GEI-12571A

0132

INSTRUCTIONS

SYNCHRONOUS MOTOR CONTROL

with

SLIP-CYCLE IMPEDANCE RELAY

GENERAL ELECTRIC

INSTRUCTIONS GEI-12571A

SYNCHRONOUS-MOTOR CONTROL

WITH

SLIP-CYCLE IMPEDANCE RELAY

INDUSTRY CONTROL DEPARTMENT

GENERAL ELECTRIC

SALEM, VA. 24153

7-66 (250)

SYNCHRONOUS-MOTOR CONTROL
WITH
SLIP-CYCLE IMPEDANCE RELAY

GENERAL

Synchronous motor controllers for a particular motor rating can be operated magnetically or semi-magnetically by any one of the five most common starting methods, as required for a particular installation.

These starting methods, including the controller nomenclature, are classified as follows:

Method	Magnetic*	Semi-magnetic**
Full voltage	CR7065	CR7066
Reduced voltage (autotransformer)	CR7061	CR7062
Reduced voltage (resistor)	CR7063	
Reduced voltage (reactor)	CR7073	
Part-winding	CR7067	

* Magnetic control of a-c power with automatic field control.

** Manual control of a-c power with automatic field control.

For any starting method employed to apply a-c power to the motor stator, a reliable and accurate means of controlling the application and removal of field excitation is provided by use of the slip-cycle impedance relay.

The system of field control, as included herein, provides the following features:

1. Accurate speed selection
2. Favorable angle selection
3. Simple adjustment
4. Prompt pull-out (field removal) protection

Complete motor protection is provided in conjunction with the automatic field control, and consists of the following:

Motor shutdown (or field removal for resynchronizing as required) immediately after pull-out

Temperature overload relays (hand reset) for individual protection of the stator and squirrel-cage windings (Because of the widely different heating characteristics of these windings, individual protection assures that full use is made of the thermal storage ability of the motor under all conditions.)

INSTALLATION

The controller must be mounted rigidly in the vertical position.

REMOVE all packing, bracing, or blocking from all contacts on each device, which is for transit purposes only. OPERATE each movable contact device manually to assure free movement and full contact action. REMOVE all traces of any foreign matter from all contact surfaces.

Where such oil-immersed devices as contactors, oil circuit breakers, or oil dashpots (undervoltage or current trip coils) are employed, remove each oil tank or container and fill to the indicated level with the oil supplied with the controller. It is to be noted that no oil substitution should be made without first consulting the nearest Sales Office of the General Electric Company.

Inspect all wiring, making sure that the connections are clean and tight and that there are adequate clearances for all devices.

All external wiring from the controller must be made in strict accordance with the main connection diagram supplied with the controller. (Refer to PURCHASER'S NOTES listed in the main connection diagram.)

Any separate switching means for reversing the direction of motor rotation must be connected in the circuit between the controller and motor for correct functioning of the field control relay (FR).

As indicated in the main connection diagram supplied with the controller, inspect the wiring to determine definitely that the starting and field discharge-resistor circuit is connected and in parallel with the motor field through the discharge (closed) contact of the field-applying contactor (FC) and the squirrel-cage protective relay (SCR).

Do not apply power to the controller or motor until the instructions under "Operation" and "Adjustment" have been studied.

OPERATION

For information concerning the operational sequence of a-c power switching to the motor windings for the particular type of controller

involved, reference should be made to the main connection diagram supplied with controller.

1. A-c Power Switching to the Motor

(a) Magnetic Full-voltage Starting

Pressing the start button will cause the main line contactor or breaker to close and full voltage to be applied to the motor terminals.

(b) Magnetic Reduced Voltage

Pressing the start button will cause the starting contactor or breaker to close and reduced voltage to be applied to the motor terminals. After a predetermined time interval an adjustable-time transfer relay will operate to reconnect the motor from the starting connection to the running- or full-voltage connection. The time setting of the transfer relay should be set for the average maximum time required for the motor to reach maximum speed under operating conditions. An initial trial start should be made with a temporary maximum time setting of the transfer relay to determine the interval required.

(c) Magnetic Part-Winding Starting

The sequence of the a-c power switching means for part-winding starting is equivalent to that mentioned in paragraph 1.b , where a portion of the motor winding is first connected to the power source. After a predetermined time interval a second portion of the motor winding is connected in parallel with the first portion; or, in effect, normal or full voltage is applied to all windings of the motor.

(d) Semi-magnetic Starting

This method of starting is similar to magnetic starting, except that manual operation of the a-c power-switching devices is required.

2. Field Application

a. Description

The slip-cycle impedance relay is used to apply and remove automatically the field excitation of a synchronous motor. In addition to the slip-cycle impedance relay, associated control devices are also provided. Diagram M-6980271 shows a general type of control scheme for a magnetic, full-voltage controller. Together with the related operating functions of such devices as relay (FR), contactor (FC), and relays (TR1) and (CR1), automatic application and removal of field may also be employed with the other starting methods mentioned in the section, "General."

The slip-cycle impedance relay functions as a sensitive speed-responsive device to apply field excitation to the motor at the correct speed for successful synchronizing. If, after the motor has synchronized, it should pull out of step because of an abnormal overload, a drop in line voltage, or a loss of excitation voltage, the relay will act to remove field excitation.

The field contactor (FC) and the sequence time relay (TR1) are each provided with two coils: a top, or closing coil, and a bottom, or holding coil.

The relay (FR) operates on variation in the impedance of the armature winding, which occurs during each slip cycle out of synchronism. The contacts of relay (FR) alternately open and close as synchronous speed is approached. As acceleration continues, contacts (9-5) remain open and (9-10) closed for longer and longer intervals of time. For a measure of this time, (TR1) bottom coil (18-20) is provided with a capacitor (C2). When this coil is de-energized for a time interval exceeding the time-discharge rate of the capacitor (C2) connected in parallel with the bottom coil of relay (TR1), relay (TR1) will operate its control contacts by the top (TR1) closing coil (9-15). The field contactor (FC) is provided with a resistor (R6) connected in parallel with the (FC) bottom coil (19-20). After (TR1) operates to open contact (9-19) and close (5-19), relay (FR) contact (9-5) opens on the next slip cycle to de-energize (FC) bottom coil (19-20). At a predetermined time delay, pickup of (FC) is provided by means of the resistor (R6), which traps the flux originally established in this coil; thus the time-delay of the stored energy in this coil provides a predetermined time interval for the closing of (FC) by operation of the top coil (10-20). The time interval of (FC) closing, after the operation of (TR1), provides that (FC) shall close and apply field excitation at a favorable angular position of the rotating a-c field of the stator with respect to the field of the rotor.

When field contactor (FC) applied field excitation, (FC) interlock (15-20) opened to de-energize (TR1) top coil (9-15). Relay (TR1) is provided with a predetermined time delay drop-out by means of the capacitor (C1) connected in parallel with coil (9-15). When this coil is de-energized, the time-discharge rate of capacitor (C1) into the coil (9-15) of (TR1), provides time dropout. This interval permits the rotor to reach a steady state condition after the initial application of field excitation.

Resistor (R7) is connected in series with rectifier (REC) to provide a loading means and regulate the output of the rectifier.

The time settings of relay (TR1) and contactor (FC) are adjusted and set at the factory for the particular motor involved and no further adjustment is required.

b. Sequence of operation (Refer to M-6980271)

All devices are shown in the de-energized position.

With a-c power available, pressing the start button energizes relay (CR1), which causes (CR1) contacts (32-2) and (32-26) to close, (LE) to be energized, and full voltage to be applied to the motor stator windings. (CR1) contacts (25-14) open and (25-7) close, connecting (FR) relay for field application operation. A hold circuit is established by (LE) interlock (1-32) around the start button.

When (LE) interlock (40-4) is closed, both top and bottom coils of (TR1) and (FC) are energized. Since the bottom armatures of (TR1) and (FC) are closed, the bottom coils hold or lockout and prevent operation of either device. At the instant the coils of (TR1) and (FC) are energized, capacitors (C1) and (C2) are fully charged.

As the motor accelerates and synchronous speed is approached, contacts (9-5) and (9-10) of (FR) relay open and close, respectively, during each slip cycle out of synchronism. When a predetermined speed is obtained, and (FR) contact (9-5) remains open for a sufficient time interval, the top coil (9-15) of (TR1) will cause (TR1) contacts (5-19) to close, (9-19) to open, (5-18) to open, and (9-10) to close. During a part of the slip cycle and after (TR1) operated, (FR) contact (9-5) will open to de-energize the bottom coil (19-15) of (FC) from control source 9, through contact (9-5) of (FR) and closed contact (5-19) of (TR1) (contact 9-19 or (TR1) is open). After a predetermined time interval, (FC) top coil (10-20) will cause (FC) to close, applying field excitation and opening the discharge contact (F1-42A) of (FC). Contact (15-20) of (FC) opens to de-energize (TR1) top coil (9-15). (FC) contact (2-24) de-energizes relay (CR1) coil (24-25) and contact (26-32) of (FC) forms a holding circuit to (LE) coil (26-25). When (CR1) is de-energized, contacts (32-2), (7-25), and (9-10) open and (CR1) contact (14-25) closes. Contacts (7-25) and (14-25) of (CR1) recalibrate (FR) for operation under conditions of pull-out. After a predetermined time delay (TR1) opens contact (9-10) in parallel with (FR) contact (9-10). (FR) contact (9-10) for normal synchronous operation (field applied), remains closed to energize the top coil (10-20) of (FC).

3. Field Removal on Pull-out

If the motor should pull out of synchronism because of abnormal operations, (FR) contact (9-10) will instantly open and cause (FC) top coil (10-20) to be de-energized, and instantly remove field excitation. Contact (26-32) of (FC) will also de-energize coil (26-25) of (LE) and disconnect the power supply from the motor.

Provided that the motor torque and type of driven load permits resynchronizing, the addition of jumpers across (CR1) contact (32 2) and (FC) contact (32-36) will provide field removal only on pull-out. Under such conditions (FR) relay is recalibrated by (CR1) contacts (14-25) opening and (7-25) closing and the operating sequence for reapplication of field excitation will be the same as above.

ADJUSTMENT

For adjustment of the slip-cycle impedance relay (FR), refer to instructions GEH-1070, which is included herein for additional information if required.

For information concerning the other devices associated with the complete equipment, including a description of their operation, adjustment, and maintenance, see the instructions included with the controller.

It will be noted, from the main connection diagram included with the controller, that three connection (current) studs (terminals No. 11, 12, and 13) are provided on the slip-cycle impedance relay (FR), two of which are connected to the secondary circuit of the current transformers. The primary of the current transformers is connected in the motor circuit. These connection studs, or current taps, are provided in order that the correct connection can be made at the factory for the particular motor involved.

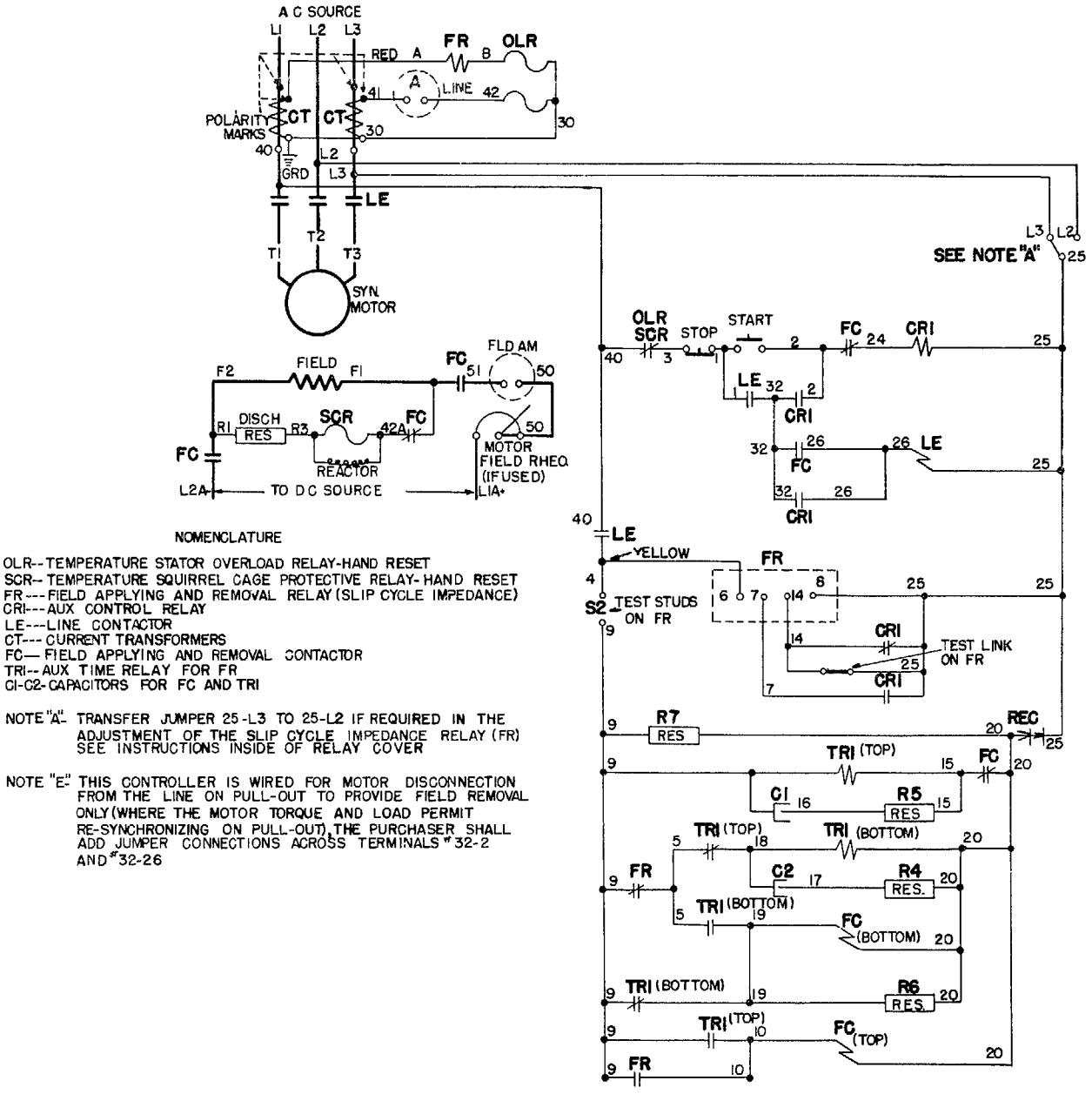
In order to reduce the number of adjustments of the field relay for the initial operation of the motor, the current stud connection taps provided on the relay (FR) assure, for a given motor, the maximum sensitivity and most accurate means of controlling field excitation. In extreme cases, where data are not available for the motor involved, current connections can be made in ac-

cordance with those shown in the connection print, K-6962091P1, 2, or 3, included herein, for three-or two-phase power circuits. The values of current indicated under the above connection reference are the currents impressed on the relay (FR) at approximately 95 per cent of synchronous speed (less field excitation and 100 per-cent applied terminal voltage) and does not necessarily represent the limitations of the operating range of the relay. If reconnections or changes are made in the current connection studs of relay (FR), readjustment should be made in strict accordance with instructions GEH-1070.

RENEWAL PARTS

When ordering renewal parts other than those listed by catalog number, the part should be described in detail, giving the complete nomenclature of the device as it appears on the nameplate and main connection diagram.

Description	No. Req	Cat. No.
CR2800-1626-B Field Contactor (FC)		
Stationary main contact tip	3	5349227G1
Movable main contact tip	3	5349227G2
Main shunt (top)	2	5346461G2
Main shunt (bottom)	1	5907279G1
Main adjusting spring	1	2415140
Contact tip spring	3	2415665
Interlock assembly	2	4986984G12
Retaining washer for main contact spring	3	5382909P2
Spring for lower arc chute	1	2415611
Arc chute (right side)	3	1435843
Arc chute (left side)	1	5964624G2
Arc chute (left side)	2	5964621
CR2820-1709-A Relay (TR1)		
Main adjusting spring	1	2415398
Interlock assembly	2	4986984G11



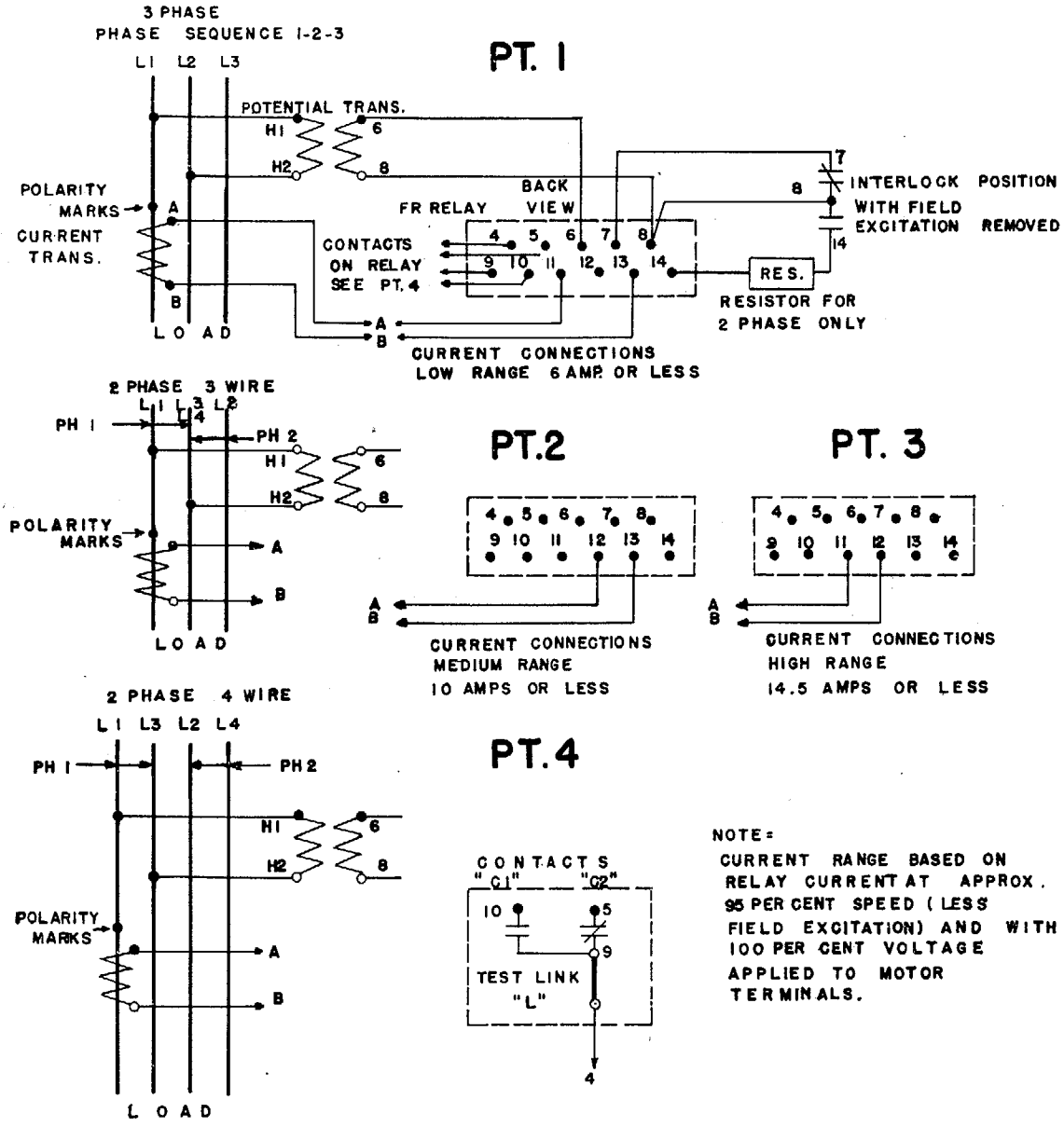
NOMENCLATURE

OLR--TEMPERATURE STATOR OVERLOAD RELAY-HAND RESET
SCR--TEMPERATURE SQUIRREL CAGE PROTECTIVE RELAY-HAND RESET
FR---FIELD APPLYING AND REMOVAL RELAY (SLIP CYCLE IMPEDANCE)
CRI---AUX CONTROL RELAY
LE---LINE CONTACTOR
CT---CURRENT TRANSFORMERS
FC—FIELD APPLYING AND REMOVAL CONTACTOR
TRI--AUX TIME RELAY FOR FR
C1-C2-CAPACITORS FOR FC AND TRI

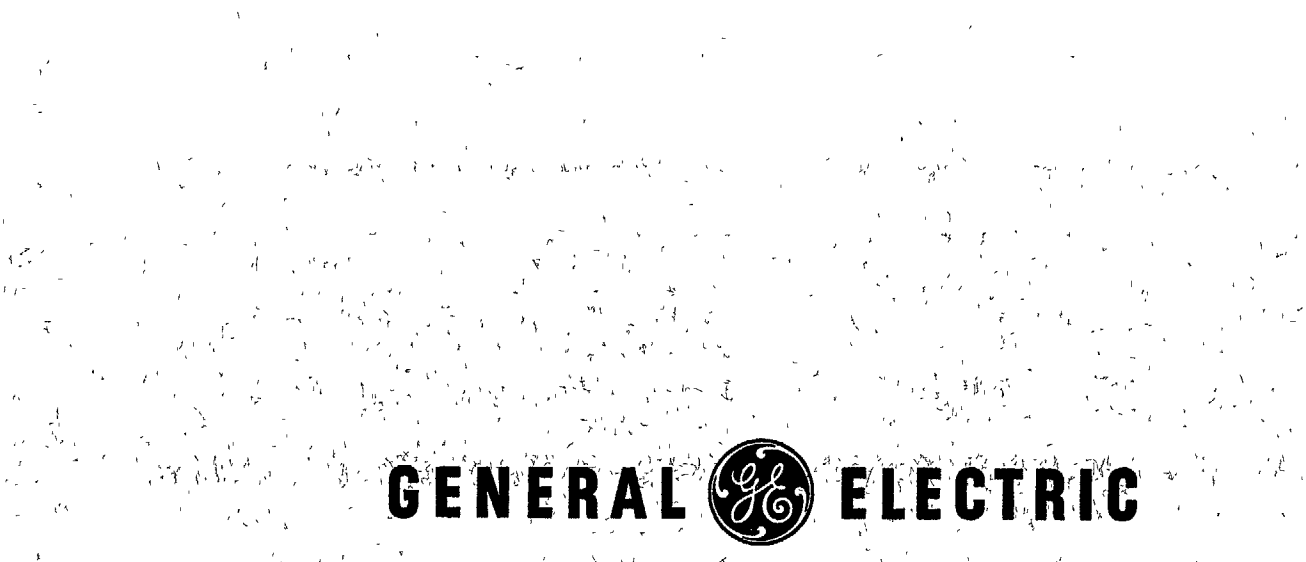
NOTE "A"- TRANSFER JUMPER 25-L3 TO 25-L2 IF REQUIRED IN THE ADJUSTMENT OF THE SLIP CYCLE IMPEDANCE RELAY (FR) SEE INSTRUCTIONS INSIDE OF RELAY COVER

NOTE "E" THIS CONTROLLER IS WIRED FOR MOTOR DISCONNECTION FROM THE LINE ON PULL-OUT TO PROVIDE FIELD REMOVAL ONLY (WHERE THE MOTOR TORQUE AND LOAD PERMIT RE-SYNCHRONIZING ON PULL-OUT), THE PURCHASER SHALL ADD JUMPER CONNECTIONS ACROSS TERMINALS #32-2 AND #32-26

M-6980271 Elementary diagram for magnetic full-voltage synchronous-motor controller



K-6962091 Connection diagram for slip-cycle impedance relay


GENERAL ELECTRIC