GEK-28768A

Instructions

Slip Guard Relay
IC3655A100

TABLE OF CONTENTS

CHAPTER 1

1-1. DESCRIPTION

The slip-guard relay is a solid state device which monitors the phase angle of voltage and current and provides a relay output signal to remove field or shut down a motor when the power factor lags below a predetermined value for a predetermined time.

The trip value of the lagging power factor is readily adjustable by a potentiometer which provides a range over which the power factor setting can be selected. The range is 0.6 to 1.0 lagging.

There is also a time delay feature built into this device which provides a period of time within which the power factor can vary without tripping. This is to take care of transient conditions. This period of time is readily adjustable by changing the position of a potentiometer over a range of 0.2 to 1.0 seconds.

This device can be furnished with or without a meter that indicates the power factor at which the motor is running. This feature eliminates the need for a separate power-factor instrument, and facilitates testing and start up checks of the motor and starter.

A zero reading with the motor not running on the meter (if so equipped) indicates the relay has not tripped and that the motor has been shut down by another cause. If not equipped with a meter the indicating light in the sealed relay inside the slip guard relay indicates the tripped condition.

A test of the relay operation can be made with the motor off and only control power on the relay (no current), the meter will read unity. Rotating the PF dial beyond unity in the lead direction should cause the relay to trip.

The output of the device is a set of normally-open relay contacts rated 7 amps, 115 or 230 volts.

1-2. TYPE OF PROTECTION PROVIDED

1. Out-of-step (slipping) operation due to excessive shaft load.
   Power factor will lag and the slip-guard relay will drop out within time setting on dial. Contacts can be set to remove field excitation or shutdown motor as required.
2. Sudden stall while running.
   This condition is characterized by high line current and lagging power factor. Since slip-guard is not affected by current magnitude, the lagging power factor will drop out the relay so as to shutdown the motor.
3. Loss of excitation; slipping without field current.
   The precise response of the slip-guard to power factor as set on the calibrated dial will permit motor shutdown on loss of excitation if the dial is set at the expected induction motor power factor, which will be about .80.
4. Stall on starting, prolonged acceleration, or failure of field to be applied. (Incomplete Sequence).
   The slip-guard may be used in conjunction with a definite time relay set at the expected accelerating time to detect incomplete sequence. The slip-guard is normally inhibited during starting (since power factor is always lagging during starting), but once the inhibitor is removed by a function such as the definite time relay, the slip-guard will respond to lagging power factor to indicate a non-synchronous condition; stall, or prolonged acceleration.

1-3. APPLICATION

Synchronous motors are designed to run at constant speed and drive shaft load by torque derived from polarized iron cores on their rotors which magnetically link corresponding stator poles. Whenever the rotor turns at a speed less than the stator, the motor is said to "slip". Slip can occur with the field poles magnetized, which will create wide pulsations in torque at the motor shaft each time a stator pole passes a rotor pole.Corresponding pulsations occur in the line current to the motor. Both types of pulsations can be damaging. Torque pulsation can interfere with efficient power system operation. Slipping with rotor poles magnetized (field applied) is therefore always unacceptable for a synchronous motor and some means must be provided to prevent it.

One of the most reliable indicators of synchronous and asynchronous (out-of-step) operation is power factor in the line to the motor. That is, the phase angle between voltage and current. Synchronous motors seldom, if ever, operate continuously at lagging power factor. They run at either unity or some value of leading angle between current and voltage. Lagging power factor always appears when the motor load angle increases, becoming fully lagging (90°) as the motor just pulls out of step. Lagging power factor may therefore be utilized to initiate action to prevent slipping.

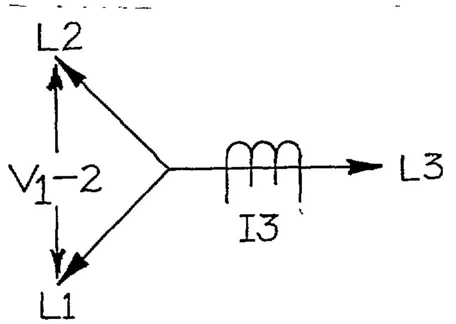
Torque and power pulsations during slip can be reduced by removing field current to the rotor poles. The motor would then run essentially as an induction motor by its squirrel cage winding. Slip with field current removed is tolerable to the load and power system but intolerable for any length of time to the motor squirrel cage winding itself, since it is designed with limited thermal capability and for short-time operation. Motor Power Factor during induction motor operation (that is with field removed) is always lagging. However, the degree to which the current lags the voltage is less than at pull-out when field poles are excited. Lagging power factor therefore, can again be utilized as an indicator of "slip" during induction motor operation.

For synchronous motors, therefore, some means must be provided to guard against two kinds of slip; slip with field applied, which causes 90 degree lagging (0%) power factor, and slip when running without field applied which causes lagging power factor in the order of 60 to 80 percent. The slip-guard relay can protect a synchronous motor against both types of slip.

Although lagging power factor always occurs during slip, there are other transient situations of the power system and motor which can cause a momentarily lagging power factor. These situations may be of such short duration that the motor will continue to run in synchronism. Very rapid response of a power factor relay in these situations would cause unnecessary shutdown, therefore, a built-in time delay (adjustable) permits setting the slip-guard to delay operation unless the power factor remains lagging for a predetermined time, indicating persistant pull-out.

1-4. DESCRIPTION OF OPERATION OF RELAY

An analog voltage signal appears at point N in the circuit Sh. 1-4, whose magnitude is proportional to the phase angle between line current and line voltage. At unity power factor the angle is 90 degrees if voltage input at points O and P is from L1, to L2, and the current input at F and G is from L3. Phase rotation being L_1-L_2-L_3.



The EXCLUSIVE-OR power factor circuit is arranged so that output signal is 5 volts (5 MA thru Power Factor Meter) at unity power factor, zero at 90 degrees lag (0 P.F.), and 10 volts (10 MA thru PFM) at 90 degrees lead (1.0 P.F.). Output signal varies between 0 and 10 volts in relation to the cosine of the angle between voltage and current inputs.

1-4.1. Brief Description of Circuit Operation: See Sh. 1-4

Positive half waves of voltage input L_1-L_2 turn Q5 on, and positive half waves of current input L_3 turn Q6 on. Whenever Q5 and Q6 are both in the same state, either ON or OFF, Q9 is turned ON. The circuit therefore has four extremes:

1. Q5 and Q6 both ON: voltage at R36 is low, and base drive of Q9 is through R31 and R30; Q8 is OFF since voltage is low at its base. Q9 is ON and shunts current to COMM away from power factor meter.
2. Q5 and Q6 both OFF: voltage at R36 is high which drives Q9. Q8 is ON but cannot lower Q9 base drive due to 15K R30. Q9 being ON shunts current to COMM away from power factor meter.
3. Q5 ON and Q6 OFF: voltage low at R36 and R35 but high at R37 which turns Q8 ON. Q8 decreases drive on Q9 and turns it off; current then flows through PFM.
4. Q5 OFF and Q6 ON: voltage high at R35 and low at R36; R36 cannot drive Q9, and Q8 turns ON to prevent drive through R31 and R30. Q9 OFF, current flows through power factor meter.

In summary, lagging power factor results in LOW output signal at point N due to shunting effect of Q9.

Q2 will drive Q12 in proportion to the difference in currents through Q10 and Q11. As Q10 is turned ON, Q2 drives Q12 and prevents charging C10 and the firing of uninjunction Q14. Since lagging power factor results in low output to point N from the power factor circuit, Q12 is turned OFF and allows C10 to charge to the stand-off voltage of Q14, fires SR1 and drops out relay RR.

Relay RR therefore drops out on lagging PF at a point as set by R105. Time delay trip is set by R106 (the time to charge C10).

Power factor logic shown on Sh. 1-5 is therefore applicable to the total device. Low signal resulting from lagging power factor will drop out relay RR. High signal resulting from unity or leading power factor will hold the relay in.

Relay RR is initially energized (picked up) by shorting terminals TB1-R and TB1-D. The dropout circuit is inhibited by tying point A to COMM. RR will drop out from lagging PF after the inhibiting connection is opened, C7 charges, and power factor goes lagging long enough to charge C10. C7 therefore introduces an initial time delay to allow for motor pull-in time.

1-5. OPERATION OF CONTROL SYSTEM

Before operating the equipment it is important that the module be properly sequenced. H1 H2 H3 H4 must be same phase sequence as L1-L2 of motor and current S & T must be same phase as H3 current.

This device requires a minimum of 50 milliampere signal from 3CT in line 3.

During starting or accelerating period the power factor meter should read lagging. If it reads leading- the current connections at S & T must be reversed.

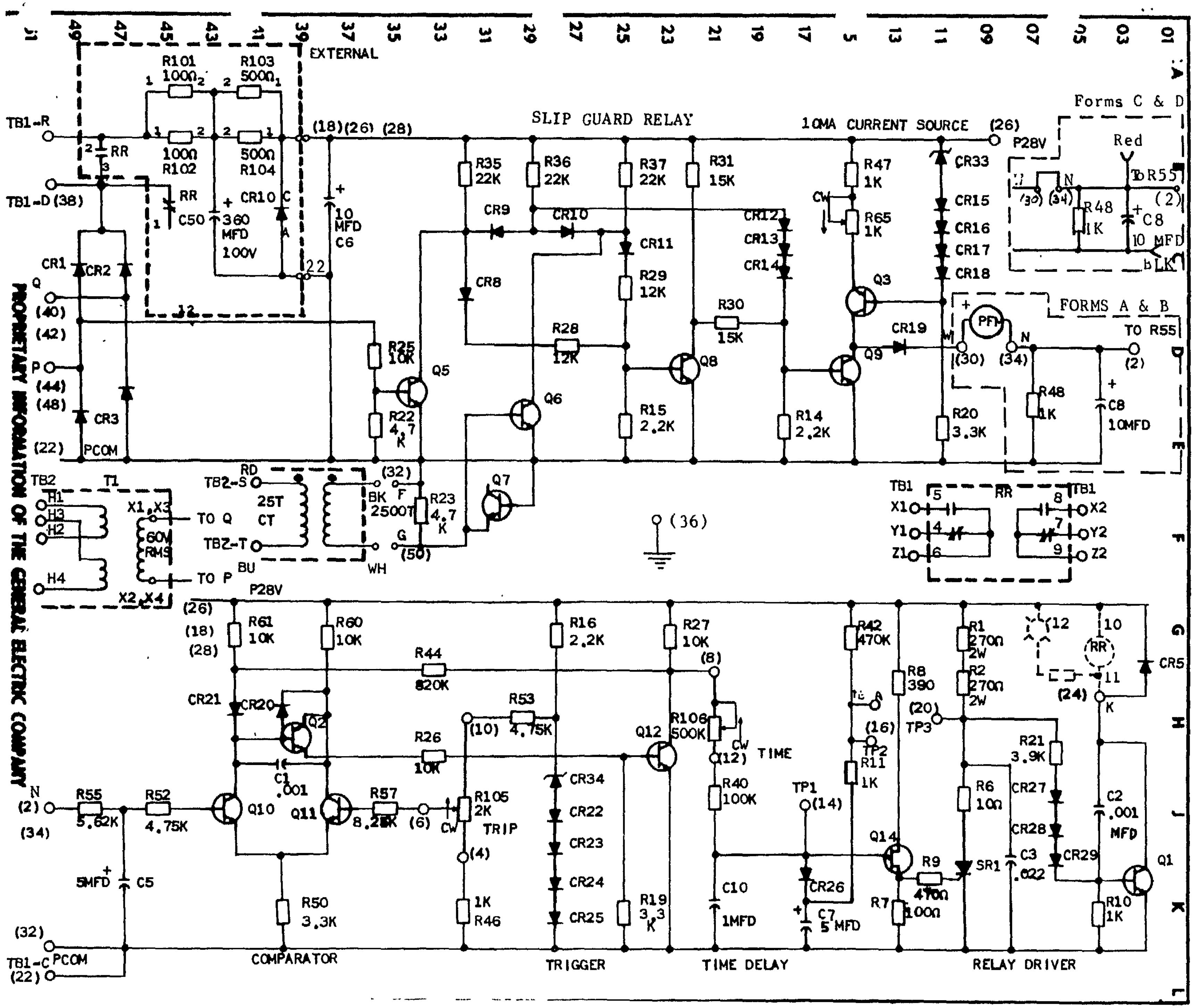
Also during starting a built-in timing feature desensitizes the relay when the field is applied for a period of 5 times the normal drop out tine. This allows the motor to stabilize during this time period.

1-6. OPERATING SEQUENCE FOR BRUSHLESS SYNCHRONOUS MOTOR (REFER TO SH. 1-6 FOR TYPICAL CURRENT DIAGRAM).

1. Depressing start button energizes timer TR and motor contactor M. Interlock on contactor M closes circuit at terminals D & R on slip guard relay signaling the relay that motor is running. Contacts Z2 - X2 and X1 - Z1 on slip guard relay are closed to establish holding circuit to keep motor running under normal conditions. TR contacts short terminals A-C on power factor relay to disable the circuit until motor has accelerated and reached a stable condition.
2. After motor has reached stable condition TR contacts open permitting the slip guard relay to provide its function of monitoring power factor and shutting down the equipment when power factor falls below proper value by opening "RR" contacts in power factor relay and opening "M" contactor.
3. When a power factor meter is included the power factor is displayed directly on the instrument scale.
4. When power factor meter is omitted in its place is a set of test receptacles for plugging in an external instrument to determine power factor. The red receptacle is a positive polarity and the black receptacle is a negative polarity. The output is a voltage equal to 1 volt per 18° of phase difference between voltage and current wave forms.

1-7. OPERATING SEQUENCE FOR CONVENTIONAL SYNCHRONOUS MOTOR(REFER TO SH. 1-8 FOR TYPICAL CIRCUIT).

1. Before starting, check out module per instructions under "Brushless Synchronous motor".
2. Depress start button to pick up "M" contactor and start motor.
3. "M" interlock provides signals to D & R terminals on slip guard relay.
4. "FC" normally closed contact provides signal to A & C Terminals on slip guard relay.
5. Slip Guard relay contactor at terminals Z2-X2 and X1-21 are connected in series with FC contactor coil.



PROPRIETARY INFORMATION OF THE GENERAL ELECTRIC COMPANY

Elementary Diagram

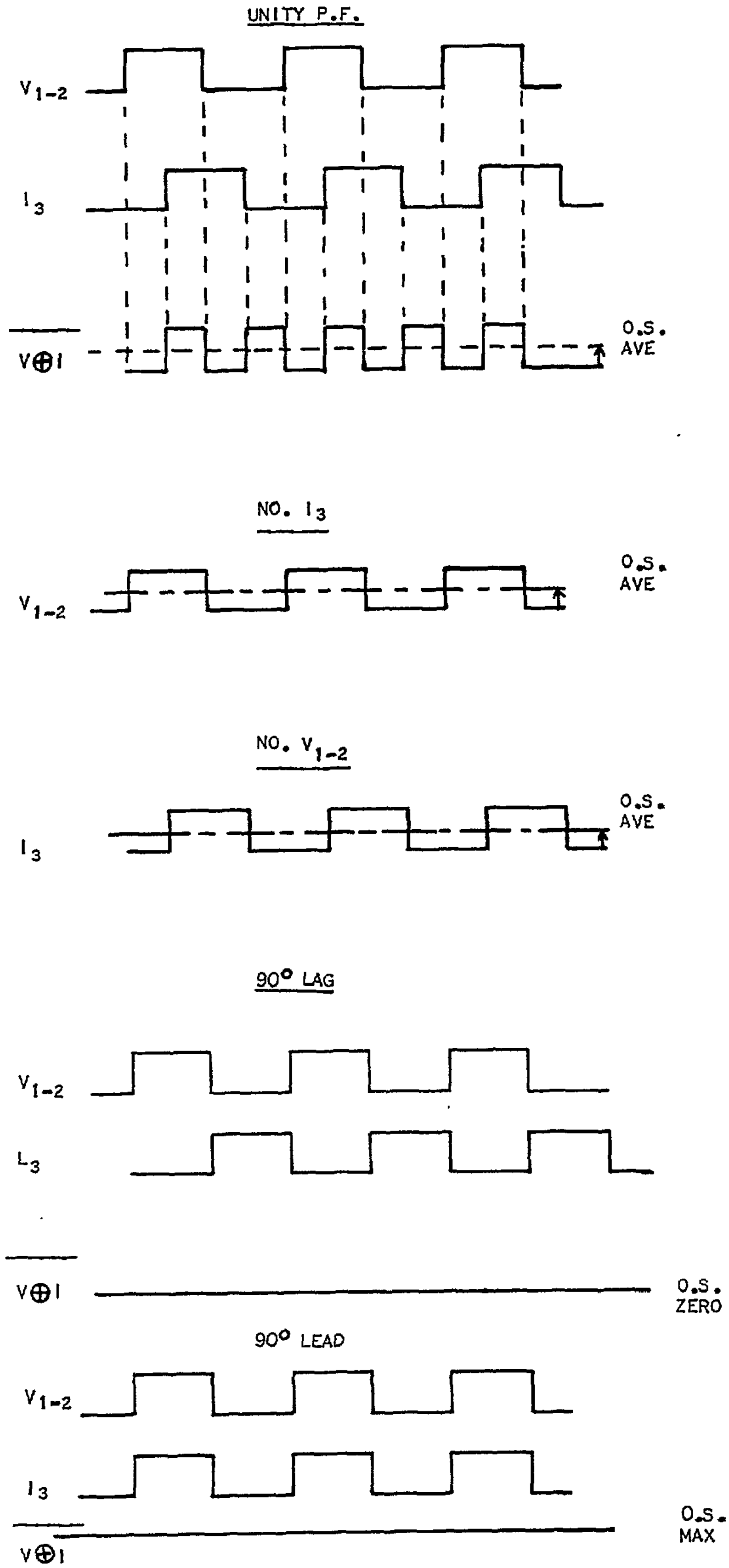
Slip Guard Relay IC3655A100

IC3655A100 RELAY

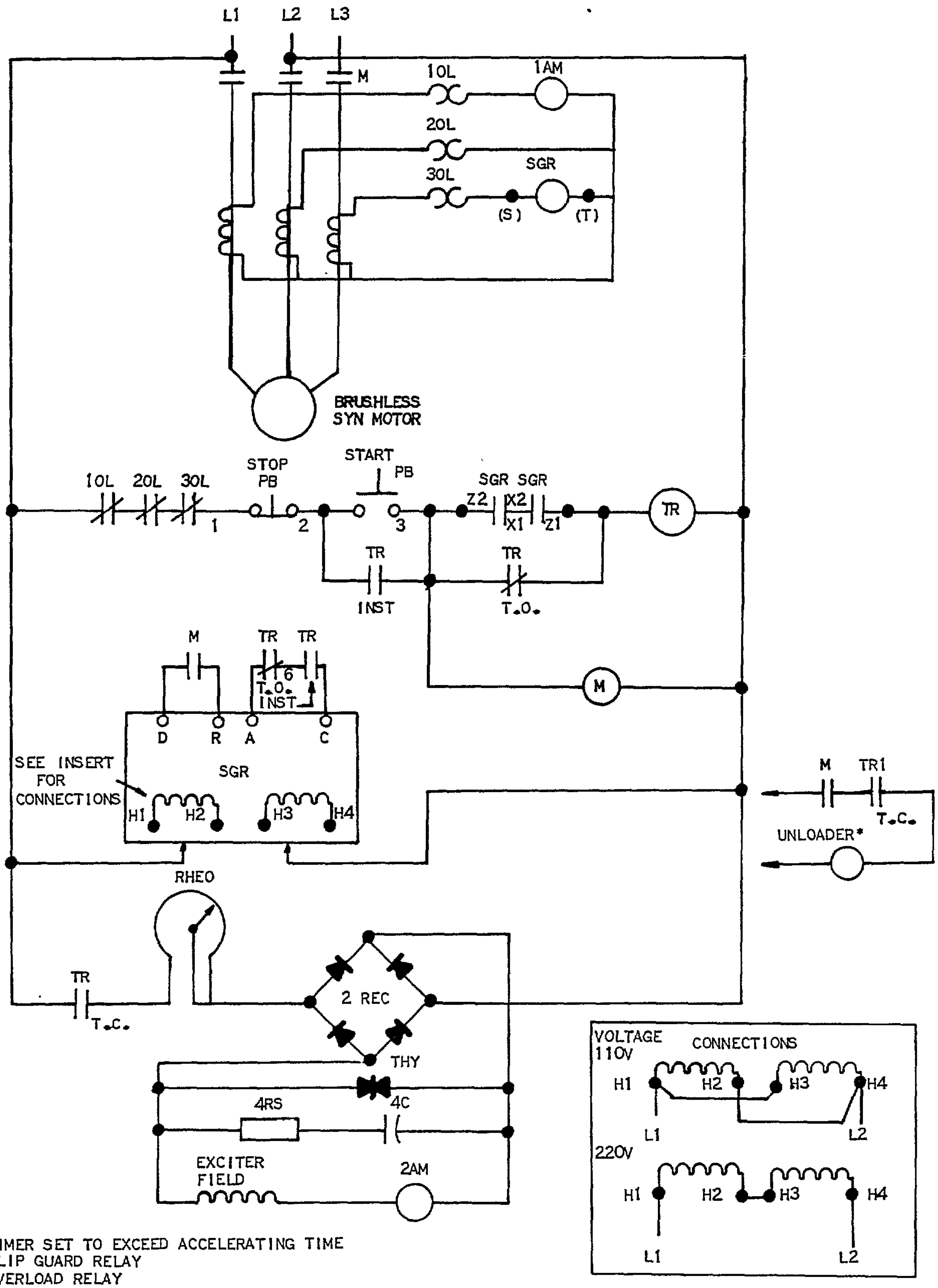
EXCLUSIVE-OR LOGIC

OUTPUT SIGNAL IS ON ONLY WHEN V_{1-2} AND L_3 ARE COINCIDENT IN TIME-PHASE RELATIONSHIP.

OUTPUT SIGNAL (OS) MUST DROP BELOW AVERAGE VALUE TO REACH RELAY DROPOUT SETTING.



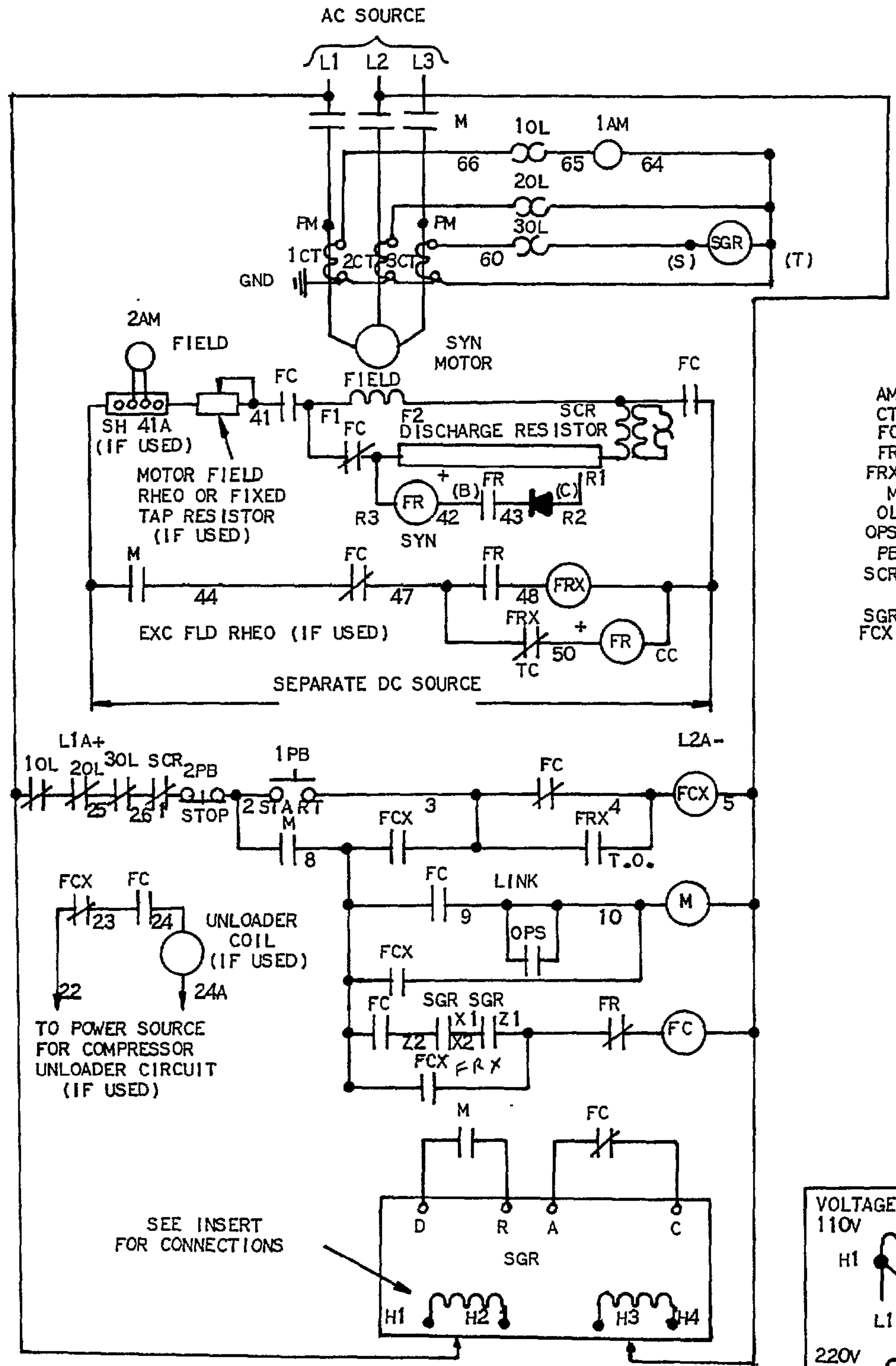
IC3655A100 Relay Exclusive or Logic



TR - TIMER SET TO EXCEED ACCELERATING TIME
SGR - SLIP GUARD RELAY
OL - OVERLOAD RELAY
M - LINE CONTACTOR

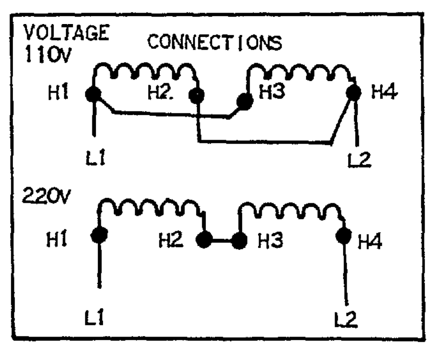
* - REMOTE TO CONTROL

Typical Circuit for Brushless Synchronous Motor Control

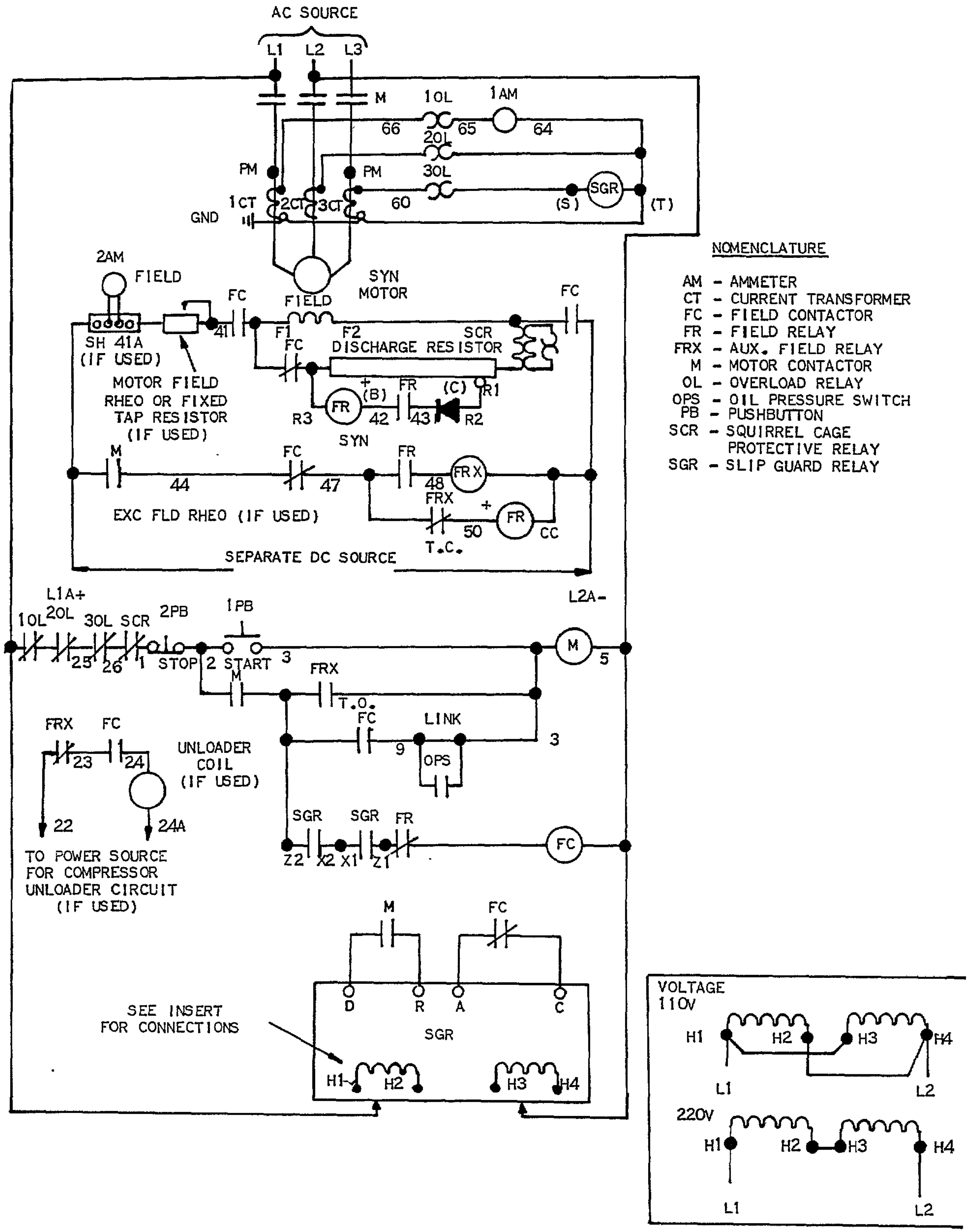


NOMENCLATURE

AM - AMMETER
CT - CURRENT TRANSFORMER
FC - FIELD CONTACTOR
FR - FIELD RELAY
FRX - AUX. FIELD RELAY
M - MOTOR CONTACTOR
OL - OVERLOAD RELAY
OPS - OIL PRESSURE SWITCH
PB - PUSHBUTTON
SCR - SQUIRREL CAGE PROTECTIVE RELAY
SGR - SLIP GUARD RELAY
FCX - FIELD AUX. RELAY



Typical Circuit for Synchronous Motor Control Showing Slip Guard Relay in Place of Magnetic Relay IC28201751



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