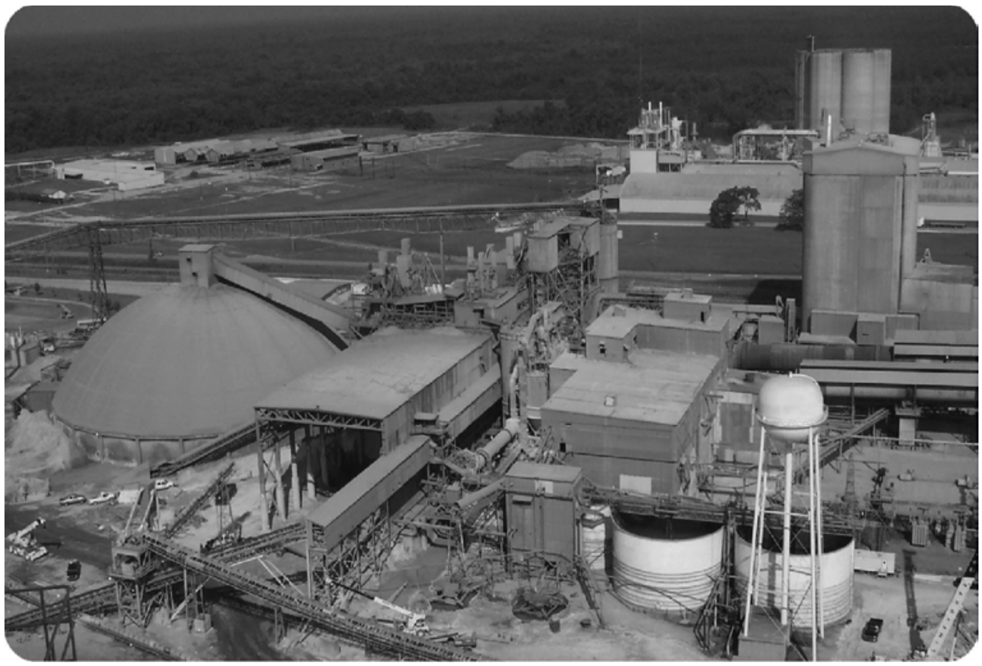
Installation Instructions

Allen-Bradley

SYNCPRO II™

Publication 1902-IN001B-EN-E



Important User Information

Solid-state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.rockwellautomation.com/literature/) describes some important differences between solid-state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid-state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Product Description

Chapter 1

Receiving and Storage

Chapter 2

Installation

Chapter 3

Chapter 4

Setup and Commissioning

Chapter 5

Programming SyncPro II

Chapter 6

Monitoring

Notes:

Product Description

Introduction

The SyncPro II consists of a programmable small logic controller (MicroLogix™ 1500) with the following additional peripheral items:

- PanelView™ Component Terminal C400
- Power Factor Transducer
- Analog/Digital Pulse Board
- Conditioning Resistors
- Interposing Relays FSR and ESR

The SyncPro II system is designed to provide supervisory protection and field control to a brush-type synchronous motor controller, proper field application timing, squirrel-cage protection against long acceleration and stall conditions as well as running pullout protection by monitoring motor power factor. When combined with a suitable induction motor protection relay, the SyncPro II provides the necessary overload protection to the brush-type synchronous motor.

IMPORTANT	Although the SyncPro II makes use of some standard MicroLogix 1500 programmable controller components, it is imperative that the controller is a dedicated unit expressly for the control and protection of the field of a single synchronous motor. The firmware and hardware configuration must only be used for its designed purpose. Do not attempt to modify the controller in any way for another use. No additional PLC control cards can be added nor should the firmware/program be modified.

Related Documentation

The following publications contain information for components associated with the SyncPro II.

Publication 2711C-IN001_-EN-P	PanelView Component Terminal - Installation Instructions
Publication 1900-2.10	Measuring for Synchronous Motor Data
Publication 900-1.0	Synchronous Motor Control
Publication SGI-1.1	Safety Guidelines for Application, Installation and Maintenance
Publication 1764-UM001_-EN-P	MicroLogix 1500 Programmable Controller

Synchronous Motor Theory

The synchronous motor is a commonly used industrial motor favored for its higher efficiency, superior power factor, and low inrush currents. Typical applications that benefit from the constant operating speed include refiners, head box fan pumps, chippers, etc. Synchronous motors are particularly well suited to low RPM applications. The synchronous brush-type motor is composed of a three-phase stator winding, a DC rotor winding, and a squirrel-cage winding.

The stator winding is identical to that of an induction motor and, as such, the direction of motor rotation depends on the rotation of the stator flux. The direction can be changed by reversing two of the stator leads, just as it does with induction motors.

The rotor contains laminated poles which carry the DC field coils that are terminated at the slip rings. It also has a squirrel-cage winding composed of bars embedded in the pole faces and shorted by end rings. The squirrel-cage winding is also known as “damper” or “amortisseur” winding. This winding enables the motor to accelerate to near synchronous speed so that the DC supply can be applied to the field windings for synchronizing the motor to the line (typically 95%).

These field windings are connected through slip rings to a discharge resistor during start up. The resistor is required to dissipate the high voltages that are induced into the field windings from the stator, and it is removed from the circuit when the DC field voltage is applied. The synchronous motor can be compared to a transformer, with the three-phase stator resembling the primary and the field winding acting like a secondary. Through this transformer action, an induced voltage is generated in the motor field during starting. The induced signal can be used to protect the squirrel-cage winding by monitoring the motor speed during acceleration and to determine when the DC field can be excited for synchronization. At zero speed, the frequency induced into the field is 60 Hz, at 95% speed the frequency induced is 3 Hz (for a 60 Hz system).

Once at 95% speed, the DC field is supplied with either 125 V DC or 250 V DC and the discharge resistor is removed from the circuit. The excitation in the field windings creates north and south poles in the rotor which lock into the rotating magnetic field of the stator. The slip rings are used to connect the field windings to the discharge resistor and static exciter. It is at these slip rings that the field resistance of the motor can be measured to confirm the required field voltage and current at rated power factor. If, for example, the field voltage is 125 V DC and the current is 20 amps DC, then the resistance measured should be about 6 Ω, based on Ohms Law.

Protection Theory

Theory of Operation

When the NOT STOP and START signals go high, an internal timer is started (see Figure 4 and Figure 5). The START signal must be dropped before another start can be initiated. The timer is preset based on the slip frequency of the motor. If the timer expires prior to achieving the maximum asynchronous speed, the starting sequence will halt, the TRIP output will be dropped and the PanelView will display a message indicating the faulted condition. The TRIP signal is restored when there are no faults and the Fault/Reset PB input is received.

NOTE: The NOT STOP and START can be tied together to indicate a RUN condition to control the device without separate signals. The RUN output follows the start input if the motor is permitted to start, (i.e. no faults and the EQUIPMENT SHUTDOWN is high).

If the programmed percentage of synchronous speed is obtained within set time limits, the FIELD RELAY is energized. The power factor is now monitored and displayed on the PanelView. If the power factor drops below the programmed values, the TRIP and FIELD RELAY outputs will be dropped and the PanelView 300 will display a message indicating the faulted condition. Under normal conditions the FIELD RELAY is maintained until the NOT STOP signal is removed.

The slip frequency is calculated from a square wave input representing the slip frequency. Based on this frequency, the allowable starting time is calculated. This calculation is based on three set points which are entered by the user, as well as a 'function order' used to shape the curve. The three required set points for squirrel-cage protection trip time are:

- Set Point 4: at synchronizing = 95%
- Set Point 5: at 50% speed
- Set Point 6: at stalled

The time curve between stalled frequency and 50% speed is assumed to be linear. The time between 50% speed and the synchronizing speed is to the nth order such that unity makes it linear, 2-5 makes it exponential in nature. The higher the order, the shorter the times near to 50% speed and the higher the times near the synchronous speed set point (i.e. bottom of curve (time vs. frequency) is flatter and then rises more steeply).

NOTE: If the time set point at the maximum programmed percentage of synchronous speed is set below that of the extended stall (i.e. 50% speed curve), the function between 50% speed and synchronous speed will also be treated as linear. (For example, the slope between 50% speed and synchronizing speed is flatter than the slope between stalled and 50% speed).

When the maximum programmed percentage of synchronous speed (set point) is obtained, the field coil is energized on the falling pulse of the negative square wave (i.e. a rising sinusoid) from the slip frequency generator. A fixed time period after synchronization, the autoload signal is raised. The field coil is energized only if the TRANSITION COMPLETE has been received.

Squirrel-Cage Winding Protection	Protects the squirrel-cage winding from long acceleration and stall conditions during starting.
Field Winding Application Control	The signal that triggers application of the field excitation when the programmed asynchronous speed is obtained.
Incomplete Sequence Timing Relay	Trips the system if the overall starting time is exceeded.
Pull Out Protection	Monitors the lagging power factor during running to detect a loss of synchronism
Field Voltage Failure Relay Input	Monitors the condition of the static exciter output. This relay must be supplied by the customer if the SyncPro II is not supplied as a configured unit within an Allen-Bradley motor controller.

Optional Equipment

- Field Current Failure Relay
- Load and Unload Auxiliary Contacts – The outputs are energized 2 sec. after the field is applied and is maintained until the field is removed.

Display/Metering Features

The product in conjunction with the PanelView 300e Micro Terminal (PV) will perform the following metering/display functions:

- display all detected fault conditions
- display the slip frequency and starting time during startup
- display the power factor during run mode.
- accept set points for the following:
  - maximum % asynchronous speed [% of synchronous speed]
  - power factor set point and trip delay
  - maximum allowable time at stalled state (maximum slip
  - maximum allowable time at 50% speed
  - maximum allowable time at synchronizing speed (typically at 95% speed)
  - function order (allows adjustment of the slope of the acceleration/stall time trip curve).
  - incomplete sequence timer trip delay
  - fault mask for PF transducer diagnostics

Refer to Chapter 5 for complete details.

Typical Synchronous Starter Components

Motor Contactor (M)

The following details outline some of the common components that which the SyncPro II can be connected to, or are part of the SyncPro II protection package.

The motor contactor is used to provide and switch the power supplied to the motor stator. It is controlled by the SyncPro II package and is necessary to remove stator power in the event of a stop command or a trip condition. Two normally open contactor auxiliaries may be required; one mandatory N.O. contact to give contactor status information to the SyncPro II, and one may be needed as a hold-in contact for the main control circuit.

Motor Contactor Pilot Relay (CR1 or MR)

This interposing relay allows the SyncPro II output to pick up the main contactor coil. The power requirements of the pick-up coils used in most medium voltage motor starters would exceed the switching capability of the 1764-24BWA output contact.

Field Voltage Relay (FVR)

When energized, this DC relay indicates that the DC exciter supply is healthy and producing an adequate level of DC excitation. The field voltage relay is required to prevent starting the motor unless DC excitation is available. A field voltage relay is recommended as the SyncPro II does not have the ability to determine the level of the exciter output voltage. It is needed to prevent unnecessary starts when synchronization cannot occur.

Equipment Shutdown Relay (ESR) (Included with SyncPro II)

The ESR relay combines the status of customer supplied protective and interlock devices to a single contact input on the SyncPro II.

When ESR is energized, it is an indication that all external trip and interlock contacts to the SyncPro II are in a "not tripped" condition. All external trips and interlocks must be wired in series with the ESR coil in order to be properly addressed by the SyncPro II.

Phase Angle Transducer (Included with SyncPro II)

The phase angle transducer provides a conditioned 4…20 mA signal to the analog module of the SyncPro II system. The transducer is factory calibrated to provide a specific output at zero (0) lagging power factor, at 1.0 or unity power factor, and at zero (0) leading power factor. These factory settings must not be altered.

The SyncPro II processor scales and interprets this signal to compare it to the power factor trip set point and to cause a trip to occur if the power factor drops below the programmed value for more than the specified power factor trip time delay. If the DC excitation is lost, a low voltage condition exists, or the motor is being overloaded to a point where the motor can no longer maintain synchronous speed, the motor power factor will react by dropping to a very lagging value. This indicates that the motor is slipping poles and the controller should be shut down to protect the motor.

The phase angle transducer monitors voltage across lines 1 and 2, along with the current in line 3 to obtain a power factor reading. When the reading is below the set points programmed, the SyncPro II will shut down the starter.

Discharge Resistor

The discharge resistor is specified by the motor manufacturer for a specific application to obtain correct starting and pull in torques and to provide a means of discharging the motor induced field voltage when starting and stopping the motor. The field winding has more turns than the stator winding and when power is applied to the stator, the field acts like the secondary windings of a current transformer. A field winding without a discharge path will produce a voltage greater than its insulation rating, and as such, requires a means to discharge or limit the voltage. If the discharge resistor is not connected during a start, the induced voltage can build to a point where the field winding insulation can be damaged. The resistor is also used to provide reference points to the SyncPro II synchronous motor protector (see Chapter 4).

Field Contactor (FC)

The field contactor provides two normally open and one normally closed power poles. The normally open contacts apply DC power to the motor field windings when the contactor is energized. Prior to energization and after de-energization, the normally closed pole makes the path to the discharge resistor to allow the dissipation of energy induced in the field during starting. It also provides a path to discharge the stored energy in the large inductive motor field winding on stopping of the motor.

Resistors RF1 and RF2

These resistors are used to attenuate the voltage which reaches the analog/digital pulse board. Set up of these resistors is important because if the signal voltage to the board is too low (too much resistance) then pulses will not be produced. If too little resistance is used, the voltage may be too high which could damage the analog/digital pulse board (see Figure 10 on page 33).

Analog/Digital Pulse Board

This board converts the voltage sinusoidal waveform across the discharge resistor and, by examining the zero crossings, creates a digital pulse train of an equal frequency to the induced slip frequency occurring in the discharge resistor. At start (zero speed), the frequency will be 60 Hz, at 95% speed, the frequency will be 3 Hz (for a 60 Hz system). This feedback is used by the SyncPro II to determine the speed of the motor at any time during acceleration and when the motor has reached the desired speed set point to synchronize.

Input/Output Descriptive Control

Listing

NOT STOP INPUT (I:2/0)

This signal must be maintained high for the SyncPro II to operate. When the signal is taken low, the software identifies this as a normal stop for the motor.

IMPORTANT	The SyncPro II does NOT have control over stopping the motor. The main portion of the motor controller performs this control function.

The NOT STOP signal must be given in parallel to that of the hardware, i.e. from the same PLC output or push button.

START INPUT (I:2/1)

The rising edge of this signal starts the operation of the SyncPro II. This signal is maintained high for two-wire control or may be dropped after initial starting if three-wire control is used. In both cases, this signal controls the START output. After a fault has occurred, this input must be taken low before another start command will be recognized (see Figure 4 and Figure 5).

RUN OUTPUT (0:0/1)

This output is used to control motor starting. It is the START input conditioned by all permissives. That is to say that this output will follow the state of the input as long as all permissives are met. Thus in two-wire control, this output is actually a RUN command and will stay high until either a fault occurs or a stop is issued. In three-wire control the output is maintained only as long as the input is maintained, a fault occurs, or a stop is issued.

EQUIPMENT SHUTDOWN RELAY (ESR) INPUT (I:2/7)

This fault input is used to group all external faults. It notifies the SyncPro II that the system has stopped for an external reason. The SyncPro II will send a message indicating the reason for the stoppage. In the normal state this signal is held high, going low on a fault condition. While this signal is low, a start signal will not be accepted. Typically, all emergency stops or external faults (i.e. overloads, motor protection relays) will be wired to an ESR relay. This relay is then fed into the SyncPro II for logging and control and also tied into the hardware to stop the motor.

TRIP OUTPUT (O:0/0)

This output is high during normal conditions. When the SyncPro II detects a fault, the output goes low and the SyncPro II stops the motor. The trip output is typically wired into the ESR circuit. It will be set high when there are no faults and the FAULT RESET PB is momentarily raised high.

Field Application

TRANSITION COMPLETE CONTACT INPUT (I:2/6) (OPTIONAL)

The field relay output will not be energized until this input permissive is given. Once the field relay is picked up, this permissive is no longer required. If the permissive is not given prior to the squirrel-cage protection timing out or the incomplete sequence timing out, the SyncPro II will fault and stop the motor.

If unused, it must be tied high. This input is intended for an external input such as the RUN contact of an autotransformer starter. It prevents synchronization until the autotransformer starter has first transitioned to full voltage RUN mode.

FIELD RELAY OUTPUT (O:0/2)

This output controls the field contactor relay which applies the field to the motor. This output is energized when the transition complete permissive is given and the synchronous setpoint has been reached. The field is then applied either on the rising waveform or after a fixed time period of one second if the motor synchronizes on reluctance torque. The output is dropped whenever the NOT STOP is removed, the EQUIPMENT SHUTDOWN RELAY is removed, or a fault is detected.

Feedback

MOTOR CONTACTOR FEEDBACK CONTACT INPUT (I:2/8)

This input indicates to the SyncPro II that the motor contactor is closed, confirming that the motor is running. It also allows the SyncPro II to detect a fault in the contactor circuit.

FIELD CONTACTOR FEEDBACK CONTACT INPUT (I:2/5)

This input indicates to the SyncPro II that the field contactor has picked up, confirming that the field has been applied. (The signal must come from the auxiliary of the coil which ultimately applies the field, i.e. contactor.) If missing, the SyncPro II detects a fault in the field circuit.

TRIP/RESET PB INPUT (I:2/2)

This input from the push button on the panel will reset any fault condition in the SyncPro II. Once no fault exists, the fault condition will be removed from the PanelView and the TRIP output will be set.

Fault Detection

FIELD VOLTAGE RELAY INPUT (I:2/3)

When the signal is low, it indicates a lack of field voltage. This input is monitored for a fault condition only while starting, prior to applying the field. Tie this input high if it is not used. When this contact is high, it verifies that the static exciter is providing an appropriate DC voltage.

FIELD CURRENT RELAY INPUT (I:2/4) (OPTIONAL)

When the signal is low, it indicates a lack of field current. This input is monitored for a fault condition after the field has been applied. Tie this input high if it is not used. This optional input verifies there is DC current flowing from the static exciter to the motor field. It is redundant since the power factor trip feature will trip if the field current is lost.

POWER FACTOR INPUT (I:1/0)

The signal supplied to the SyncPro II is from the Phase Angle Transducer, representing a power factor of zero (0) lagging to zero (0) leading respectively. Note that the SyncPro II firmware has been tailored to this specific transducer. No substitution is allowed.

SLIP GENERATOR POWER INPUT (I:0/1)

This fault input is monitored during idle and starting periods. It is normally held high by the power supply to the Slip Pulse Generator.

SLIP GENERATOR NEGATIVE INPUT (-) (I:0/0)

Connect to the negative terminal (N) of the Slip Pulse Generator.

SLIP GENERATOR POSITIVE INPUT (+) (I:0/2)

Connect to the positive terminal (P) of the Slip Pulse Generator.

Status

AUTO LOAD OUTPUT (O:0/3)

Output is energized two seconds after the field is applied and remains closed until the field is removed from the motor by a stop or a fault.

SCP TRIP OUTPUT (O:0/8)

Output is set high when a Squirrel-Cage Protection Fault occurs. It is reset when the TRIP output goes high after pushing the reset button. This signal can be used for indication, via a pilot light, or it can be used as an optional trip output.

MOTOR PULLOUT TRIP OUTPUT (O:0/9)

Output is set high when the power factor lags for longer than the programmed trip time delay indicating that the motor has pulled out. It is reset when the TRIP output goes high after pushing the reset button. This signal can be used for indication, via a pilot light, or it can be used as an optional trip output.

INCOMPLETE SEQUENCE TRIP OUTPUT (O:0/10)

Output is set high when an Incomplete Start Sequence Fault occurs. It is reset when the TRIP output goes high. This signal can be used for indication, via a pilot light, or it can be used as an optional trip output.

Custom

I:2/10 to I:2/15 are custom fault inputs. If any are true, they trip the unit off.

Specifications

General

Operating Power	
Input Line Voltage	120V AC, 50/60 Hz
Input Current	0…5 A
Temperature and Humidity	
Temperature (Maximum Ambient)	Operating: 0…40ºC (32…104ºF)
	Storage: -20…65ºC (-4…149ºF)
Humidity	5…95% (non-condensing) Maximum temperature: 40 ºC (104 ºF)

For Phase Angle Transducer

General	
Accuracy	3% span
Housing	Flame retardant plastic case
Weight	2.4 kg maximum
Climate	
Storage	-20…70 ºC (-4…158 ºF)
Temperature range	Operational at 0…60 ºC (32…140 ºF) Calibrated at 23 ºC (73 ºF)
Humidity	Up to 95% relative humidity, non-condensing
Input	
Frequency	50/60 Hz
Current	0.2…10 A
Range (A)	20…120%
Burden	5 VA maximum
Voltage	115…230V, ±10%
Range (V)	±20% (20…120% with separate auxiliary) Burden 1 VA maximum
Overload Capacity	
Six times rated current for 30 s	
1.25 rated voltage for 10 s	
Electrical Tests	
Dielectric Test	2 kV RMS per BS 5458
Impulse Test	5 kV transient as BEAMA 219 and BS 923
Surge Withstand	ANSI C37-90A
Certification	CSA Approved

PVc C400 Specifications

See Publication 2711C-IN001_-EN-P, pages 30…31.

MicroLogix 1500 Specifications

See Publication 1764-UM001_-EN-P, Appendix A.

Notes:

Receiving and Storage

Receiving

Upon receiving the controller, remove the packing and check for damage that may have occurred during shipping. Report any damage immediately to the claims office of the carrier.

IMPORTANT	If the SyncPro II is an integral component of a brush-type synchronous starter, special receiving and handling instructions will apply. For details, refer to the service manual provided with the equipment.

Storage

It is important to consider the following storage requirements if you are not installing your controller immediately after receiving it.

- Store the controller in a clean, dry, dust-free environment.
- Storage temperature must be maintained between -20…65 °C (-4…149 °F).
- Relative humidity must not exceed 95%, non-condensing.

Notes:

Installation

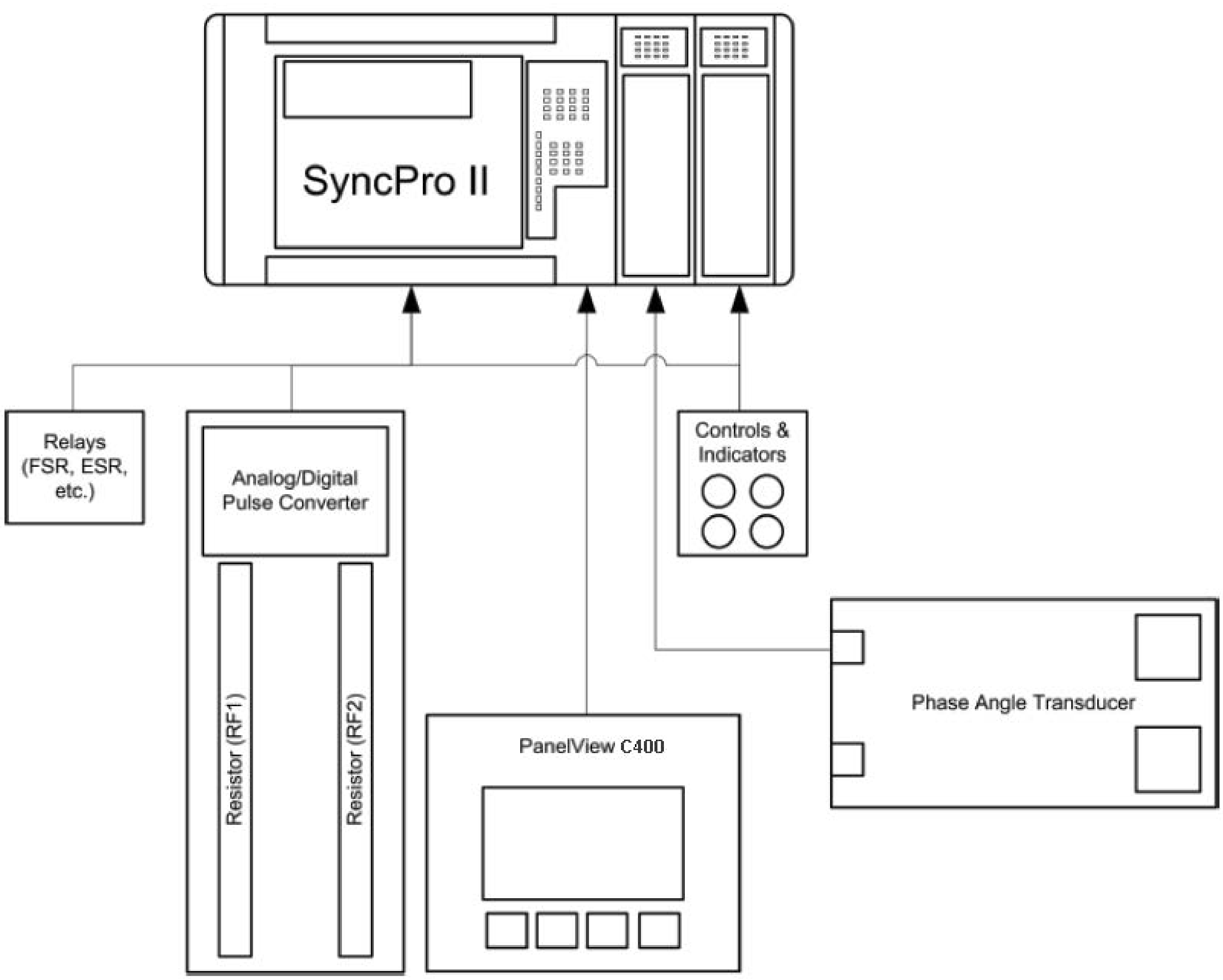
Arrangements

The SyncPro II is offered in three arrangements.

Component Level

The SyncPro II may be ordered as individual components for maximum flexibility when installing the controller. The user may then mount the components in a configuration most suitable to his main motor controller equipment layout. Care must be exercised to ensure the SyncPro II processor has adequate ventilation provided around it. Refer to Figure 6 for typical wiring of the components.

Figure 1 - SyncPro II Component Configuration



Open Frame Configuration

The SyncPro II components are mounted on a panel, except the PanelView display module and the illuminated push button for trip indication and reset function. See Figure 2 for mounting dimensions of the main unit panel. Quick installation within the main controller is possible with this arrangement.

IMPORTANT	The PanelView is supplied with a two-meter cord for connection with the SyncPro II processor. Mount the PanelView in a suitable location to make this connection.

Figure 2 - Mounting Dimensions

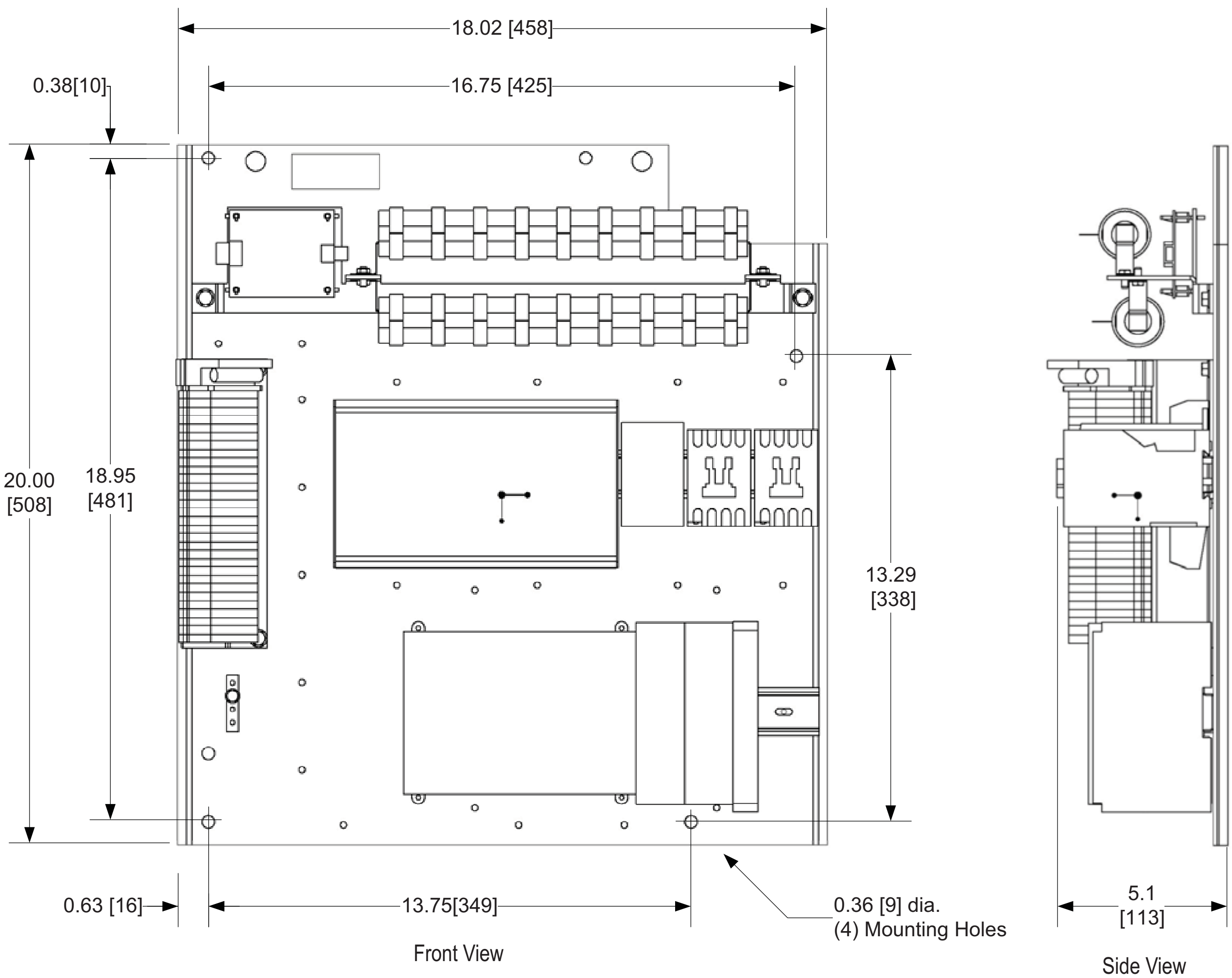
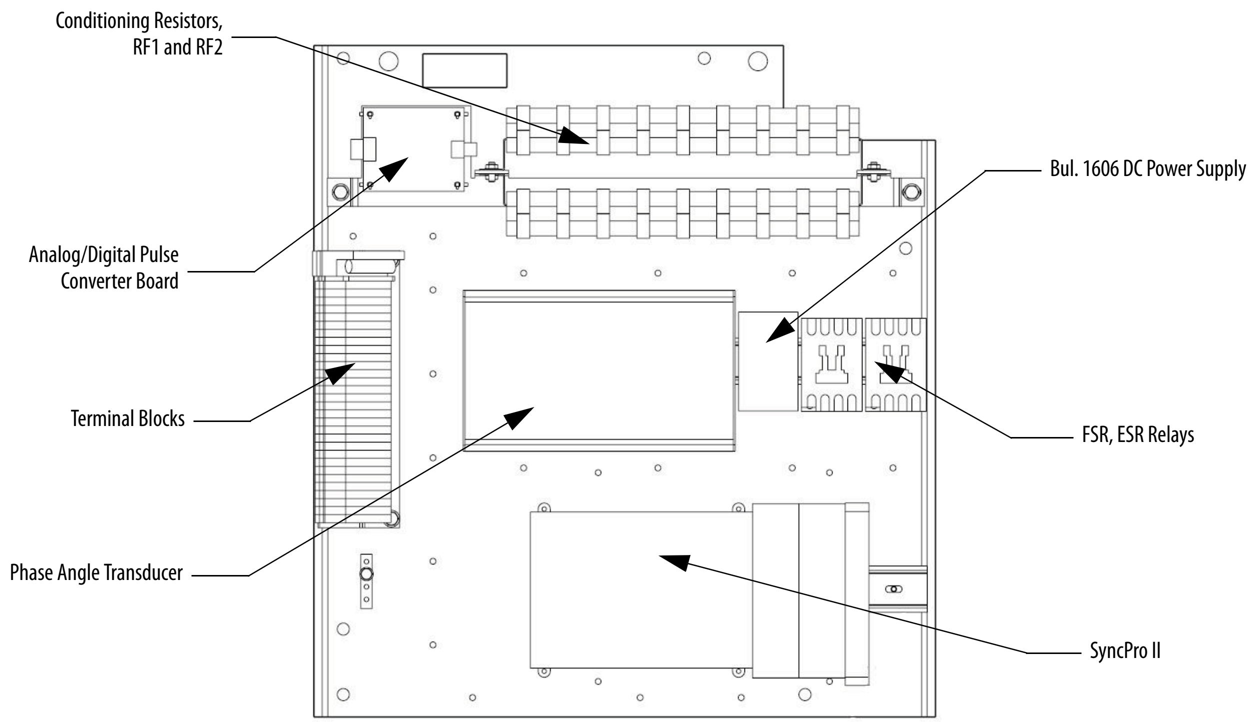


Figure 3 - Component Layout



Integral to a completed low voltage or medium voltage controller

The SyncPro II is also available as a component of a Rockwell Automation/Allen-Bradley synchronous motor controller, incorporating the components shown in Figure 3. Although the layout in the starter is different, control and functionality remain the same.

Grounding

The grounding required by the SyncPro II panel has been brought to a common grounding bar mounted on the panel. It is important that once the unit is installed, that this grounding bar is wired to the starter ground bus. It is important that a proper ground is made as the SyncPro II has a number of low voltage signals which, if not properly grounded, may be vulnerable to noise causing erratic operation.

Wiring Guidelines

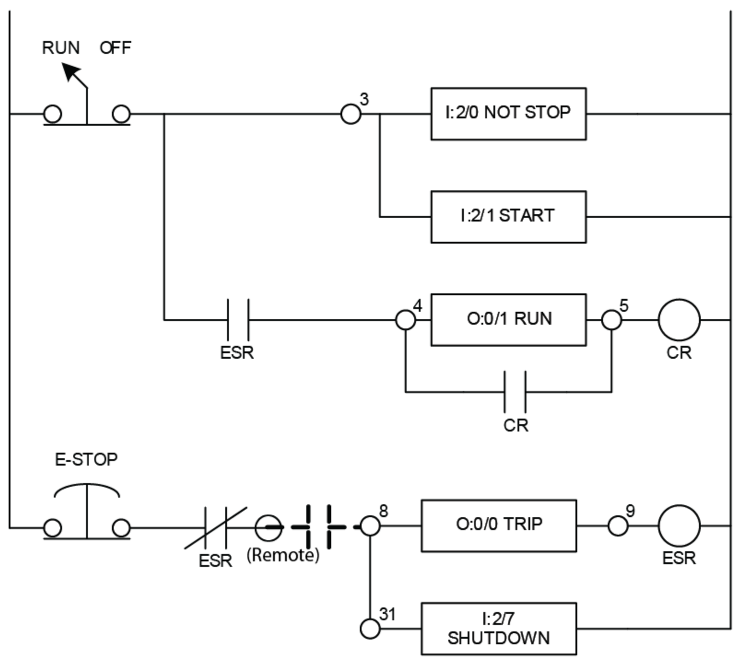
The SyncPro II can accept either two- or three-wire control. The control chosen will determine the configuration of the control hardware. Consider the following two inputs and single output when selecting the type of control:

I:2/0	NOT STOP input
I:2/1	START input
0:0/1	RUN output

If using two-wire control, the two inputs (I:2/0 and I:2/1) are tied together. They are both low in order to stop the SyncPro II (see Summary on page 32) and both high in order to run the device. To start the device after a fault, the START input (I:2/1) must be taken low and then closed again. In this configuration, the RUN output acts as a run command (see Figure 4).

If using three-wire control, the NOT STOP input must be maintained high in order to run the device. Momentarily opening this input will cause the SyncPro II to stop (see Summary on page 32). Momentarily closing the START input will start the SyncPro II (given that all permissives are satisfied). In this configuration, the RUN output acts as a start command (see Figure 5).

Figure 4 - Two-wire Control



In both cases, the RUN output will follow the state of the START input, provided that all starting conditions are met. Note that in all cases, stopping the motor is done via the hardwired control circuit logic, and notification only is given to the SyncPro II.

Figure 4 shows a typical two-wire control circuit. The selector switch is used to control the NOT STOP and the START as a pair. It is also used to ensure the motor is stopped via the hardwired control circuit logic, (even though in this case the RUN output will be removed when the selector switch is turned off).

The ESR circuit ensures the motor is stopped for any fault condition occurring either externally or when detected by the SyncPro II. Once the ESR has dropped out (detected by the loss of I:2/7), the selector switch must be switched off and on to initiate a start. This prevents a premature start if the fault condition is cleared and the selector switch is still in the run position.

Figure 5 shows a typical three-wire control circuit. The STOP PB must be maintained high in order to initiate a start and to run the system. The button also ensures that the motor is stopped via the hardware circuit. The momentary START PB is used to create a RUN (START) output signal of the same duration as the input signal as long as there are no faults detected by the SyncPro II.

Figure 5 - Three-wire Control

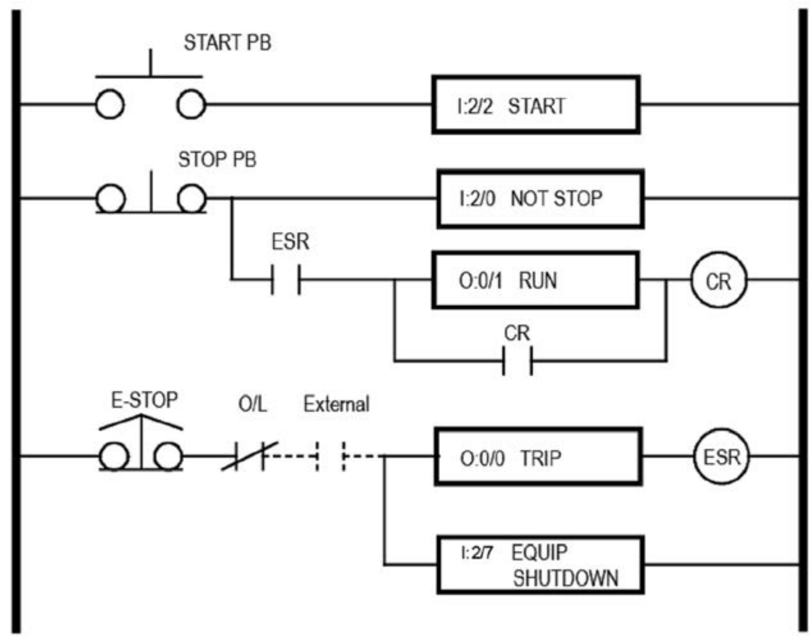


Figure 6 - Typical Wiring A

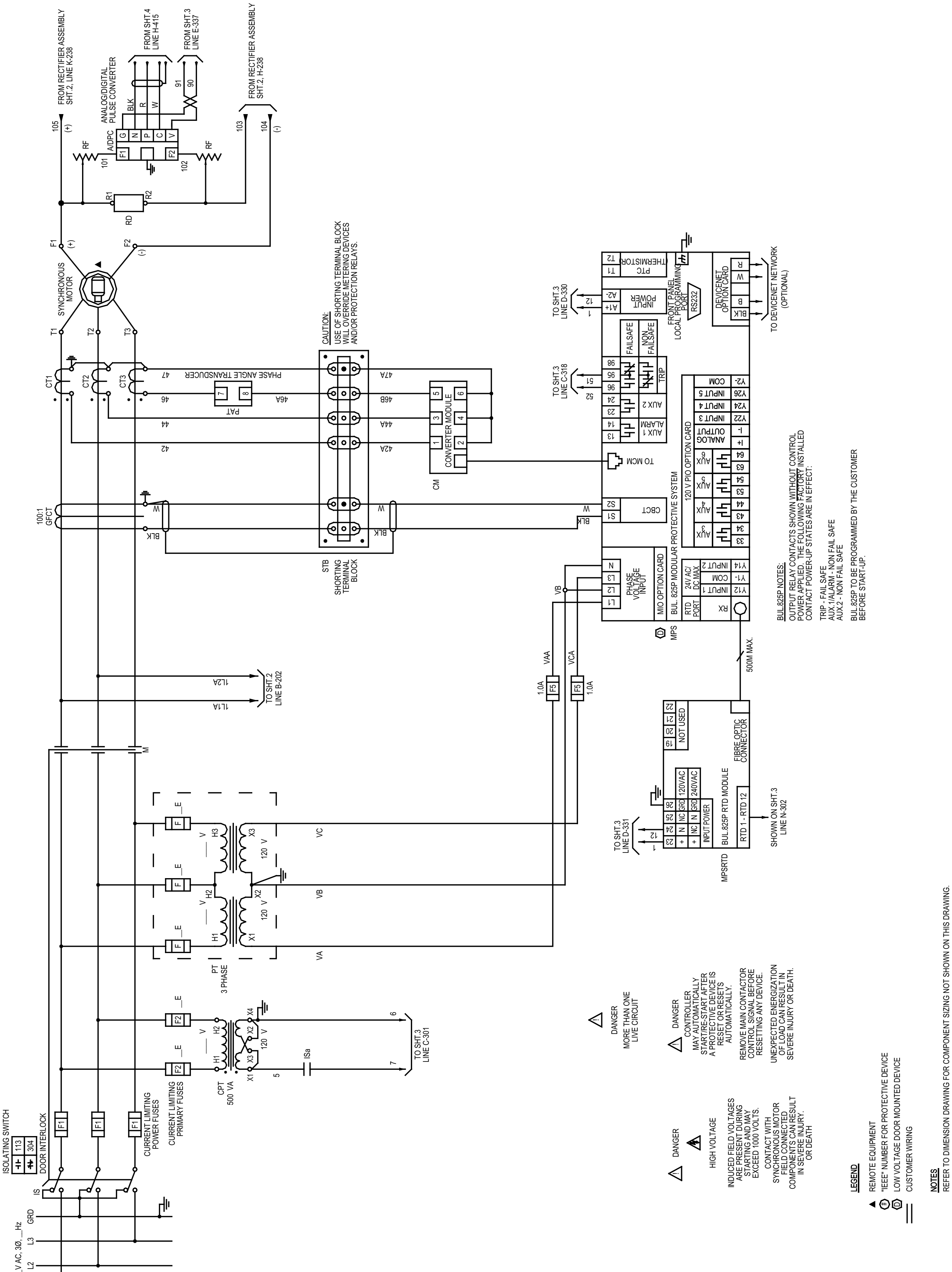


Figure 7 - Typical Wiring B

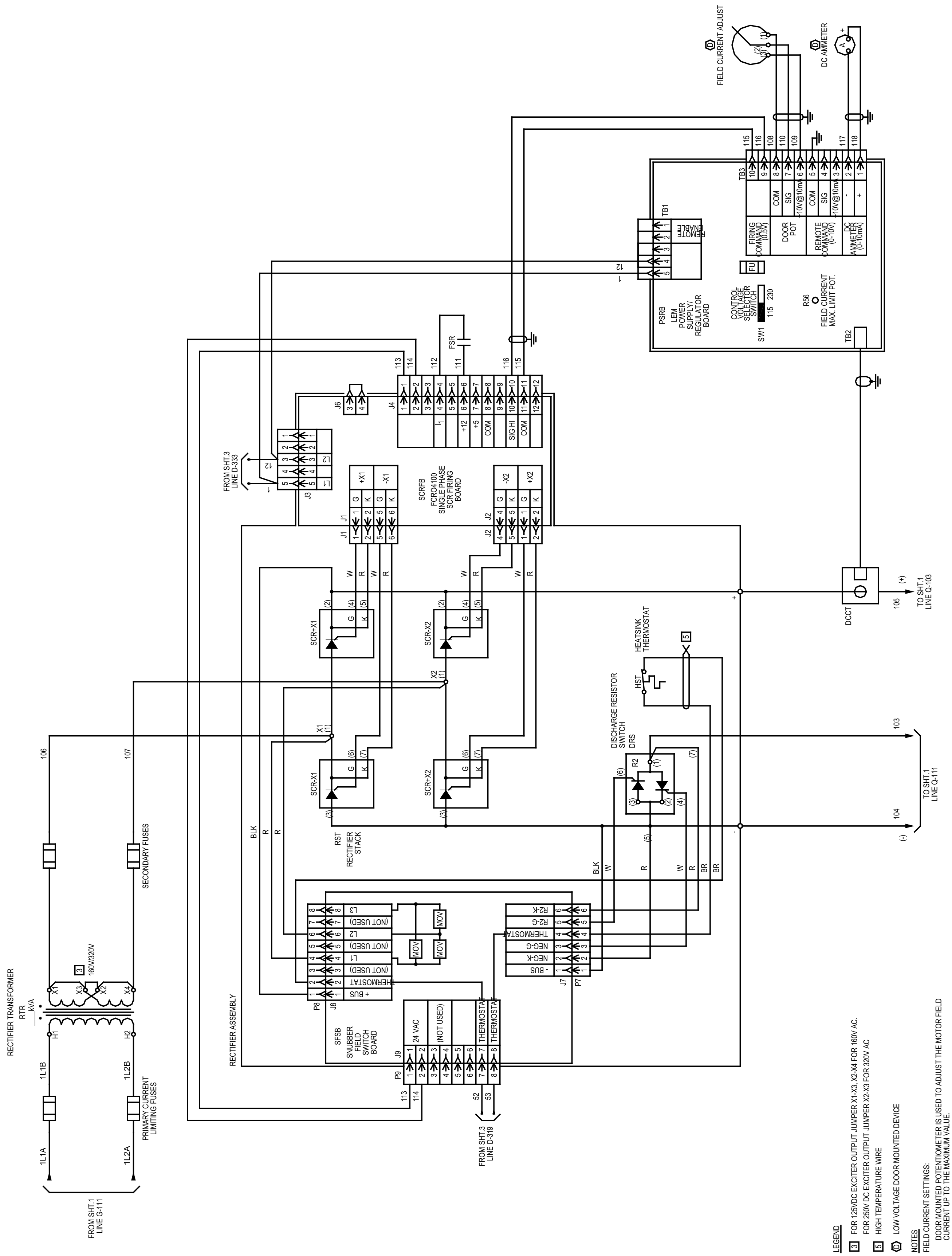


Figure 8 - Typical Wiring C

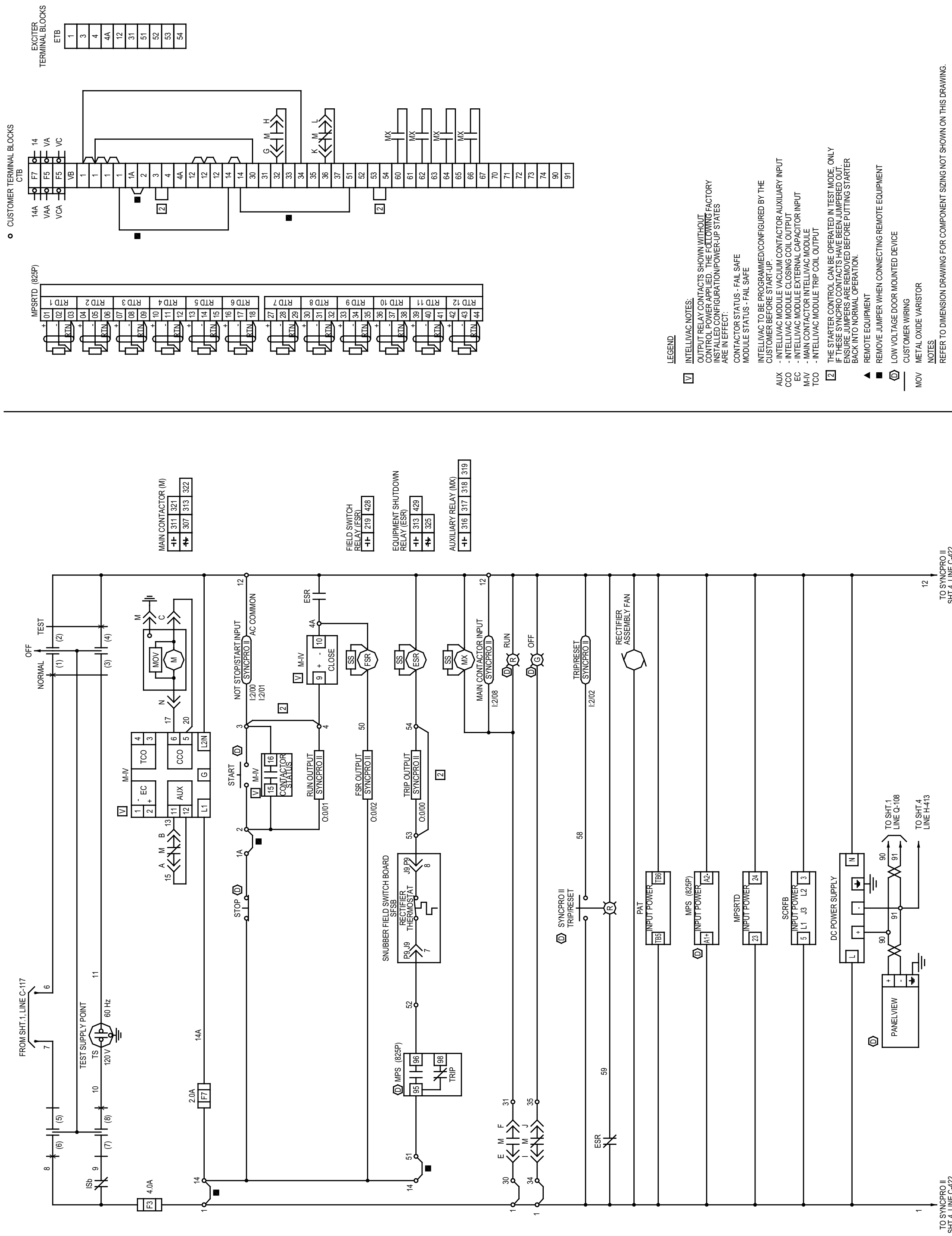
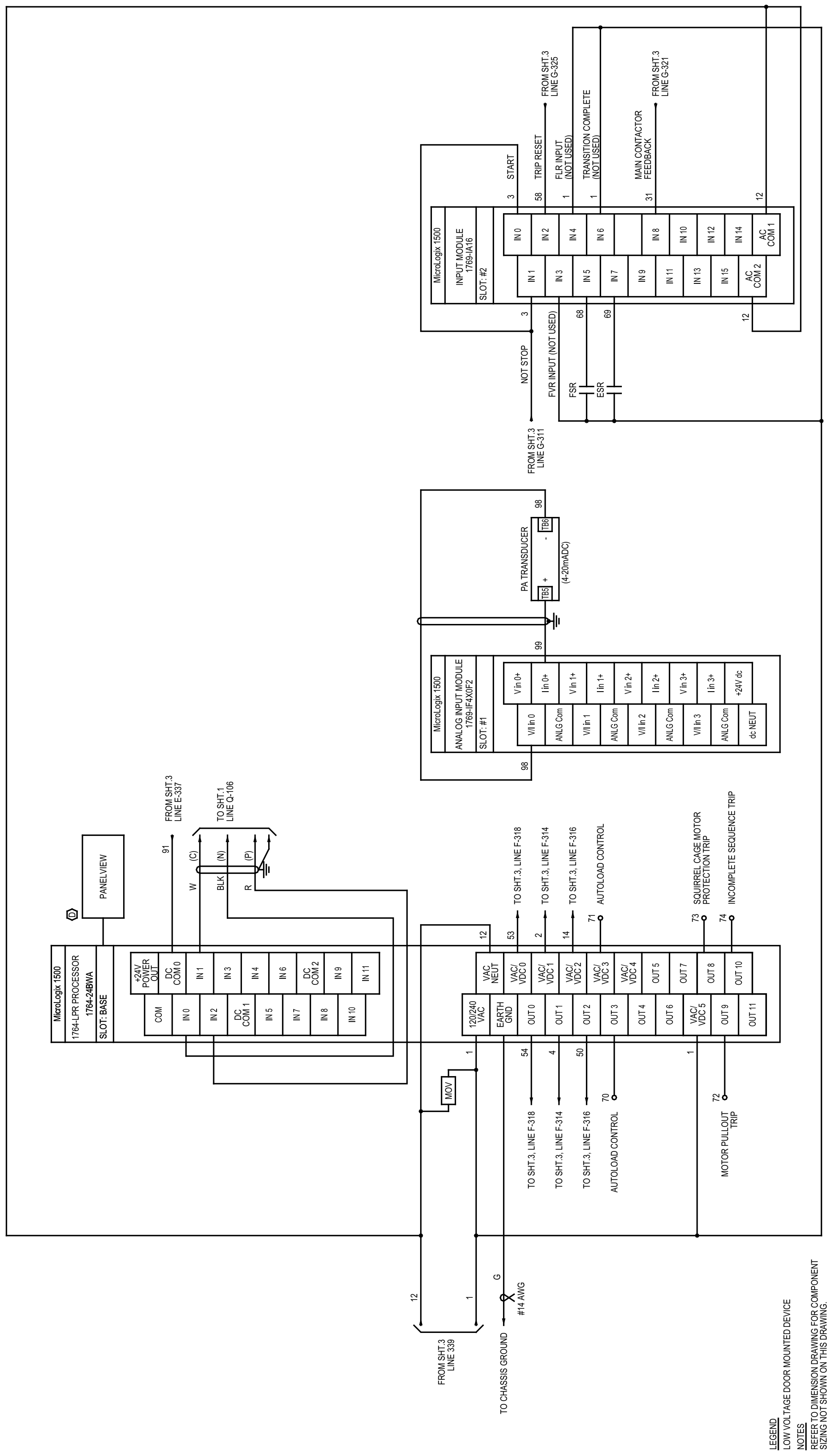


Figure 9 - Typical Wiring D



In this case (three-wire) since the START signal is only momentary, the hardware must perform the sealing function using the control relay, CR. The START output is really an extension of the START input, except that the output is conditioned by any fault conditions.

The ESR circuit ensures the motor is stopped for any fault condition occurring either externally or when detected by the SyncPro II. Once the ESR has dropped out, a start will not be permitted until the fault condition is reset.

It should be noted that in all cases, the TRIP output is removed when a fault is detected. This fault includes both external hardware faults (as recognized by the EQUIPMENT SHUTDOWN signal) and faults which are generated by the SyncPro II such as a power factor trip.

Summary

1. The RUN output will follow the state of the START input, given there are no faults detected by the SyncPro II.
2. Once a fault is detected, the START input must be taken low before the RUN output will be allowed to operate.
3. All motor stopping must be controlled by hardwired control circuit logic. The SyncPro II is only notified of the stoppage to determine what is happening. Any time the motor stops without first removing NOT STOP input, an error condition will be detected.
4. When using three-wire control, a contact from the CR relay must be used to seal in around the RUN output.

Setup and Commissioning

Setup

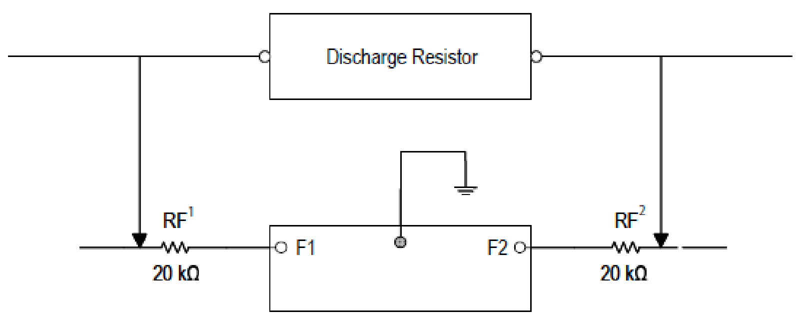
Check the following components of the SyncPro II once it has been installed.

RF1 & RF2 Resistor Setup

The synchronous motor field discharge resistor feedback resistors (RF1, RF2) are necessary to attenuate the induced voltage waveform which appears across the field discharge resistor during starting (Figure 11). The resistors (RF1, RF2) reduce the voltage which is seen at the terminals of the analog/digital pulse converter to a level which is acceptable to the optoisolators on the board. Guidelines for resistor settings are contained in Table 1 on page 36.

The resistance value shown is the amount of resistance which is required on each lead which is connected to the A/D pulse board (F1, F2). For example, if the induced voltage on the discharge resistor is 1000V at zero speed and 600V at 95% speed (across the entire discharge resistor), then it is necessary to select taps on the RF1 and RF2 to provide 20 kΩ at RF1 and 20 kΩ at RF2.

Figure 10 - Discharge Resistor Installation



These settings must be made prior to any start attempt.

Determining the induced voltage which will appear across the discharge resistor during starting can be done two ways.

1. If motor data is available the voltage can be determined by multiplying the discharge resistance by the induced currents at zero and 95% speed as given by the motor manufacturer.

EXAMPLE

Induced current @ 0% speed: 20 A

Induced current @ 95% speed:12 A

Discharge resistance: 50 Ω

Therefore:

Induced voltage @ 0% speed: 20A x 50 Ω = 1000V

Induced voltage @ 95% speed: 12A x 50 Ω = 600V

2. A measurement can be taken using a storage oscilloscope or a strip chart recorder, see publication 1900-2.10 for correct set point values. The waveform obtained will have a peak value which must be converted to an rms value. This is done by dividing the peak-to-peak value by $2\sqrt{2}$ or 2.828.

When doing this, a portion of the discharge resistor only should be used, 1 Ω can then be used to determine the value which will be on the entire resistor.

EXAMPLE

A strip chart recording is taken across a 1 Ω portion of a 50 Ω discharge resistor. The following peak to peak values are obtained:

0 speed: 56V p-p

95% speed: 34V p-p

Therefore:

0 speed rms voltage across 1 Ω	56 / 2.828 = 20V rms
95% speed rms voltage across 1 Ω	34 / 2.828 = 12V rms
0 speed rms current across 1 Ω	20V / 1Ω = 20A rms
95% speed rms current across 1 Ω	12V / 1Ω = 12A rms

Once the induced voltage has been determined, make the appropriate selection from Table 1 on page 36. Wires from each end of the discharge resistor should then be determined to the appropriate taps on the RF1 and RF2 resistors. Both the 0 and 95% speed induced voltages must fall between the upper and lower limits defined on the chart.

Procedure for Selection of Resistors

RD = Discharge resistance	___________ Ω
RSD = Sample resistance	___________ Ω
Vpp0 = 0% speed peak to peak voltage	___________ V (Vpeak@0)
Vpp95 = 95% speed peak to peak voltage	___________ V (Vpeak@95)
Vrms 0 = Induced voltage (0% speed)	___________ V (Vrms@0) Vp0/2.828
Vrms 95 = Induced voltage (95% speed)	___________ V (Vrms@95) Vp95/2.828
Io = Induced current (0% speed)	___________ A (Arms@0)Vrms0/Rs
I95 = Induced current (95% speed)	___________ A (Arms@95)Vrms95/Rs
V0 = Induced voltage (0% speed)	___________ V I0 x Rd
V95 = Induced voltage (95% speed)	___________ V I95 x Rd
0 speed induced voltage across the entire discharge resistor	50 Ω * 20 A= 1000V
95% speed induced voltage across the entire discharge resistor	50 Ω * 12 A = 600V
RF1/RF2 Resistance Required	___________ Ω

RF1 & RF2 Resistor

"RF" Resistor tap settings

Figure 11 - Discharge Resistor Setup

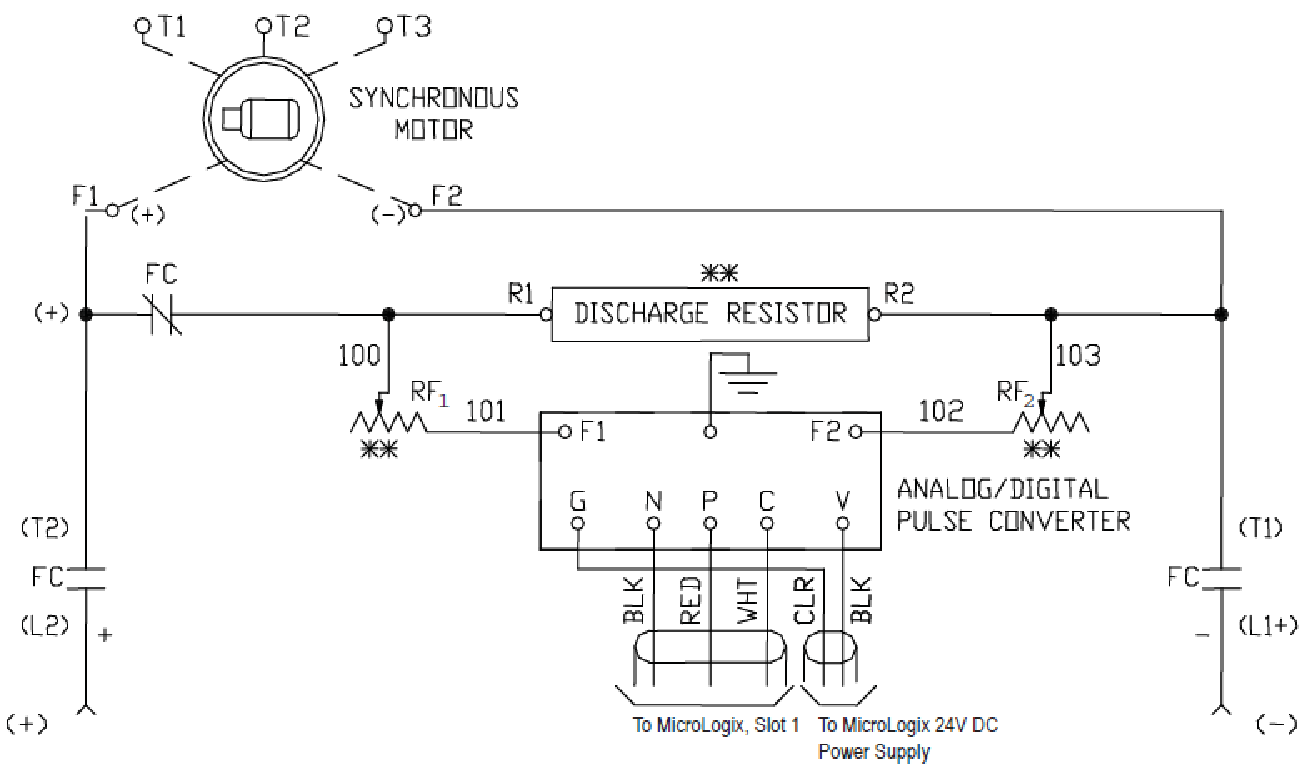


Table 1 - Feedback Resistor Values • Synchronous Field Feedback Board

RF1/RF2 Resistance (KΩ)[1]	Usable Voltage Range	
	Lower Limit	Upper Limit
2.5	80	160
5	160	320
7.5	230	480
10	320	640
12.5	400	800
15	490	950
17.5	560	1100
20	640	1300

(1) Resistance value is per resistor (two required).

Motor induced currents will cause a voltage to be produced across the synchronous motor starter field discharge resistor. This voltage is connected to the feedback resistors and the tap to be selected on these resistors is dependent on this voltage level. For example, if the discharge resistor value is 20 Ω and the induced currents are 30 A at 0 speed and 18 A at 95% speed, then the induced voltage seen by the feedback resistors will range from 600V (0 speed) to 360V (95% speed). The selection would then be 10 kΩ on each of the two resistors.

In the event that the induced voltage proves to be higher than allowed by the chart, it will be necessary to tap the field discharge resistor at a point which will allow the value to fall within the chart. Contact Rockwell Automation for assistance at 1-519-740-4790.

Commissioning

1. Complete and verify that the setup procedures (see page 33) have been completed. This should include verifying that the parameters programmed into the SyncPro II are appropriate for the motor. See Chapter 5 for further details on programming.
2. Verify that the SyncPro II has been wired into the motor starter circuit as indicated by the wiring diagram.
3. Remove the wire from the Field Contactor Relay (FCR) coil either at the I/O point (0:0/2) or at the FCR coil itself. Tie back and insulate the wire so that it cannot accidentally short out to ground or another electrical point. This will disable the field contactor so that the starter will not attempt to synchronize.

IMPORTANT	The contactor must be disabled in this manner rather than removing the field cables from the contactor. The discharge path through the discharge resistor must be maintained; otherwise, a voltage high enough to damage the field insulation will occur at the open field windings. This is similar to the effect which occurs if a current transformer secondary winding is left open circuited.

4. If during the previous setup procedure for the discharge resistors RF1 and RF2, the induced currents were not known, then the next step would be to bump the motor with the RF1 and RF2 resistors disconnected. The method detailed in publication 1900-2.10 for determining the motor data by measurement using a strip chart recorder should be done at this time. The RF1 and RF2 resistors should then be set up as shown in Figure 11 with the data obtained. It is necessary to use jumpers at the SyncPro II trip output, and the run output, for the motor bump.

ATTENTION: During the jogging procedure, the SyncPro II does not protect the motor. Monitor the procedure closely to avoid damage to the motor.

ATTENTION: Do not use jumpers at the ESR contact as this will also eliminate any external protective trips such as line overcurrent, fault protection, etc. which are still necessary for the bump. See Figure 8 for the jumper placement, and the points at which to disconnect the wires.

ATTENTION: During synchronization, voltages that may exceed 1000 volts are present at the Rf1 and Rf2 resistors. To avoid shock hazard, do not touch the resistors.

The phase angle transducer, as wired from the factory, is set up for the customer to run his wiring with an ABC line orientation. If this was not observed, the user has two options. First, the line cables can be moved (switching any two incoming lines will do) so that ABC now exists (BCA or CAB are also acceptable), OR the current transformer leads to the transducer can be swapped at the transducer.

5. If the RF1/RF2 connections were removed for step 4, they should now be reconnected at this point and set to the appropriate tap. The motor may now be bumped for rotation. Allow the motor to accelerate to rated subsynchronous speed and monitor the following items at this time.
   - The time to accelerate to rated subsynchronous speed
   - The point at which the I/O point 0:0/2 picks up (which normally would energize the field contactor) occurs to see if it appears to be occurring at 95% speed
   - Monitor Power Factor during acceleration. It should be lagging.
   - This will also prove that the power factor transducer connection is in the correct orientation with the incoming current and voltages. If the polarity is incorrect, switching the C3A and C3B connections should correct the situation.

The phase angle transducer connections are correct provided that the transducer power and voltage reference inputs are connected to Line 1 and 2 and the current reference is Line 3. If the incoming connections into the starter have been made B-A-C, rather than A-B-C, the polarity will also be incorrect even though the correct starter lines have been brought to the transducer. In either event, the correction is the same, reverse the C3A and the C3B current transformer connections.

> ⚠ **ATTENTION:** To avoid damage to the motor, do not allow the motor to run without synchronizing (at 95% speed) for longer than required to perform this test. Most motors are only capable of running for about 60 seconds at 95% speed without synchronizing.

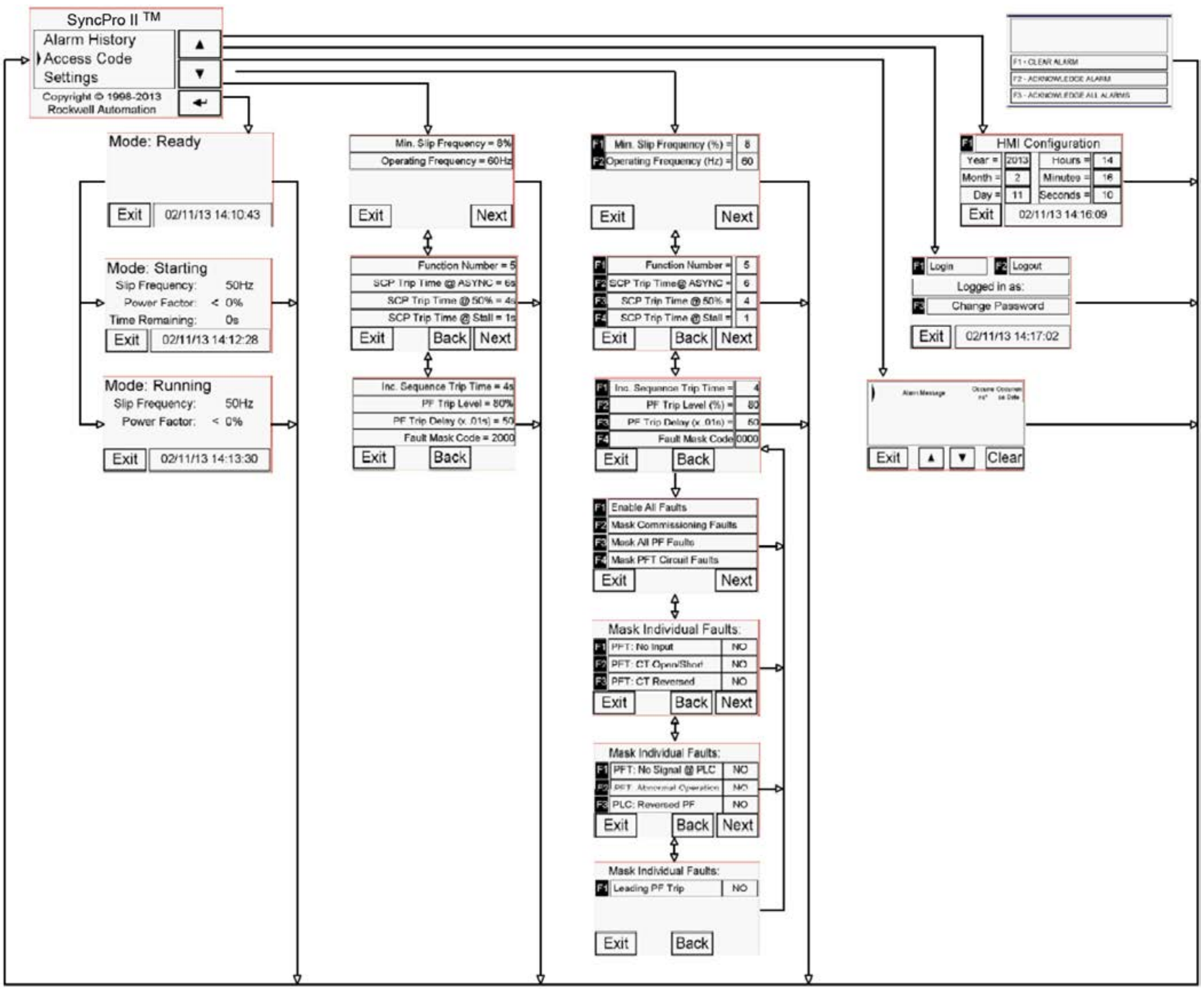
6. After completing the actions in Step 5, if the equipment appears to be operating in the correct manner, then the leads can be reconnected to the FCR coil which was removed in Step 3.
7. The motor can now be normally started. Once the motor has synchronized, a good check is to vary the DC excitation. Verify that when the DC current to the field is reduced, the motor power factor becomes more lagging and if increased, the motor power factor becomes more leading. Verify that the MicroLogix is getting all the inputs according to the circuit diagram.

Programming SyncPro II

Overview

The SyncPro II programming is performed via the PV300 display unit provided. The SyncPro II menu structure has been designed to optimize workflow. Please refer to Menu Map below.

Figure 12 - Programming Menu Map



Main Menu

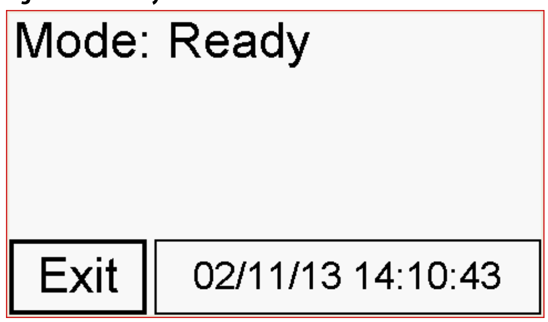
The main menu provides access to the following screens.

SyncPro II Status	Provides idle, starting, running status information
View Set Points	Allows viewing of SyncPro II operation and protection set points.
Edit Set Points	Allows viewing of SyncPro II operation and protection set points
Alarm History	Lists alarm/fault history recorded with relative time stamping
Access Code	Allows users to log in or log out to provide access control to operation and protection set points.
Settings	Allow editing of general HMI configuration such as language, relative time/date stamp

SyncPro II Status

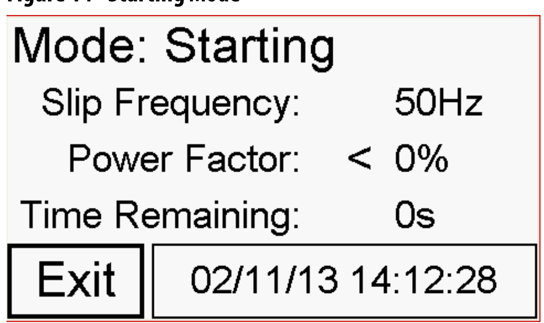
These screens are displayed when the motor is idle, starting, or running. The PVc C400 automatically switches to one of the following screens after a period of inactivity.

Figure 13 - Ready Mode



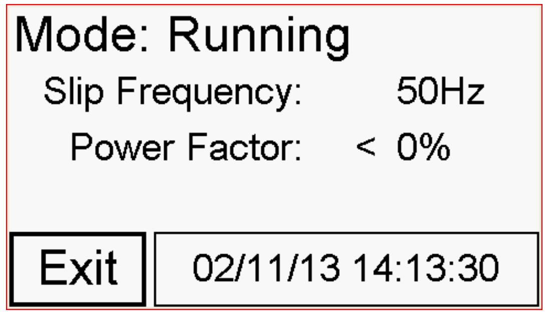
Ready mode (Figure 13) indicates the SyncPro II has not detected any software or hardware faults and is ready to start.

Figure 14 - Starting Mode



During the *Starting* mode (Figure 14), the motor slip frequency in Hz power factor in %, and time to a squirrel cage protection in seconds are displayed. The power factor value is accompanied by either a < or > symbol to indicate lagging or leading power factor. Typical power factor readings during staring are lagging. If leading power factor is displayed, please confirm voltage and current input connections for proper sequencing (e.g. V_{ab}, I_c).

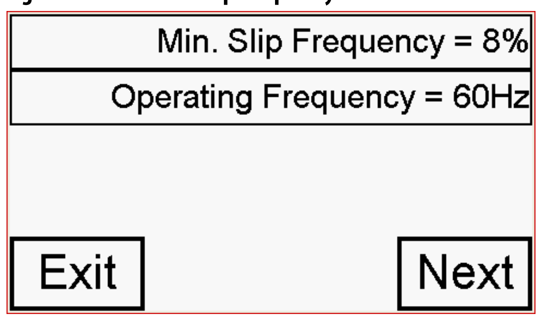
Figure 15 - Running Mode



In the *Running* mode, the slip frequency and power factory is displayed. During normal operation, the slip frequency is 0 Hz, and power factor is approximately 100% for unity.

View Set Points

Figure 16 - Minimum Slip Frequency



Set Point 1: Minimum Percent Synchronous Slip Frequency

This set point determines the percentage of synchronous speed at which the DC voltage is to be applied by the field switch/contactor. The SyncPro II monitors the frequency of the induced voltage across the discharge resistor during starting. When this frequency indicates that the motor has achieved the desired sub synchronous speed at which it is allowable to synchronize, the SyncPro II energizes the coil of the field switch/contactor. The SyncPro II ensures that the application of the field contactor coincides with the rising edge of the induced voltage waveform which makes for a smooth transition. If the motor pulls into synchronism due to reluctance torque, the SyncPro II will detect no pulses and then will apply DC voltage to the field after a one second delay.

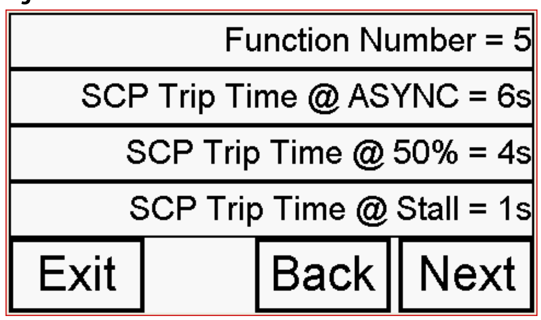
$$SP_1 = \frac{f_{Minimum\_slip}}{f_{operating}}$$

Set Point 2: Operating Frequency

This set point determines the operating system frequency. This allows the SyncPro II to properly determine the appropriate minimum percent slip frequency.

$$SP_2 = f_{operating}$$

Figure 17 - Function Number



Set Point 3: Function Number

The function number entry determines the slope of the curve between the 50% speed trip time and the 95% speed trip time – set point 4 and 5. Although the trip time is set as 50% and 95% speed, the intermediate points between these values can be shaped to cause the trips for 51% and 94% to occur more or less quickly depending on which function number is selected. According to Figure 17, more time is allowed when function 1 is selected, and less time is allowed when function 5 is selected.

$$SP_3 = F(f, t_a, t_b)$$
$$SP_3 = t_b \text{ ,if } f < f_{50\%}$$
$$SP_3 = t_a \text{,if } f_{50\%} \le f < f_{sp2}$$

$$M = \frac{t_{sp5} - t_{sp6}}{f_{50\%} - f_{sp6}}, \quad B = t_{sp6} - Mf_{sp2}$$

$$k_a = \frac{(f_{50\%} - f_{sp1})^x}{t_{sp4} - Mf_{sp1} - B}, \quad k_b = \frac{(f_{50\%} - f)^x}{k_a}$$

$$ta = Mf + B, \quad t_b = t_a + k_b$$

Table 2 - Function Numbers

Variable	Function Number
t_{sp4}	Squirrel-Cage Protection Trip Time (at 95% speed)
t_{sp5}	Squirrel-Cage Protection Trip Time (at 50% speed)
t_{sp6}	Squirrel-Cage Protection Trip Time (at stall)
f	Detected slip frequency
f_{sp1}	Minimum Percent Synchronous Slip Frequency
$f_{50\%}$	Squirrel-Cage Protection Trip Frequency
f_{sp2}	Operating Frequency

Set Point 4: Squirrel-Cage Protection Trip Time (at 95% speed)

This time setting determines the maximum length of time the synchronous motor may run at 95% speed before it is shut down. The squirrel-cage winding of the synchronous motor is not rated to run the motor continuously even at no load and therefore must be shut down if synchronism does not occur. Time should be set to motor manufacturer's specifications.

$$SP_4 = t_{sp4}$$

Set Point 5: Squirrel-Cage Protection Trip Time (at 50% speed)

It is possible that a synchronous motor can accelerate only to an intermediate speed and either not accelerate further or take too long to accelerate further due to overloading. This would cause the squirrel-cage windings to overheat if allowed to continue unchecked. This setting limits the time that the motor can operate at 50% speed to the safe maximum recommended by the manufacturer.

$$SP_5 = t_{sp5}$$

Set Point 6: Squirrel-Cage Protection Trip Time (at stall)

In the event that a synchronous motor fails to accelerate at start up it will go into a stall condition at zero speed. This can occur if the motor is overloaded at start. The time entered at this set point should be the maximum allowable stall time on the Squirrel-Cage Winding as defined by the motor manufacturer.

$$SP_6 = t_{sp6}$$

IMPORTANT	The squirrel-cage winding of a synchronous motor has a very limited capability. Generally, the stall time allowed by the squirrel-cage winding is less than the time that the stator winding is capable of. It is possible that a motor with a stator capable of a 20 second stall would have a rotor which can only endure a stall condition of 5 seconds.

Set Point 7: Incomplete Sequence Trip Time Delay

Once a synchronous starter has been commissioned, the acceleration and synchronization times should remain fairly consistent provided that the starting load does not vary significantly. The incomplete sequence timer can be set to a time delay that is slightly higher than the slowest acceleration time. The aforementioned squirrel-cage protection features protect the motor, but they also let it go to its thermal limitations. The Incomplete Sequence Timing Relay (ISTR) set point can be adjusted to take the starter off-line earlier than the squirrel-cage protection trip time (set point 5) in the event of a field contactor failure or some other mechanical problem that prevents synchronization. This action minimizes motor heating during an equipment failure.

$$SP_7 = t_{IST}$$

Set Point 8: Power Factor Trip

As discussed earlier, power factor can be sued to determine if a motor has pulled out of synchronism due to loss of excitation, overloading or a severe undervoltage. At this time, the motor should be taken off line to protect the stator and field.

$$SP_8 = PF_{trip}$$

Set Point 9: Power Factor Trip Time Delay

Once it is determined that the motor has a lagging power factor due to a pullout condition, the trip condition can be time delayed to allow the motor a brief opportunity to pull back into synchronism.

$$SP_9 = t_{PF\_Delay}$$

Set Point 10: Diagnostic Fault Mask

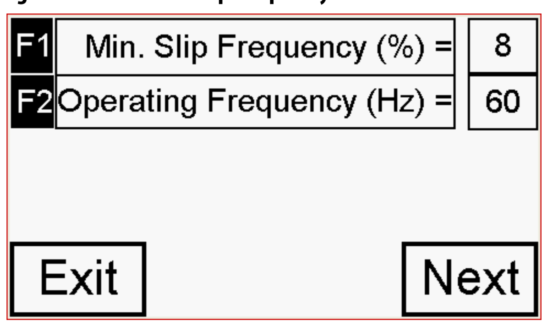
This parameter/screens are used to define a fault mask code that will disable individual diagnostic faults. The value is based on the 16 bit Fault Mask Word. Please refer to Edit Set Points section for additional information.

Table 3 - Mask Description

Code	Mask Description
0	Enable All Faults
272	Mask Commissioning Faults
2000	Mask All Power Factor Faults
1984	Mask Power Factor Transducer Circuit Faults
64	Mask Power Factor Transducer No Input Fault
128	Mask Power Factor Transducer CT Open/Shorted Fault
256	Mask Power Factor Transducer CT Input Reversed Fault
512	Mask Power Factor Transducer No Signal at PLC Fault
1024	Mask Power Factor Transducer Abnormal Operation Fault
16	Mask PLC Reversed Power Factor Fault

Edit Set Points

Figure 18 - Minimum Slip Frequency



Set Point 1: Minimum % Synchronous Slip Frequency

Allowable Range: 2…10% (slip at which synchronization will occur as a percentage of synchronous speed)

Factory Default setting: 5% (95% speed)

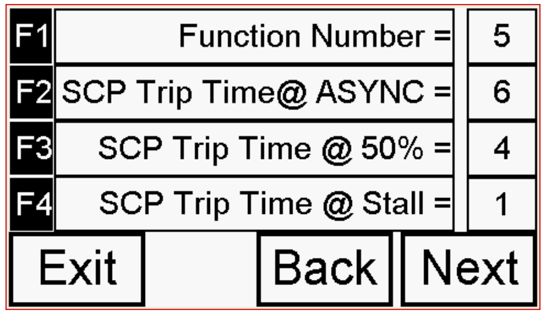
Typically set at: 5%

Set Point 2: Operating Frequency

Allowable Range: 50 or 60 Hz

Factor Default: 60 Hz

Figure 19 - Function Number



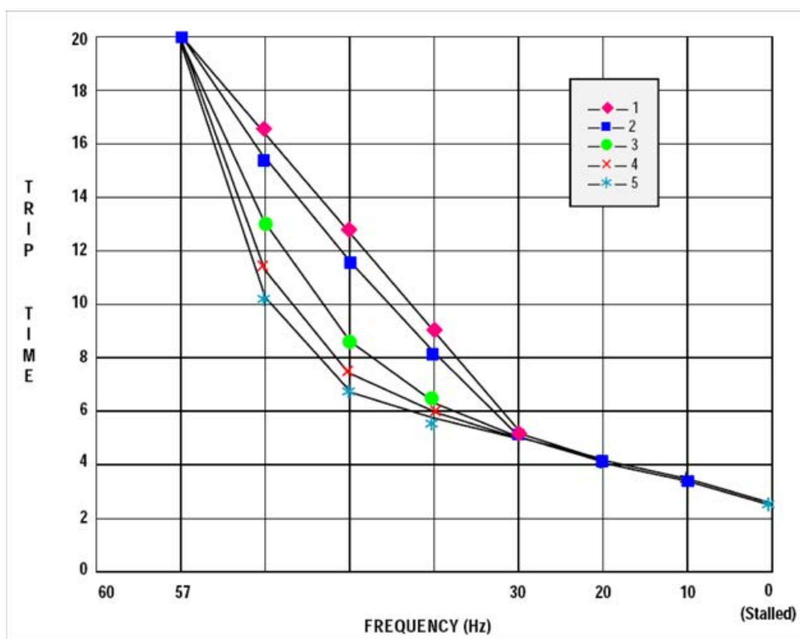
Set Point 3: Function Number

Allowable Range: 1…5

Factory Default Setting: 3 (Function curve 3)

In the example below the 50% speed has been set to 5 seconds, and the 95% speed is set to 20 seconds for a 60 Hz system.

Figure 20 - Trip Time



Set Point 4: Squirrel-Cage Protection Trip Time (at 95% speed)

Allowable Range: 5…80 seconds

Factory Default Setting: 5 s (5 seconds)

Set Point 5: Squirrel-Cage Protection Trip Time (at 50% speed)

Allowable Range: 2 s to Value in Set Point 4

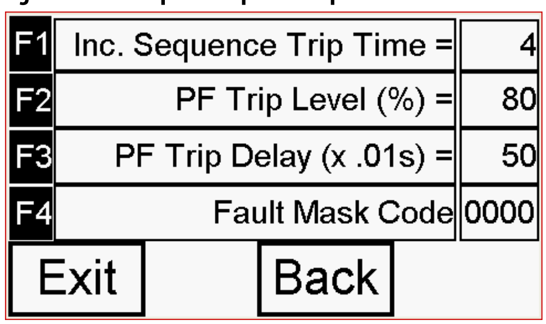
Factory Default Setting: 2 s (2 seconds)

Set Point 6: Squirrel-Cage Protection Trip Time (at stall)

Allowable Range: 1 s to Value in Set Point 5

Factory Default Setting: 1 s (1 second)

Figure 21 - Incomplete Sequence Trip Time



Set Point 7: Incomplete Sequence Trip Time Delay

Allowable Range: 1…80 seconds

Factory Default Setting: 3 seconds

Set Point 8: Power Factor Trip

Allowable Range: 60…100 (% of unity)\

Factory Default Setting: 80 (0.8 lagging power factor)

Set Point 9: Power Factor Trip Time Delay

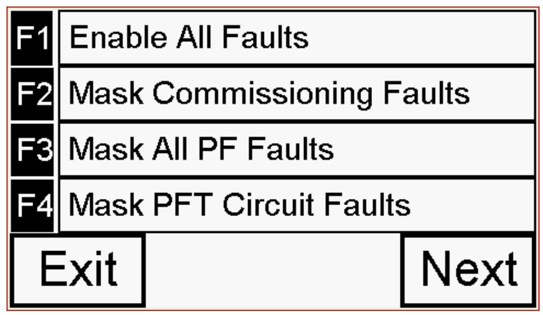
Allowable Range: 0…100 s (0.01 second units)

Factory Default Setting: 50 s (0.5 second delay)

Set Point 10: Diagnostic Fault Mask

The Fault Mask value can be calculated by selecting either a Fault Mask groups or individual faults. When switching between mask groups it is recommended that the fault code be cleared/reset by selecting “Enable All Faults”.

Figure 22 - Diagnostic Fault Mask



Either group or individual mask can be used at one time. The resultant fault mask code will be function of the 16 bit fault mask word use. It is possible to selectively mask individual faults by adding up the fault values and entering the result. For example, to disable the Reversed PF at Syncpro II and No Signal at Syncpro II, the mask value would be 528 (16 +512). Refer to Table 4 on page 49 for additional information.

Figure 23 - Mask Individual Faults

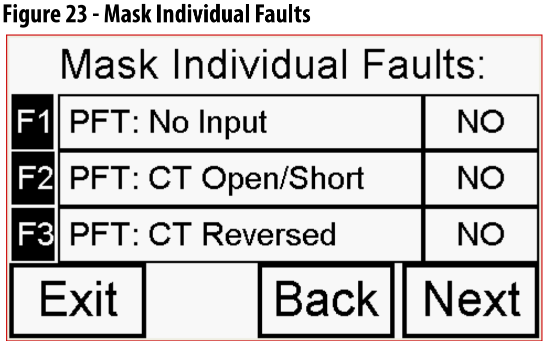


Figure 24 - Individual Faults

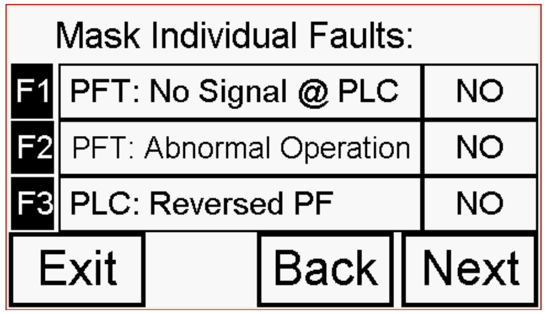
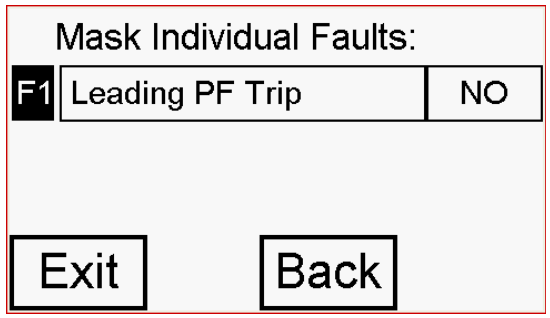


Figure 25 - Individual Faults (cont'd)



The value entered during prompting may not be the same value displayed if the value can be represented more clearly by some other combination of faults, i.e. The value of 272 (16 + 256) corresponds to 1.

Table 4 - Fault Mask Word

Mask Code	Fault Mask Word (16bit)																Mask Description
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Enable All Faults
272	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	Mask Comm. Faults
2000	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	Mask All PF Faults
1984	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	Mask PFT Circuit Faults
64	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	PFT: No Input
128	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	PFT: CT Open/Short
256	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	PFT: CT Reversed
512	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	PFT: No Signal @ PLC
1024	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	PFT: Abnormal Operation
16	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	PLC: Reversed PF

Alarm History

The Alarm Banner screen will appear if any alarm condition exists in the system. The screen provides three user options:

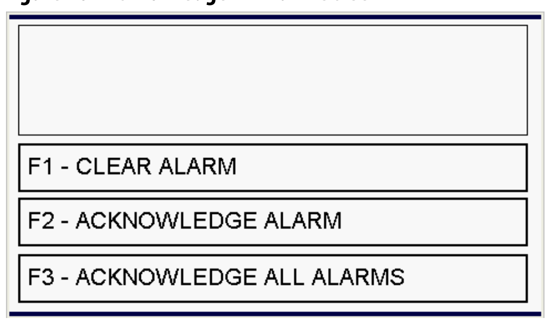
- Clear Alarm
- Acknowledge Alarm
- Acknowledge All Alarms

The clear Alarm option will remove the currently displayed fault and not record the fault in the Alarm History.

The Acknowledge Alarm option will remove the currently displayed fault and record the fault in the Alarm History with the relative time stamp. After a single alarm has been acknowledged, the next unacknowledged on if any will appear on the screen. If none unacknowledged alarms are left and all faults have been cleared the Main Menu Screen will be displayed.

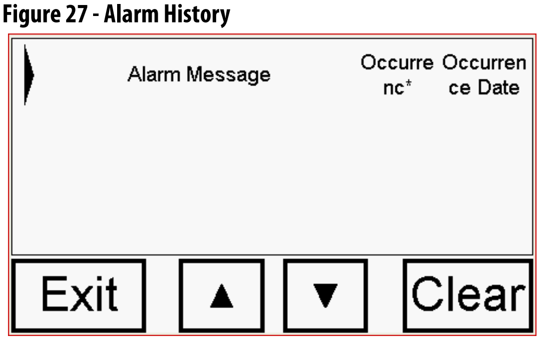
The Acknowledge All Alarm option will remove the currently displayed fault along with all additional faults in the fault stack/buffer and record all the fault(s) in the Alarm History with the relative time stamp.

Figure 26 - Acknowledge All Alarm Screen



The Alarm History Screen displays all the acknowledged alarms with date and time. Using the arrow keys you can scroll through up to 50 previous alarm conditions. The Alarm History may be cleared with the Clear key.

Figure 27 - Alarm History

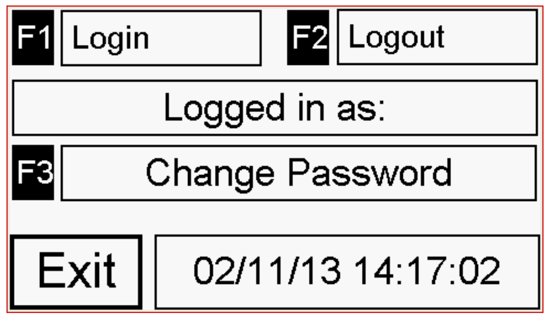


Access Code

The Access Code Screen allows authorized users to log in to secured screens and modify their own password. To log in, press the F1 key and enter your user ID and password using the alphanumeric keypad that opens during a login request. Login is successful if the "Logged in as:" indicator displays the correct username.

To change your password, press F3 and enter the current and new password to make the change. If both passwords match, then it successfully changes. Press F2 key to log out in the end of the session. The "Logged in as:" indicator username will disappear.

Figure 28 - Log In/Log Out

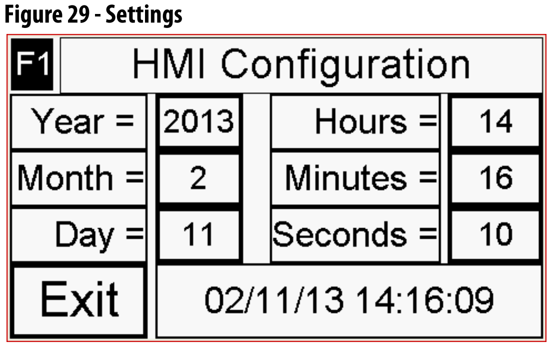


Prior to programming the unit a user must log in with full access writes. The default administrator (admin) Access Code is "12345". It is recommended this be changed during product commissioning.

Settings

The Settings Screen provides access to PVc C400 built-in HMI configuration screen and offers capability to set up SyncPro II relative time stamp. Please not that the time stamp is reset when power is removed.

Figure 29 - Settings



Notes:

Monitoring

Phase Angle/Power Factor

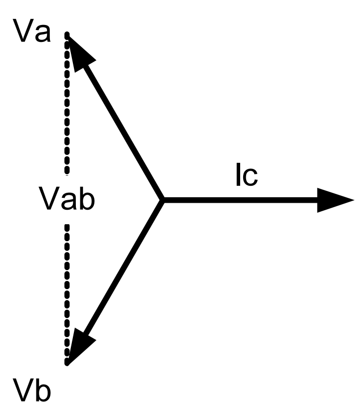
A key protection component of the SyncPro II is to monitor Power Factor. Monitoring Power Factor is one of the most reliable methods to determine if a motor is running properly. The SyncPro II system utilizes a Phase Angle Transducer which provided a proportional signal to the measured phase angle (angle difference between motor voltage and current).

The phase angle transducer board provides a 4…20mA output proportional to -90…90°. The SyncPro II utilizes this input to calculated Power Factor.

$$PF = Cos(\theta)$$

To provide an accurate measurement the voltage and current inputs must be in the proper relationship, V_{ab} and I_c.

Figure 30 - Voltage and Current Inputs Relationship



Faults

Fault Detection and Diagnostics

The product incorporates numerous fault detections in addition to the starting squirrel-cage protection and running pullout protection previously mentioned.

Prior to starting the motor, diagnostics are performed that detect the:

a. Lack of 24V supply to the slip frequency generator.
b. Reversed Power Factor Leads between the SyncPro II and tansducer.
c. Lack of the EQUIPMENT SHUTDOWN (external fault) signal.
d. Loss of Setpoint Data.

Upon starting the motor, additional diagnostics are performed. Any of these conditions will abort the start. Diagnostics performed are:

a. Lack of either pulse signal from the slip frequency generator.
b. Lack of field voltage or field current (if applicable).
c. Power Factor Transducer Circuit Fault.

Power Factor Circuit Fault

This fault covers a number of possibilities such as reversed leads at the CT, shorted CT input, loss of control power to transducer or a faulted transducer.

An incomplete start sequence timer (setpoint 7) is utilized to abort the starting if abnormal long periods are encountered. This time is set independent of the squirrel-cage protection times.

While the motor is running, the motor is protected by monitoring fault conditions for:

a. Loss of synchronization. Minimum power factor lag is selectable, as is the duration of running.
b. Loss of feedback from the field contactor.
c. Loss of the EQUIPMENT SHUTDOWN caused by an external fault.

In all cases, faults are displayed on the PanelView 300 and can be reset via the RESET push button.

Troubleshooting

Last Trip Table

To aid in troubleshooting, the unit stores the last 50 recorded faults. These can be accessed by viewing the contents of the alarm history.

Table 5 - Troubleshooting Guide

Problem or Trip Indicated	Indication of the following conditions	Possible Solutions
Pullout trip (power factor) [PULL OUT TRIP (POWER FACTOR)]	• Motor overloaded • Loss of DC excitation • Static exciter DC current level set too low	• Lessen the motor loading and/or overload • Repair static exciter • Increase current setting on static exciter if lagging • Decrease current setting on static exciter if leading • Mask leading power factor trip if application/ motor is designed for it
Squirrel-cage Protection Trip [SQUIRREL-CAGE PROTECTION TRIP]	• Motor overloaded at start	• Remove or lessen load for start
Incomplete Start Sequence Time Exceeded [INCOMPLETE START SEQUENCE TRIP]	• Motor overloaded at start • Field contactor or FC pilot relay coil failure	• Remove or lessen load for start • Replace coil(s)
No Transducer Input [POWER FACTOR XDCR – NO INPUTS]	• The transducer is putting out less than 12 mA when the motor is off (should be 12 mA)	• Check the wiring for the voltage sensing on the transducer board. • Replace phase angle transducer board if necessary. • Replace analog card in SyncPro II chassis
CT Open/Shorted [POWER FACTOR XDCR – CT OPEN/SHORT]	• The CT is either open or shorted.	• Check the wiring between the CT and the transducer board. • Replace the CT if necessary.
CT Reversed [POWER FACTOR XDCR– CT REVERSED]	• The CT is incorrectly wired to the transducer board.	• Reverse the leads of the CT at the transducer board.
No Signal @ SLC [POWER FACTOR XDCR– NO SIGNAL AT PLC]	• There is no signal at the PLC analog card from the PF transducer board.	• Check the wiring between the transducer board and the PLC analog card. • Ensure that there is power to the transducer board. • Replace the PLC analog card or transducer board as required.
Transducer Problem [POWER FACTOR XDCR CIRCUIT FAULT]	• The transducer is behaving unpredictably.	• This is an all-encompassing fault and could include anything from the CT, the transducer board, or the PLC analog card

Table 5 - Troubleshooting Guide (Continued)

Problem or Trip Indicated	Indication of the following conditions	Possible Solutions
Pulse Board 24 V Failure [PULSE BOARD 24 VDC FAILURE]	• Connection has not been made between the analog/digital pulse board and the SyncPro II DC input card or from the discharge resistor to the same A/D pulse board. • 24VDC power supply has had a failure	• Check the connections at the A/D pulse board. • Check fuse in power supply. Check for 24 V at power supply. Replace power supply if necessary. • Replace A/D pulse board.
Field Voltage Loss [FIELD VOLTAGE LOSS]	• The static exciter is not actively producing DC or the FVR relay coil has failed. • Wrong polarity on FVR coil. • Incorrect voltage rating of FVR coil. • Exciter Enable (EE) relay did not pick up.	• Service the static exciter or repair the FVR relay. • AC Voltage to the bridge absent • 10 VDC on Op Amp Board Absent • Check polarity on FVR coil. • Check voltage rating of FVR coil. • Verify the control circuit.
Field Current Loss [FIELD CURRENT LOSS]	• The current relay which monitors the motor field current is not providing an energized contact to verify that the static is functional.	• Check both the field current relay and the static exciter for possible failures.
No Field Coil Feedback [NO FIELD COIL FEEDBACK]	• The SyncPro II has requested the field contactor to energize but the feedback contact from this contactor is not showing as closed.	• The field contactor coil has failed. Replace the coil. The connection to the FC auxiliary has not been made. Check the wiring. • The FC auxiliary contact has failed. Replace the contact.
Reversed PF @ SyncPro II [REVERSED PF AT PLC]	• The connections from the PF transducer to the analog card have been accidentally reversed.	• Switch the positive and negative transducer output leads at the analog card.
External Hardware Fault [EXTERNAL HARDWARE FAULT]	• An external device to the SyncPro II is not functioning as expected.	• Check external devices.
Pulse Board Positive and Negative Pulse Missing [PULSE BOARD POSITIVE MISSING] [PULSE BOARD NEGATIVE MISSING]	• The SyncPro II is not seeing a pulse train being supplied from the A/D board at the time of starting. • The RF1/RF2 resistor selection is not correct. The signal is too weak to provide the necessary pulse train	• Pulse train would be lost if either the A/D card failed, the RF/RF2 selection is incorrect, or if the connection is not made from the A/D board to the SyncPro II. • Review the RF1/RF2 setup parameter and verify the procedure performed (see 'Commissioning', item 4, on page 4-7).
Contactor Feedback Lost [NO MOTOR CONTACTOR FEEDBACK]	• The SyncPro II monitors the status of the synchronous motor stator contactor while running. • The male/female connector of the vacuum contactor is not matched properly. • The PLC I/O card slot 2 input 8 is faulty.	• The main contactor coil has failed. Replace the coil. The connection of the M auxiliary contact has not been made. Check the wiring. • The contact has failed. Replace. • Ensure the connector is matched properly. • Replace the I/O board. • Check the fuse.
Halt Synch Relay	• The program/remote/run switch on the PLC processor may be in program mode.	• Turn the key switch to the «RUN» mode position.

The phase angle transducer, as wired from the factory, is set up for the customer to run his wiring with and ABC line orientation. If this was not observed, the user has two options. First, the line cables can be moved (switching any two incoming lines will do) so that ABC now exists (BCA or CAB are also acceptable), OR the current transformer leads to the transducer can be swapped at the transducer.

Spare Parts

SyncPro II Spare Parts List

Table 6 - Spare Parts List

Part Number	Designation	Description	Quantity
800H-PRTH1GR	Trip/Reset	Red Illuminated Push Button	1
800T-N65		Lamp for Red Push Button	1
800T-N318R		Lens for Red Push Button	1
700-CF220D	FCR, ESR	Relay	1
X-251089	F3	Fuse 4 amp.	1
80165-778-51-R	—	Analog/Digital Board	1
80025-817-01-R	20 kΩ tapped	Power Resistor 20 kΩ tapped	2
700DC-P200Z1	FVR	Field Voltage Relay – 125 V DC exciter	1
700DC-P200Z2		Field Voltage Relay – 250 V DC exciter	1
80190-020-01-R	120 V	Phase Angle Transducer Board	1
80190-020-02-R	240 V		1
2711C-T4T		PanelView Component C400 Terminal	1
1761-CBL-PM02		RS-232 (DF1) cable	1
1606-XLP50E		DC Power Supply	1
1769-IF4XOF2		Analog I/O Module	1
1764-24BWA		MicroLogix 1500 Base Unit	1
1764-LRP		MicroLogix 1500 Processor (unprogrammed)	1
1769-IA16		Digital Input Module	1

Notes:

Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products. At http://www.rockwellautomation.com/support, you can find technical manuals, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools. You can also visit our Knowledgebase at http://www.rockwellautomation.com/knowledgebase for FAQs, technical information, support chat and forums, software updates, and to sign up for product notification updates.

For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect^{SM} support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://www.rockwellautomation.com/support/.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/rockwellautomation/support/overview.page, or contact your local Rockwell Automation representative.

New Product Satisfaction Return

Rockwell Automation tests all of its products to help ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned, follow these procedures.

United States	Contact your distributor. You must provide a Customer Support case number (call the phone number above to obtain one) to your distributor to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for the return procedure.

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