capacity.

Design Features

The 3ARR3 and 3ARR22 potential type starting relays are enclosed relays designed for remote mounting from the equipment it is controlling.

The design is an iron core, armature actuated, electro-magnetic relay with a single-pole, single-throw normally closed contact structure. The armature engages the contact structure at a specific coil voltage value to open the relay contacts during the motor starting function.

The relay is designed for “clean” pick up within the calibration range. The mechanical load curve of the armature and contact structure action, and the magnetic pull curve from the coil are optimized such that once the armature begins its pick-up action, there is no “stalling” of the armature as it picks up the load of the contact spring. This ensures that there is always “clean” action of the contacts.

Materials

Materials are corrosion resistant or plated for long life in typical applications.

Base and cover materials are selected based on the application requirements. General Purpose Phenolic is the standard plastic. Melamine Phenolic material is available for more severe application conditions.

The large electrical contacts are (Ag CdO) silver/cadmium oxide composition for reliable disconnection of the start capacitor.

Terminal Options

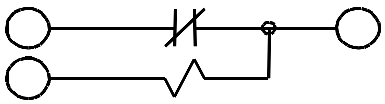
The design affords easy access to the wiring terminals.

- Quick Connect Tabs
  0.032” x 0.250” (0.8 mm x 6.3 mm)
  Tin-plated Brass
- Screw Type Terminals
  #8-32 Tin-plated Brass
- Spare Terminals
  Spare Terminals are available for interconnections

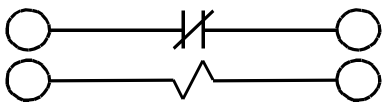
Note: If there is a wiring terminal in position 6 on 3ARR3 relays, it must be the same polarity as #1, #2, and #4 to prevent possible “flashover”. If there is no terminal in position 6, then position 4 can be either polarity.

Circuits

Circuits are available for a three-terminal, common coil and contact circuit; or a four-terminal, isolated coil and contact configuration.



Common Coil Circuit



Isolated Coil Circuit

Coils

All coils have Class B insulation with a maximum allowed winding temperature of 120° C (by change in resistance method).

There are (16) standard coil groups, with ratings from 130 to 500 volts AC, 60 Hz. 50 Hz coil ratings range from 117 to 470 volts AC. The ratings are based on an 80° C temperature rise above a 40° C effective ambient temperature at the relay.

Contact Ratings

3ARR3 35 amperes (max), 50/60 Hz, break only.

3ARR22 50 amperes (max), 50/60 Hz, break only.

Mounting

A variety of standard mounting brackets are available which provide suitable mounting means for specific applications. The relay may be mounted in any position, but the calibration is position sensitive; therefore, the relay is calibrated for the specific mounting position in the application. The plastic cover permits mounting to metal without additional insulation.

Approvals

U.L.	File #	SA639	3ARR3/3ARR22
CSA	File #	11746-15	3ARR3
CSA	File #	11746-115	3ARR22
VDE	License No. 97252 Ref. No. 4376.15-4510-8007/A1F		3ARR3/3ARR22

General Application Considerations

The parameters and characteristics which must be evaluated for a satisfactory application are:

1. Motor Curves.
   (Max, Nom, Min Supply Volts)
   Motor Speed vs. Torque
   (Starting and Running)
   Motor Speed vs. Start Winding Volts
   (Start Capacitor In/Out)
2. Ratings in Amperes.
   Required Electrical Rating of the Contacts in Amperes. Determines the relay design required. (3ARR3/3ARR22)
3. Mechanical Form
   - Number and types of terminals (quick connect or screw)
   - Circuitry
     Common coil or isolated coil
   - Mounting Bracket Type
     Select from standard designs
     Other special features which may be required
4. Coil Voltage Rating.
   Follow Application Procedure.
5. Calibration.
   Follow Application Procedure.
6. Mounting Position.
   Customer specification for calibrating the relay in the position in which it will be mounted.

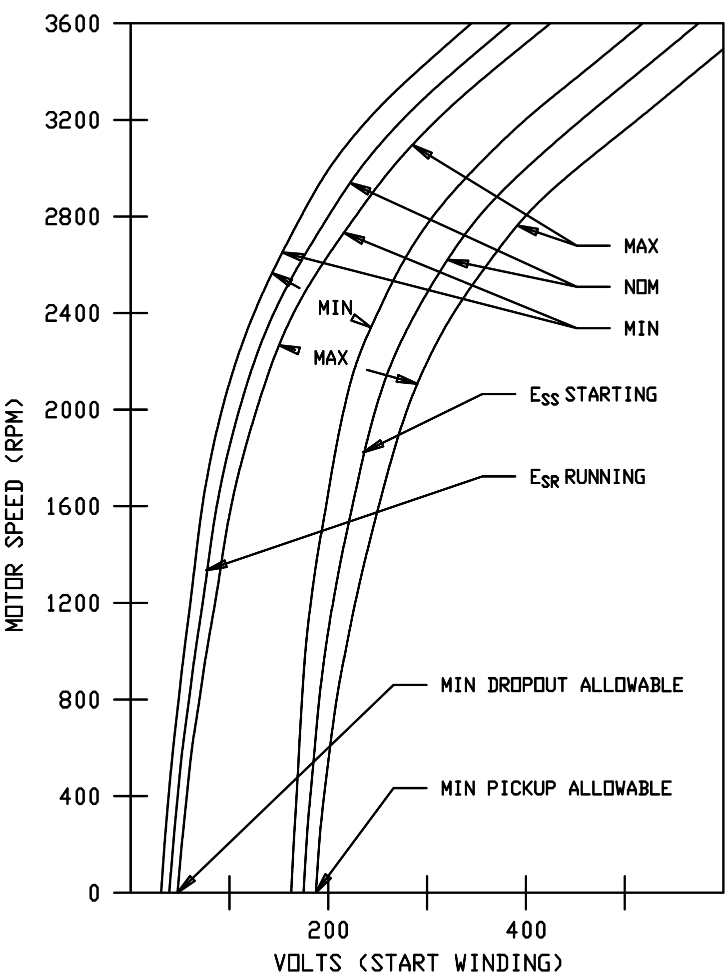
Endurance

100,000 to 500,000 operations depending on load.

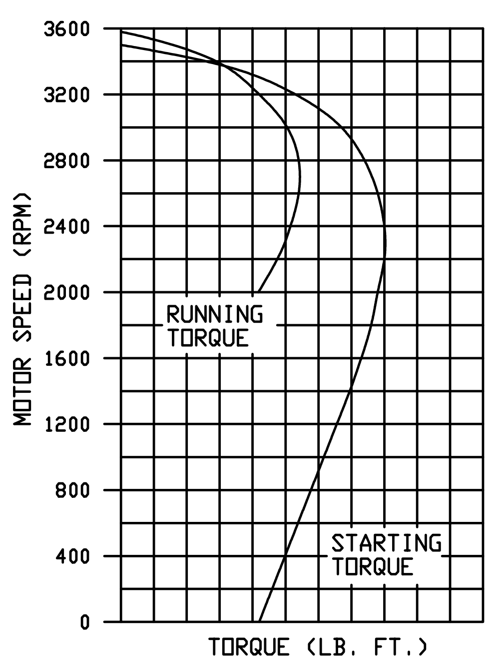
Motor Curves

Prior to beginning the procedure for determining the functional characteristics of the relay, the motor curves for start winding voltage vs. motor speed should be examined to see if the shapes of the curves lend themselves to a good application.

These curves should be obtained from the motor suppliers who generally are aware of motor curve characteristics which facilitate the application of potential type starting relays. See Figures 3 and 4 for typical start winding voltage and torque curves. Other basic electrical measurements on the motor/compressor will also assist in the application.



START WINDING VOLTAGE VS. MOTOR SPEED
TYPICAL CAPACITOR START MOTOR
(NOM, MIN, MAX SUPPLY VOLTAGE)
TWO-POLE, 60 Hz MOTOR
FIG.3



OUTPUT TORQUE VS. MOTOR SPEED
TYPICAL CAPACITOR START MOTOR
(NOMINAL SUPPLY VOLTAGE)
TWO-POLE, 60 Hz MOTOR
FIG.4

NOTE:
FOR A TWO-POLE, 50 Hz MOTOR,
SYNCHRONOUS SPEED IS 3000 RPM.

From the specified motor data, GE Application Data Work Sheets *(Appendix A)* and Coil Group/Calibration Tables *(74-407791 Appendix B)* are used to select the proper coil group and calibration for either 60 or 50 Hz applications. Appropriate suffix numbers and letters are identified and made part of the full model number.

To make a good application, the curves should exhibit a significant change in start winding voltage with a change in speed. If the curves are "unusually straight", it is difficult to make a good application. Since the relay responds to changes in voltage, a significant difference in voltage is required for a specific change in speed. However, excessive changes in start winding voltage with speed can result in high disconnect voltage and current on the start capacitor. It may also require a relay with a very high differential to prevent the relay from dropping out while the motor is running.

Definitions

Supply (Line) Voltage

Value of voltage at the input terminals of the motor. Specified as "Nominal", "High"(+10%), or "Low" (-15%).

Ess

Voltage across the start winding with start capacitor in the circuit.

Esr

Voltage across the start winding with start capacitor out of the circuit.

Ecs

Voltage across the start capacitor with the capacitor in the circuit during starting.

Transfer Speed

Selected RPM of the motor at which the start capacitor is disconnected and motor will pull up to normal running speed.

Crossover Speed

Motor speed above which the running torque exceeds the starting torque.

Coil Voltage Rating

Continuous voltage which can be applied to the relay coil without exceeding the maximum allowable coil winding temperature.

Pickup Voltage

Determines the "transfer speed" at which the start capacitor is disconnected. Allowance is made in the specified pickup voltage to compensate for the response time of the relay.

Cold Pickup Voltage

Value of pickup voltage when the relay coil is "cold". This is the condition when the coil has not been energized and is the lowest expected pickup voltage. (Coil temp approx 40° C.)

Hot Pickup Voltage

Value of pickup voltage after the coil has been energized during a run cycle and has not cooled down to the ambient temperature during the off cycle. (Coil temp approx 95° C.)

When a coil is energized continuously, the resistance value of the coil wire increases; therefore, a higher voltage is required to produce enough current to actuate the relay.

Dropout Voltage

Value of voltage at which the relay will dropout, allowing the contacts to reclose after the compressor or motor is de-energized.

Dropout voltage is related to the rating of the relay coil. The higher the coil rating, the higher the range of dropout voltage.

The minimum dropout voltage must be greater than the maximum value of Esr at zero speed with maximum supply voltage.

Load Current

Maximum expected current which the relay contacts will break to disconnect the start capacitor. It can be calculated using the maximum capacitor voltage, the capacitance value of the capacitor, and the frequency. This value must be within the rating of the relay contacts.

Application Procedures

General

There are various procedures used to select the correct functional elements and characteristics of the relay to be applied, depending on the amount of information available. The more operating information available, the better the application.

Aside from general information pertaining to terminals, circuits, and mounting position, the primary decisions concern relay type (3ARR3 or 22), coil group, and calibration.

The Application Data Work Sheets *(Appendix A)* are step-by-step procedures and should be followed for each application.

It is recommended that the characteristics be measured on the motor/compressor at the expected supply voltage and frequency for the best applications. There are some approximations which may be used to convert coil performance and calibration from one frequency to another, but they should be used with caution.

Potential relay applications involve compromises to ensure specific performance requirements are not violated. This means reviewing data and preliminary calculations and refining them to provide the optimum relay characteristics.

Mounting Location

The relay should not be mounted in a location where there is close proximity to large pieces of magnetic material which may link the magnetic flux of the relay and change the calibration. If another location is not possible, the calibration of the relay may be modified to compensate for the effect.

The relay also should not be mounted in a location where it will be subject to substantial vibration or shock which may alter the calibration or cause the contacts to open prematurely.

The relay may be mounted in any one of the six possible positions *(Appendix B and C)*; however, position #6 should be avoided. In position #6, the return spring may not properly seat the armature in its pivots especially on low calibration models. This can cause a first-cycle error in calibration.

Mounting Brackets

The standard mounting brackets are shown in Appendix C. Any of the four shown may be specified. If another design is required, there would be special tooling required.

Coil Group Selection Procedure

1. Determine the maximum continuous start winding voltage which the relay coil will see during the normal running of the motor/ compressor.

   Measure Esr at synchronous speed (no load) with the maximum expected supply voltage (nominal + 10%) and at the frequency of the application (60 or 50 Hz).

   If voltage data is not available at synchronous speed, use 110% of Esr at approximately 3500 RPM for two-pole 60 Hz motors or 1750 RPM for four-pole motors at maximum supply voltage. For 50 Hz motors, use 110% Esr at approximately 2900 PM. (1450 RPM for four-pole.)

2. Select appropriate coil group from Application Data Sheets *(74-407791 Appendix B)* for the applicable voltage and frequency.

Because the coil designs have a very large number of turns, there is a significant inductive reactance which has an effect on the heat rise of the coil, depending on whether the coil voltage frequency is 60 or 50 Hz. Sheets 1 and 3 are ratings for 60 Hz and Sheets 2 and 4 are for 50 Hz applications.

The Data Sheets contain (16) standard coil groups for which the voltage rating for continuous coil operation is listed for two specific temperature rise values (80° C and 60° C). The maximum start winding voltage in the application must not exceed the maximum coil voltage rating for an 80° C temperature rise.

All coils have a 120° C total temperature rating, based on IEC 730-1 (EN 60730-1). Therefore, in an application where the effective ambient is 40° C, an allowable rise of 80° C is within the 120° C temperature rating of the coil. The effective ambient temperature at the relay plus the heat rise of the coil must not exceed 120° C.

If the effective ambient temperature at the relay is expected to exceed 40° C, then a coil group with a higher voltage rating should be selected.

The tables show voltage ratings for 60° C temperature rise as a guide for selecting coils where the effective relay ambient may exceed 40° C.

Note: *Be sure that the effective ambient at the relay is checked in the worst conditions for highest expected ambient temperature. Some applications may have unusually high effective ambients due to small space constraints, tighter enclosures, and/or insulation around the motor/compressor compartment for noise damping.*

Calibration Specification Procedure

Calibration values can be approached from two directions. One is starting at the optimum transfer speed and working down from a value of maximum hot relay pickup volts which will disconnect the start capacitor at the optimum transfer speed. The most common procedure is to start with a calculation of the minimum cold pickup volts which will not be less than a voltage surge at Ess at zero speed when the circuit is energized. The calculation includes a safety factor. From this minimum cold pickup value, along with the speed change during the response time of the relay, it can be observed whether or not the transfer speed is appropriate for proper pull-in up to normal running speed.

In either approach, both maximum and minimum operating parameters and the relay functional tolerances must be evaluated prior to final selections. To determine the correct value of pickup voltage, there must be compensation for the response time of the relay. The motor will typically accelerate approximately 700 RPM for two-pole 60 Hz motors (400 RPM four-pole motors) from the time the relay pickup action is started until the relay contacts open and disconnect the start capacitor. For 50 Hz motors, an approximate value is 500 RPM for two-pole and 300 RPM for four-pole.

The minimum cold pickup voltage should be no less than 130% of the start winding voltage under starting conditions, at locked rotor (zero speed), and at high supply line voltage (nominal + 10%). This will prevent premature operation of the relay in response to a transient surge of voltage which occurs when the motor is initially energized. Maximum start winding voltage at zero speed occurs with maximum supply voltage, and maximum values of start and run capacitors connected.

The minimum cold pickup voltage must also be high enough that when the start capacitor is disconnected, there is enough running torque to pull the motor up to normal running speed.

The maximum hot pickup voltage value should be low enough that the motor will always get to a speed high enough under load conditions to pick up the relay and disconnect the start capacitor.

It is advisable to disconnect the capacitor at the lowest speed which will start the motor. This will assure the capacitor voltage and disconnect current of the relay contacts are kept as low as possible.

In all cases, the minimum relay dropout voltage must be greater than the maximum Esr at zero speed with maximum supply line voltage to assure that the relay drops out when the motor is de-energized.

The current which the relay contacts must break to disconnect the start capacitor can be calculated by formulas in Appendix A. This value of current must be less than the contact rating of the relay. If it is not, the capacitor must be disconnected at a lower speed to reduce Ecs to a value which will be within the relay contact rating or a higher rated relay (3ARR22) should be used.

After the approximate value of hot (or cold) pickup has been determined, refer to the previously selected coil group table in the Application Calibration Tables *(74-407791 Appendix B*) for the appropriate calibration letters which best fit the speed-torque-voltage values of the motor curves.

Note: *Once values are determined, they must be rechecked for the effects of all maximum and minimum tolerances, capacitance of the start capacitor, and capacitor voltage and current.*