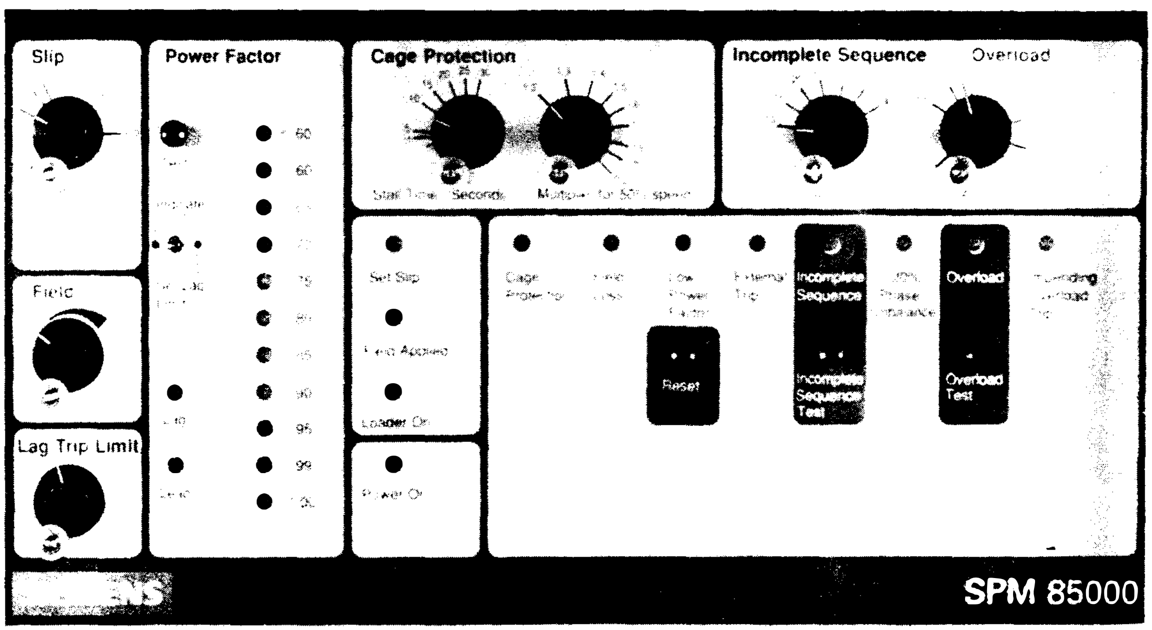
SIEMENS

SPM 85000

Solid State Synchronizing and Protection Module

Instructions
Installation
Operation
Maintenance
MVC-9048



Introduction and Safety

WARNING

Working in or around electrical equipment can cause shock, burn or electrocution if accidental contact is made with energized parts.

Turn off power supplying this equipment before any adjustments, servicing, wiring, parts replacement, or before any act requiring physical contact with electrical working components of this equipment is performed.

The successful and safe operation of motor control equipment is dependent upon proper handling, installation, operation and maintenance, as well as upon proper design and manufacture. Failure to follow certain fundamental installation and maintenance requirements may lead to personal injury and the failure and loss of control equipment, as well as damage to other property.

Siemens SPM 85000 solid state synchronous motor controllers are built in accordance with the latest applicable provisions of the National Electrical Code, Underwriters' Laboratories Standards and Procedures, NEMA, ANSI, and the National Electrical Safety Code. Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with these publications and all warnings, safety notices, and maintenance.

Qualified Person

For the purpose of this manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment, and the hazards involved. In addition, he must have the following qualifications:

(a) Is qualified and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.

(b) Is qualified in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc. in accordance with established safety practices.

Danger

For the purpose of this manual and product labels, **DANGER,** indicates death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

For the purpose of this manual and product labels, **WARNING,** indicates death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

For the purpose of this manual and product labels, **CAUTION** indicates minor personal injury or property damage can result if proper precautions are not taken.

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NOTE

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the local Siemens sales office.

The contents of this instruction manual shall not become part of or modify any prior or existing agreement, commitment or relationship. The sales contract contains the entire obligation of Siemens. The warranty contained in the contract between the parties is the sole warranty of Siemens. Any statement contained herein do not create new warranties or modify the existing warranty.

Introduction

The Siemens SPM 85000 solid state synchronizing and protection module described in this instruction manual provides all functional and protective requirements unique to AC polyphase synchronous motors equipped with field slip rings. In addition, it provides stator overload protection. This instruction information is common to synchronous motors regardless of stator rating or starting method. The starting method may be full or reduced voltage employing starting reactors, resistors, or autotransformers.

This instruction manual is intended to supplement the instruction literature provided for the starting equipment. However, the stator overload protection described in this manual replaces the thermal overload relay described in the instruction literature for the motor. The instruction literature for the motor will include the controller, starting contactor, protective devices, and associated installation, operation, and maintenance information. The starting equipment will normally be identical to that employed by squirrel cage induction motors of comparable rating.

Synchronous Motors

Synchronous motors are most frequently used to drive pumps, compressors and other large industrial equipment. They provide a constant speed drive, and they are capable of operating at leading power factor thereby improving overall plant power factor.

A standard synchronous motor has three independent sets of windings: A stator winding, a squirrel cage winding, and a field winding. The stator windings are energized with three phase line voltage when the main contactor closes. The resulting stator current produces sinusoidal flux which rotates at a synchronous speed which is proportional to the AC power line frequency and the number of stator poles. The squirrel cage winding (sometimes referred to as damper winding or amortisseur winding) is located in the pole faces of the rotor. The interaction between the induced currents in the squirrel cage winding and the rotating stator flux produces starting and accelerating torque in the same manner as a squirrel cage induction motor. The field winding is distributed around the rotor poles. When DC current is introduced into this winding, constant-polarity poles are established on the rotor. This produces torque which aligns these fixed rotor poles with the poles of the rotating flux field produced by the stator currents. Hence, excitation of the field winding causes the motor to operate at synchronous speed. If the synchronous motor is very lightly loaded and coupled to low inertia, it may be possible for the motor to run at synchronous speed without the application of external excitation. This is known as "reluctance torque synchronization".

Control Equipment Requirements

Synchronous motors start and accelerate toward synchronous speed as induction motors. The squirrel cage winding is designed strictly for normal starting duty and must be protected by the control equipment. If abnormal starting conditions occur, the control equipment will remove the motor from the line before the squirrel cage winding is damaged. DC excitation is not applied to the field winding in the starting mode since no useful torque would be produced. The field winding develops a large open-circuit voltage during starting. To prevent this high induced voltage from puncturing the field winding or damaging the control equipment, a field discharge resistor is connected across the open field winding. This resistor allows current flow through the field winding and limits the induced voltage to a safe value. When the synchronous motor has accelerated to an optimum point near synchronous speed, the control equipment applies DC excitation to the field winding and disconnects the discharge resistor. This locks the rotor "in-step" and the motor runs at synchronous speed. The criterion for satisfactorily pulling a synchronous motor into step is generally accepted to be the application of external field voltage at "optimum speed" and "optimum angle" in order to limit the pull-in period of the rotor to 180 electrical degrees. This prevents detrimental effects upon the load and power system which can result from several slip cycles with field applied. The optimum speed for field application is determined by motor design and system inertia. It usually is in the range from zero to ten percent slip. The optimum angle for field application occurs when the induced field current passes through zero going from negative to positive. At this instant, the rotor is in correct angular position to be pulled into step and maximum pull-in torque is available. If reluctance torque synchronization should occur before "optimum angle" is sensed, the control equipment should proceed to apply the external field voltage.

When synchronous motors are running at synchronous speed, pull-out of synchronism can occur due to excessive loading, excessive reduction of field excitation, or excessive dips in supply voltage. The control equipment must provide pull-out protection because severe transients can be imposed on both the electrical and mechanical systems.

To summarize, control equipment should provide the following functions:

A. Connect and disconnect the synchronous motor to and from the AC power line by means of pushbuttons (three wire control) or selector switches (two wire control).

B. Automatically apply DC excitation to the field winding of the motor at optimum speed and optimum angle for maximum pull-in torque, or after reluctance torque synchronization occurs.

C. Protect the motor against overheating by means of overload protection, squirrel cage protection, and incomplete sequence protection.

D. Automatically insert and remove the field discharge resistor as required.

E. Provide immediate removal of field excitation when pull-out of synchronism occurs and resynchronize or shutdown the motor depending on the situation.

F. Provide for adjustment and regulation of field excitation, thus allowing control of the power factor at which the motor operates.

G. Optionally, provide regulation of motor power factor to a constant value by automatically adjusting field excitation to compensate for changing load conditions.

The Siemens SPM 85000 solid state synchronizing and protection module provides functions A through F above as standard. With the addition of the optional Power Factor Regulator Module, function G is accomplished.

Description

The SPM 85000 solid state synchronizing and protection module consists of four major components: a control and protection module, a power module, an exciter transformer, and a field discharge resistor. An optional Power Factor Regulator Module is available.

A. Control and Protection Module (C/P-M)

The control and protection module is shown in **Figure 1**. This unit initiates and controls motor synchronizing, field application, and motor protection. It consists of a printed circuit board and front panel enclosed in a steel housing with a hinged front cover. The front panel contains settings, adjustments, and indicators. Wiring terminals are located on the bottom of the unit. The control and protection module is designed to mount on the compartment door of a motor control cubicle. The (C/P-M) module dimensions are shown in **Figure 6**.

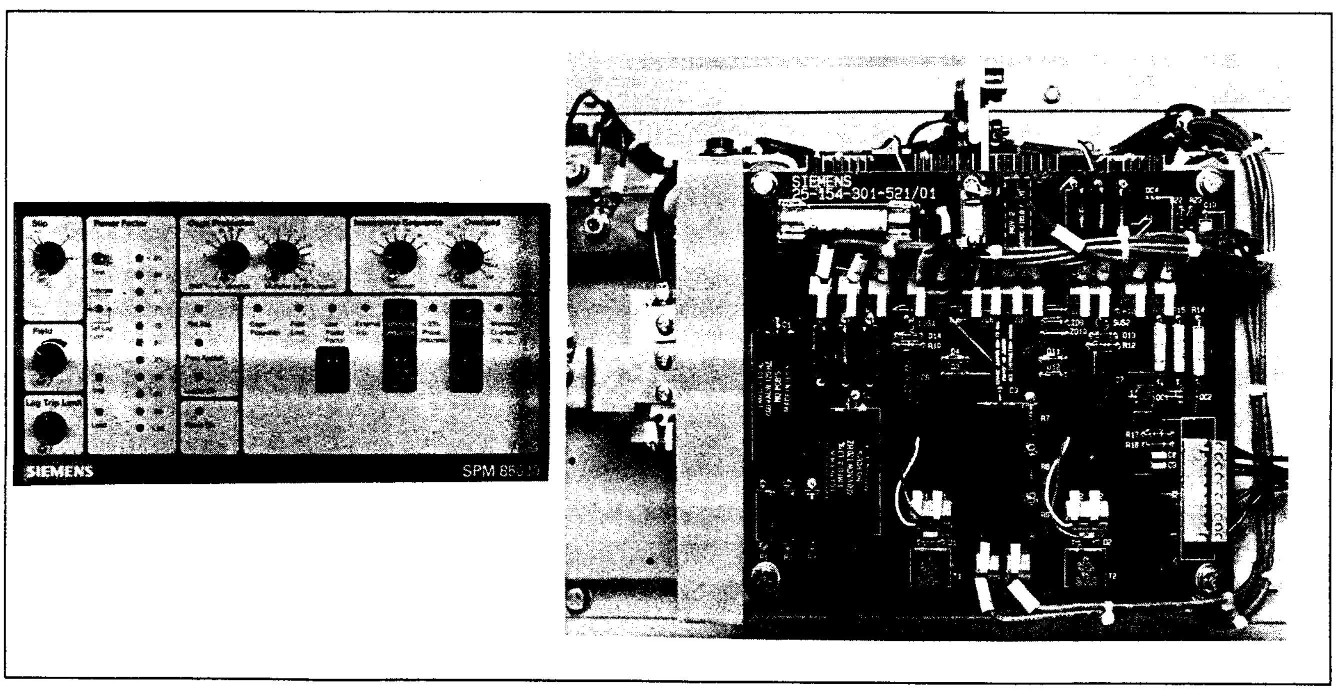


Figure 1. Control and Protection Module (C/P-M), shown with the Power Module (P-M).

B. Power Factor Regulator Module (PF-M) (Optional)

The optional power factor regulator module (PF-M) can be added to the C/P-M to allow synchronous operation at constant motor power factor. The module consists of a printed circuit board and front panel which plugs directly into the left side of the C/P-M. Once installed on the C/P-M, the PF-M requires no further wiring connections. The steel housing which encloses the C/P-M contains enough extra space to accommodate the optional PF-M without increasing the overall dimensions.

C. Power Module (P-M)

The power module is shown in **Figure 2.** This unit contains two silicon-controlled rectifiers (SCR's) which switch the motor field when a signal is received from the control and protection module. It also contains two additional SCR's and associated control circuitry (independent from the control and protection module) which insert and remove the field discharge resistor. Wiring terminals are provided for the motor field connection. The power module dimensions are shown in **Figure 7**.

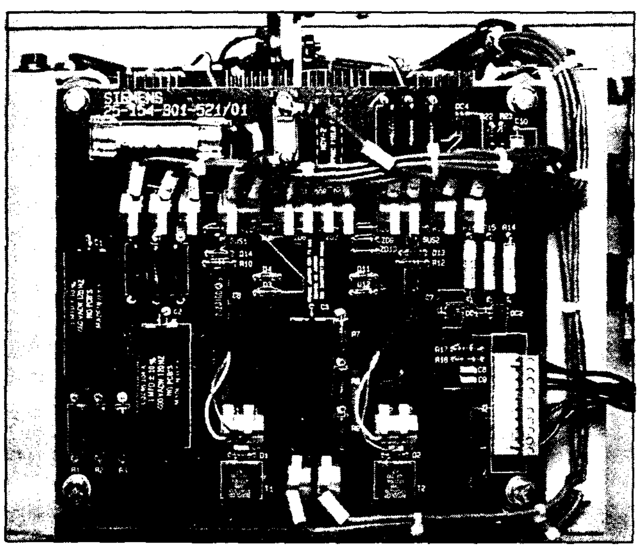


Figure 2. Power Module (P-M)

D. Exciter Transformer

The exciter transformer is a single phase power transformer with a center-tapped secondary winding which provides the motor field excitation. The secondary voltage rating is specially selected for use with the SCR controlled power module. An exciter transformer is shown in **Figure 3.** Exciter transformer overall dimensions vary with kVA rating and are listed in **Figure 8**.

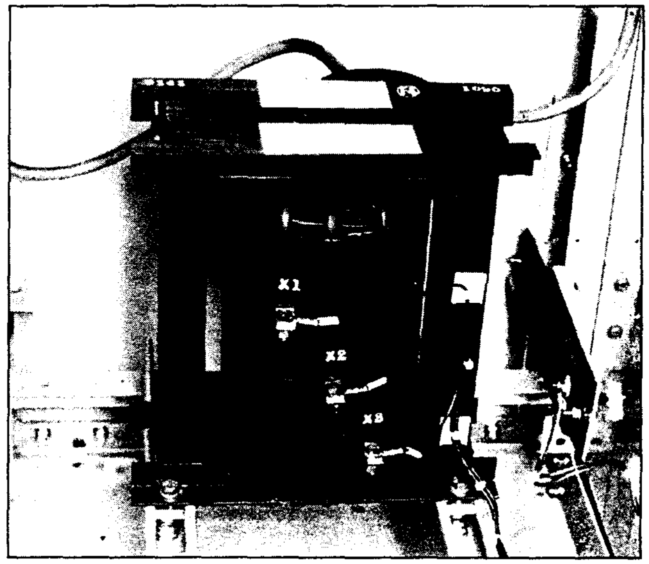


Figure 3. Exciter Transformer

E. Field Discharge Resistor

The rating of the field discharge resistor (not shown) is specified for a given motor by the motor manufacturer to provide required starting torque and limit induced field voltage.

Ratings

1. Field Excitation
   Maximum field excitation is 250 volts DC, 150 amperes DC self-cooled. An optional, fan-cooled, power module can be provided which is rated 400 amperes DC. Field current is maintained at its set value, independent of supply voltage fluctuations, from 85 to 110 percent nominal voltage.

2. Operating Temperature
   60°C Ambient Maximum.
   -20°C Ambient Minimum

3. Relay Contacts
   All input and output relay contacts are rated NEMA B300 as follows:

Voltage AC Volts	Current, Continuous Amperes	Voltamperes	
		Make	Break
120	5	3600	360
240	5	3600	360

4. Stator Current Transformer Input
   1-5 amperes, 50/60 Hz, Three Phase, 2.5VA burden @ 5 amperes, 60 Hz
5. Field Current Transformer Input
   3-5 amperes, 50/60 Hz, Single Phase, 2.5VA burden @ 5 amperes, 60 Hz
6. Potential Transformer Input
   120VAC +/-10% 50/60 Hz
7. Control Power Input
   115VAC +/-10%, 50/60 Hz, Single Phase
8. Noise Isolation
   Complies with the requirements of electrical noise tests described in NEMA Standards Publication No. ECS2-230, and ANSI/IEEE Standard C37.90.1-1989.
9. Maximum Induced Field Voltage - 1350V RMS Maximum with discharge resistor inserted (125VDC Field); 1150V RMS Maximum (250VDC Field).
10. Minimum Induced Field Voltage—100V RMS Minimum with discharge resistor inserted.

NOTE
A field shunt resistor (625 ohm, 175 Watt) is provided when the motor rated field current is less than 10 amperes.

Receiving

An immediate inspection should be made for any damage which may have occurred during shipment upon receipt of this equipment. The inspection should include examination of the packaging material, the control and protection module, the power module, the exciter transformer, the discharge resistor, and any other devices supplied with this equipment. Be sure to look for concealed damage and do not discard the packaging material. If damage is found, note damage on the Bill of Lading prior to accepting receipt of the shipment, if possible.

> **NOTE**
>
> The way visible shipping damage is treated by the consignee prior to signing the delivery receipt can determine the outcome of the damage claim to be filed. Notification to the carrier within the 15 day limit on concealed damage is essential if loss resulting from unsettled claims is to be eliminated or minimized.
>
> A claim should be immediately filed with the carrier, and the Siemens sales office should be notified if damage or loss is discovered. A description of the damage and as much identification information as possible should accompany the claim.

Handling

The SPM 85000 solid state synchronizing and protection module contains fragile electronic components which may be damaged if proper care is not exercised during handling. Whenever possible, the control and protection module and the power module should be transported in their original boxes with all packaging material included. Avoid subjecting this equipment to severe shock or vibration. Lift or carry this equipment only by means of the steel housing on the control and protection module or the steel mounting base on the power module.

Storage

This equipment must be stored in a clean, dry, dust and condensation free environment if it cannot be placed into service reasonably soon after receipt. Always store this equipment in its original boxes with all packaging material included. Do not store equipment outdoors. Any scratches or gouges on painted steel parts suffered from shipping or handling should be touched up with a can of spray paint to prevent rusting.

Site Preparation and Mounting

Installation shall be in accordance with the National Electrical Code, ANSI, and NFPA standards.

The Siemens SPM 85000 solid state synchronizing and protection module should be mounted in a clean, dry, heated, and well ventilated location which is readily accessible for inspection and maintenance. A typical mounting arrangement for this equipment in a Siemens Series 81000™ motor controller is shown in **Figure 4**.

Certain characteristics of the mounting arrangement shown in **Figure 4** must be incorporated into all installations of the SPM 85000 solid state synchronizing and protection module. Referring to **Figure 4**, the power module (1) must mount with the cooling fins on the SCR heat sink (2) aligned vertically as shown. This is necessary to prevent overheating of the SCR's. The power module and the control and protection module (3) must be located in sufficient proximity with each other to ensure that their interconnecting wires (4) do not exceed 6 feet in length. Otherwise, the field application SCR's and control circuitry may not function properly.

Use the special wire harness provided with the equipment for this interconnection. The steel mounting base of the power module (5) must be grounded to the enclosure either through its mounting means or with an additional grounding connection. The exciter transformer, shown in **Figure 3**, should be isolated from the rest of the control equipment since its primary winding is energized with line voltage. The control and protection module should mount to the enclosure door as shown so that indicating lights are visible and settings and adjustments can be performed with the enclosure door closed. Refer to **Figure 5** for the door cutout configuration. **Figures 6, 7,** and **8** show outline dimensions for the C/P-M, the P-M, and the exciter transformer respectively.

Wire the SPM 85000 solid state synchronizing and protection module in strict accordance with the main wiring diagram supplied with the motor controller. Be certain that all grounded points indicated in **Figure 16** are securely connected to ground.

Refer to **Figure 9** for wiring terminal layouts for the power module and the control and protection module. **Figure 16** shows typical schematics for complete synchronous motor controllers with main stator vacuum contactors.

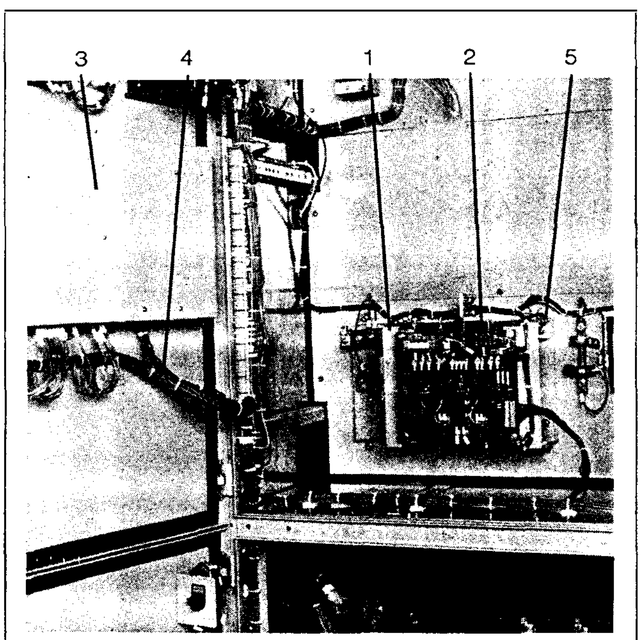


Figure 4. Cubicle and Door Mounting of C/P-M and P-M

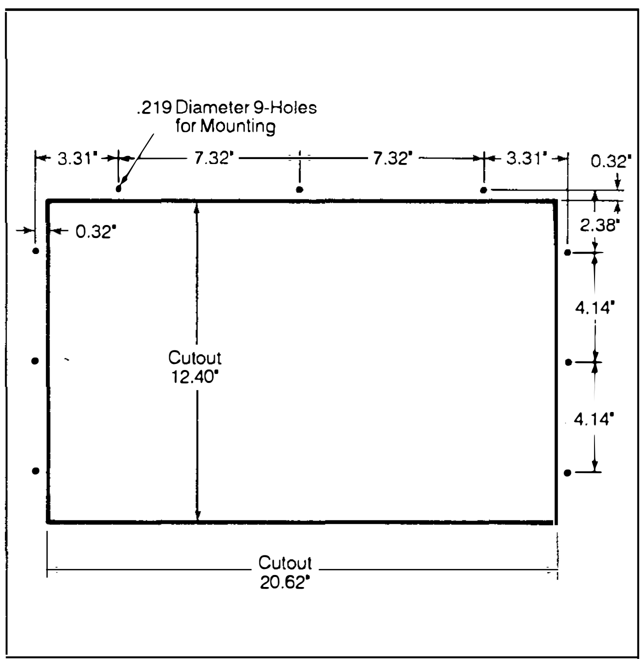


Figure 5. Door Cutout Configuration

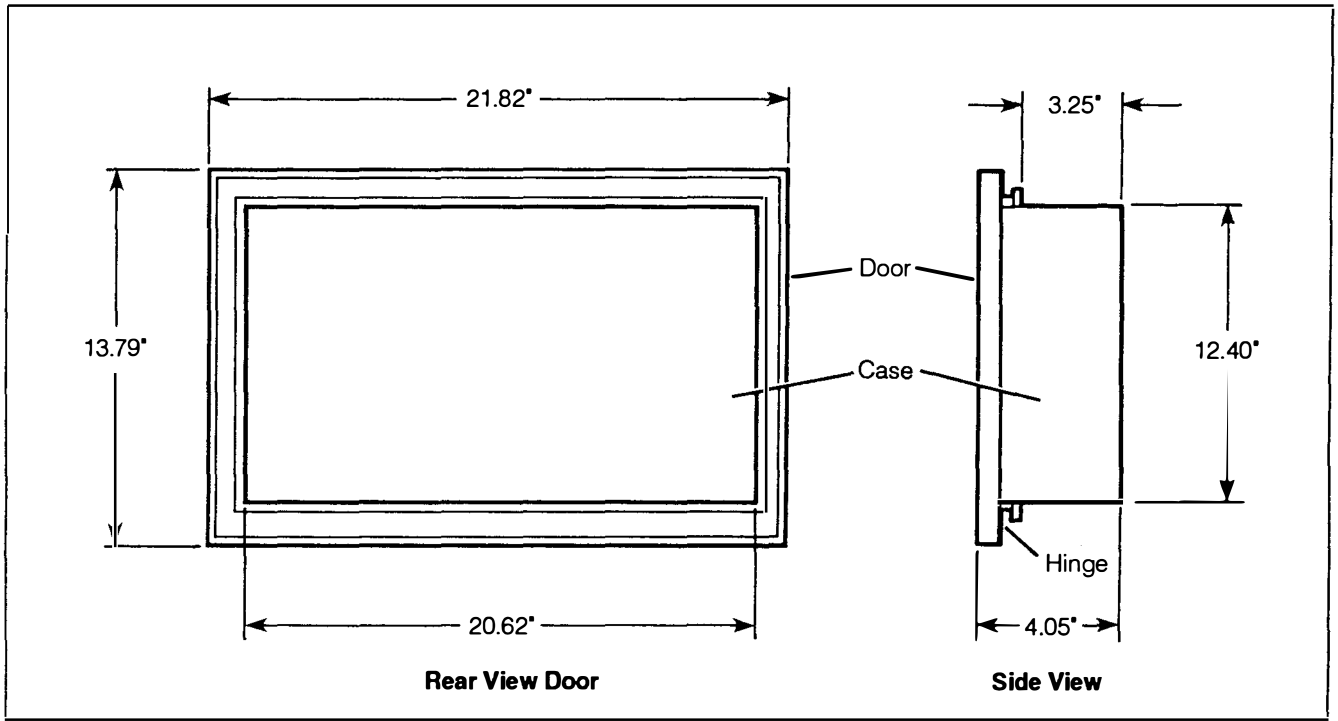


Figure 6. Control and Protection Module (C/P-M) Outline Dimensions

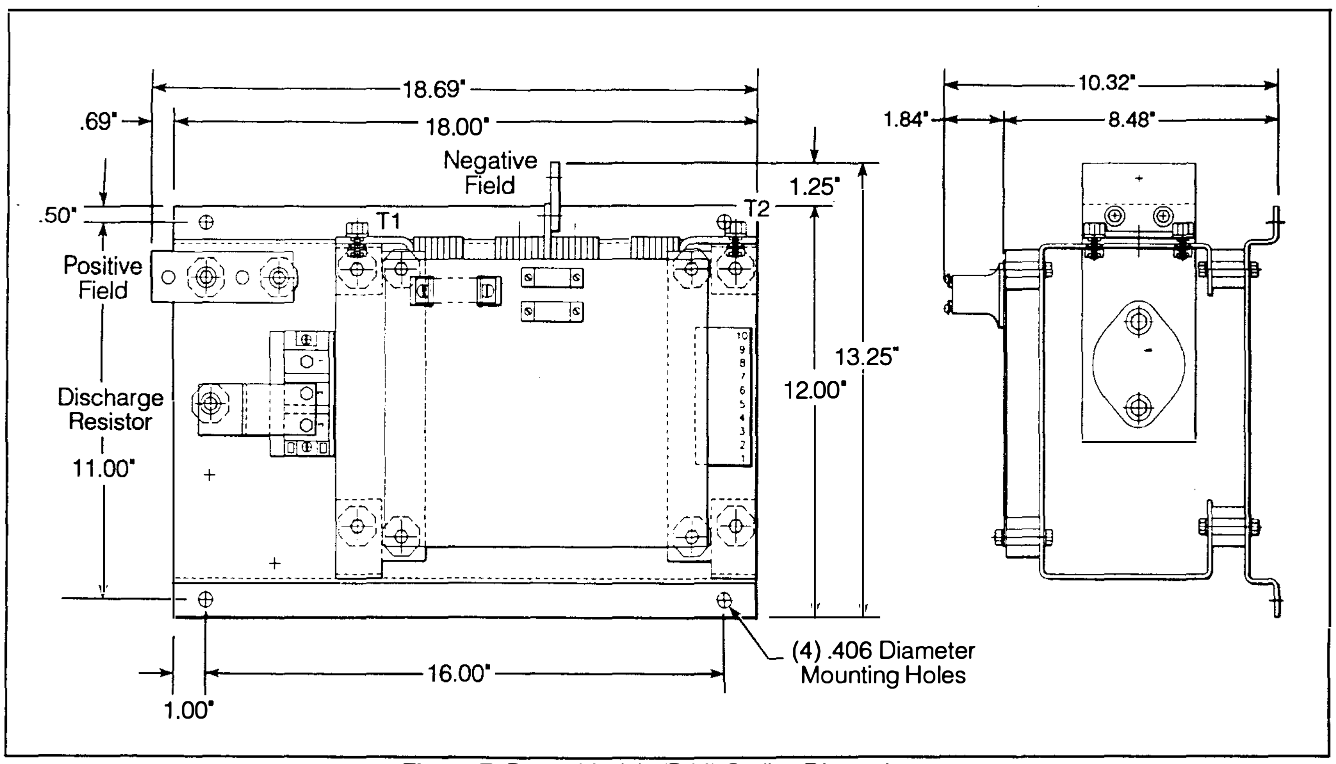


Figure 7. Power Module (P-M) Outline Dimensions

Settings and Adjustments

⚠ WARNING

Tampering with settings and adjustments on the control and protection module can cause substantial equipment damage.

Settings and adjustments should be verified or changed only by qualified personnel who have become thoroughly familiar with all installation, operation, maintenance, and troubleshooting instructions contained in this instruction manual.

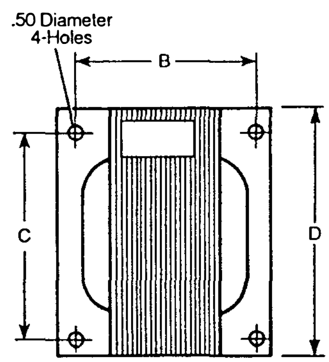
All settings and adjustments provided with the control and protection module must be carefully determined based on the manufacturers data for the synchronous motor with which it will be used. All settings except for the field current setting will be preset at the factory when the SPM 85000 solid state synchronizing and protection module is ordered. All settings and adjustments should be verified before the controller is placed into service. This procedure is explained in the Operation section of this instruction manual.

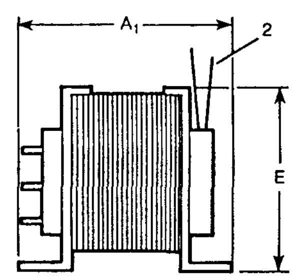
Field Replacement

The SPM 85000 solid state synchronizing and protection module can be supplied for field replacement of any existing synchronous motor controls which employ the Allis-Chalmers Type 230 polarized field application and removal relay. Before the SPM 85000 controller is installed as a replacement, all of the existing synchronous motor control equipment and

25-213-072-(Mark No.)

Mark No.	Primary Volts	Secondary Volts	kVA	Hz	A	B	C	D	E	Approx. Weight.
001	6600	382/191	5	60	11.5	4.5	9.5	14.5	14.0	125
002	6600	382/191	7.5	60	12.0	4.75	10.0	15.0	15.0	155
003	6600	382/191	10	60	13.0	5.75	10.0	17.0	16.0	210
004	6600	382/191	15	60	12.0	5.5	7.25	14.0	19.0	225
005	6600	382/191	20	60	12.5	6.25	8.0	15.5	20.5	265
006	6600	382/191	25	60	13.0	6.75	8.5	16.0	21.0	300
007	6600	382/191	30	60	14.5	7.25	9.25	18.0	23.5	385
008	6600	382/191	40	60	15.0	7.25	9.75	19.0	25.0	450
009	6600	382/191	50	60	16.0	8.0	10.0	21.0	26.0	525
010	6600	382/191	60	60	16.5	8.5	10.5	21.5	26.5	575
011	6600	382/191	75	60	17.0	9.0	11.0	22.0	27.0	705
012	6600	382/191	100	60	19.0	10.5	11.0	24.0	30.0	1020
013	6600	382/191	125	60	20.0	11.0	13.0	25.0	31.0	1110
014	6600	764/382	5	60	11.5	4.5	9.5	14.5	14.0	125
015	6600	764/382	7.5	60	12.0	4.75	10.0	15.0	15.0	155
016	6600	764/382	10	60	13.0	5.75	10.0	17.0	16.0	·210
017	6600	764/382	15	60	12.0	5.5	7.25	14.0	19.0	225
018	6600	764/382	20	60	12.5	6.25	8.0	15.5	20.5	265
019	6600	764/382	25	60	13.0	6.75	8.5	16.0	21.0	300
020	6600	764/382	30	60	14.5	7.25	9.25	18.0	23.5	385
021	6600	764/382	40	60	15.0	7.5	9.75	19.0	25.0	450
022	6600	764/382	50	60	16.0	8.0	10.0	21.0	26.0	525
023	6600	764/382	60	60	16.5	8.5	10.5	21.5	26.5	575
024	6600	764/382	75	60	17.0	9.0	11.0	22.0	27.0	705
025	6600	764/382	100	60	19.0	10.5	11.0	24.0	30.0	1020
026	6600	764/382	150	60	21.0	12.0	13.0	26.0	32.0	1325
027	6600	764/382	200	60	28.0	12.0	13.0	26.5	33.0	1430
028	6600	764/382	250	60	30.0	12.0	13.0	27.0	35.0	1635





Notes:

1. Dimensions marked are maximum dimensions. May be smaller.
2. Primary leads are furnished.

Figure 8. Exciter Transformer Selection Chart and Dimensional Data

stallation. If a DC generator is used as a source for field excitation with the existing equipment, it should be completely disconnected and its field short circuited. The SPM 85000 solid state synchronizing and protection module must be wired into the remainder of the existing circuit in strict accordance with the updated wiring diagram with which it is provided.

Power Factor Regulator Installation

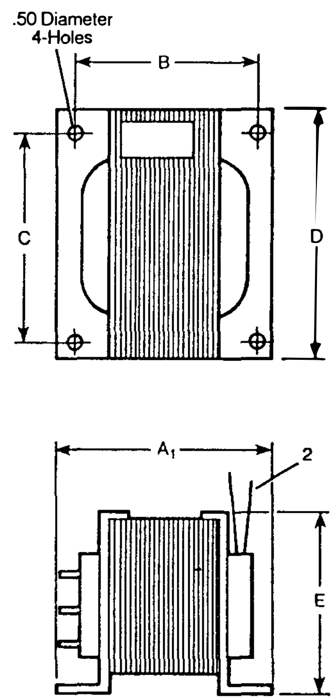
The power factor regulator module (PF-M) may be purchased either factory-installed or added in the field.

To install the PF-M to the C/P-M, it is necessary to perform a few simple steps:

1. Carefully remove the PF-M from its packaging.
2. Remove the anti-static foam strip from the pins on the connector located on the right hand side of the PF-M. After this point, be careful not to touch the pins, as static discharge can damage sensitive components on the circuit board.
3. Locate the mating connector on the left hand side of the C/P-M. On this connector there is a label instructing you to remove a jumper on the C/P-M circuit board. Remove the jumper at this time.
4. Carefully plug the PF-M into the C/P-M.
5. Secure the PF-M to the steel housing by installing the five (5) screws and lockwashers provided with the PF-M.

25-213-136-(Mark No.)

Mark No.	Primary Volts	Secondary Volts	kVA	Hz	A	B	C	D	E	Approx. Weight
001	13,800	382/191	5	60	16.5	4.5	9.5	18.5	21.0	190
002	13,800	382/191	7.5	60	17.0	4.75	10.0	19.0	22.0	220
003	13,800	382/191	10	60	18.0	5.75	10.0	21.0	23.0	290
004	13,800	382/191	15	60	17.0	5.5	7.25	18.0	26.0	310
005	13,800	382/191	20	60	17.5	6.25	8.0	19.5	27.5	350
006	13,800	382/191	25	60	18.0	6.75	8.5	20.0	28.0	390
007	13,800	382/191	30	60	19.5	7.25	9.25	22.0	30.5	485
008	13,800	382/191	40	60	20.0	7.25	9.75	23.0	32.0	555
009	13,800	382/191	50	60	21.0	8.0	10.0	25.0	33.0	635
010	13,800	382/191	60	60	21.5	8.5	10.5	25.5	33.5	680
011	13,800	382/191	75	60	22.0	9.0	11.0	26.0	34.0	810
012	13,800	382/191	100	60	24.0	10.5	11.0	28.0	37.0	1100
013	13,800	382/191	125	60	25.0	11.0	13.0	29.0	38.0	1200
014	13,800	764/382	5	60	16.5	4.5	9.5	18.5	21.0	190
015	13,800	764/382	7.5	60	17.0	4.75	10.0	19.0	22.0	220
016	13,800	764/382	10	60	18.0	5.75	10.0	21.0	23.0	290
017	13,800	764/382	15	60	17.0	5.5	7.25	18.0	26.0	310
018	13,800	764/382	20	60	17.5	6.25	8.0	19.5	27.5	350
019	13,800	764/382	25	60	18.0	6.75	8.5	20.0	28.0	390
020	13,800	764/382	30	60	19.5	7.25	9.25	22.0	30.5	485
021	13,800	764/382	40	60	20.0	7.5	9.75	23.0	32.0	555
022	13,800	764/382	50	60	21.0	8.0	10.0	25.0	33.0	635
023	13,800	764/382	60	60	21.5	8.5	10.5	25.5	33.5	680
024	13,800	764/382	75	60	22.0	9.0	11.0	26.0	34.0	810
025	13,800	764/382	100	60	24.0	10.5	11.0	28.0	37.0	1100
026	13,800	764/382	150	60	26.0	12.0	13.0	30.0	39.0	1400
027	13,800	764/382	200	60	33.0	12.0	13.0	30.5	40.0	1470
028	13,800	764/382	250	60	35.0	12.0	13.0	31.0	42.0	1650



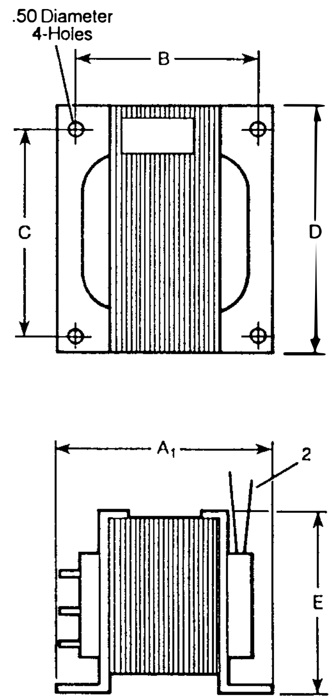
Notes:

1. Dimensions marked are maximum dimensions. May be smaller.
2. Primary leads are furnished.

Figure 8. Exciter Transformer Selection Chart and Dimensional Data (continued)

25-205-967-(Mark No.)

Mark No.	Primary Volts	Secondary Volts	kVA	Hz	*1 A	B	C	*1 D	*1 E	Approx. Weight
001	2300	382/191	5	60	11.5	4.5	9.5	14.5	14.0	115
002	2300	382/191	7.5	60	12.0	4.75	10.0	15.0	15.0	145
003	2300	382/191	10	60	13.0	5.75	10.0	17.0	16.0	195
004	2300	382/191	15	60	12.0	5.5	7.25	14.0	19.0	210
005	2300	382/191	20	60	12.5	6.25	8.0	15.5	20.5	250
006	2300	382/191	25	60	13.0	6.75	8.5	16.0	21.0	285
007	2300	382/191	30	60	14.5	7.25	9.25	18.0	23.5	360
008	2300	382/191	40	60	15.0	7.25	9.75	19.0	25.0	430
009	2300	382/191	50	60	16.0	8.0	10.0	21.0	26.0	510
010	2300	382/191	60	60	16.5	8.5	10.5	21.5	26.5	560
011	2300	382/191	75	60	17.0	9.0	11.0	22.0	27.0	690
012	2300	764/382	5	60	11.5	4.5	9.5	14.5	14.0	115
013	2300	764/382	7.5	60	12.0	4.75	10.0	15.0	15.0	145
014	2300	764/382	10	60	13.0	5.75	10.0	17.0	16.0	195
015	2300	764/382	15	60	12.0	5.5	7.25	14.0	19.0	210
016	2300	764/382	20	60	12.5	6.25	8.0	15.5	20.5	250
017	2300	764/382	25	60	13.0	6.75	8.5	16.0	21.0	285
018	2300	764/382	30	60	14.5	7.25	9.25	18.0	23.5	360
019	2300	764/382	40	60	15.0	7.5	9.75	19.0	25.0	430
020	2300	764/382	50	60	16.0	8.0	10.0	21.0	26.0	510
021	2300	764/382	60	60	16.5	8.5	10.5	21.5	26.5	560
022	2300	764/382	75	60	17.0	9.0	11.0	22.0	27.0	690
023	2300	764/382	100	60	19.0	10.5	11.0	24.0	30.0	970
024	2300	764/382	150	60	21.0	12.0	13.0	26.0	32.0	1300
025	4000	382/191	5	60	11.5	4.5	9.5	14.5	14.0	115
026	4000	382/191	7.5	60	12.0	4.75	10.0	15.0	15.0	145
027	4000	382/191	10	60	13.0	5.75	10.0	17.0	16.0	195
028	4000	382/191	15	60	12.0	5.5	7.25	14.0	19.0	210
029	4000	382/191	20	60	12.5	6.25	8.0	15.5	20.5	250
030	4000	382/191	25	60	13.0	6.75	8.5	16.0	21.0	285
031	4000	382/191	30	60	14.5	7.25	9.25	18.0	23.5	360
032	4000	382/191	40	60	15.0	7.25	9.75	19.0	25.0	430
033	4000	382/191	50	60	16.0	8.0	10.0	21.0	26.0	510
034	4000	382/191	60	60	16.5	8.5	10.5	21.5	26.5	560
035	4000	382/191	75	60	17.0	9.0	11.0	22.0	27.0	690
036	4000	764/382	5	60	11.5	4.5	9.5	14.5	14.0	115
037	4000	764/382	7.5	60	12.0	4.75	10.0	15.0	15.0	145
038	4000	764/382	10	60	13.0	5.75	10.0	17.0	16.0	195
039	4000	764/382	15	60	12.0	5.5	7.25	14.0	19.0	210
040	4000	764/382	20	60	12.5	6.25	8.0	15.5	20.5	250
041	4000	764/382	25	60	13.0	6.75	6.5	16.0	21.0	285
042	4000	764/382	30	60	14.5	7.25	9.25	18.0	23.5	360
043	4000	764/382	40	60	15.0	7.5	9.75	19.0	25.0	430
044	4000	764/382	50	60	16.0	8.0	10.0	21.0	26.0	510
045	4000	764/382	60	60	16.5	8.5	10.5	21.5	26.5	560
046	4000	764/382	75	60	17.0	9.0	11.0	22.0	27.0	690
047	4000	764/382	100	60	19.0	10.5	11.0	24.0	30.0	970
048	4000	764/382	150	60	21.0	12.0	13.0	26.0	32.0	1300
049	2300	382/191	100	60	19.0	10.5	11.0	24.0	30.0	970
050	2300	382/191	125	60	20.0	11.0	13.0	25.0	31.0	1090
051	2300	764/382	200	60	28.0	12.0	13.0	26.5	33.0	1400
052	2300	764/382	250	60	30.0	12.0	13.0	27.0	35.0	1600
053	4000	382/191	100	60	19.0	10.5	11.0	24.0	30.0	970
054	4000	382/191	125	60	20.0	11.0	13.0	25.0	31.0	1090
055	4000	764/382	200	60	28.0	12.0	13.0	26.5	33.0	1400
056	4000	764/382	250	60	30.0	12.0	13.0	27.0	35.0	1600



Notes:

1. Dimensions marked are maximum dimensions. May be smaller.
2. Primary leads are furnished.

Figure 8. Exciter Transformer Selection Chart and Dimensional Data (continued)

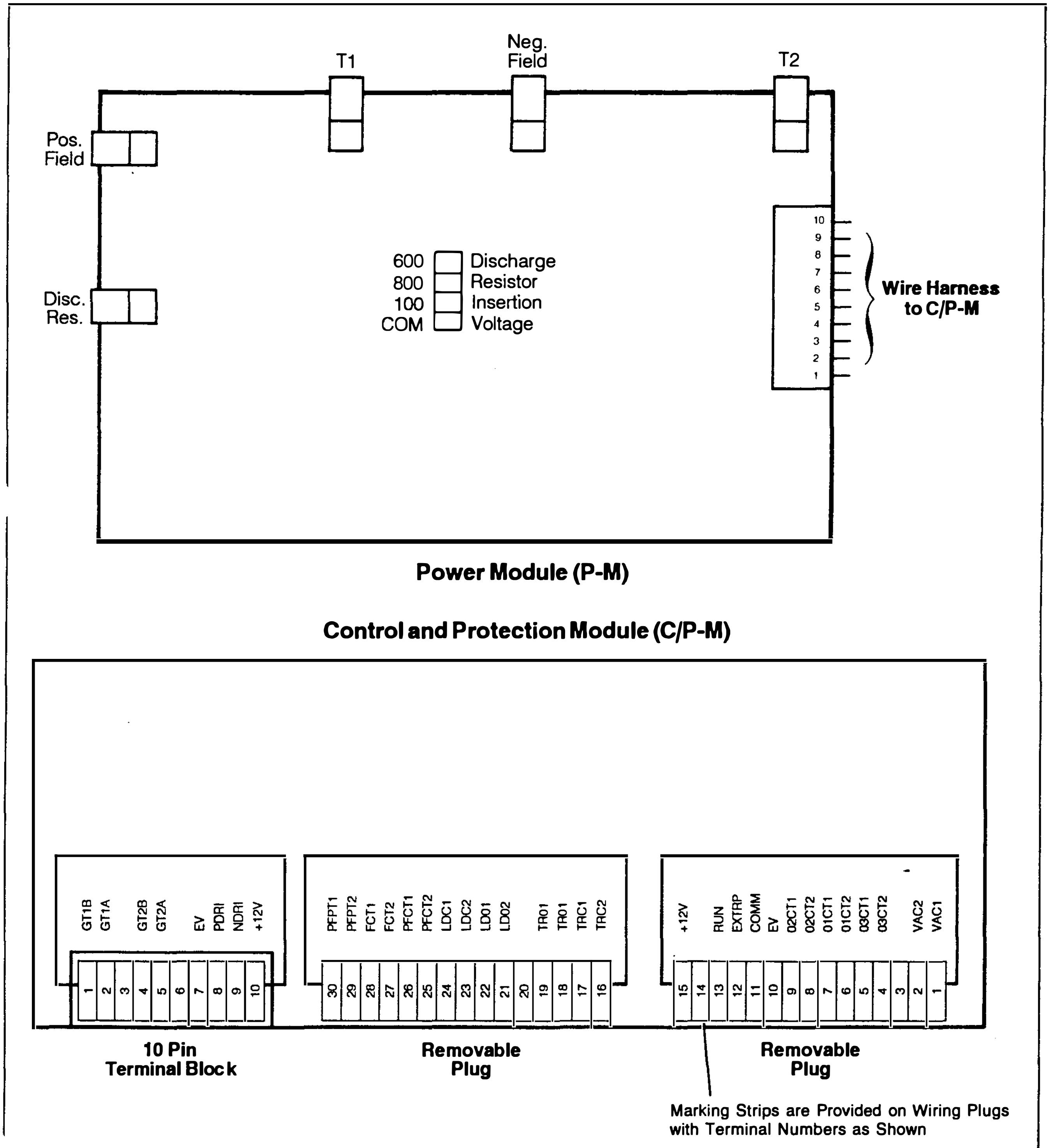


Figure 9. Wiring Terminal Layout for the Power Module (P-M) and Control and Protection Module (C/P-M)

Pre-Energization Check

WARNING

Failure to check out this equipment prior to energization can cause severe damage to the motor field winding and to the control equipment.

Perform the following checks before energizing equipment.

1. Clean any excessive amounts of dust and dirt that may have accumulated if the controller has been in storage. Refer to the Maintenance section of this manual for recommended cleaning procedure.
2. Inspect all wiring and verify that connections are clean and tight.
3. Verify that the polarity of the potential transformer, current transformer, and control power inputs to the C/P-M are as shown on the main wiring diagram. Also verify that the phase rotation of the incoming line connections is correct.
4. Check the operation of the field discharge resistor firing circuit with a DC high-pot tester as follows:
   a) Disconnect motor field leads from positive and negative field terminals on power module.

WARNING

Accidental contact with dielectric test equipment can cause shock, burn, or electrocution.

Dielectric testing should be conducted by qualified personnel. Refer to test device instructions for safety instructions.

   b) Connect a DC high potential tester between the positive and negative field terminals on the power module. Slowly increase the test voltage from zero to approximately the following:

      125V Field—600VDC
      250V Field—1200VDC

      If leakage current flows and the voltage cannot be increased, the controller is functioning properly.
   c) Reverse the polarity of the DC high potential tester, and repeat step b.
   d) Re-connect motor field leads to power module field terminals.
5. Connect test control power to the main stator contactor and check the control and protection module as follows:
   a) When control power is applied to the control and protection module, the SET SLIP and POWER ON indicating lights should come on.

      If the power factor regulator module is installed, the FIELD CURRENT light should come on.
   b) Depress the OVERLOAD TEST button and hold it depressed until the OVERLOAD light comes on. This should occur after the test trip time period shown in Table 2 in the OVERLOAD PROTECTION section of this instruction manual. After the overload recovery time shown in Table 2 has elapsed, press the RESET button and the OVERLOAD light should go out.
   c) Depress and hold the INCOMPLETE SEQUENCE TEST button. The INCOMPLETE SEQUENCE light should glow dimly and then come on bright after a time equal to the INCOMPLETE SEQUENCE ADJUSTMENT setting. Depress the RESET button. The light should go out.
   d) Depress and hold the POWER FACTOR TEST button. The LOW POWER FACTOR light should come on after 2 seconds. Press the RESET button and the light should go out.
6. With test control power still applied to the stator contactor, verify or perform the following settings and adjustments:
   a) Turn the POWER FACTOR switch to the SET LAG LIMIT position. The lag power factor limit will be displayed on the power factor indicator. To change the setting, adjust the LAG PF LIMIT ADJUSTMENT control knob until the desired lag power factor limit is displayed. Lock the knob in this position with its locking screw and

return the POWER FACTOR switch to the INDICATE position.

b) Check the CAGE PROTECTION settings. These settings should be set as explained in the SQUIRREL CAGE PROTECTION section of this instruction manual.

c) The SLIP ADJUSTMENT setting should correspond to the optimum speed for motor field application. This information should be provided by the motor manufacturer. If a manufacturers' recommended slip setting is not available, the SLIP ADJUSTMENT setting should be set at 2 Hz.

d) Check the overload tripping class setting. The switches should be set for the desired tripping class as explained in the OVERLOAD PROTECTION section of this instruction manual. The OVERLOAD ADJUSTMENT setting should be set for the motor full load current as explained in the OVERLOAD PROTECTION section of this manual.

7. Perform pre-energization checks on the stator control equipment as detailed in the appropriate instruction manuals.

The controller may now be energized by connecting main incoming power.

Initial Start-Up Procedure without Power Factor Regulator

For the initial start-up of a synchronous motor with the SPM 85000 solid state synchronizing and protection module without the power factor regulator option, carefully follow the procedure outlined below. Determine that the controller cycles through the sequence of events described. The initial start should be performed with the synchronous motor unloaded, if possible.

> **NOTE**
>
> Multiple consecutive restarts should be minimized to prevent Cage Protection trip from occurring. After Cage Protection trip occurs, a cooldown period of an hour and a half is required before the C/P-M can be reset and the motor restarted. The maximum number of consecutive restarts allowed by the C/P-M will vary depending on the Cage Protection settings and the acceleration time of the synchronous motor.

1. Turn the FIELD ADJUSTMENT control knob to approximately the middle of its setting range.

2. Reset the control and protection module by depressing the Reset button.

3. Close the main contactor with the START pushbutton or selector switch. This should produce the following sequence of events:

   a) SET SLIP light goes out.

   b) As the motor accelerates, the power factor indicator should move from <.60 Lag toward unity.

   c) When the motor reaches the set slip, SET SLIP light goes on.

   d) FIELD APPLIED light comes on immediately after SET SLIP light if optimum angle is sensed or two seconds after SET SLIP light if reluctance torque synchronization occurs.

   e) LOADER ON light comes on three seconds after FIELD APPLIED light.

If this sequence of events does not occur exactly as described, refer to the TROUBLESHOOTING section of this instruction manual. Otherwise proceed to Step 4.

4. Turn the FIELD ADJUSTMENT knob until the motor is excited with rated field current. Lock the knob at this setting.

5. Verify that all adjusting knobs are locked at the established settings.

The controller may now be placed into service.

Initial Start-Up Procedure with Power Factor Regulator

For initial start-up of the SPM 85000 equipped with the optional power factor regulator, follow the instructions below:

1. Turn the FIELD adjustment control knob to approximately the middle of its setting range.
2. Turn the POWER FACTOR adjustment to approximately the middle of its setting range.
3. Turn the REGULATOR MINIMUM CURRENT adjustment to the maximum of its setting range.
4. Put the REGULATOR MODE switch in the FIELD CURRENT position.
5. Reset the C/P-M by depressing the RESET button.
6. Close the main contactor with the start pushbutton or selector switch. This should produce the following sequence of events:
   a) SET SLIP light goes out.
   b) As the motor accelerates, the power factor indicator should move from <.60 Lag toward unity.
   c) When the motor reaches the set slip, SET SLIP light comes on.
   d) FIELD APPLIED light comes on immediately after SET SLIP light if optimum angle is sensed or two seconds after SET SLIP light if reluctance torque synchronization occurs.
   e) LOADER ON light comes on three seconds after FIELD APPLIED light.

If this sequence of events does not occur exactly as described, refer to the TROUBLESHOOTING section of this instruction manual. Otherwise proceed immediately to Step 7.

NOTE
Steps 7 and 8 will establish the limits of maximum and minimum field excitation current which the regulator can apply while regulating the motor power factor to a constant value.

The minimum current limit is necessary so that the power factor regulator does not completely remove the field if the load is suddenly reduced. The maximum current limit is necessary to avoid values of current greater than the nameplate rated field current.

7. Turn the FIELD adjustment knob until the DC ammeter indicates motor nameplate rated field current. This setting establishes the regulator maximum current. Lock the knob at this setting.
8. Depress and hold the SET pushbutton and turn the REGULATOR MINIMUM CURRENT adjustment until the DC ammeter indicates the desired minimum regulator current. Lock the knob at this setting. The suggested value of regulator minimum current is that value of field current which causes the motor to operate at unity power factor when it is completely unloaded.

To operate the motor at constant field current, leave the REGULATOR MODE switch in the FIELD CURRENT position. In this mode, field current will remain constant at the value set in Step 7 and the motor power factor will vary with the load applied.

To operate the motor at constant power factor, perform Steps 9 and 10:

9. Put the REGULATOR MODE switch in the POWER FACTOR position. The POWER FACTOR light should come on.
10. While watching the power factor indicating lights, turn the POWER FACTOR adjustment slowly until the motor runs at the desired power factor (normally 1.0 or 0.8 leading depending on motor design). Lock the knob at this setting. The regulator will now automatically adjust the field excitation current as the load changes in order to maintain constant motor power factor.

After performing the above steps, verify that all adjustment knobs are locked at the established settings. The motor may now be placed in service.

Description of Operation

Refer to **Figures 10** and **16. Figure 10** is a flow chart for the operation of the SPM 85000 synchronous controller. **Figure 16** is a typical schematic for applications of the SPM 85000 Solid State synchronous motor controller which employ vacuum stator controls.

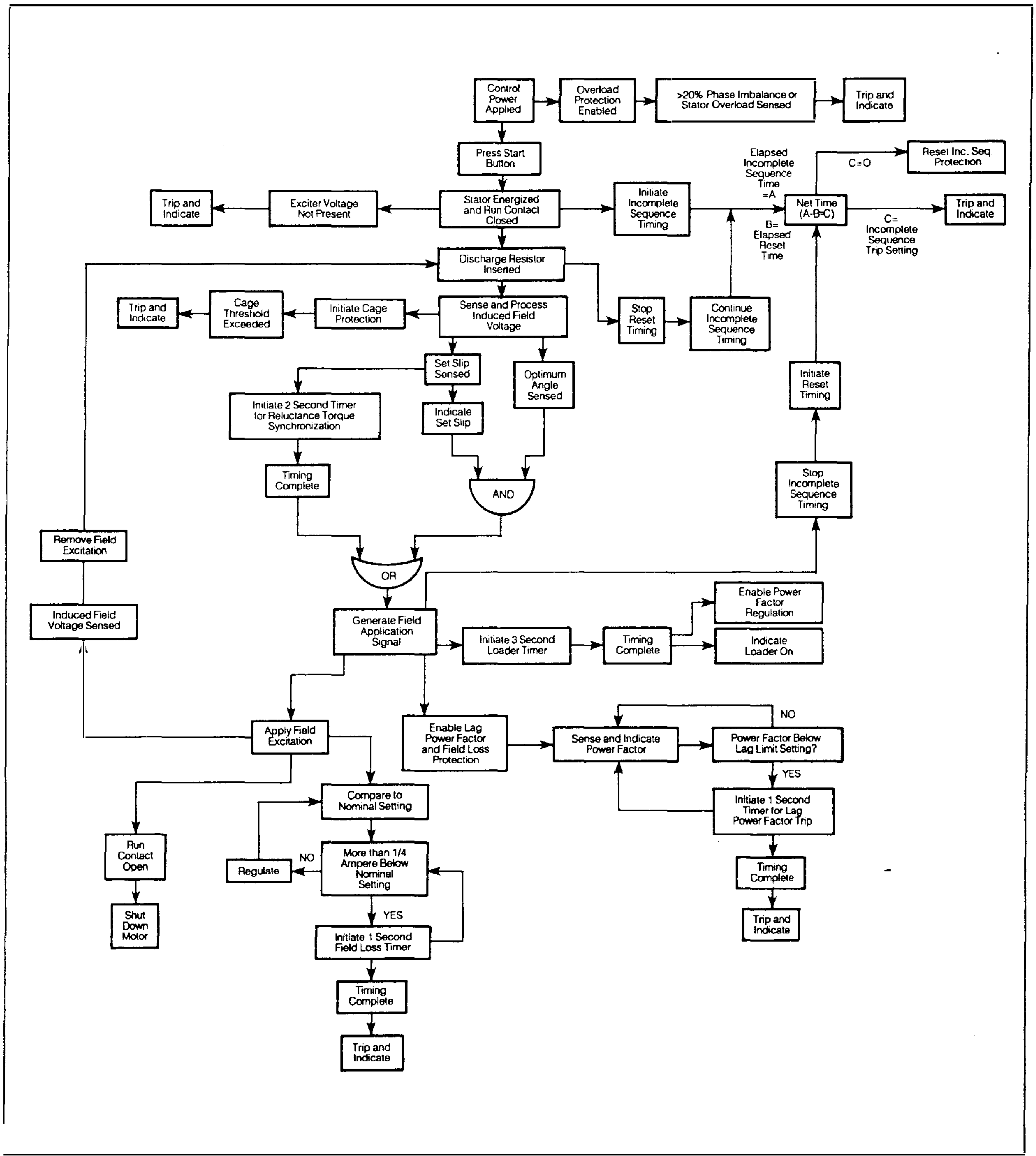


Figure 10. Operation Flow Chart

Starting and Synchronizing

When the main contactor (M) is racked onto its line stabs, control power is applied to the SPM 85000 control and protection module (C/P-M) through the line switch interlock (LSI).

Closing the START pushbutton or selector switch energizes the motor stator through the main contactor and closes the RUN input to the C/P-M. The power module (P-M) automatically inserts the field discharge resistor if the peak instantaneous induced field voltage reaches 600 Volts on a 125V field or 1200 Volts on a 250V field. Overload protection is enabled when control power is available and the C/P-M is reset. When the RUN contact closes, the incomplete sequence protection is initiated and the C/P-M begins to sense and process the induced field voltage. The RUN contact also initiates the cage protection. If the incomplete sequence protection completes its timing sequence or the cage protection exceeds its threshold before DC field excitation is applied to the motor, then the C/P-M will trip the main contactor and indicate which trip has occurred. If exciter voltage is not present after the RUN contact closes, or if an exciter MOV has shorted, EXT TRIP will occur.

When the synchronous motor has accelerated to a speed equal to the slip setting on the C/P-M, the C/P-M indicates SET SLIP, initiates a two second timer for reluctance torque synchronization, and begins to search for the "optimum angle" for field application. If the motor synchronizes on reluctance torque, the optimum angle may not be sensed, and the C/P-M will send a field application signal to the P-M after two seconds. If reluctance torque synchronization does not occur, the field application signal will be generated as soon as the "optimum angle" is sensed. The field application signal initiates a three second loader timer and fires the power SCR's on the P-M which in turn apply DC field excitation to the synchronous motor. After the loader timer completes its three second timing sequence, it closes a set of loader output contacts and the C/P-M indicates LOADER ON. If the power factor regulator is installed and the regulator mode switch is set to POWER FACTOR, the closing of the LOADER output contacts also causes power factor regulation to be enabled at this time. The field application signal also enables the lag power factor protection and field loss protection and it initiates timed reset of the incomplete sequence timer. The incomplete sequence timer will be reset if the field remains applied for a time approximately equal to the time which had elapsed between initiation of the incomplete sequence timer and field application. If the field is removed during this reset period, the incomplete sequence timer will resume its timing sequence until another field application signal is generated or the set INCOMPLETE SEQUENCE ADJUSTMENT time is reached. In the former case it will resume timed reset, and in the latter case it will trip the main contactor and indicate INCOMPLETE SEQUENCE.

Synchronous Operation

After field excitation is applied to the synchronous motor and it is operating at synchronous speed, the C/P-M continuously monitors power factor and field current. If the power factor drops below the lag limit setting, power factor trip will occur with a one second time delay. As long as 85-110% nominal exciter voltage is available, the C/P-M will maintain the field current at its nominal setting. If field current drops below set current by more than 1/4 ampere (measured at the FCT1-FCT2 input to the C/P-M) for one second, field loss trip will occur. If AC induced field voltage is sensed by the C/P-M (i.e. loss of synchronism has occurred), the DC field excitation will be immediately removed and the C/P-M will attempt to resynchronize the motor. If a stator overload is sensed by the overload protection, then overload trip will occur. If greater than 20% stator current unbalance is sensed, overload trip may occur.

Opening the STOP pushbutton or selector switch opens the main contactor and the RUN input to the C/P-M. This will shut down the motor. The motor may be restarted by reclosing the START pushbutton or selector switch. If the motor is shut down due to a trip on the C/P-M, the C/P-M must be manually reset before the motor can be restarted.

Overload Protection

Microprocessor controlled three-phase stator overload protection is provided with the control and protection module. Current proportional to the stator line current is sensed as an analog value from the 5-amp secondary windings of individual phase current transformers. This current is converted into a proportional voltage, rectified, digitized and applied to a microprocessor where balanced or unbalanced loads are distinguished and the magnitude of the current is compared to a trip threshold reference. The trip threshold is 110-115% of the set current established by the OVERLOAD ADJUST setting on the C/P-M. If the trip threshold is exceeded, overload trip will occur.

When stator current exceeds 100% of set current, the IMPENDING OVERLOAD TRIP light will start flashing. It will change to a steady light if the overload exceeds the trip threshold, thus indicating that tripping is imminent. When greater than 20% phase unbalance is sensed the C/P-M will indicate >20% PHASE UNBALANCE, lower the trip threshold to 90-95% of set current, and trip on overload if stator current

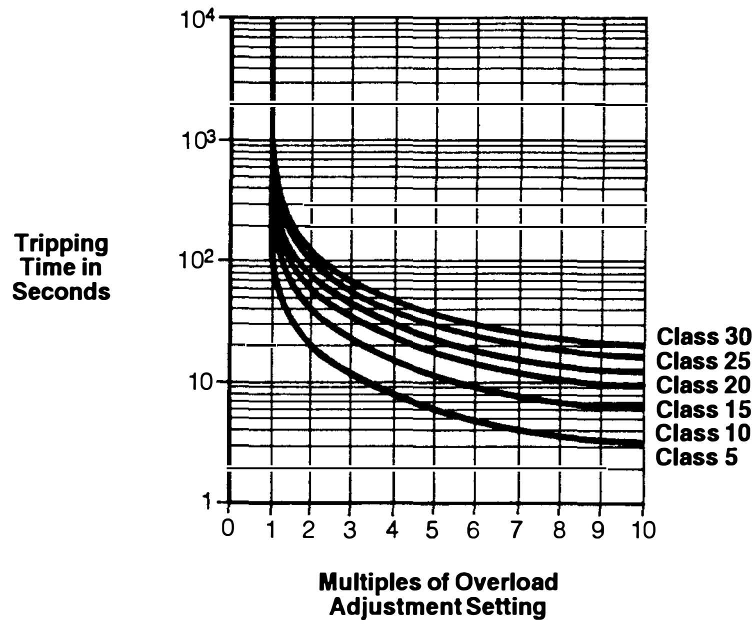


Figure 11. Overload Tripping Characteristic for Cold Start with Balanced Three Phase Load

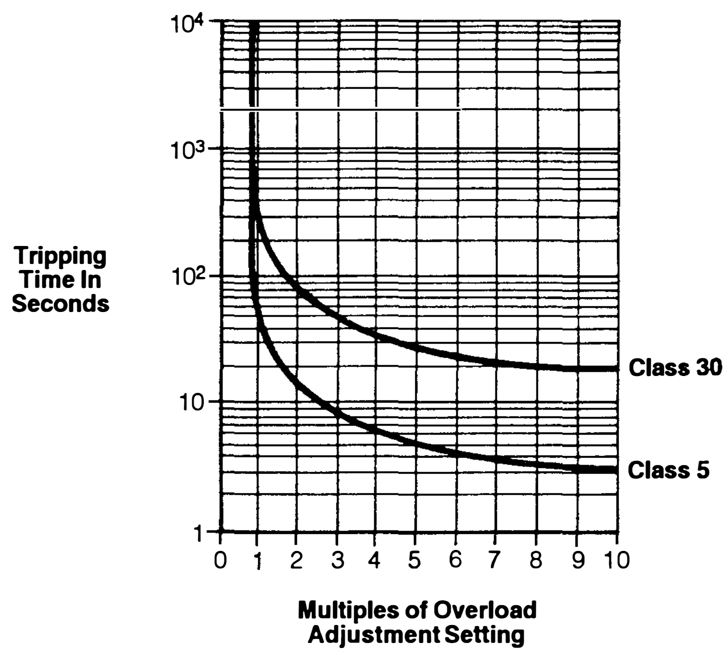


Figure 12. Overload Tripping Characteristic for Cold Start with Single Phase Load

exceeds this reduced trip threshold. Percent phase unbalance is defined as follows:

$$\frac{\text{Max. Dev. of Current from Arithm. Mean Value x 100}}{\text{Arithm. Mean Value}}$$

After tripping has occurred the OVERLOAD light comes on to indicate tripped status, and the motor is shut down. The overload protection must be reset with the RESET button after tripping. This is only possible after the recovery time shown in Table 2 has elapsed.

The stator overload protection can be set to operate with a NEMA class 5, 10, 15, 20, 25, or 30 time-current characteristic. This is accomplished by means of the four dip switches located behind the front panel of the C/P-M at the upper right corner as viewed from the front. The first switch (SW1) defeats phase unbalance protection when it is opened. Switches (SW2), (SW3), and (SW4) determine tripping class. **Table 1** shows a diagram of switch settings for the different tripping classes. The tripping class defines the maximum time in seconds at which overload trip will occur when carrying a current of 600% of the trip setting during a cold start. For example, when set for class 20 operation, overload trip will occur within 20 seconds. Table 2 shows the tripping time for cold starting at 600% current setting, the maximum test tripping time depending on the tripping class (SW1 off), and the maximum recovery time after tripping (SW1 off).

Figure 11 shows the overload tripping characteristic for a cold start with balanced three-phase loading. For a single-phase (100% phase unbalance) condition during a cold start, tripping is initiated according to the tripping characteristic shown in **Figure 12.** In the event of a stator overload while running, the overload tripping characteristic is reduced as compared to a cold start (i.e. 0% preloading) depending on the motor preloading as a percentage of the current setting. Table 3 shows the influence of preloading on tripping time.

Table 1. Tripping Class Switch Settings

Tripping Class	SW4	SW3	SW2
5	O	X	X
10	X	O	X
15	O	O	X
20	X	X	O
25	O	X	O
30	X	O	O

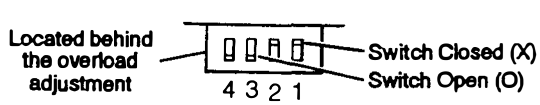


Table 2. Tripping and Recovery Times

Tripping Class	600% Trip Time (Seconds)	Maximum Test Trip Time* (Seconds)	Maximum Recovery Time* (Seconds)
5	4.8	4	25
10	9.5	6	40
15	14	9	60
20	18	12	70
25	23.5	15	90
30	28	18	100

*SW1 Off

Table 3. Time to Trip as Function of Preloading

Preloading in % of Current Setting	Time to Trip in % of Cold Start Trip Time
0	100
50	99
80	55
100	30

Markings on the OVERLOAD ADJUSTMENT knob denote full load amps. The adjustment knob should be set on the basis of full load motor current marked on the motor nameplate or on the basis of actual running current. When setting the overload protection on the basis of motor nameplate full load current, use the following formula:

$$\text{Dial Setting} = \frac{\text{Nameplate Full Load Current x Service Factor}}{\text{Current Transformer Ratio}}$$

For example, for a particular motor, nameplate full load current is 200 amperes, nameplate service factor is 1.15, and current transformer ratio is 300/5. Then,

$$\text{Dial Setting} = \frac{200 \times 1.15}{300/5} = 3.83$$

The overload protection can be set on the basis of actual motor running current by using the IMPENDING OVERLOAD TRIP light. With the motor running, adjust the dial setting until the IMPENDING OVERLOAD TRIP light starts flashing. Then turn the knob clockwise until the light just stops flashing. Lock the knob at this setting.

Squirrel Cage Protection

Thermal protection for the synchronous motor squirrel cage winding is provided with the control and protection module. The squirrel cage winding is not designed for continuous operation and is susceptible to overheating whenever the motor is running out of synchronism i.e. during starting and during operation after pull-out of synchronism has occurred. Motor manufacturers specify the "maximum stall time" and the "maximum running time at 50% speed" for a particular motor. The SPM 85000 squirrel cage protection, when properly set based on these limits, ensures that the synchronous motor is removed from the line before its squirrel cage winding is damaged.

The field discharge resistor is inserted across the synchronous motor field winding whenever the motor is running out of synchronism. Therefore, the squirrel cage protection circuitry monitors the induced field current in the discharge resistor which has a frequency that is inversely proportional to the motor speed. When discharge resistor current is sensed, pulses are generated which are proportional to its frequency. These pulses are integrated and compared to a trip threshold established by the CAGE PROTECTION settings on the C/P-M. If the trip threshold is exceeded, CAGE PROTECTION trip will occur. A cooldown period of an hour and a half must be allowed before the squirrel cage protection can be reset and the motor restarted.

The SPM 85000 squirrel cage protection can be set for a particular motor based on the "maximum stall time" and the "maximum running time at 50% speed" specified for the motor. The STALL TIME setting on the C/P-M corresponds to the maximum stall time at zero speed. The MULTIPLIER FOR 50% SPEED setting corresponds to the ratio of maximum running time at 50% speed to the maximum stall time. For example, for a particular motor which has a maximum stall time 10 seconds and a maximum running time at 50% speed of 15 seconds, the CAGE PROTECTION settings on the C/P-M should be 10 and 1.5. If the ratio of 50% run time to stall time for a particular motor is greater than 2, set the MULTIPLIER FOR 50% SPEED setting at 2. **Figure 13** shows typical tripping curves for the SPM 85000 squirrel cage protection. All curves will fall between the two extreme curves shown for the MULTIPLIER FOR 50% SPEED setting equal to 1 and 2.

Reduced voltage starting employing starting reactors, resistors, or autotransformers may be used to start a synchronous motor. If this type of starting is used, the allowable stall time for the motor is increased due to the reduction in starting current. The reduction in starting voltage and motor heating is proportional to the square of the current. Therefore, the STALL TIME setting on the C/P-M can be increased by the following multiplier:

$$(V_R / V_S)^2$$

V_R = Motor Rated Voltage
V_S = Starting Voltage

For example, for a particular motor, nameplate rated voltage is 4160 volts and the maximum allowable stall time is 7 seconds. The motor is to be started with an autotransformer at 65% rated voltage (2704 volts). The reduced voltage stall time multiplier is obtained by squaring the voltage reduction ratio as indicated above. 4160 volts divided by 2704 volts gives a voltage ratio of 1.54. This ratio squared gives a multiplier of 2.4. Then,

Stall Time (Reduced Voltage) = 7 x 2.4 = 16.8

The STALL TIME setting should be set at 16.8 seconds. If the product of the reduced voltage multiplier and the motor maximum allowable stall time is greater than 30 seconds, set the STALL TIME knob at 30 seconds.

An adjustable incomplete sequence timing circuit is provided with the SPM 85000 C/P-M as additional squirrel cage protection. When the RUN input to the C/P-M closes, the incomplete sequence protection begins its timing sequence. If it reaches a preset time before field excitation is applied to the synchronous motor or if field excitation does not remain applied for a time approximately equal to the motor acceleration time, then the C/P-M will trip and indicate INCOMPLETE SEQUENCE. The incomplete sequence protection will intersect the squirrel cage protection curves at some percentage of synchronous speed as shown in **Figure 13**. If the synchronous motor accelerates beyond this intersection point before it fails to complete its starting sequence, then the incomplete sequence protection will shut down the motor.

The incomplete sequence protection should be set 5 seconds above the motor acceleration time or 5 seconds above the acceleration time of the motor-load combination if the motor is to be started under load. If the motor acceleration time is less than 5 seconds, the incomplete sequence protection should be set at its minimum setting of 10 seconds. The incomplete sequence protection can be set with the INCOMPLETE SEQUENCE ADJUSTMENT knob on the C/P-M.

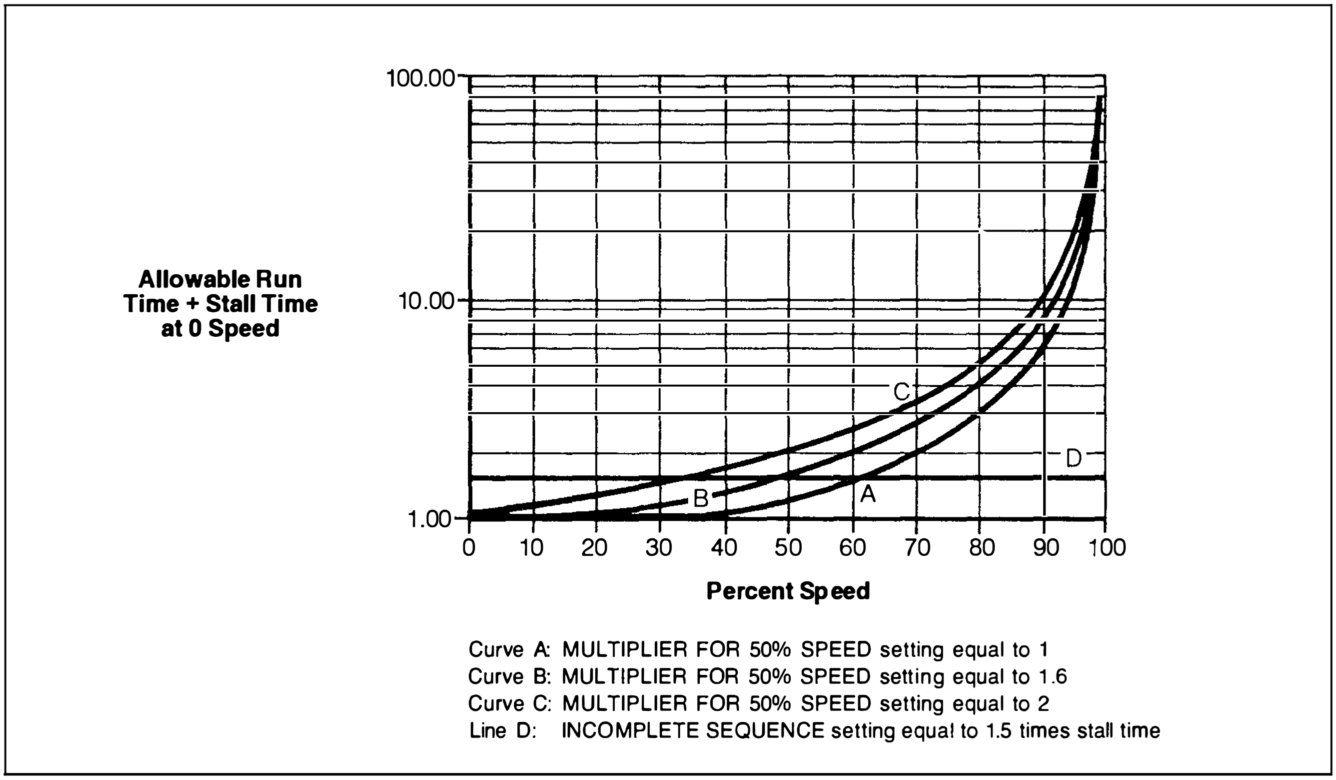


Figure 13. Typical Squirrel Cage Protection Tripping Curves

Pull-Out Protection

Synchronous motors normally operate at synchronous speed with unity or leading power factor. The motor can pull-out of synchronism if an excessive load is applied to the motor shaft, the supply voltage is reduced excessively, or field excitation is too low. As the motor approaches pull-out, its load angle increases above rated and power factor becomes increasingly lagging until it is fully lagging (90°) at the instant when pull-out occurs. Therefore, lagging power factor indicates that a synchronous motor is in danger of pulling out of synchronism. If the synchronous motor pulls out of synchronism for any reason, the SPM 85000 P-M will immediately insert the field discharge resistor and the C/P-M will remove field excitation. Removal of field excitation during slip will minimize damaging torque and power pulsations to the motor load and power system. After pull-out of synchronism has occurred, the synchronous motor runs as an induction motor with a lagging power factor. Therefore, lagging power factor also indicates that the motor is running out of synchronism.

The SPM 85000 solid state synchronizing and protection module accomplishes synchronous motor pull-out protection with lag power factor protection and field loss protection. If field current drops below set current by more than 1/4 ampere (measured at the FCT1 - FCT2 input to the C/P-M) for one second, the C/P-M will trip and indicate FIELD LOSS. If power factor drops below the lag limit setting for one second, the C/P-M will trip and indicate LOW POWER FACTOR. Lag power factor trip is delayed by one second to minimize nuisance tripping due to momentary voltage dips in the power system and to enable the controller to attempt to resynchronize the motor after pull-out has occurred. To set the lag power factor limit on the C/P-M, flip the POWER FACTOR switch to the SET LAG LIMIT position. The lag power factor limit should be set higher than the motor power factor when running without field applied to ensure that power factor trip is possible after pull-out of synchronism occurs. The lag limit setting is displayed on the vertical row of LED's to the right of the POWER FACTOR switch. Turn the LAG P F LIMIT ADJUSTMENT switch until the desired lagging power factor limit is displayed on the LED's. Lock the adjustment at the desired setting and return the POWER FACTOR switch to the INDICATE position.

⚠WARNING

Accidental contact with energized wiring or bus system can cause electric shock, burn or electrocution.

Disconnect and lock-out incoming power and control voltage sources before beginning work on this or any other electrical equipment.

Check all control circuit terminals with a voltmeter to make certain that the equipment is totally deenergized. Use only approved high voltage test equipment to check voltage on power terminals. Do not attempt to measure high voltage with a volt ohm meter.

It is recommended that a safety ground be connected to the power bus after the system has been deenergized, and prior to working on the equipment. Follow the procedure outlined in the pre-energization check section of this manual before power is restored.

For the safety of maintenance personnel as well as others who might be exposed to hazards associated with maintenance activities, the safety related work practices of NFPA 70E, part 11, should always be followed when working on electrical equipment. Maintenance personnel should be trained in the safety practices, procedures and requirements that pertain to their respective job assignments.

The customer must establish a periodic program to ensure trouble-free and safe operation. The frequency of inspection, periodic cleaning, and preventive maintenance schedule will depend upon the operation conditions. NFPA Publication 70B "Electrical Equipment Maintenance" may be used as a guide to establish such a program. A preventive maintenance program is not intended to cover reconditioning or major repair, but should be designed to reveal, if possible, the need for such actions in time to prevent malfunctions during operation. The following items should be included in any maintenance checklist.

- Conductors
- Terminals and Connections
- Recommended Tightening Torques
- Periodic Cleaning
- Control Fuses
- Printed Circuit Boards

Maintenance of the SPM85000 solid state synchronizing and protection module should only be performed with the main stator contactor deenergized and withdrawn from the controller compartment.

Conductors

Examine insulation on conductors for overheating or chafing against metal edges that could progress into an insulation failure. Any damaged conductors should be replaced. Replacement conductors should be re-routed, braced or shielded if needed to avoid similar damage in future operation. Temporary wiring should be removed or replaced by permanent wiring.

Terminals and Connections

Loose electrical connections can cause overheating that can lead to equipment malfunction or failure. Loose bonding or grounding can compromise safety and/or function.

Terminal screws, lugs, bus connections, bonding and grounding connections should be inspected for tightness and retightened securely as required. Fuse clips should be checked for signs of overheating, looseness, or inadequate spring pressure, and replaced if necessary. All terminals, connections, and conductors should be examined for evidence of overheating, corrosion, or pitting. Any parts found to be damaged should be replaced, using parts supplied or recommended by Siemens. Evidence of overheating may include discolored conductors, terminals or parts; or melted, charred or burned insulation.

Recommended Torque

When making bolted assemblies, the following considerations should be generally followed. The recommended torque is determined by the size of hardware used (refer to **Table 4**).

1. Metal-to-Metal—Apply standard torque.
2. Metal-to-Insert Molded in Compound—Apply approximately 2/3 of standard torque.
3. Compound-to-Insert Molded in Compound Part—Apply approximately 1/2 of standard torque.
4. Compound-to-Compound—Apply approximately 1/2 of standard torque.

Periodic Cleaning

Accumulation of dust and foreign material such as coal dust, cement dust, or lamp black must be removed from all control equipment and all surfaces must be wiped clean at regular intervals. Dirty, wet, or contaminated parts should be replaced unless they can be cleaned effectively. Dust can collect moisture, causing voltage breakdown and it can reduce the effectiveness of heat sinks.

Control equipment parts should be cleaned by vacuuming or wiping with a dry cloth or soft brush. Use care to avoid damaging delicate parts. Liquid cleaners, including spray cleaners, are not recommended due to the possibility of residues. Solvents should not be used on printed circuit boards. Compressed air is not recommended for cleaning because it will only redistribute contaminants on other surfaces, and may damage delicate parts. The inside bottom of the cubicle or enclosure should also be cleaned, including removal of any hardware or debris, so that any new or unusual wear or loss of parts occurring after the inspection may be more readily detected during subsequent maintenance.

Control Fuse Replacement

When control fuses need to be replaced, fuses of identical rating must be used. Control fuses on the C/P-M are located at the bottom of the printed circuit board on the component side of the board. When replacing a C/P-M control fuse, use care to avoid damaging delicate parts on the printed circuit board.

Printed Circuit Board Replacement

The SPM 85000 solid state synchronizing and protection module is equipped with two printed circuit boards. One board is contained in the control and protection module and the other board is contained in the power module. The printed circuit boards may be replaced using the following procedures:

A. Power Module

The printed circuit board may be removed from the power module by disconnecting all wiring leaving the board, and removing the four screws which attach the corners of the board to the red standoffs. Each wire which is disconnected from the printed circuit board must be clearly marked and identified so that it will reconnected to its original terminal location when the board is replaced. Carefully lift the printed circuit board away from the standoffs, allowing the four SCR gate leads to slip past the board as shown in **Figure 14.** The printed circuit board may be replaced using the reverse procedure to that which was used to remove it.

B. Control and Protection Module (see **Figure 15**)

If the control and protection module printed circuit board must be replaced for any reason, then the entire C/P-M front panel/circuit board assembly must be replaced.

To remove the C/P-M, it is necessary to:

1. Disconnect and lay aside the three wiring plugs.

Table 4. Recommended Torque Values

Thread Size	Standard Torque Metal-to-Metal (in.-lbs.)	2/3 Standard Torque Metal-to-Insert (in.-lbs.)	1/2 Standard Torque Compound-to-Insert (in.-lbs.)	1/2 Standard Torque Compound-to-Compound (in.-lbs.)
8-32	14-20	10-14	7-10	7-10
10-32	20-30	13-20	10-15	10-15
1/4-20	40-60	26-40	20-30	20-30
5/16-18	168-228	110-150	84-114	84-114
3/8-16	240-360	160-240	120-180	120-180
1/2-13	480-600	320-400	240-300	240-300

2. Remove the seven screws and lockwashers which attach the C/P-M to the housing. These screws are accessible from the rear of the housing.
3. Remove the C/P-M from the housing.

Reinstall the C/P-M using the reverse procedure.

Perform the "Pre-Energization Check" procedures detailed in this manual before restoring equipment to service.

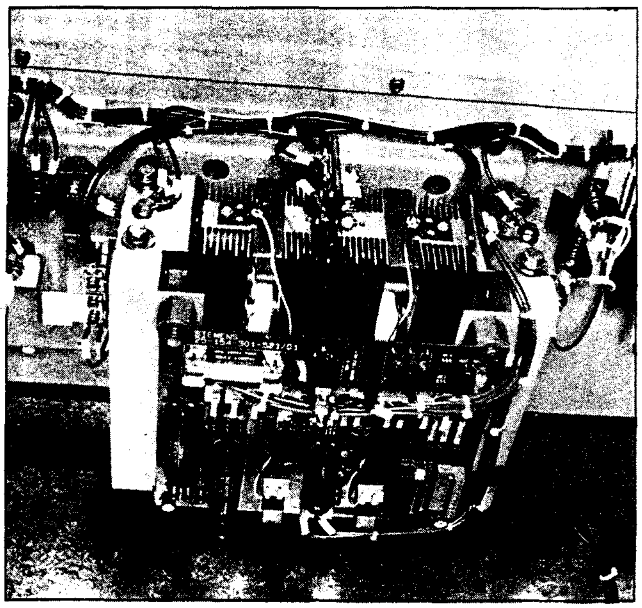


Figure 14. Power Module Printed Circuit Board

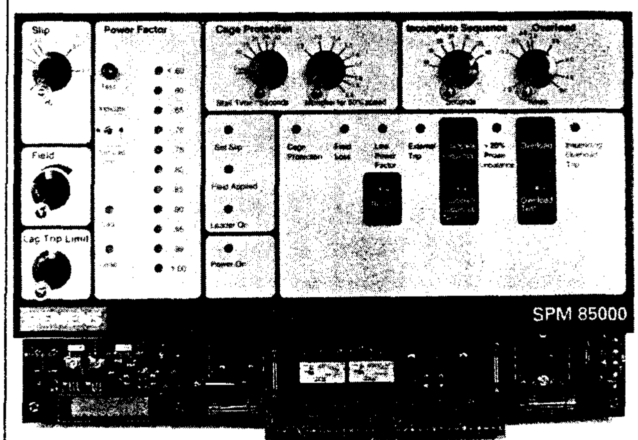


Figure 15. Control and Protection Module (C/P-M)

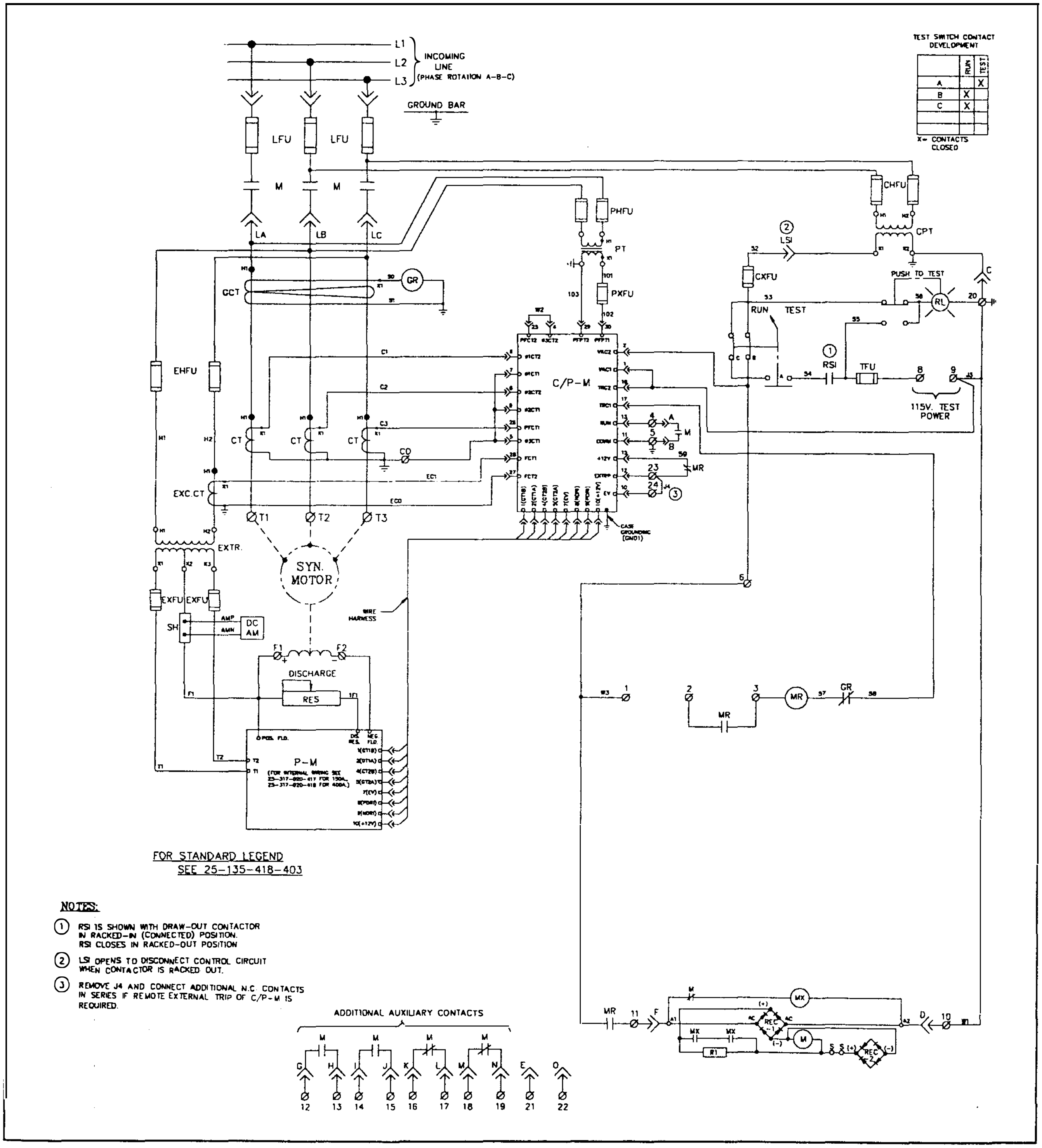


Figure 16. Typical Control Circuit for Series 85000 Solid State Synchronizing and Protection Module with Vacuum Stator Controller.

In the event that operating problems are encountered, use the following troubleshooting chart to isolate the cause of the malfunction and find the remedy. If the corrective action given in the chart fails to correct the difficulty, consult your field sales representative.

The following information is required if it is necessary to write to Siemens relative to the equipment problems:

1. Manufacturer's serial number and part number, if available.
2. Nameplate data on synchronous motor.
3. Length of time in service.
4. Description of problem.
5. Any other pertinent information.

WARNING

Accidental contact with energized components can cause shock, burn or electrocution.

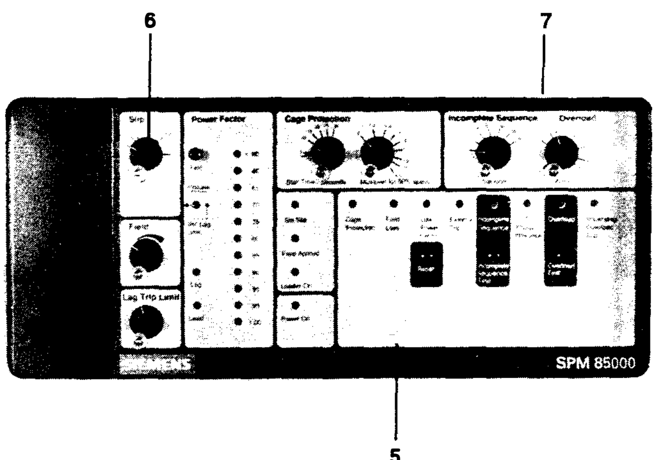
Disconnect and lock out all power supplying this equipment except where low voltage control power is required prior to making these checks and exercise extreme caution at all times.

Trouble	Cause	Remedy
No POWER ON indication on C/P-M	Blown control fuse.	Check control fuses on primary and secondary of CPT and on C/P-M printed circuit board.
Motor will not start	Blown control fuse failure of main contactor.	Check control fuses on primary and secondary of CPT and on C/P-M printed circuit board. Check main contactor and its associated controls
Motor starts but will not synchronize	Blown exciter fuse or rectifier fuse.	Check fuses on primary and secondary of exciter transformer and on P-M.
	Shorted MOV on P-M.	Check MOV and replace if shorted.
	Set slip too low. Motor cannot accelerate to set slip level.	Increase the SLIP ADJUSTMENT setting on the C/P-M.
	Check CAGE PROTECTION set.	Check CAGE PROTECTION settings. Check motor acceleration time. Readjust as required.
Motor starts but will not synchronize	Induced field voltage too low.	Check the operation of the field discharge resistor firing circuit as explained in the Pre-Energization Check section of this manual. Check discharge resistor insertion voltage setting on P-M. For 125V field, a jumper should be connected between the 600 and COM terminals. Replace if missing. For 250V field, no jumper is supplied. Add a jumper between the 1000 and COM terminal. If motor still fails to synchronize, replace with a jumper between 800 and COM terminals; and, finally with a jumper between 600 and COM, if necessary.
	OVERLOAD trip occurs.	Check OVERLOAD ADJUSTMENT setting and overload tripping class setting as explained in the OVERLOAD PROTECTION section of this instruction manual.

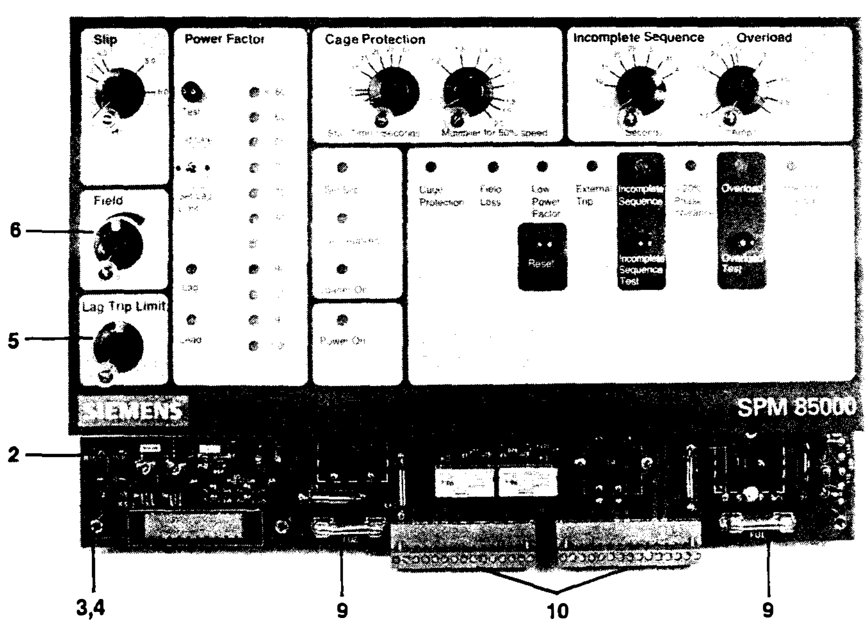
Trouble	Cause	Remedy
	Polarity of voltage input to C/P-M is reversed.	Check polarity of 115V or 230V input to C/P-M. Reverse if required.
	Motor trying to accelerate excessive load.	Check for tight bearings, inadequate lubrication, faulty operation or setting of unloading devices, excessive material in machinery, or jammed machinery.
		C/P-M indicates leading power factor during motor starting.
		Incorrect polarity of sensing input to C/P-M.
		Check polarity of stator CT and PT inputs to C/P-M and correct as required.
	Incorrect phase rotation of incoming line connections.	Check phase rotation of L1, L2, L3 connections.
Motor starts and synchronizes but shuts down shortly after application of field excitation.	No excitation voltage.	Check for available DC excitation voltage. Check exciter transformer fuses and replace if blown.
	No excitation current-open circuit at motor field, brushes, or leads.	Locate discontinuity in motor field circuit and correct as required.
	Lag power factor limit set too high.	Reduce the SET LAG LIMIT adjustment on C/P-M to approximately .80.
	Insufficient field excitation.	Increase FIELD ADJUSTMENT setting as required.
Motor shuts down during normal running.	Excessive load applied to motor shaft. LOW POWER FACTOR light is on.	Check for tight bearings, inadequate lubrication, excessive material in machinery, or jammed machinery. Restart motor.
	Loss of field excitation. LOW POWER FACTOR or FIELD LOSS light is on.	Check exciter transformer, exciter transformer fuses, and connections to motor field.
	System voltage transient causes exciter MOV to operate.	Check MOV on P-M and replace if shorted.
	Stator overload. OVERLOAD light is on.	
Power factor regulator does not operate	Jumper not removed	Reduce motor load or correct conditions causing overload. Check OVERLOAD ADJUSTMENT setting and correct if required.
		Remove the jumper (J2) located on the C/P-M circuit board behind the lag trip limit adjustment. See **Figure 15**.

Control and Protection Module Bill of Material See Figure 17			
Item	**Description**	**Part Number**	**Quantity**
1	C/P-M Mounting Plate	25-213-112-023	1
2	C/P-M Printed Circuit Board	25-154-301-236	1
3	Threaded Spacer (1.5)	A1-HSC-FJM-BED	5
4	Threaded Spacer (.75)	A1-HSC-EJF-BBD	5
5	Front Panel	D1-300-001-001	1
6	Potentiometer Knob	D1-HKH-000-003	7
7	Hinged Front Cover	25-213-112-502	1
8	Interconnecting Wire Harness	25-135-228-509	1
9	C/P-M Power Supply Fuse	D1-FST-FAO-001	2
10	Wiring Plug (C/P-M) 15 Pt.	D1-TBM-BOO-002	2

(a) Complete C/P-M



(b) C/P-M with Cover Removed



(c) C/P-M Rear View

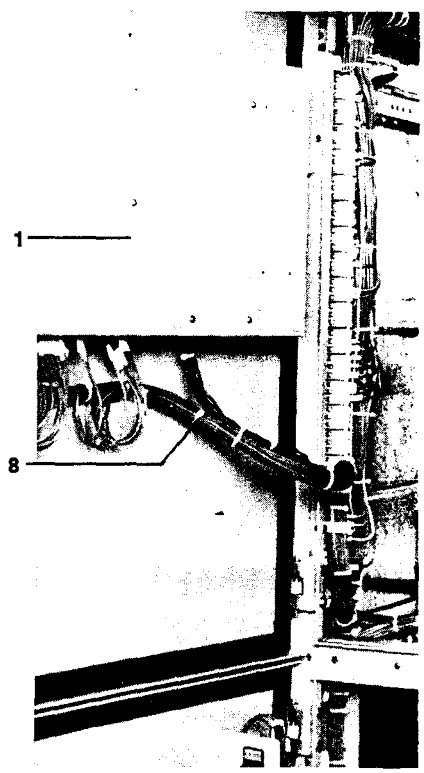
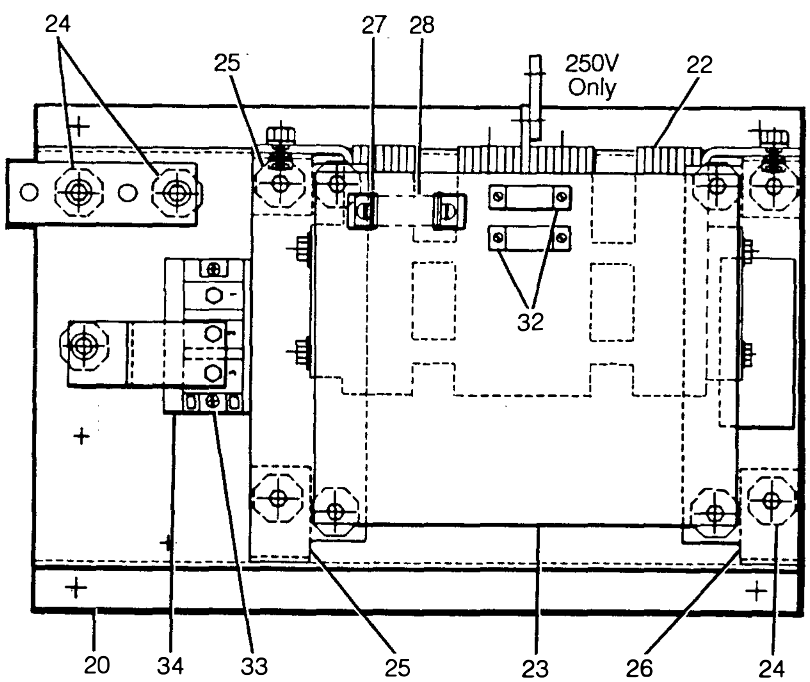
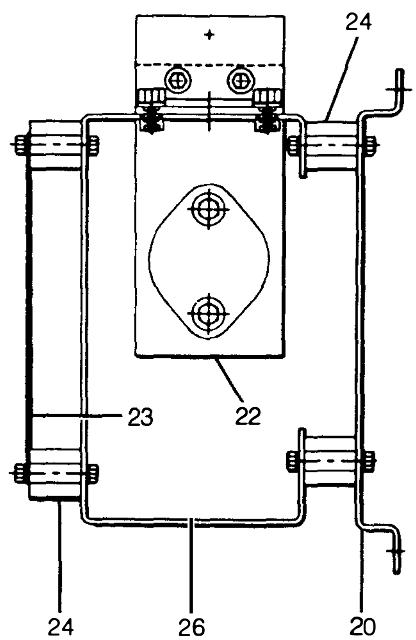


Figure 17.

Power Module Bill of Material (See Figure 18)			
Item	**Description**	**Part Number**	**Quantity**
20	P-M Mounting Plate	25-213-112-029	1
22	Silicon Controlled Rectifier	25-154-301-231	2
23	P-M Printed Circuit Board	25-154-301-521	1
24	Standoff Insulator	00-871-311-109	11
25	Mounting Bracket L.H.	25-154-301-098	1
26	Mounting Bracket R.H.	25-154-301-099	1
27	Rectifier Fuse Clip	25-127-244-005	2
28	Rectifier Fuse	25-135-983-002	1
32	Surge Absorber (MOV)	25-154-301-302	1 (125V Field) 2 (250V Field)
33	Silicon Controlled Rectifier Module	25-135-228-060	1
34	SCR Module Heat Sink	25-135-228-065	1
35	Field Lugs	See Lead Sheet	2
36	Fan Assembly	25-154-301-819	1 (400A Panel)
37	Transformer for Fan	25-213-150-001 25-213-150-002	1 (125V—400A) 1 (250V—400A)
38	Sec. Fuse for Fan Transf. .6A	00-871-145-319	1 (400A Panel)
39	Pri. Fuse for Fan Transf. 1.0 A Pri. Fuse for Fan Transf. .6 A	24-166-040-013 24-166-040-010	2 (125V—400A) 2 (250V—400A)



(a) Front View

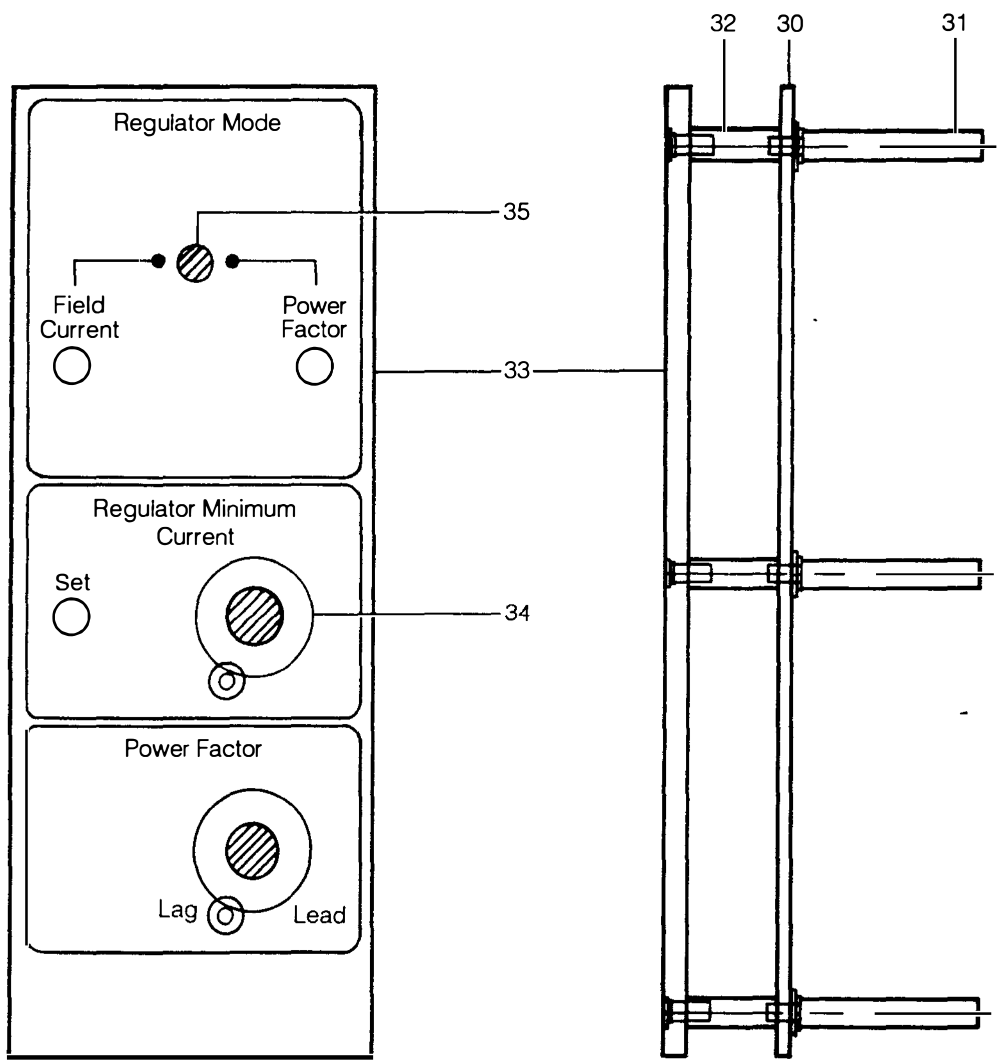


(b) Side View

Figure 18.

Power Factor Regulator Module Bill of Material (See Figure 19)			
Item	**Description**	**Part Number**	**Quantity**
30	Printed Circuit Board	25-154-301-551	1
31	Threaded Spacer (1.5)	A1-HSC-FJM-BED	5
32	Threaded Spacer (.75)	A1-HSC-EJF-BBD	5
33	Front Panel	25-154-301-166	1
34	Potentiometer Knob	D1-HKH-000-003	2
35	Button Knob for Pushbutton Sw.	D1-HKH-000-001	1

Power Factor Regulator Module



(a) Front View

(b) Side View

Figure 19.

SIEMENS

Siemens Energy
& Automation, Inc.
Electrical Apparatus Division

P.O. Box 29503
Raleigh, NC 27626
(919) 365-6660

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