Synchronous Transfer Controller

Controller for MV motors via VFD or soft starter

Reference Manual

BENSHAW
Applied Motor Controls

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BENSHAW
Applied Motor Controls

Contents

1. Important reader notice

This manual contains the information to install and program the Benshaw Synchronous Transfer Controller.

This manual may not cover all of the applications for the Benshaw Synchronous Transfer Controller. Also, it may not provide information on every possible contingency concerning installation, programming, operation, or maintenance specific to the Synchronous Transfer Controller.

The content of this manual will not modify any prior agreement, commitment or relationship between the customer and Benshaw. The sales contract contains the entire obligation of Benshaw. The warranty enclosed within the contract between the parties is the only warranty that Benshaw will recognize and any statements contained herein do not create new warranties or modify the existing warranty in any way.

Any electrical or mechanical modifications to Benshaw products without prior written consent of Benshaw will void all warranties and may also void cUL listing or other safety certifications. Unauthorized modifications may also result in product damage, operation malfunctions or personal injury.

Incorrect handling of the controller may result in an unexpected fault or damage to the controller. For best results, carefully read this manual and all warning labels before installation and operation. Keep this manual on hand for reference.

There are two symbols used in this manual to highlight important information:

ELECTRICAL HAZARD

Warns of situations in which a high voltage can cause physical injury, death and/or damage equipment.

CAUTION

Warns of situations in which physical injury and/damage to equipment may occur by means other than electrical.

HIGH VOLTAGE

Load control equipment and electronic controllers are connected to hazardous line voltages. When servicing controllers and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

2. Safety

Electric shock prevention

- While power is on or the controller is running, do not open the front cover. You may get an electrical shock.
- This controller contains high voltage, which can cause electric shock resulting in personal injury or loss of life.
- Remove all AC power from the controller before servicing.
- Do not connect or disconnect wires to or from the controller when power is applied.
- Make sure ground connection is in place.
- Always install the controller before wiring. Otherwise, you may get an electrical shock or be injured.
- Operate any switches with dry hands to prevent an electrical shock.
- Risk of electric shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

Injury prevention

- Only qualified personnel may service the equipment.
- Make sure power-up restart is off to prevent any unexpected operation of the load.
- Make sure proper shield installation is in place.
- Apply only the voltage that is specified in this manual to the terminals to prevent damage.

Transportation and installation

- Use proper lifting gear when carrying products, to prevent injury.
- Make sure that the installation position and materials are suitable for the weight of the controller. Refer to the installation information in this manual for correct installation.
- If parts are missing or the controller is damaged, do not operate the Synchronous Transfer System.
- Do not stand or rest heavy objects on the controller.
- Do not subject the controller to impact or dropping.
- Make sure to prevent screws, wire fragments, conductive bodies, oil or other flammable substances from entering the controller.

Trial run

- Check all parameters, and ensure that the application will not be damaged by a sudden start-up.

Emergency stop

- To prevent the machine and equipment from causing a hazardous condition if the controller fails, provide a safety backup such as an emergency stop.

3. Introduction

3.1 Multi-motor applications

For applications that employ multiple high horsepower medium voltage motors, it's common practice to use a single VFD or soft starter to reduce system cost.

VFD applications

Variable frequency drives are used for applications where it's necessary to trim the total system output. One example is a pumping station that feeds a pipeline and needs to actively control the pressure or flow rate.

The VFD brings motors up to full speed one at a time, as needed. Once a motor is up to full speed, the output of the VFD is synchronized to the line. The motor is then transferred from the VFD to the line. This is called an up transfer.

The same thing can be done in reverse to reduce the system output. A motor that's attached to the line can be transferred to a synchronized VFD and then run at a reduced speed, or decelerated smoothly to a stop by the VFD. This is called a down transfer.

Soft starter applications

Soft starters are used for applications where it's not necessary to trim the total system output. One example is a pumping station that feeds a tank or reservoir and needs to adjust the number of running pumps in order to respond to fluctuations in demand.

The soft starter brings motors up to full speed one at a time, as needed. Once a motor is up to full speed, it is transferred from the soft starter to the line. This is also called an up transfer.

3.2 Capabilities

The Synchronous Transfer Controller controls multiple motors using two contactors per motor and either a variable frequency drive, a soft starter, or both.

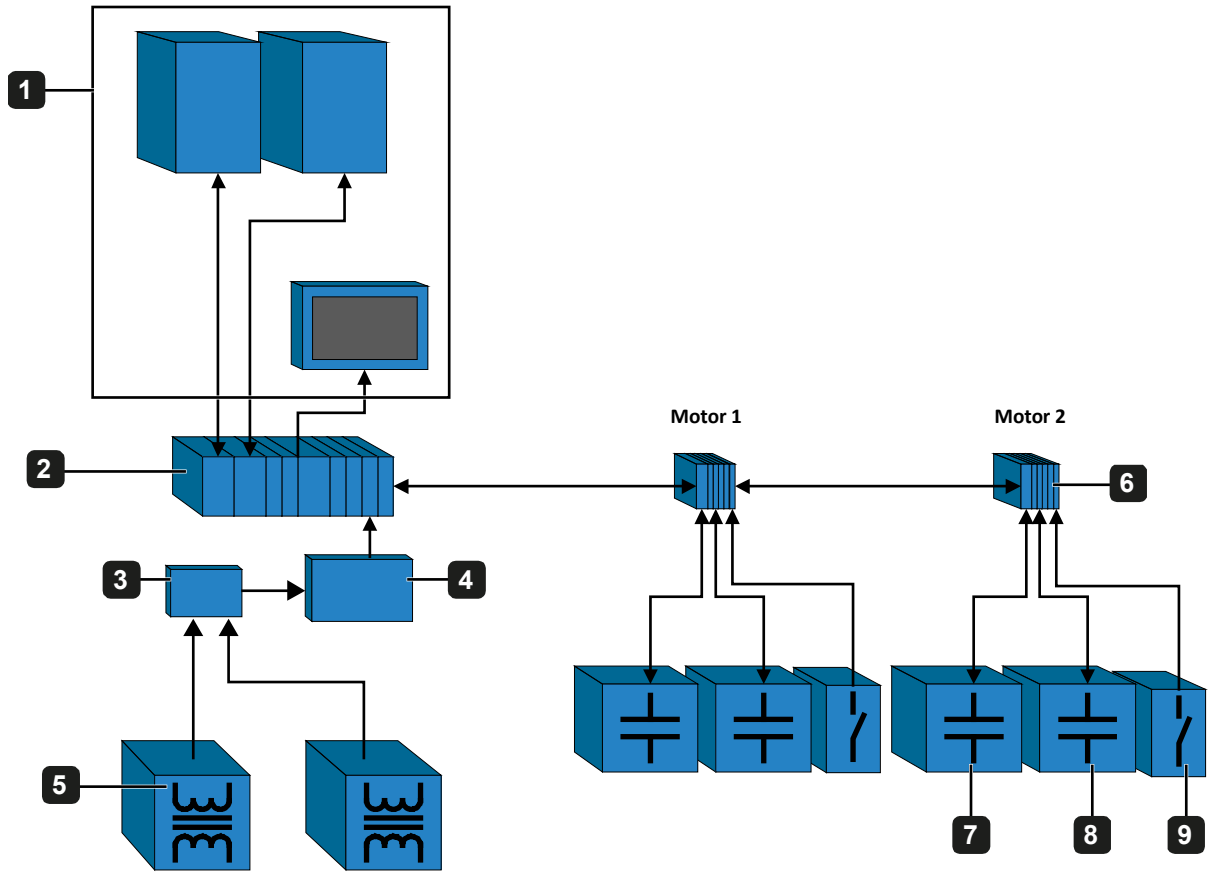
The Synchronous Transfer Controller can:

- control up to 10 motors
- perform closed transfers
- work with VFD only, soft starter only, or VFD with a soft starter backup
- work with Benshaw's M2L300 medium voltage drive
- perform both up and down transfers with the VFD
- store detailed events in the VFD's event log
- use different VFD parameter settings for each motor
- integrate its status information on the VFD's HMI
- work with any soft starter
- operate without an HMI for soft starter only systems
- support 50 Hz and 60 Hz line frequencies

3.3 Components

The Synchronous Transfer Controller uses a PACSystems RX3i Controller from Emerson, with RSTi Distributed Slice I/O to control and monitor each motor's contactors.

Figure 1 – System components



1	1 x M2L300 medium voltage drive with HMI and/or a soft starter
2	1 x RX3i Controller
3	1 x filter card to condition the line and VFD voltage feedbacks
4	1 x PSM terminal assembly
5	2 x potential transformers (PT): one for line voltage feedback and one for VFD voltage feedback
6	1 x RSTi Distributed Slice I/O block for each motor
7	1 x start contactor for each motor
8	1 x line contactor for each motor
9	1 x motor protection relay for each motor to protect it while operating across the line (recommended)

The RX3i Controller consists of:

1x IC695HCS012	12-slot backplane
2x IC695PSA140	120/240 VAC power supply modules
1x IC695ACC400	CPU energy pack
1x IC695CPE310	RX3i CPU
1x IC695PNC001	Profinet controller module
1x IC694ALG221	4-channel, 4-20 mA analog input module
1x IC694MDL241	16-point, 24 VAC/VDC digital input module
1x IC694MDL740	16-point, 12/24 VDC, 0.5 A digital output module
1x IC694PSM001	Power sync and measurement module
1x IC694ACC200	Power sync and measurement terminal assembly

Each motor's block of RSTi Distributed Slice I/O consists of:

1x STXPNS001	Profinet IO scanner module
1x ST-7241	Field power distribution module
2x ST-1804	4-channel 110 VAC digital input modules
1x ST-2748	8-channel relay output module

The RX3i Controller, PSM Terminal Assembly and filter card are typically mounted inside a wall-mountable enclosure with the VFD's HMI on its door. The line PT is often located in a separate medium voltage section, while the VFD PT is often located in the VFD's output reactor section.

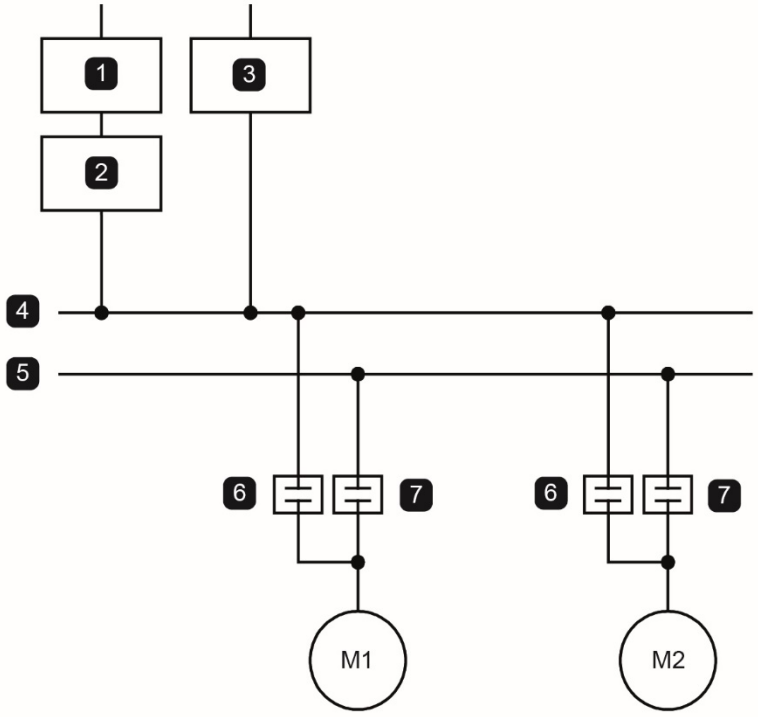
The RSTi Distributed Slice I/O blocks are typically located close to each motor's contactors and motor protection relay.

- The IO on the RX3i Controller is referred to as the local IO.
- The IO on each RSTi block is referred to as the remote IO.

When a VFD with HMI is supplied, the HMI incorporates a status screen for the Synchronous Transfer Controller. However, the Synchronous Transfer Controller can operate without an HMI when a soft starter is supplied and a VFD is not.

3.4 Power wiring

Figure 2 – Simplified power wiring diagram for two motors, a VFD and a soft starter.



1	VFD
2	Output reactor
3	Soft starter
4	Start bus
5	Line bus
6	Start contactor (for M1/M2)
7	Line contactor (for M1/M2)
8	M1/M2 = Motor 1/Motor 2

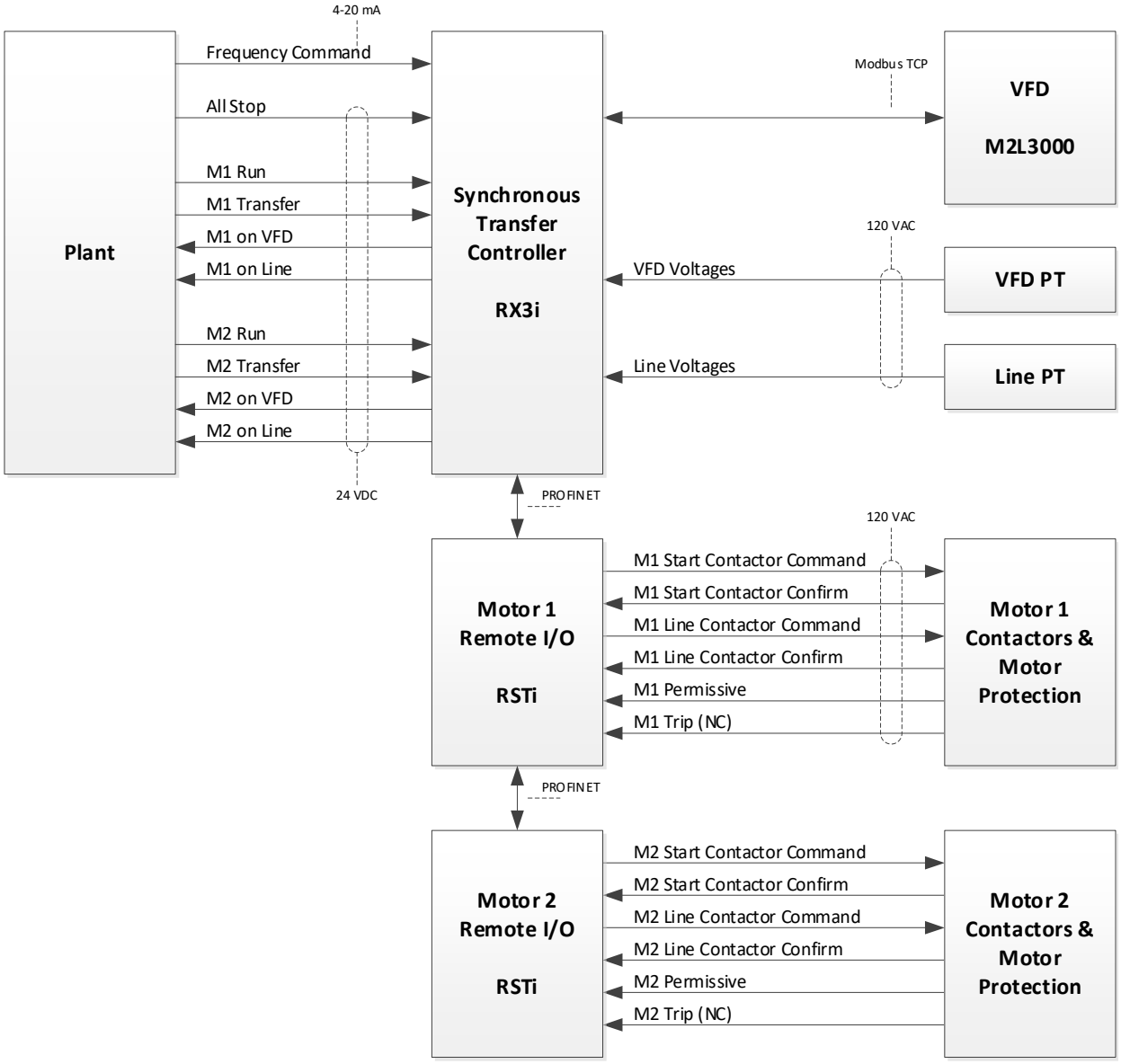
Two buses feed both motors. The start bus is fed by either the VFD or the soft starter to start or run one motor at a reduced frequency or voltage. The line bus is fed by the utility.

The Synchronous Transfer Controller controls the VFD, soft starter and motor contactors.

Additional isolation contactors and disconnect switches may be included, but are not controlled or monitored directly by the Synchronous Transfer Controller.

3.5 Control wiring

Figure 3 – Simplified control wiring diagram for two motors and a VFD



The diagram shows typical signals between the plant and the Synchronous Transfer Controller. Additional signals are available for use. All digital inputs and outputs are configurable.

The 4-20 mA frequency command must be connected to Local AI 1 on the RX3i controller.

4. Parameters

The Synchronous Transfer Controller's parameters are configured using the Benshaw Connect software. Benshaw Connect can connect to the Synchronous Transfer Controller through its Modbus TCP or Modbus RS-485 interface.

4.1 Operation

These parameters configure the general behavior and operation of the Synchronous Transfer Controller.

Motor Count

Sets the number of motors to be controlled.

Range: 1 – 10

Default: 4

Start with VFD

Set to Enabled for systems with a Benshaw M2L3000 Variable Frequency Drive. Otherwise, set to Disabled.

Options: 0 Disabled
1 Enabled

Default: 1 Enabled

Start with Soft Starter

Set to Enabled for systems with a soft starter. Otherwise, set to Disabled.

Options: 0 Disabled
1 Enabled

Default: 0 Disabled

Start Across the Line

Set to Enabled to allow starting a motor directly across the line by closing its line contactor if the VFD and/or soft starter is out of service and bypassed. This may be an option for backup operation when the VFD and soft starter are out of service.

Only enable across the line starting if the motor, load, and electrical system can tolerate the torque transient and current inrush produced by starting the motor across the line.

Options: 0 Disabled
1 Enabled

Default: 0 Disabled

VFD Parameter Sets

The Synchronous Transfer Controller and VFD can load separate VFD parameter sets for each motor. This can be useful when the motors being controlled are not identical.

Options: 0 Disabled
1 Enabled

Default: 0 Disabled

Contactor Control

For new installations, the Synchronous Transfer Controller controls each motor's start and line contactors.

If the plant has its own logic to control each motor's start and line contactors, set Contactor Control to Plant. The Synchronous Transfer Controller will use the Start Contactor Confirm input and Line Contactor Confirm input.

Plant Contactor Control requires an engineered solution to coordinate with the existing plant logic and to generate the Start Contactor Confirm and Line Contactor Confirm signals. Contact Benshaw for assistance.

Options: 0 Synchronous Transfer Controller
1 Plant

Default: 0 Synchronous Transfer Controller

Contactor Fail Delay

Sets the maximum time the Synchronous Transfer Controller will wait for a Confirm signal from the start or line contactor. This delay applies after a close or open command, or if the signal changes unexpectedly during operation.

If the confirmation feedback is not as expected after the delay, the Synchronous Transfer Controller will declare a Contactor Failure.

Range: 0.1 – 3.0 seconds

Default: 1.0 seconds

Sync Fail Delay

Sets the maximum time the Synchronous Transfer Controller will wait for the VFD to successfully synchronize to the line before declaring a Sync Failure.

Range: 0.1 – 60.0 seconds

Default: 30.0 seconds

VFD Fault on Down Transfer

Sets the Synchronous Transfer Controller's response if the VFD faults while performing a down transfer, or if the VFD was not ready before the down transfer was commanded. The Synchronous Transfer Controller can keep the motor running on the line and wait for the VFD to be ready, or disconnect the motor from the line for a coast to stop.

Options: 0 Disconnect Motor
1 Keep Motor on Line

Default: 0 Disconnect Motor

Speed Command at Zero Scale

When the motor is running on VFD, the plant commands the VFD frequency with a 4-20 mA signal to the Synchronous Transfer Controller on Local AI 1. *Speed Command at Zero Scale* sets the speed command associated with 4 mA.

Range: 0.00 – 55.00 Hz

Default: 0.00 Hz

Speed Command at Full Scale

When the motor is running on VFD, the plant commands the VFD frequency with a 4-20 mA signal to the Synchronous Transfer Controller on Local AI 1. *Speed Command at Full Scale* sets the speed command associated with 20 mA.

Range: 5.00 – 60.00 Hz

Default: 60.00 Hz

Up Transfer Voltage Setpoint

Sets the voltage level setpoint for the VFD when it synchronizes its voltage level to the line during an up transfer. The level is specified as a percentage of line voltage.

Range: 95.0 – 105.0 %

Default: 100.0 %

Up Transfer Phase Setpoint

Sets the phase angle difference setpoint for the VFD when it synchronizes its output phase angle to the line during an up transfer. A positive setpoint value makes the VFD lag behind the line. A negative setpoint value makes the VFD lead the line.

Range: -5.0 – 5.0 degrees

Default: 1.5 degrees

Down Transfer Voltage Setpoint

Sets the voltage level setpoint for the VFD when it synchronizes its voltage level to the line during a down transfer. The level is specified as a percentage of line voltage.

Range: 95.0 – 105.0 %

Default: 100.0%

Down Transfer Phase Setpoint

Sets the phase angle difference setpoint for the VFD when it synchronizes its output phase angle to the line during a down transfer. A positive setpoint value makes the VFD lag behind the line. A negative setpoint value makes the VFD lead the line.

Range: -5.0 – 5.0 degrees

Default: 1.5 degrees

At Speed Frequency Tolerance

When an up transfer is commanded, the VFD first ramps up to match the line frequency. It remains at line frequency for 0.2 seconds before it begins to match the line voltage and phase angle.

The *At Speed Frequency Tolerance* defines how closely the VFD must match line frequency.

If the VFD is operating in some limited capacity, such as a low DC bus voltage, it may not be able to reach line frequency and remain stable.

Range: 0.10 – 5.00 Hz

Default: 0.40 Hz

Test Mode

This parameter places the Synchronous Transfer Controller in special operating modes for different testing.

If *Test Mode* is set to Never Transfer, an up transfer command will synchronize the VFD to the line but it will not perform the up transfer.

Options:
0 Off
1 Never Transfer

Default: 0 Off

4.2 Input points

The digital inputs are fully configurable. Any internal digital input signal may be bound to any digital input point. This lets the system designer scale the system up or down to meet customer requirements for interfacing to the plant. Contact Benshaw Engineering to establish the digital input signals required to interface with the plant so they can be wired to terminal blocks at the factory.

An internal digital input signal must not be bound to more than one digital input point, either local or remote.

Changes to signal bindings only take affect when the Synchronous Transfer Controller is not busy transferring a motor, or running a motor on the VFD or soft starter.

Digital input points that are not bound to internal digital input signals may be connected to other equipment and monitored over Modbus by reading their corresponding Modbus Discrete Input registers.

Local DI 1 through Local DI 16 & Remote N DI1 through Remote N DI 8

The RX3i Controller has 16 local digital input points (Local DI 1~Local DI 16) and each motor's RSTi Distributed I/O has eight remote digital input points (Remote N DI 1~Remote N DI 8). Each digital input point can be individually bound to an internal digital input signal.

Options

	0	No binding	10	VFD Bypass
	1	Watchdog In	11	Soft Starter Bypass
	2	All Stop NO	12	M1 Run
	3	All Stop NC	13	M1 Transfer
	4	Reset Sync Fail	14	M1 Start Contactor Confirm
	5	Start Contactor Confirm	15	M1 Line Contactor Confirm
	6	Line Contactor Confirm	16	M1 Permissive
	7	Soft Starter Ready	17	M1 Trip NC
	8	Soft Starter Running	…	
	9	Soft Starter UTS	71	M10 Trip NC

Defaults

Local DI 1 = 3 All Stop NC	Remote 1 DI 1 = 14 M1 Start Contactor Confirm
Local DI 2 = 4 Reset Sync Fail	Remote 1 DI 2 = 15 M1 Line Contactor Confirm
Local DI 3 = 10 VFD Bypass	Remote 1 DI 3 = 16 M1 Permissive
Local DI 4 = 0 No binding	Remote 1 DI 4 = 17 M1 Trip NC
Local DI 5 = 12 M1 Run	Remote 1 DI 5 = 0 No binding
Local DI 6 = 13 M1 Transfer	Remote 1 DI 6 = 0 No binding
Local DI 7 = 18 M2 Run	Remote 1 DI 7 = 0 No binding
Local DI 8 = 19 M2 Transfer	Remote 1 DI 8 = 0 No binding
Local DI 9 = 24 M3 Run	…
Local DI 10 = 25 M3 Transfer	Remote 10 DI 1 = 68 M10 Start Contactor Confirm
Local DI 11 = 30 M4 Run	Remote 10 DI 2 = 69 M10 Line Contactor Confirm
Local DI 12 = 31 M4 Transfer	Remote 10 DI 3 = 70 M10 Permissive
Local DI 13 = 0 No binding	Remote 10 DI 4 = 71 M10 Trip NC
Local DI 14 = 0 No binding	Remote 10 DI 5 = 0 No binding
Local DI 15 = 0 No binding	Remote 10 DI 6 = 0 No binding
Local DI 16 = 0 No binding	Remote 10 DI 7 = 0 No binding
	Remote 10 DI 8 = 0 No binding

Watchdog In	When the Watchdog In signal is bound to a digital input point, the Synchronous Transfer Controller monitors that signal. If the signal doesn't toggle for five seconds, the Synchronous Transfer Controller disconnects all motors and stops toggling its Watchdog Out signal. If the Watchdog In signal is not bound to any input point, the Synchronous Transfer Controller does not monitor that signal.
All Stop NO All Stop NC	The All Stop signal commands the Synchronous Transfer Controller to disconnect all motors. The motors will coast to stop. All Stop NO asserts the command when the digital input point goes high. All Stop NC asserts the command when the digital input point goes low.
Reset Sync Fail	If the VFD fails to synchronize to the line during an up or down transfer within the time allowed by *Sync Fail Delay*, the Synchronous Transfer Controller asserts the Sync Failed output signal. Sync Failed remains high until either the Reset Sync Fail signal goes high, or the transfer attempt is aborted.
Start Contactor Confirm Line Contactor Confirm	If Contactor Control is set to Plant, the plant must provide these signals. The Synchronous Transfer Controller uses them as conditions for advancing through the stages of up and down transfers. If Contactor Control is set to Synchronous Transfer Controller, these signals are not used.
Soft Starter Ready Soft Starter Running Soft Starter UTS	When the Synchronous Transfer Controller uses a soft starter to start a motor, it uses the Soft Starter Ready and Soft Starter Running signals to advance through the stages controlling the soft starter. It uses the soft starter UTS signal to know when the motor has reached full speed so it can begin the up transfer sequence.
VFD Bypass Soft Starter Bypass	When multiple starting methods are enabled, the methods are prioritized: 1. VFD 2. Soft Starter 3. Across the Line VFD is the highest priority and Across the Line is the lowest. If the VFD or soft starter is out of service, use the VFD Bypass and Soft Starter Bypass signals to instruct the Synchronous Transfer Controller to use the next available starting method.

M1 Run
M1 Transfer

The M1 Run and M1 Transfer signals command the Synchronous Transfer Controller to run and transfer Motor 1.

When operating on a VFD:

- Applying the M1 Run signal commands Motor 1 to run at the speed commanded by the 4-20 mA analog input.
- Applying the M1 Transfer signal while Motor 1 is running on the VFD commands an up transfer. The VFD ramps the motor up to line frequency, then synchronizes its voltage level and phase angle to the line. The Synchronous Transfer Controller then transfers the motor from the VFD up to the line.

The M1 Run and M1 Transfer signals must remain high as long as the motor is to continue running on the line.

Removing M1 Transfer while Motor 1 is running on the line commands a down transfer. The VFD turns on and synchronizes to the line. The Synchronous Transfer Controller then transfers the motor from the line down to the VFD. The VFD ramps the motor down to the frequency commanded by the 4-20 mA analog input.

For applications that do not use down transfer and do not run on VFD at less than line frequency, the plant does not need to provide Motor Transfer signals.

If the Motor Transfer signal is not bound to any input point, applying the Motor Run signal starts the motor with the VFD and immediately initiates an up transfer.

When operating on a soft starter:

- Applying the M1 Run signal when either *Start with VFD* is set to Disabled, or the VFD Bypass input signal is high, commands Motor 1 to start with the soft starter. Once the Soft Starter UTS signal goes high, the Synchronous Transfer Controller transfers the motor from the soft starter up to the line.

When starting Across the Line:

- If *Start Across the Line* is set to Enabled and neither a VFD nor soft starter is available, applying the M1 Run signal commands the Synchronous Transfer Controller to start the motor by closing its line contactor.

Removing the M1 Run signal while the motor is running on the line commands the Synchronous Transfer Controller to disconnect the motor for a coast to stop regardless of the starting method.

M1 Start Contactor Confirm
M1 Line Contactor Confirm

If *Contactor Control* is set to Synchronous Transfer Controller, these signals are used as conditions for advancing through the stages of up and down transfers for Motor 1.

If *Contactor Control* is set to Plant, these signals are not used.

M1 Permissive M1 Trip NC	M1 Permissive can be used to connect to an emergency stop for Motor 1.M1 Trip NC can be used to connect to a motor protection relay for Motor 1.Both the M1 Permissive and M1 Trip NC signals must be high before the Synchronous Transfer Controller will run Motor 1. If either goes low while the motor is running, the Synchronous Transfer Controller will disconnect the motor for a coast to stop. If the Motor Permissive signal is not bound to any input point, the signal is ignored. If the Motor Trip NC signal is not bound to any input point, the signal is ignored.

4.3 Output points

The digital outputs are fully configurable. Any internal digital output signal may be bound to any digital output point. This lets the system designer scale the system up or down to meet customer requirements for interfacing to the plant.

Contact Benshaw Engineering to establish the Digital Output Signals required to interface with the plant so they can be wired to terminal blocks at the factory.

An internal digital output signal must not be bound to more than two digital input points, one local and one remote.

Changes to signal bindings only take effect when the Synchronous Transfer Controller is not busy transferring a motor, or running a motor on the VFD or soft starter.

Digital output points that are not bound to internal digital output signals may be connected to other equipment and controlled over Modbus by writing to their corresponding Modbus coils.

Local DO 1 through Local DO 16 & Remote N DO1 through Remote N DO 8

The RX3i Controller has 16 local digital output points (Local DO 1~Local DO 16) and each motor's RSTi Distributed I/O has eight remote digital output points (Remote N DO 1~Remote N DO 8). Each digital output point can be individually bound to an internal digital output signal.

Options	0	No binding	8	M1 Start Contactor Command
	1	Watchdog Out	9	M1 Line Contactor Command
	2	Invalid Commands	10	M1 Disconnected
	3	Transferring	11	M1 on VFD
	4	VFD Ready	12	M1 on Line
	5	Synced	13	M1 on Soft Starter
	6	Sync Failed	…	
	7	Soft Starter Run Command	67	M10 on Soft Starter

Defaults	Local DO 1 = 2 Invalid Commands	Remote 1 DO 1 = 8 M1 Start Contactor Command
	Local DO 2 = 3 Transferring	Remote 1 DO 2 = 9 M1 Line Contactor Command
	Local DO 3 = 6 Sync Failed	Remote 1 DO 3 = 0 No binding
	Local DO 4 = 0 No binding	Remote 1 DO 4 = 0 No binding
	Local DO 5 = 11 M1 on VFD	Remote 1 DO 5 = 10 M1 Disconnected
	Local DO 6 = 12 M1 on Line	Remote 1 DO 6 = 11 M1 on VFD
	Local DO 7 = 17 M2 on VFD	Remote 1 DO 7 = 12 M1 on Line
	Local DO 7 = 18 M2 on Line	Remote 1 DO 8 = 13 M1 on Soft Starter
	Local DO 8 = 23 M3 on VFD	…

Local DO 10 = 24 M3 on Line
Local DO 11 = 29 M4 on VFD
Local DO 12 = 30 M4 on Line
Local DO 13 = 0 No binding
Local DO 14 = 0 No binding
Local DO 15 = 0 No binding
Local DO 16 = 0 No binding

Remote 10 DO 1 = 62 M10 Start Contactor Command
Remote 10 DO 2 = 63 M10 Line Contactor Command
Remote 10 DO 3 = 0 No binding
Remote 10 DO 4 = 0 No binding
Remote 10 DO 5 = 64 M10 Disconnected
Remote 10 DO 6 = 65 M10 on VFD
Remote 10 DO 7 = 66 M10 on Line
Remote 10 DO 8 = 67 M10 on Soft Starter

Watchdog Out	The Watchdog Out signal toggles periodically. If the Watchdog In signal is bound to an input point and it doesn't toggle for five seconds, the Watchdog Out signal stops toggling.
Invalid Commands	The Invalid Commands signal indicates when a request to start or stop a motor can't be honored. Possible reasons include: The VFD or soft starter is not ready The motor has a Permissive or Trip NC input asserted The VFD or soft starter is busy servicing a different motor A motor's transfer signal is high while its run signal is low
Transferring	The Transferring signal indicates when a transfer is in progress. This could be an up or down transfer with the VFD or starting with the soft starter.
VFD Ready	Then VFD Ready signal indicates when the VFD is ready to run.
Synced	The Synced signal indicates when the VFD has synchronized to the line.
Sync Failed	The Sync Failed signal indicates that the VFD fails to synchronize to the line during an up or down transfer within the time allowed by *Sync Fail Delay*. Sync Failed remains high until either the Reset Sync Fail signal goes high, or the transfer attempt is aborted.
Soft Starter Run Command	The Soft Starter Run Command is used to control a soft starter.
M1 Start Contactor Command M1 Line Contactor Command	If *Contactor Control* is set to Synchronous Transfer Controller, it uses these signals to control each contactor. If *Contactor Control* is set to Plant, these signals are not used.
M1 Disconnected M1 on VFD M1 on Line M1 on Soft Starter	These signals indicate the status of Motor 1.

4.4 PSM

The power sync and measurement module in the RX3i rack and the panel-mounted power sync and measurement terminal assembly receive the line and VFD voltage feedbacks for synchronizing the VFD to the line. The line voltage feedback connects to Grid 1. The VFD voltage feedback connects to Grid 2. See *Figure 2* on page 8.

These parameters configure the PSM operation and indicate the feedback connection methods. These parameters are set at the factory according to the supplied equipment.

PT Ratio

The turns ratio of the line and VFD potential transformers used for feedback.

Range: 0.00 – 655.35

Default: 35.00

Nominal Voltage

Sets the nominal line voltage. The Synchronous Transfer Controller will only allow an up or down transfer using the VFD if both the line and VFD voltage levels are between 90% and 115% of nominal.

Range: 240 – 15000 V

Default: 4160 V

Nominal Frequency

Sets the nominal line frequency. This is used internally for applying the appropriate scaling factors to the voltage feedback signals.

Options:

	0	50.00 Hz
	1	60.00 Hz

Default: 1 60.00 Hz

Terminal Assembly Connection

The PSM module in the RX3i rack connects to the panel-mounted terminal assembly with two cables, one for the line feedback on Grid 1, and one for the VFD feedback on Grid 2. The terminal assembly has two connections for each grid. One is for use when the stepped-down voltage feedback is in the 120 VAC range. The other is for use when the stepped-down voltage feedback is in the 600 VAC range.

Options:

	0	120 VAC
	1	600 VAC

Default: 0 120 VAC

Connection Mode

The PSM module and terminal assembly can accommodate step-down potential transformers connected in either wye or delta mode.

Options: 0 Wye
1 Delta

Default: 1 Delta

Delta Mode

When the step-down potential transformers are connected in delta mode, the PSM module and terminal assembly can accommodate either the Phase B or Phase C tied to common.

Options: 0 B Phase Common
1 C Phase Common

Default: 0 B Phase Common

Phase A Voltage, Phase B Voltage, Phase C Voltage

When the step-down potential transformers are connected in delta mode, the line-to-neutral voltage for the phase connected to common must be calculated.

Set the connected phase to Calculated. Set the unconnected phases to Measured.

Options: 0 Calculated
1 Measured

Defaults		
Phase A Voltage	1	Measured
Phase B Voltage	0	Calculated
Phase C Voltage	1	Measured

4.5 Grid 1 (Line) Calibration, Grid 2 (VFD) Calibration

The PSM module in the RX3i rack and the panel-mounted PSM terminal assembly are fitted with labels showing their calibration factors. Entering calibration factors in the software may produce more accurate voltage measurements.

The calibration parameters are optional. The VFD can successfully perform up and down transfers without calibration values. Entering the calibration factors may improve the accuracy of the line and VFD voltage levels displayed on the Sync Status screen of the HMI.

Module Offset, Module Gain

These adjust the offset and gain of the PSM module in the RX3i rack for Grid 1 and Grid 2. The value is in decimal format.

Range: -1000 – 1000

Default: 0

VA L Gain, VB L Gain, VC L Gain

These adjust the gains for the 120 VAC connection of the panel-mounted PSM terminal assembly for Grid 1 and Grid 2. The value is in hexadecimal format.

Range: 0000 – FFFF

Default: 4000

VA H Gain, VB H Gain, VC H Gain

These adjust the gains for the 600 VAC connection of the panel-mounted PSM terminal assembly for Grid 1 and Grid 2. The value is in hexadecimal format.

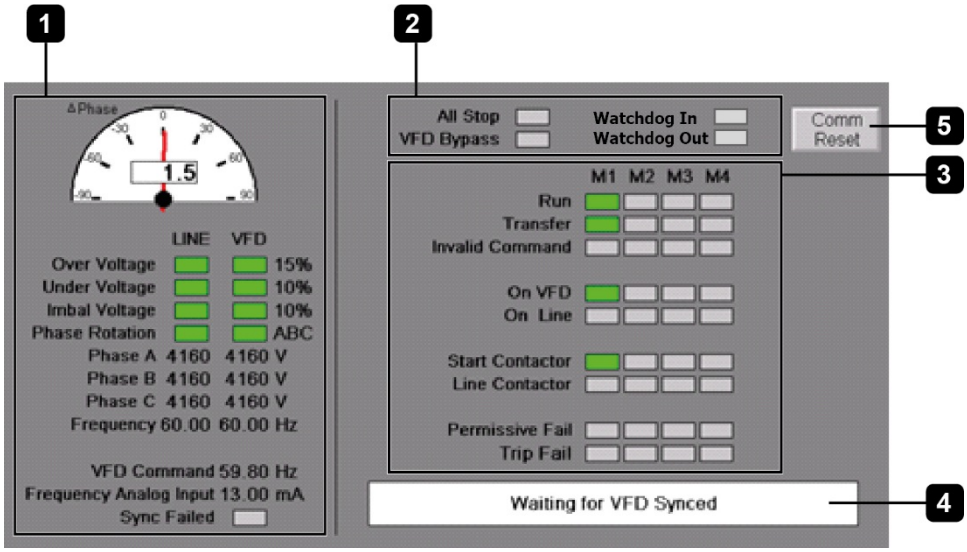
Range: 0000 – FFFF

Default: 4000

5. HMI

When the Synchronous Transfer Controller is supplied with an M2L300 medium voltage VFD, the VFD's HMI incorporates a screen to view the status of the Synchronous Transfer Controller.

Figure 4 – Synchronous Transfer Controller Status Screen on VFD's HMI



1	Line and VFD feedback
2	System I/O indicators
3	Motor indicators
4	Message banner
5	Communications reset

5.1 Line and VFD feedback

The left side of the screen shows information related to line and VFD feedback. This information is used to synchronize the VFD's output voltage to the line.

Synchroscope

The Synchroscope activates when the VFD is synchronizing to the line. It shows the difference in phase angle between the VFD and the line voltage. A positive value indicates the VFD is lagging ahead of the line. A negative value indicates the VFD is leading behind the line.

Transfer precheck indicators

After the VFD has synchronized to the line, the Synchronous Transfer Controller checks the line and VFD voltage before transferring the motor.

- Overvoltage: Voltage must not be higher than 115% of nominal
- Undervoltage: Voltage must not be lower than 90% of nominal
- Voltage Imbalance: Voltage imbalance must not exceed 10%
- Phase Sequence: Phase sequence must be ABC

Indicator color	Description
Green	Pass
Red	Fail
Light gray	Inactive

Sync failed indicator

If the VFD cannot synchronize to the line within the time allowed by *Sync Fail Delay*, the Sync Failed indicator lights up red.

5.2 System I/O indicators

The screen reports the status of key system IO signals. The signals are only reported if they are bound to an IO point.

Signal	Description
All Stop	Red = An All Stop command is active (All Stop NO is high or All Stop NC is low).
VFD Bypass	Red = VFD Bypass input is high
Watchdog In	Flashing gray/green = the Watchdog In input is toggling Red = the Watchdog In input is not toggling
Watchdog Out	Flashing gray/green = the Watchdog Out input is toggling

5.3 Motor indicators

The screen reports the status of key IO signals for each motor. The signals are only reported if they are bound to an IO point.

Signal	Description
Run	Green = the Motor Run input is high.
Transfer	Green = the Motor Transfer input is high.
Invalid Command	Red = a motor command cannot be performed.
On VFD	Green = the motor is connected to the VFD.
On Line	Green = the motor is connected to the line.
On Soft Starter	Yellow = the motor is connected to the soft starter. This indicator is only visible when the VFD Bypass input is high.
Start Contactor/ Line Contactor	Gray = The motor’s Contactor Command output and Contactor Confirm input are both low. Green = The motor’s Contactor Command output and Contactor Confirm input are both high. Flashing gray/green = The motor’s Contactor Command output and Contactor Confirm input don’t match.
Permissive Fail	Red = the motor’s Permissive input is low.
Trip Fail	Red = the motor’s Trip NC input is low.

Invalid command

Invalid Command indicator is red when a motor command cannot be performed. Possible causes include:

- The VFD or soft starter is not ready
- The VFD or soft starter is connected to a different motor
- The motor's Permissive or Trip NC input is high
- The motor is disconnected and its Transfer input is high while its Run input is low.

5.4 Message banner

The message banner is active when a motor is starting, running, or transferring.

When a motor is starting, running, or transferring, its label (e.g. M1) at the top of the motor indicators column blinks, and the message banner indicates the state for that motor.

Message	Description
Idle	No motors are active.
Cancelling Up Transfer	The transfer input was removed before the motor transferred from the VFD to the line.
VFD Running	The motor is running on VFD.
Waiting for Line Contactor Closed Confirmation	The line contactor was commanded to close. Awaiting closed confirmation from the contactor.
Waiting for Line Contactor Open Confirmation	The line contactor was commanded to open. Awaiting open confirmation from the contactor.
Waiting for Soft Starter Run Confirmation	The soft starter was commanded to run. Awaiting run confirmation from the soft starter.
Waiting for Soft Starter Up to Speed	The soft starter was started. Awaiting up-to-speed indication from the soft starter.
Waiting for Start Contactor Closed Confirmation	The start contactor was commanded to close. Awaiting closed confirmation from the contactor.
Waiting for Start Contactor Open Confirmation	The start contactor was commanded to open. Awaiting open confirmation from the contactor.
Waiting for VFD Parameter Set Confirmation	The VFD was commanded to load a parameter set. Awaiting confirmation from the VFD.
Waiting for VFD Run Confirmation	The VFD was commanded to run. Awaiting run confirmation from the VFD.
Waiting for VFD Stopped Confirmation	The VFD faulted or was commanded to stop. Awaiting stopped confirmation from the VFD.
Waiting for VFD Synced	The VFD is synchronizing to the line. Waiting for synchronization complete.

5.5 Communications reset

The Synchronous Transfer Controller connects to the M2L300 VFD via Ethernet. If the Ethernet connection is lost, the VFD asserts a Fieldbus Communication Loss lockout and the Synchronous Transfer Controller cannot start the VFD.

Press the reset button to reestablish the Synchronous Transfer Controller’s connection to the M2L3000 VFD.

6. Modbus

The Synchronous Transfer Controller has two Modbus interfaces; a Modbus Serial RTU server is available through RS-485, and a Modbus TCP server is available through wired Ethernet. The same set of registers are available through both interfaces.

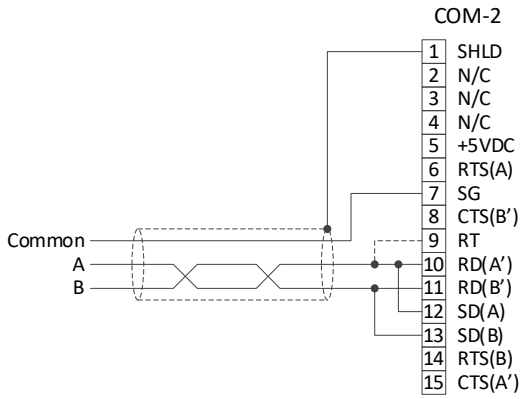
6.1 Modbus serial RTU interface

The Modbus serial RTU server is available through an RS-485 interface on COM-2 on the front face of the RX3i CPU module. The interface is configured as:

Baud	19200
Parity	none
Data Bits	8
Stop Bits	1

COM-2 is a female DB-15 connector. It should be wired as follows:

Figure 5 – Modbus RTU connections



If the Synchronous Transfer Controller is the end device on the RS-485 network, the CPU module has an internal 120 Ω terminating resistor that should be connected between A and B by shorting RT (pin 9) to A (pin 10).

6.2 Modbus TCP interface

The Modbus TCP server is available through an RJ-45 Ethernet connector on the front face of the RX3i CPU module. It has a static IP address:

IP Address 172.29.87.15

Applications with a VFD

The Synchronous Transfer Controller controls the M2L3000 VFD over the VFD's local Ethernet network. It is connected to that network through an Ethernet switch. A laptop may be temporarily connected to any free port on any switches on this network to gain access to the Modbus TCP server on the Synchronous Transfer Controller for configuration or diagnostics.

The VFD's local Ethernet network must not be connected directly to the plant's network. A router is required to connect the two networks. Contact Benshaw if the plant needs to monitor the Synchronous Transfer Controller over Modbus TCP.

Applications without a VFD

For applications without a VFD, the plant may connect directly to the Ethernet interface on the front face of the RX3i CPU module using its static IP address to gain access to its Modbus TCP server.

6.3 Modbus registers

The Modbus map consists of holding registers, coils and discrete inputs. There are no input registers.

Configuration parameters

- **Operation**

These parameters configure the general behavior and operation of the Synchronous Transfer Controller.

Motor Count	41505
Start with VFD	41500
Start with Soft Starter	41501
Start Across the Line	41503
VFD Parameter Sets	41502
Contactor Control	41555
Contactor Fail Delay	41508
Sync Fail Delay	41507
VFD Fault on Down Transfer	41509
Speed Command at Zero-Scale	41512
Speed Command at Full-Scale	41513
Up Transfer Voltage Setpoint	41550
Up Transfer Phase Setpoint	41551
Down Transfer Voltage Setpoint	41552
Down Transfer Phase Setpoint	41553
At Speed Frequency Tolerance	41554
Test Mode	41506

- **Input points**

Local DI 1	41560	Remote 3 DI 1	41608	Remote 7 DI 1	41672
Local DI 2	41561	Remote 3 DI 2	41609	Remote 7 DI 2	41673
Local DI 3	41562	Remote 3 DI 3	41610	Remote 7 DI 3	41674
Local DI 4	41563	Remote 3 DI 4	41611	Remote 7 DI 4	41675
Local DI 5	41564	Remote 3 DI 5	41616	Remote 7 DI 5	41680
Local DI 6	41565	Remote 3 DI 6	41617	Remote 7 DI 6	41681
Local DI 7	41566	Remote 3 DI 7	41618	Remote 7 DI 7	41682
Local DI 8	41567	Remote 3 DI 8	41619	Remote 7 DI 8	41683
Local DI 9	41568				
Local DI 10	41569	Remote 4 DI 1	41624	Remote 8 DI 1	41688
Local DI 11	41570	Remote 4 DI 2	41625	Remote 8 DI 2	41689
Local DI 12	41571	Remote 4 DI 3	41626	Remote 8 DI 3	41690
Local DI 13	41572	Remote 4 DI 4	41627	Remote 8 DI 4	41691
Local DI 14	41573	Remote 4 DI 5	41632	Remote 8 DI 5	41696
Local DI 15	41574	Remote 4 DI 6	41633	Remote 8 DI 6	41697
Local DI 16	41575	Remote 4 DI 7	41634	Remote 8 DI 7	41698
		Remote 4 DI 8	41635	Remote 8 DI 8	41699
Remote 1 DI 1	41576	Remote 5 DI 1	41640	Remote 9 DI 1	41704
Remote 1 DI 2	41577	Remote 5 DI 2	41641	Remote 9 DI 2	41705
Remote 1 DI 3	41578	Remote 5 DI 3	41642	Remote 9 DI 3	41706
Remote 1 DI 4	41579	Remote 5 DI 4	41643	Remote 9 DI 4	41707
Remote 1 DI 5	41584	Remote 5 DI 5	41648	Remote 9 DI 5	41712
Remote 1 DI 6	41585	Remote 5 DI 6	41649	Remote 9 DI 6	41713
Remote 1 DI 7	41586	Remote 5 DI 7	41650	Remote 9 DI 7	41714
Remote 1 DI 8	41587	Remote 5 DI 8	41651	Remote 9 DI 8	41715
Remote 2 DI 1	41592	Remote 6 DI 1	41656	Remote 10 DI 1	41720
Remote 2 DI 2	41593	Remote 6 DI 2	41657	Remote 10 DI 2	41721
Remote 2 DI 3	41594	Remote 6 DI 3	41658	Remote 10 DI 3	41722
Remote 2 DI 4	41595	Remote 6 DI 4	41659	Remote 10 DI 4	41723
Remote 2 DI 5	41600	Remote 6 DI 5	41664	Remote 10 DI 5	41728
Remote 2 DI 6	41601	Remote 6 DI 6	41665	Remote 10 DI 6	41729
Remote 2 DI 7	41602	Remote 6 DI 7	41666	Remote 10 DI 7	41730
Remote 2 DI 8	41603	Remote 6 DI 8	41667	Remote 10 DI 8	41731

- **Output points**

Local DO 1	41736	Remote 3 DO 1	41768	Remote 7 DO 1	41800
Local DO 2	41737	Remote 3 DO 2	41769	Remote 7 DO 2	41801
Local DO 3	41738	Remote 3 DO 3	41770	Remote 7 DO 3	41802
Local DO 4	41739	Remote 3 DO 4	41771	Remote 7 DO 4	41803
Local DO 5	41740	Remote 3 DO 5	41772	Remote 7 DO 5	41804
Local DO 6	41741	Remote 3 DO 6	41773	Remote 7 DO 6	41805
Local DO 7	41742	Remote 3 DO 7	41774	Remote 7 DO 7	41806
Local DO 8	41743	Remote 3 DO 8	41775	Remote 7 DO 8	41807
Local DO 9	41744				
Local DO 10	41745	Remote 4 DO 1	41776	Remote 8 DO 1	41808
Local DO 11	41746	Remote 4 DO 2	41777	Remote 8 DO 2	41809
Local DO 12	41747	Remote 4 DO 3	41778	Remote 8 DO 3	41810
Local DO 13	41748	Remote 4 DO 4	41779	Remote 8 DO 4	41811
Local DO 14	41749	Remote 4 DO 5	41780	Remote 8 DO 5	41812
Local DO 15	41750	Remote 4 DO 6	41781	Remote 8 DO 6	41813
Local DO 16	41751	Remote 4 DO 7	41782	Remote 8 DO 7	41814
		Remote 4 DO 8	41783	Remote 8 DO 8	41815
Remote 1 DO 1	41752	Remote 5 DO 1	41784	Remote 9 DO 1	41816
Remote 1 DO 2	41753	Remote 5 DO 2	41785	Remote 9 DO 2	41817
Remote 1 DO 3	41754	Remote 5 DO 3	41786	Remote 9 DO 3	41818
Remote 1 DO 4	41755	Remote 5 DO 4	41787	Remote 9 DO 4	41819
Remote 1 DO 5	41756	Remote 5 DO 5	41788	Remote 9 DO 5	41820
Remote 1 DO 6	41757	Remote 5 DO 6	41789	Remote 9 DO 6	41821
Remote 1 DO 7	41758	Remote 5 DO 7	41790	Remote 9 DO 7	41822
Remote 1 DO 8	41759	Remote 5 DO 8	41791	Remote 9 DO 8	41823
Remote 2 DO 1	41760	Remote 6 DO 1	41792	Remote 10 DO 1	41824
Remote 2 DO 2	41761	Remote 6 DO 2	41793	Remote 10 DO 2	41825
Remote 2 DO 3	41762	Remote 6 DO 3	41794	Remote 10 DO 3	41826
Remote 2 DO 4	41763	Remote 6 DO 4	41795	Remote 10 DO 4	41827
Remote 2 DO 5	41764	Remote 6 DO 5	41796	Remote 10 DO 5	41828
Remote 2 DO 6	41765	Remote 6 DO 6	41797	Remote 10 DO 6	41829
Remote 2 DO 7	41766	Remote 6 DO 7	41798	Remote 10 DO 7	41830
Remote 2 DO 8	41767	Remote 6 DO 8	41799	Remote 10 DO 8	41831

PSM

The power sync and measurement module in the RX3i rack and the panel-mounted power sync and measurement terminal assembly receive the line and VFD voltage feedbacks for synchronizing the VFD to the line. The line voltage feedback connects to Grid 1. The VFD voltage feedback connects to Grid 2. See *Figure 2* on page 8.

These parameters configure the PSM operation and indicate the feedback connection methods. These parameters are set at the factory according to the supplied equipment.

PT Ratio	41510
Nominal Voltage	41526
Nominal Frequency	41528
Terminal Assembly Connection	41504.1
Connection Mode	41504.3
Delta Mode	41504.12
Phase A Voltage	41504.4
Phase B Voltage	41504.6
Phase C Voltage	41504.8

- **Grid 1 (Line) calibration, Grid 2 (VFD) calibration**

	Grid 1	Grid 2
Module Offset	41514	41529
Module Gain	41515	41530
VA L Gain	41516	41531
VB L Gain	41519	41534
VC L Gain	41522	41537
VA H Gain	41517	41532
VB H Gain	41520	41535
VC H Gain	41523	41538

Status meters

- **Sync**

Frequency Command to VFD	41105	0.01 Hz	The speed at which the Synchronous Transfer Controller is commanding the VFD.
Phase Shift	41203	0.1 degrees	The difference in phase between the line voltage and the VFD voltage.

- **Grid 1 (Line)**

Over Voltage	41202.1	
Under Voltage	41202.2	
Voltage Imbalance	41202.5	
Negative Sequence	41202.0	
Phase A Voltage	41204	Volts
Phase B Voltage	41205	Volts
Phase C Voltage	41206	Volts
Frequency	41207	0.01 Hz

- **Grid 2 (VFD)**

Over Voltage	41202.9	
Under Voltage	41202.10	
Voltage Imbalance	41202.13	
Negative Sequence	41202.8	
Phase A Voltage	41214	Volts
Phase B Voltage	41215	Volts
Phase C Voltage	41216	Volts
Frequency	41217	0.01 Hz

- **Input signals**

Plant Frequency Request	41108	0.01 Hz
Watchdog In Fail	41200.1	
All Stop	41200.2	
Reset Sync Fail	41200.3	
Start Contactor Confirm	41200.4	
Line Contactor Confirm	41200.5	
VFD Bypass	41200.6	
Soft Starter Ready	41200.7	
Soft Starter Running	41200.8	
Soft Starter UTS	41200.9	
Soft Starter Bypass	41200.10	

M1 Run	41226.0	M2 Run	41228.0
M1 Transfer	41226.1	M2 Transfer	41228.1
M1 Start Contactor Confirm	41226.3	M2 Start Contactor Confirm	41228.3
M1 Line Contactor Confirm	41226.5	M2 Line Contactor Confirm	41228.5
M1 Permissive	41226.6	M2 Permissive	41228.6
M1 Trip NC	41226.7	M2 Trip NC	41228.7
M3 Run	41230.0	M4 Run	41232.0
M3 Transfer	41230.1	M4 Transfer	41232.1
M3 Start Contactor Confirm	41230.3	M4 Start Contactor Confirm	41232.3
M3 Line Contactor Confirm	41230.5	M4 Line Contactor Confirm	41232.5
M3 Permissive	41230.6	M4 Permissive	41232.6
M3 Trip NC	41230.7	M4 Trip NC	41232.7
M5 Run	41234.0	M6 Run	41236.0
M5 Transfer	41234.1	M6 Transfer	41236.1
M5 Start Contactor Confirm	41234.3	M6 Start Contactor Confirm	41236.3
M5 Line Contactor Confirm	41234.5	M6 Line Contactor Confirm	41236.5
M5 Permissive	41234.6	M6 Permissive	41236.6
M5 Trip NC	41234.7	M6 Trip NC	41236.7
M7 Run	41238.0	M8 Run	41240.0
M7 Transfer	41238.1	M8 Transfer	41240.1
M7 Start Contactor Confirm	41238.3	M8 Start Contactor Confirm	41240.3
M7 Line Contactor Confirm	41238.5	M8 Line Contactor Confirm	41240.5
M7 Permissive	41238.6	M8 Permissive	41240.6
M7 Trip NC	41238.7	M8 Trip NC	41240.7
M9 Run	41242.0	M10 Run	41244.0
M9 Transfer	41242.1	M10 Transfer	41244.1
M9 Start Contactor Confirm	41242.3	M10 Start Contactor Confirm	41244.3
M9 Line Contactor Confirm	41242.5	M10 Line Contactor Confirm	41244.5
M9 Permissive	41242.6	M10 Permissive	41244.6
M9 Trip NC	41242.7	M10 Trip NC	41244.7

- **Output signals**

Invalid Commands	41101.7
Sync Failed	41101.8
Transferring	41101.9
Watchdog Out	41101.10
Soft Starter Run Command	41101.11
VFD Ready Status	41101.12

M1 Start Contactor Command	41226.2	M2 Start Contactor Command	41228.2
M1 Line Contactor Command	41226.4	M2 Line Contactor Command	41228.4
M1 Disconnected	41227.2	M2 Disconnected	41229.2
M1 on VFD	41227.8	M2 on VFD	41229.8
M1 on Line	41227.9	M2 on Line	41229.9
M1 on Soft Starter	41227.10	M2 on Soft Starter	41229.10

M3 Start Contactor Command	41230.2	M4 Start Contactor Command	41232.2
M3 Line Contactor Command	41230.4	M4 Line Contactor Command	41232.4
M3 Disconnected	41231.2	M4 Disconnected	41233.2
M3 on VFD	41231.8	M4 on VFD	41233.8
M3 on Line	41231.9	M4 on Line	41233.9
M3 on Soft Starter	41231.10	M4 on Soft Starter	41233.10

M5 Start Contactor Command	41234.2	M6 Start Contactor Command	41236.2
M5 Line Contactor Command	41234.4	M6 Line Contactor Command	41236.4
M5 Disconnected	41235.2	M6 Disconnected	41237.2
M5 on VFD	41235.8	M6 on VFD	41237.8
M5 on Line	41235.9	M6 on Line	41237.9
M5 on Soft Starter	41235.10	M6 on Soft Starter	41237.10

M7 Start Contactor Command	41238.2	M8 Start Contactor Command	41240.2
M7 Line Contactor Command	41238.4	M8 Line Contactor Command	41240.4
M7 Disconnected	41239.2	M8 Disconnected	41241.2
M7 on VFD	41239.8	M8 on VFD	41241.8
M7 on Line	41239.9	M8 on Line	41241.9
M7 on Soft Starter	41239.10	M8 on Soft Starter	41241.10

M9 Start Contactor Command	41242.2	M10 Start Contactor Command	41244.2
M9 Line Contactor Command	41242.4	M10 Line Contactor Command	41244.4
M9 Disconnected	41243.2	M10 Disconnected	41245.2
M9 on VFD	41243.8	M10 on VFD	41245.8
M9 on Line	41243.9	M10 on Line	41245.9
M9 on Soft Starter	41243.10	M10 on Soft Starter	41245.10

- **Input points**

Digital input points that are not bound to internal digital input signals may be connected to other equipment and monitored over Modbus by reading their corresponding Modbus Discrete Input registers.

Local AI 1	30065	Remote 3 DI 1	11161	Remote 7 DI 1	11225
Local AI 2	30066	Remote 3 DI 2	11162	Remote 7 DI 2	11226
Local AI 3	30067	Remote 3 DI 3	11163	Remote 7 DI 3	11227
Local AI 4	30068	Remote 3 DI 4	11164	Remote 7 DI 4	11228
		Remote 3 DI 5	11169	Remote 7 DI 5	11233
Local DI 1	11113	Remote 3 DI 6	11170	Remote 7 DI 6	11234
Local DI 2	11114	Remote 3 DI 7	11171	Remote 7 DI 7	11235
Local DI 3	11115	Remote 3 DI 8	11172	Remote 7 DI 8	11236
Local DI 4	11116				
Local DI 5	11117	Remote 4 DI 1	11177	Remote 8 DI 1	11241
Local DI 6	11118	Remote 4 DI 2	11178	Remote 8 DI 2	11242
Local DI 7	11119	Remote 4 DI 3	11179	Remote 8 DI 3	11243
Local DI 8	11120	Remote 4 DI 4	11180	Remote 8 DI 4	11244
Local DI 9	11121	Remote 4 DI 5	11185	Remote 8 DI 5	11249
Local DI 10	11122	Remote 4 DI 6	11186	Remote 8 DI 6	11250
Local DI 11	11123	Remote 4 DI 7	11187	Remote 8 DI 7	11251
Local DI 12	11124	Remote 4 DI 8	11188	Remote 8 DI 8	11252
Local DI 13	11125				
Local DI 14	11126	Remote 5 DI 1	11193	Remote 9 DI 1	11257
Local DI 15	11127	Remote 5 DI 2	11194	Remote 9 DI 2	11258
Local DI 16	11128	Remote 5 DI 3	11195	Remote 9 DI 3	11259
		Remote 5 DI 4	11196	Remote 9 DI 4	11260
		Remote 5 DI 5	11201	Remote 9 DI 5	11265
Remote 1 DI 1	11129	Remote 5 DI 6	11202	Remote 9 DI 6	11266
Remote 1 DI 2	11130	Remote 5 DI 7	11203	Remote 9 DI 7	11267
Remote 1 DI 3	11131	Remote 5 DI 8	11204	Remote 9 DI 8	11268
Remote 1 DI 4	11132				
Remote 1 DI 5	11137	Remote 6 DI 1	11209	Remote 10 DI 1	11273
Remote 1 DI 6	11138	Remote 6 DI 2	11210	Remote 10 DI 2	11274
Remote 1 DI 7	11139	Remote 6 DI 3	11211	Remote 10 DI 3	11275
Remote 1 DI 8	11140	Remote 6 DI 4	11212	Remote 10 DI 4	11276
		Remote 6 DI 5	11217	Remote 10 DI 5	11281
Remote 2 DI 1	11145	Remote 6 DI 6	11218	Remote 10 DI 6	11282
Remote 2 DI 2	11146	Remote 6 DI 7	11219	Remote 10 DI 7	11283
Remote 2 DI 3	11147	Remote 6 DI 8	11220	Remote 10 DI 8	11284
Remote 2 DI 4	11148				
Remote 2 DI 5	11153				
Remote 2 DI 6	11154				
Remote 2 DI 7	11155				
Remote 2 DI 8	11156				

- **Output points**

Digital output points that are not bound to internal digital output signals may be connected to other equipment and controlled over Modbus by writing to their corresponding Modbus coils.

Local DO 1	00041	Remote 3 DO 1	00073	Remote 7 DO 1	00105
Local DO 2	00042	Remote 3 DO 2	00074	Remote 7 DO 2	00106
Local DO 3	00043	Remote 3 DO 3	00075	Remote 7 DO 3	00107
Local DO 4	00044	Remote 3 DO 4	00076	Remote 7 DO 4	00108
Local DO 5	00045	Remote 3 DO 5	00077	Remote 7 DO 5	00109
Local DO 6	00046	Remote 3 DO 6	00078	Remote 7 DO 6	00110
Local DO 7	00047	Remote 3 DO 7	00079	Remote 7 DO 7	00111
Local DO 8	00048	Remote 3 DO 8	00080	Remote 7 DO 8	00112
Local DO 9	00049				
Local DO 10	00050	Remote 4 DO 1	00081	Remote 8 DO 1	00113
Local DO 11	00051	Remote 4 DO 2	00082	Remote 8 DO 2	00114
Local DO 12	00052	Remote 4 DO 3	00083	Remote 8 DO 3	00115
Local DO 13	00053	Remote 4 DO 4	00084	Remote 8 DO 4	00116
Local DO 14	00054	Remote 4 DO 5	00085	Remote 8 DO 5	00117
Local DO 15	00055	Remote 4 DO 6	00086	Remote 8 DO 6	00118
Local DO 16	00056	Remote 4 DO 7	00087	Remote 8 DO 7	00119
		Remote 4 DO 8	00088	Remote 8 DO 8	00120
Remote 1 DO 1	00057	Remote 5 DO 1	00089	Remote 9 DO 1	00121
Remote 1 DO 2	00058	Remote 5 DO 2	00090	Remote 9 DO 2	00122
Remote 1 DO 3	00059	Remote 5 DO 3	00091	Remote 9 DO 3	00123
Remote 1 DO 4	00060	Remote 5 DO 4	00092	Remote 9 DO 4	00124
Remote 1 DO 5	00061	Remote 5 DO 5	00093	Remote 9 DO 5	00125
Remote 1 DO 6	00062	Remote 5 DO 6	00094	Remote 9 DO 6	00126
Remote 1 DO 7	00063	Remote 5 DO 7	00095	Remote 9 DO 7	00127
Remote 1 DO 8	00064	Remote 5 DO 8	00096	Remote 9 DO 8	00128
Remote 2 DO 1	00065	Remote 6 DO 1	00097	Remote 10 DO 1	00129
Remote 2 DO 2	00066	Remote 6 DO 2	00098	Remote 10 DO 2	00130
Remote 2 DO 3	00067	Remote 6 DO 3	00099	Remote 10 DO 3	00131
Remote 2 DO 4	00068	Remote 6 DO 4	00100	Remote 10 DO 4	00132
Remote 2 DO 5	00069	Remote 6 DO 5	00101	Remote 10 DO 5	00133
Remote 2 DO 6	00070	Remote 6 DO 6	00102	Remote 10 DO 6	00134
Remote 2 DO 7	00071	Remote 6 DO 7	00103	Remote 10 DO 7	00135
Remote 2 DO 8	00072	Remote 6 DO 8	00104	Remote 10 DO 8	00136

7. Troubleshooting

7.1 Motor does not start

Whether commanding a motor to run on either a VFD or soft starter, the motor does not start.

Symptom The HMI shows the Invalid Command lit up red for the motor being commanded to start.

Cause The VFD or soft starter is not ready. They could be faulted or locked out.

Solution Reset the fault or clear the lockout. Correct the underlying problem.

Cause The VFD or soft starter is busy servicing a different motor.

Solution Only one motor may be operated at any given time by the VFD or soft starter.

7.2 Motor does not start on VFD

When given a Run command, the VFD doesn't start.

Symptom The HMI shows the VFD is faulted.

Solution Reset the VFD fault. Correct the underlying problem causing the VFD to be faulted.

Symptom The Lockouts, Warnings and Limits screen on the HMI shows a "Fieldbus Communication Timeout" lockout.

Cause The Synchronous Transfer Controller has lost its connection to the VFD.

Solution Press the Comm Reset button on the HMI's Sync screen.

Symptom The Lockouts, Warnings and Limits screen on the HMI shows some other lockout condition.

Solution Correct the underlying problem causing that lockout.

Symptom The Sync screen on the HMI displays the message "Waiting for VFD Parameter Set Confirmation".

Cause The Synchronous Transfer Controller is configured to use different VFD parameter sets for each motor and a parameter set for the requested motor has not been created.

Solution Either create a parameter set for the requested motor through the HMI, or set *VFD Parameter Sets* in the Synchronous Transfer Controller to Disabled.

Symptom The Sync screen on the HMI displays the message "Waiting for Start Contactor Closed Confirmation" when *Contactor Control* is set to Plant.

Cause The internal Start Contactor Confirm digital input signal is not bound to a digital input point.

Solution Bind the Start Contactor Confirm digital input signal to a digital input point.

Cause The logic feeding this specific digital input point bound to the Start Contactor Confirm digital input signal is not correct.

Solution Correct the logic feeding the digital input bound to the Start Contactor Confirm digital input signal.

7.3 Motor does not transfer from VFD to line

When given an Up Transfer command, the motor runs on the VFD, but never transfers.

Symptom The VFD goes to some low speed and the Sync screen on the HMI shows a low line frequency.

Cause There is an open fuse or damaged/loose wire in the line side potential transformer feedback path.

Solution Replace open fuses and correct damaged/loose wires.

Symptom The VFD doesn't reach line frequency and the Limit indicator on the HMI's Main screen lights up.

Cause The VFD is limiting its output and can't reach line frequency.

Solution Address the underlying condition causing the VFD to limit its output. Refer to the *M2L3000 Operation Manual*.

Symptom The VFD reaches line frequency, but the Sync Failed indicator on the HMI's Sync screen lights up after the time allowed by *Sync Fail Delay*. The VFD records a Sync Timeout event in its event log.

Cause The VFD's *Maximum Frequency* parameter isn't set higher than the line frequency.

Solution Set the VFD's *Maximum Frequency* parameter to 2 Hz above line frequency.

Cause The *Sync Fail Delay* parameter is set too short.

Solution Increase the *Sync Fail Delay* parameter.

Symptom The VFD reaches line frequency, but either the Line or VFD Phase Sequence indicators on the HMI's Sync screen are lit up red.

Cause Swapped phases of power wiring or potential transformer feedback paths cause a phase sequence error condition that prevents the transfer.

Solution Find and correct the swapped phases.

Symptom The VFD reaches line frequency, but either the Line or VFD Imbal Voltage indicators on the HMI's Sync screen are lit up red.

Cause An open fuse or loose wire in either of the potential transformer feedback paths cause a large voltage imbalance that prevents the transfer.

Solution Replace open fuses and correct loose wires.

Symptom The VFD reaches line frequency, but any of the Line and VFD Over Voltage, and Under Voltage indicators on the HMI's Sync screen are lit up red.

Cause A real over or under voltage conditions exists.

Solution Find and address the root cause.

Cause The parameters for the PSM module portion of the Synchronous Transfer Controller are not set properly.

Solution Correct the parameter settings for the PSM module.

Symptom The Sync screen on the HMI displays the message "Test Mode: Never Transfer".

Cause The *Test Mode* parameter is set to Never Transfer. In this test mode, the VFD continually synchronizes to the line but never transfers.

Solution Set *Test Mode* to None.

Symptom The Sync screen on the HMI displays the message "Waiting for Line Contactor Closed Confirmation" when *Contactor Control* is set to Plant.

Cause The internal Line Contactor Confirm digital input signal is not bound to a digital input point.

Solution Bind the Line Contactor Confirm digital input signal to a digital input point.

Cause The logic feeding this specific digital input point bound to the Line Contactor Confirm digital input signal is not correct.

Solution Correct the logic feeding the digital input bound to the Line Contactor Confirm digital input signal.

7.4 Motor does not transfer from line to VFD

When given a Down Transfer command, the motor either remains running on the line, or coasts to a stop. In either case, this is due to a VFD fault. The *VFD Fault on Down Transfer* parameter determines whether the motor will coast to stop or remain on the line.

Symptom The VFD is faulted or locked out before the Down Transfer command is sent.

Cause A down transfer cannot begin if the VFD is either faulted or locked out.

Solution Resolve the underlying issue causing the VFD to be faulted or locked out. If the VFD faulted during an up transfer, the *Up Transfer Voltage Setpoint* and *Up Transfer Phase Setpoint* parameters may need to be adjusted.

Symptom The VFD faults during the down transfer.

Cause The VFD can experience too much current during the closed transition if the voltage and phase are not properly matched and account for the shifting load on the VFD. See the *M2L3000 Operation Manual* for VFD fault information.

Solution View the current waveforms captured by the VFD when the fault occurred.

Adjust the *Down Transfer Voltage Setpoint* and *Down Transfer Phase Setpoint* parameters.

7.5 VFD produces cell faults on up transfer

Symptom The motor transfers from the VFD up to the line, but the VFD produces cell faults during the transition.

Cause The VFD can experience too much current during the closed transition if the voltage and phase are not properly matched and account for the shifting load on the VFD. See the *M2L3000 Operation Manual* for VFD fault information.

Solution View the current waveforms captured by the VFD when the fault occurred.

Adjust the *Up Transfer Voltage Setpoint* and *Up Transfer Phase Setpoint* parameters.

7.6 VFD produces motor N contactor faults

The Synchronous Transfer Controller monitors all the Start and Line Contactor Confirm input signals from all motors at all times. When the Confirm input signals are different from their corresponding Command output signals for longer than the time set in parameter *Contactor Fail Delay* , the Synchronous Transfer Controller instructs the VFD to produce a “Motor N Contactor Fault”, where ‘N’ is the number of the motor associated with that contactor.

Symptom The VFD produces a Motor N Contactor fault when starting or transitioning a motor.

Cause An internal Start Contactor Confirm or Line Contactor Confirm digital input signal is not bound to a digital input point.

Solution Bind the Start Contactor Confirm or Line Contactor Confirm digital input signal to a digital input point.

Cause A missing, loose, or damaged wire in either command circuit to the contactor’s coil, or the confirm circuit from the contactor’s aux contact.

Solution Correct the loose, damaged or missing wire.

Cause A malfunctioning contactor.

Solution Replace the contactor.

Symptom The VFD produces a Motor N Contactor fault at random times when the Synchronous Transfer Controller should not be opening or closing a contactor.

Cause Dips in the control power can cause contactors or their aux contacts to drop out.

Solution Correct the underlying problem causing dips in the control power.

Cause Missing ground wires or poorly routed control wires can cause erroneous signals in digital inputs.

Solution Check and correct grounding issues. Ensure control wires are not routed with power wires.

7.7 One motor stops unexpectedly

When bound to digital input points, the Synchronous Transfer Controller monitors the Motor Permissive and Motor Trip NC digital input signals for every motor at all times. If either goes low,

the Synchronous Transfer Controller will stop the motor and instruct the VFD to store a Motor Disabled event in its event log that captures the state of those inputs.

Symptom A motor stops unexpectedly and the VFD logs a Motor Disabled event.

Cause Either a Motor Permissive or Motor Trip NC digital input signal went low.

Solution Resolve the underlying issue.

7.8 All motors stop unexpectedly

Either an All Stop command was received or the Watchdog In digital input stopped toggling.

When bound to a digital input point, the Synchronous Transfer Controller monitors the All Stop NO or All Stop NC digital input signal and instructs the VFD to record a “Sync Controller All Stop Command Received” event if the signal is asserted (high for All Stop NO or low for All Stop NC) and it opens all motor contactors.

When the Watchdog In digital input signal is bound to a digital input point, the Synchronous Transfer Controller monitors that signal and instructs the VFD to produce a “Sync Controller Plant Watchdog Fault” if it stops toggling and it opens all motor contactors.

Symptom All motors stop unexpectedly and the VFD logs a Sync Controller All Stop Command Received event.

Cause The Plant has asserted an All Stop command.

Solution Resolve the underlying issue.

Symptom The VFD produces a Sync Controller Plant Watchdog Fault.

Cause A relay output module in the plant’s PLC that generates the signal has failed.

Solution Replace the relay output module in the plant’s PLC.

8. Maintenance

8.1 CPU energy pack status and replacement schedule

The CPU Energy Pack provides the CPU with enough energy when system power is removed for it to store parameter settings to non-volatile memory. When system power is restored, the CPU Energy Pack recharges through the cable connecting it to the CPU.

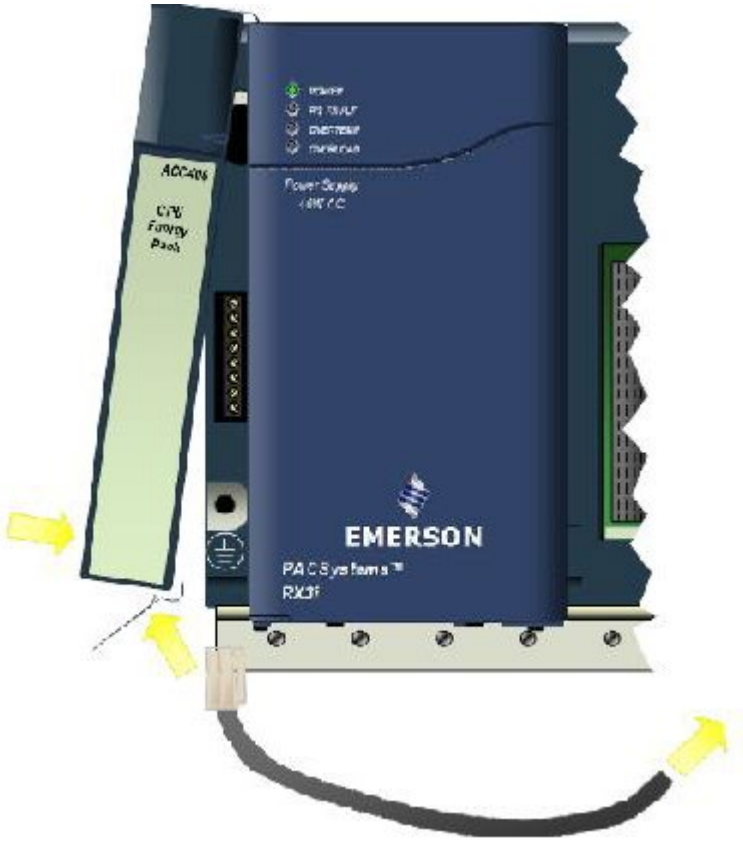
The CPU Energy Pack should be replaced every 10 years, unless it operates in an ambient temperature above 50 °C, in which case it should be replaced every five years.

The CPU Energy Pack may be replaced while the Synchronous Transfer Controller is powered up and operating.

Be sure to back up the Synchronous Transfer Controller's parameters before replacing the CPU Energy Pack.

- **Installing the energy pack**

The energy pack mounts to the left side of the RX3i rack and connects to the CPU module with a cable. To install the energy pack:



1. Engage the top mounting hooks on the frame of the energy pack to the frame of the power supply module.
2. Rotate the bottom of the energy pack into place until its latch snaps.
3. Connect the cable from the connector on the bottom of the energy pack to the bottom of the CPU module.

8.2 Backing up parameters

It is highly recommended to back up the parameter settings from the Synchronous Transfer Controller once it has been commissioned. The Benshaw Connect software provides a convenient method for saving parameter values to a file. It can also generate a report which can be printed for a hard-copy backup.

8.3 Restoring parameters

Parameter settings that have been backed up using the Benshaw Connect software can easily be restored with the Benshaw Connect software.

8.4 Backing up the application

The Synchronous Transfer Controller application may be backed up from the CPU module (IC95CPE310) to a USB flash drive. This also backs up the parameter settings. This can only be done while the application is stopped.

1. Stop the application by moving the three-position RUN MODE switch to the left, STOP position.
2. Move the three-position RDSD (Removable Data Storage Device) switch to the left, UPLOAD position.
3. Insert a USB flash drive into the USB connector.
4. Press the START pushbutton.
   - The RDSD LED flashes green during the upload to the USB flash drive and turns solid green when the upload successfully completes.
   - If the RDSD LED turns solid red, the upload failed.
5. Remove the USB Flash drive.
6. Restart the application by moving the three-position RUN MODE switch to the right, RUN IO ENABLE position.

8.5 Restoring the application

A previously backed up application may be restored from a USB flash drive to the CPU module. This can only be done while the application is stopped.

1. Stop the application by moving the three-position RUN MODE switch to the left, STOP position.
2. Move the three-position RDSD (Removable Data Storage Device) switch to the right, DOWNLOAD position.
3. Insert a USB flash drive with the backed up application into the USB connector. The RDSD LED turns solid green.
4. Press the START pushbutton.
   - If the RDSD LED flashes red, either the CPU is blank, or the target name on the USB flash drive is found to be different from that on the CPU module. If this is expected and acceptable, press the START pushbutton again to begin the download.
   - The RDSD LED flashes green during the download to the CPU module and turns solid green when the download successfully completes.
   - If the RDSD LED turns solid red, the download failed and memory in the CPU has been cleared.
5. Remove the USB flash drive.

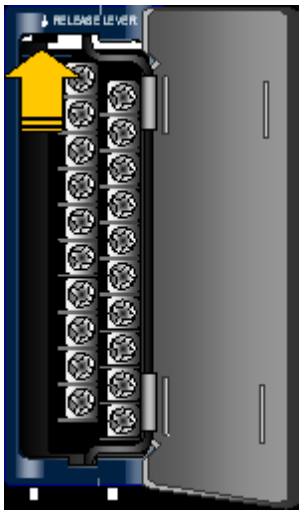
6. Restart the application by moving the three-position RUN MODE switch to the right, RUN IO ENABLE position.
7. Verify the parameter settings were properly restored.

8.6 Replacing an RX3i module

- **I/O module terminal block**

The I/O modules have removable terminal blocks to facilitate replacement without having to remove the wiring. To remove the terminal block:

1. Open the terminal block door.
2. Push the release lever to unlock the block.
3. Pull the block away from the module.



The terminal block cover may also be removed for easier access to the terminals.

To remove the cover from the block:

1. Grasp the sides of the cover.
2. Pull down on the bottom of the block.

To replace the cover on the block:

1. Align the top of the block with the bottom of the cover.
2. Slide the block upward until it clicks into place.

- **Removing a module from the backplane**

1. While depressing the release lever, pivot the module upward until its connector is removed from the backplane.
2. Lift the module up and away from the backplane to disengage the pivot hook.

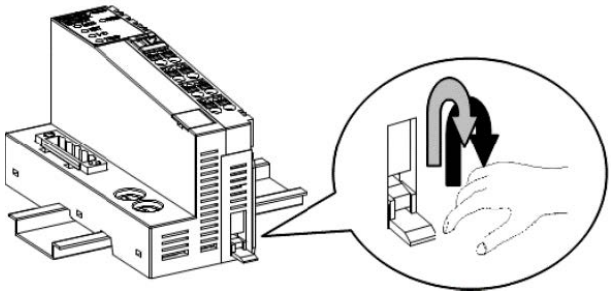
- **Installing a module on the backplane**

1. Switch the module down.
2. Push the front of the module until the release lever on the bottom of the module snaps into place on the backplane.

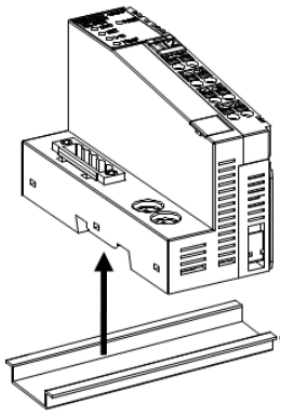
8.7 Replacing an RSTi distributed I/O module

- **Removing from the DIN rail**

1. Pull down the locking lever.

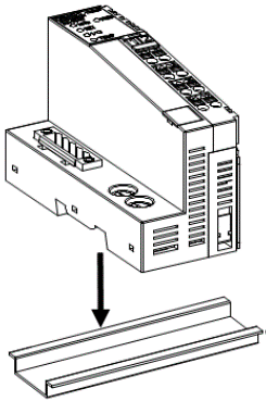


2. Push up on the bottom of the module then pull away from the rail.



- **Installing on DIN rail**

1. Push up on the locking lever.



- **Setting the Profinet module address**

If replacing the Profinet module, set its two rotary switches to match the module being replaced.

9. Hardware reference

9.1 RX3i controller

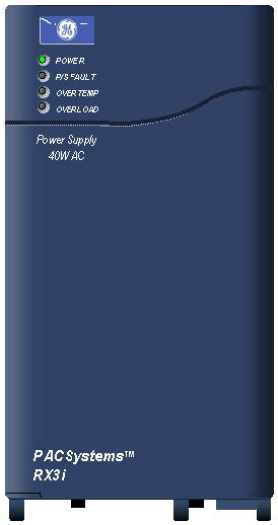
IC695ACC400 : CPU energy pack

The “STATUS” LED on the CPU module indicates the status of the CPU energy pack. Refer to *IC695CPE310 : RX3i* CPU on page 48.

- **Specifications**

  Operating temperature.....0 to 60°C
  Typical life expectancy.....10+ years @ 50°C
  .....4.5 years @ 60°C

IC695PSA140 : 120/240 VAC power supply module



The two IC695PSA140 power supplies in the RX3i rack provide power through the backplane to the other modules in the rack. They operate redundantly and allow the system to continue running if one fails. They may be hot swapped.

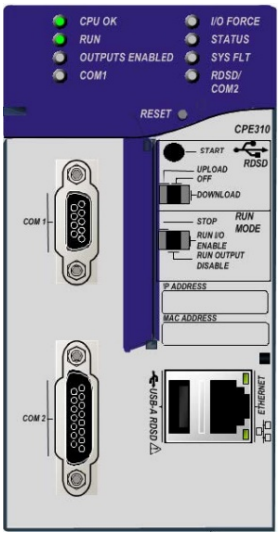
- **Specifications**

Input voltage range ..... 85 to 264 VAC or
..... 100 to 300 VDC
Maximum input power ..... 70 W
Load capacity ..... 40 W up to 40°C, derated above 40°C
Isolation (input to backplane) ..... 250 VAC continuous
..... 1500 VAC for 1 minute
Ride-through time ..... 20 milliseconds

- **LEDs**

LED Name	Status	Description
POWER	Green	Power is being supplied to the backplane.
	Amber	Power is applied to the power supply but the Power Supply switch is off.
P/S FAULT	Red	The power supply has failed and is no longer supplying sufficient voltage to the backplane.
OVERTEMP	Amber	The power supply is approaching or exceeding its maximum operating temperature.
OVERLOAD	Amber	The power supply is approaching or exceeding its maximum output capability.

IC695CPE310 : RX3i CPU



- **Specifications**

Temperature range ..... 0°C to 60°C
Ethernet 10BaseT/100BaseT RJ45
RS-232 ..... COM1, 9-pin D, non-isolated
RS-485 ..... COM2, 15-pin D, non-isolated
USB ..... USB-A 2.0

- **LEDs**

LED Name	Status	Description
CPU OK	Off	CPU problem. RUN and OUTPUTS ENABLED LEDs may be flashing in an error code pattern.
	Green	CPU has passed its power-up diagnostics and is functioning properly.
	Flashing green	If all other LEDs are off, CPU is in STOP-Halt state; possible watchdog timer fault. The CPU OK LED flashes in unison with the Outputs Enabled LED to indicate the CPU is in boot mode and is waiting for a firmware update through a serial port.
RUN	Off	CPU is in STOP mode.
	Green	CPU is in RUN mode.
	Flashing green	The Run LED flashes in unison with the OUTPUTS ENABLED LED to report an error code.
OUTPUTS ENABLED	Off	Output scan is disabled.
	Green	Output scan is enabled.
	Flashing green	The Outputs Enabled LED flashes in unison with the CPU OK LED to indicate the CPU is in boot mode and is waiting for a firmware update through a serial port.
	Flashing green	The Outputs Enabled LED flashes in unison with the Run LED to report an error code.
I/O FORCE	Amber	Override is active on a bit reference.

LED Name	Status	Description
STATU S	Flashing green	Energy pack charging. Not yet charged above the minimum voltage. This is normal when power is applied to the system and may take a few seconds. The CPU does not begin executing until the energy pack is charged.
	Green	Energy pack is charged and operating normally.
	Flashing red	Energy pack is nearing its end-of-life and should be replaced.
	Red	Energy pack failed. Parameter settings may be lost.
	Off	Energy pack is not connected.
SYS FLT	Red	CPU is in Stop/Faulted mode because a fatal fault has occurred.
COM1	Off	No activity on serial port COM1.
	Flashing green	Signal activity on serial port COM1.
RDSD / COM2	Off	No activity on serial port COM2.
	Flashing green	Signal activity on serial port COM2 or transferring data to USB flash drive.
	Green	USB flash drive inserted and is idle or the transfer is complete.
	Red	USB flash drive transfer failed.
	Flashing red	Attempt to restore an image from flash drive and the target name does match the target name in the CPU. Press Start again to continue.

- **COM2 RS-485 signals**

The Modbus RTU server is available through COM2 using RS-485. The flow control signals are not used by the application. Refer to *Modbus* on page 26 for more information.

Pin	Name	Description
1	Shield	Cable shield
2	NC	NC
3	NC	NC
4	NC	NC
5	+5Vdc	Logic power: Provides isolated +5 VDC power (300 mA maximum) for power external options.
6	RTS (A)	Differential request to send A
7	0V	Signal ground
8	CTS (B’)	Differential clear to send B
9	RT	Resistor termination
10	RD (A’)	Differential receive data A
11	RD (B’)	Differential receive data B
12	SD (A)	Differential send data A
13	SD (B)	Differential send data B
14	RTS (B’)	Differential request to send B
15	CTS (A’)	Differential clear to send A

IC694ALG221 : 4-channel, 4-20 mA analog input module

This module resides in Slot 4 on the RX3i backplane. It provides Local Analog Inputs 1 through 4 to the application. The application uses channel 1 for the VFD speed command.

This module requires an external source of 24 VDC connected to the TB1 connector on the left side of the backplane.

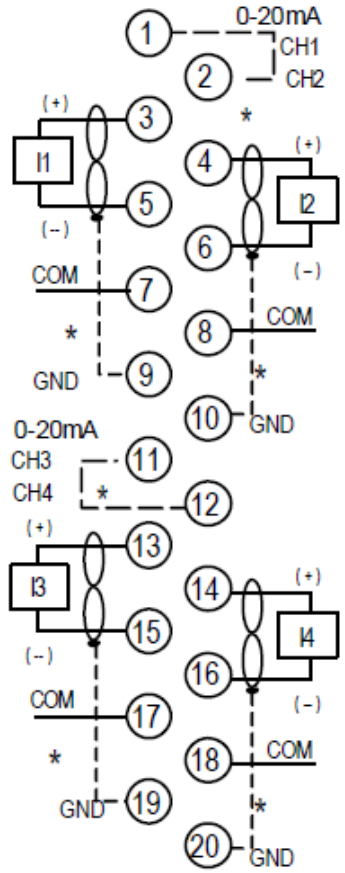
- **Specifications**

Input current range ..... 4 to 20 mA or
.....0 to 20 mA
Update rate..... 2 milliseconds
Common mode voltage.....200 volts
Isolation (input to backplane) ..... 250 VAC continuous
.....1500 VAC for 1 minute
Input impedance ..... 250 Ohms

- **LEDs**

The MODULE OK LED is on when the module's power supply is operating.

- **Terminals**



*Optional Connections

1	0-20 mA jumper for channels 1 and 2
2	
3	Channel 1+
4	Channel 2+
5	Channel 1-
6	Channel 2-
7	Common
8	Common
9	Channel 1 shield
10	Channel 2 shield
11	0-20 mA jumper for channels 3 and 4
12	
13	Channel 3+
14	Channel 4+
15	Channel 3-
16	Channel 4-
17	Common
18	Common
19	Channel 3 shield
20	Channel 4 shield

IC695PNC001 : Profinet controller module

The Profinet controller module connects the RSTi Distributed Slice I/O in order to provide the remote I/O points.

- **Specifications**

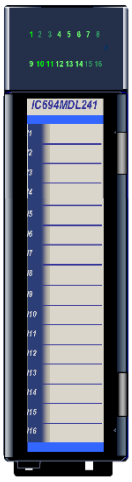
Profinet link speeds .....100 Mbps or 1000 Mbps
.....10 Mbps cannot be used for Profinet
Profinet ports .....2 RJ45 on underside of module
Temperature range .....-25°C to 60°C

- **LEDs**

LED Name	Status	Description
OK	Flashing amber	Fatal initialization
	Flashing green	Power-up completed, but backplane communications not yet established.
	Green	Power-up completed and backplane communications established.
	Green pattern	Fatal error. Flashes once between error code flashed in amber.
	Amber pattern	Fatal error. Pattern indicates error code.
LAN	Green	LAN connected
	Flashing green	LAN activity
	Green pattern	Fatal error. Flashes once between error codes flashed in amber on the OK LED.
STATUS	Green	Normal operation
	Flashing red	Invalid MAC address.
	Green pattern	Fatal error. Flashes once between error codes flahshed in amber on the OK LED.
CONFIG	Green	Configured
	Off	Not configured

LED Name	Status	Description
ACTIVE	Green	All configured Profinet devices have established connections.
	Amber	At least one, but not all configured Profinet devices have established connections.
	Off	No configured Profinet devices have established connections.
	Green pattern	Fatal error. Flashes once between error codes flashed in amber on the OK LED.
OK+LAN+STATUS	Flashing green	Invalid firmware

IC694MDL241 : 16-point, 24 VAC/VDC digital input module



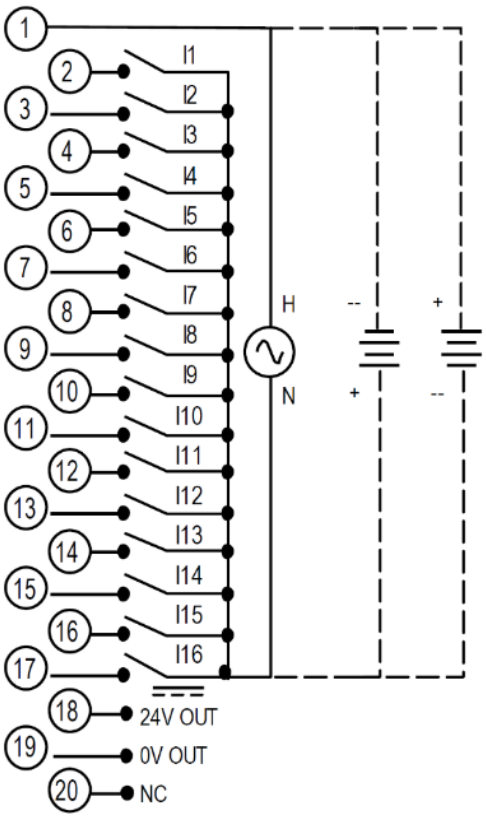
This module resides in Slot 8 on the RX3i backplane. It provides Local Digital Inputs 1 through 16 to the application.

This module provides 16 digital inputs in one group, with a common power input terminal. It can be used with AC or DC inputs. In DC mode, it can be wired for either positive or negative logic.

- **Specifications**

Rated voltage ..... 24 VAC or 24 VDC
Input voltage range ..... 0 to 30 VDC
..... 0 to 30 VAC, 50/60 Hz
Isolation (input to backplane and to frame ground) ..... 250 VAC continuous
..... 1500 VAC for 1 minute
Input current ..... 7 mA (typical) at rated voltage
Input ON state voltage ..... 11.5 to 30 VAC or VDC
Input OFF state voltage ..... 0 to 4 VAC or VDC
ON state current ..... 3.2 mA minimum
OFF state current ..... 1 mA maximum

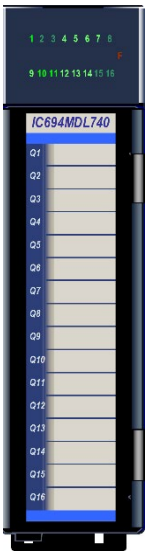
- **Terminals**



1	Inputs 1-16 common
2	Input 1
3	Input 2
4	Input 3
5	Input 4
6	Input 5
7	Input 6
8	Input 7
9	Input 8
10	Input 9
11	Input 10
12	Input 11
13	Input 12
14	Input 13
15	Input 14
16	Input 15
17	Input 16
18	24 VDC for input devices
19	0V for input devices
20	No connection

NOTE
Using the 24V OUT reduces the module's isolation to 50 VAC continuous; 500 VAC for 1 minute.

IC694MDL740 : 16-point, 12/24 VDC, 0.5 A digital output module



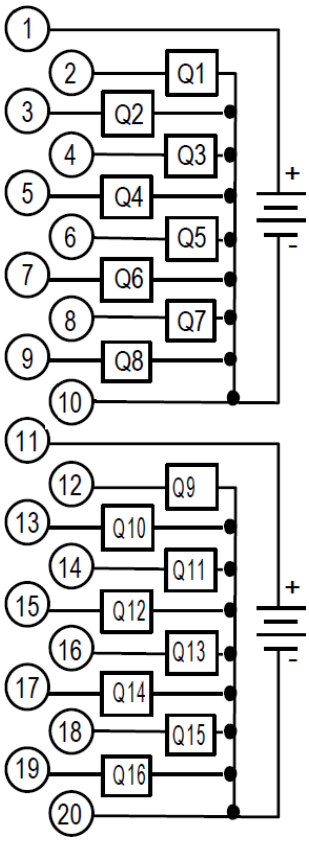
This module resides in Slot 9 on the RX3i backplane. It provides Local Digital Inputs 1 through 16 to the application.

This module provides 16 transistor output points in two groups of eight. Each group has a common power output terminal. The module has positive logic; sourcing current to loads from the user common or positive power bus with the output is high. Output devices are connected between the negative power pus and the module terminals. Power to operate field devices must be separately supplied.

- **Specifications**

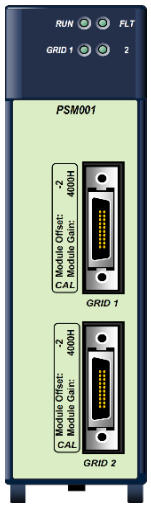
  Rated voltage ..... 12/24 VDC
  Output voltage range .....12 to 24 VDC (+20%, -15%)
  Isolation (output to backplane and to frame ground, group to group)
  ..... 250 VAC continuous
  .....1500 VAC for 1 minute
  Output current.....0.5 A max per point
  Output inrush current .....4.78 A for 10 ms
  Output voltage drop ..... 1 Volt maximum
  Output OFF state leakage..... 1 mA maximum

- **Terminals**



1	Outputs 1 – 8 DC +
2	Output 1
3	Output 2
4	Output 3
5	Output 4
6	Output 5
7	Output 6
8	Output 7
9	Output 8
10	Outputs 1 – 8 common
11	Outputs 9 – 16 DC +
12	Output 9
13	Output 10
14	Output 11
15	Output 12
16	Output 13
17	Output 14
18	Output 15
19	Output 16
20	Outputs 9 – 16 common

IC694PSM001 : Power sync and measurement module



The power sync and measurement module and power sync and measurement terminal assembly provide the application with the feedback it needs to synchronize the VFD to the line.

- **Specifications**

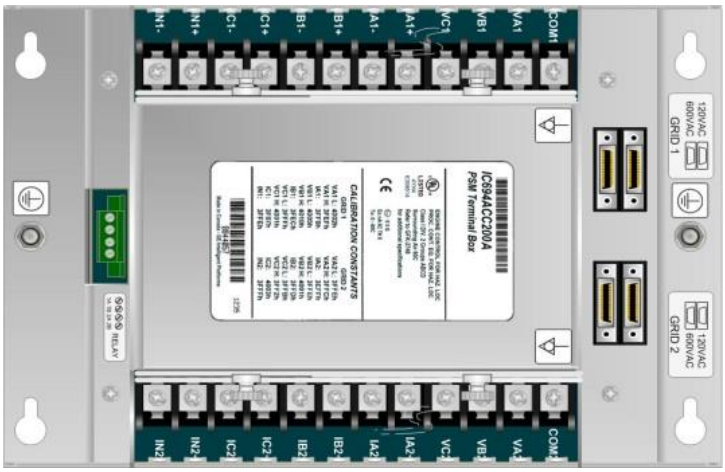
Isolation from backplane ..... 1500 VDC
Frequency range.....30 to 70 Hz
Frequency accuracy..... 0.01 Hz
Voltage accuracy 0.2%
Phase angle accuracy..... 0.1°

- **LEDs**

LED Name	Status	Description
RUN	Green	The module is operating correctly and communicating with the backplane.
	Red	The module is operating without backplane communication.
	Off	The module is not operating
FLT	Flashing green	Grid 1 and Grid 2 are going in and out of synchronization
	Green	Grid 1 and Grid 2 are synchronized without any faults
	Red	Grid 1 and Grid 2 are synchronized, but there is some grid fault condition.
	Off	Grid 1 and Grid 2 are not synchronized and there is some grid fault condition.
GRID 1	Green	Indicates a voltage signal has been detected on Grid 1.
	Red	A frequency out-of-range condition has been detected on Grid 1.
	Off	No zero-crossing signal of Grid 1 has been detected in the last 250 milliseconds.

LED Name	Status	Description
GRID 2	Green	Indicates a voltage signal has been detected on Grid 2.
	Red	A frequency out-of-range condition has been detected on Grid 2.
	Off	No zero-crossing signal of Grid 2 has been detected in the last 250 milliseconds.

IC694ACC200 : Power sync and measurement terminal assembly



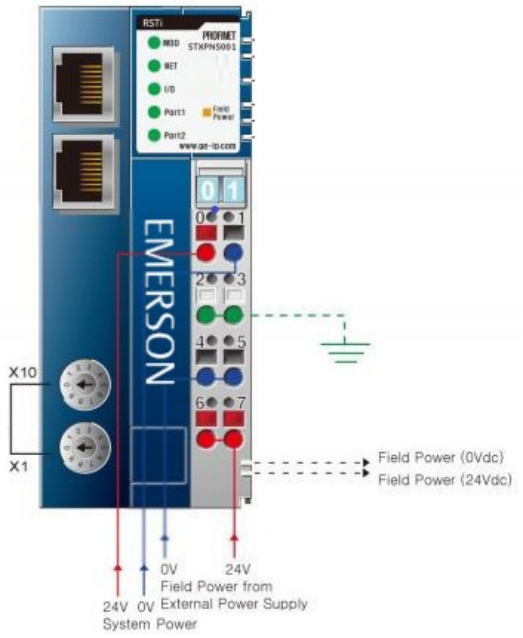
The power sync and measurement module and power sync and measurement terminal assembly provide the application with the feedback it needs to synchronize the VFD to the line.

- **Specifications**

  120 VAC voltage input range ..... 45 to 150 VAC RMS
  600 VAC voltage input range ..... 120 to 690 VAC RMS

9.2 RSTi Distributed Slice I/O

STXPNS001： Profinet IO scanner module



This module connects the block of RSTi Distributed Slice I/O to the IC695PN001 Controller Module in the RX3i rack over a Profinet network.

- **Specifications**

Temperature range ..... 0°C to 55°C
Relative humidity ..... 5% to 95%, non-condensing
System power voltage ..... 24 VDC nominal
..... 11 to 28.8 VDC
Field power voltage ..... 24 VDC nominal
..... 11 to 28.8 VDC

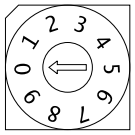
- **LEDs**

LED Name	Status	Description
MOD	Off	No power is supplied to the module
	Red	Firmware fault
	Flashing red (0.5 sec)	Invalid RAM image
	Flashing red (0.1 sec)	OS fatal error
	Flashing green (0.1 sec)	OS exception error
	Green	Normal operation
NET	Off	Not on-line
	Flashing red (0.1 sec)	Invalid configuration
	Flashing green (0.1 sec)	Profinet connected, awaiting parameters
	Red	Profinet connection aborted after exchanging I/O
	Flashing red (0.5 sec)	Profinet connection aborted before exchanging I/O
	Flashing green (0.5 sec)	Profinet connected, not exchanging I/O
	Green	Profinet connected, exchanging I/O

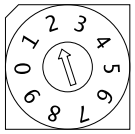
LED Name	Status	Description
I/O	Off	Not powered or no I/O modules found
	Flashing green	I/O modules configured but not exchanging I/O
	Green	I/O modules exchanging I/O
	Red	Communications fault with I/O module
	Flashing red	Failed to configure I/O modules
PORT1 PORT2	Off	Link is down
	Green	Link is present
	Flashing green	Link is active
Field Power	Off	Not supplied 24 VDC field power
	Green	Supplied 24 VDC field power

- **Rotary switches**

The two rotary switches set a two-digit decimal number for the station address. The top switch sets the first digit (1), the bottom switch sets the second digit (2). The example to the right is set to station address 02.



First Digit

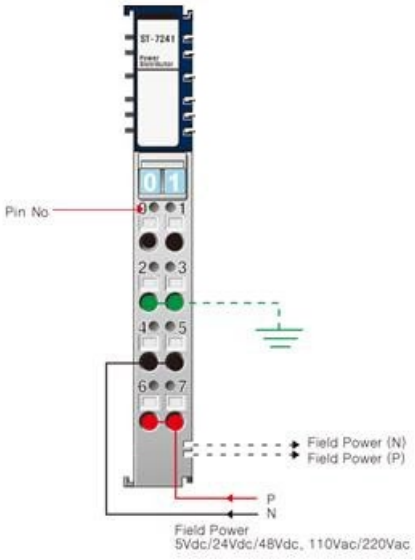


Second Digit

- **Terminals**

0	System power 24 VDC+
1	System power 0 V
2	Ground connection
3	Ground connection
4	Field power 0 V
5	Field power 0 V
6	Field power 24 VDC
7	Field power 24 VDC

ST-7241 Field power distribution module

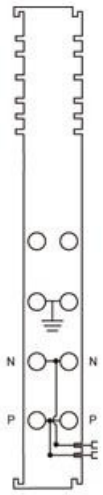


This module receives the field power for the I/O modules through its terminals and passes it to the module immediately to its right.

- **Specifications**

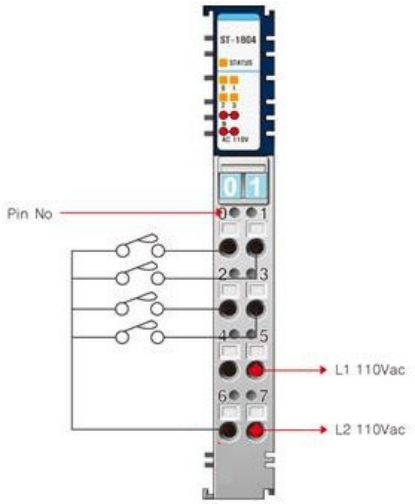
  Field power voltage..... Arbitrary
  Field power contacts current..... 10 A maximum

- **Terminals**



0	No connection
1	No connection
2	Field ground
3	Field ground
4	Field power (N)
5	Field power (N)
6	Field power (P)
7	Field power (P)

ST-1804 4-channel, 110 VAC digital input modules

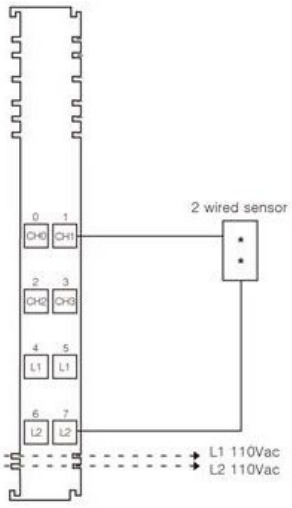


The RSTi Distributed Slice I/O has two 4-channel, 110 VAC digital input modules. They provide remote digital inputs 1 through 8 for this block of Remote IO to the application.

- **Specifications**

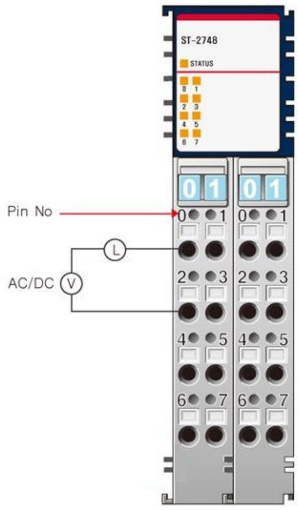
ON-state voltage ..... 110 VAC nominal
..... 85 VAC to 132 VAC
OFF-state voltage ..... 45 VAC maximum
ON-state current ..... 8 mA @ 132 VAC maximum
Input impedance ..... 11 kOhm nominal
Field power ..... 120 VAC nominal
..... 85 VAC to 132 VAC

- **Terminals**



0	Input 1 / 5
1	Input 2 / 6
2	Input 3 / 7
3	Input 4 / 8
4	L1
5	L1
6	L2
7	L2

ST-2748 8-channel relay output module



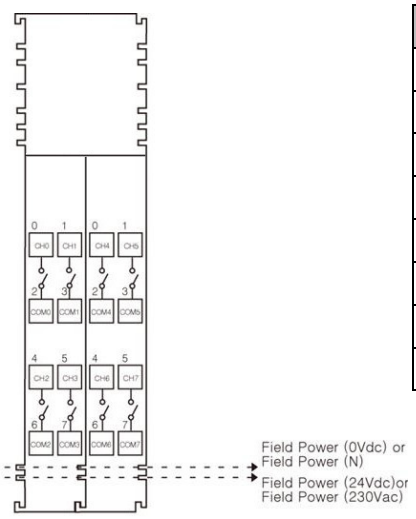
This module provides remote digital outputs 1 through 8 to the application.

- **Specifications**

Output range.....5 – 28.8 VDC @ 2.0 A resistive
.....48 VDC @ 0.8 A resistive
.....110 VDC @ 0.5 A resistive
.....240 VAC @ 2.0 A resistive
Minimum load ..... 100 uA, 100 mVDC
ON-state voltage drop..... 0.5 V max @ 2.0 A, resistive load, 24 VDC
OFF-state leakage current ..... Maximum 1.5 mA
Initial contact resistance..... 10 mOhm
Expected contact life.....300 K cycles resistive

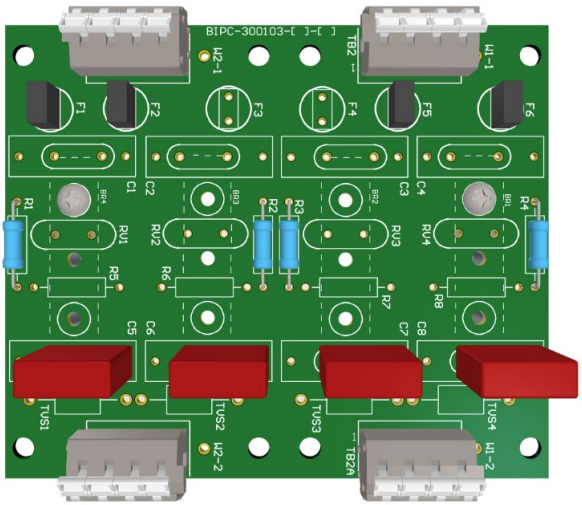
- **Terminals**

Terminal	Left Side
0	Output 1
1	Output 2
2	Output 1 common
3	Output 2 common
4	Output 3
5	Output 4
6	Output 3 common
7	Output 4 common



Terminal	Right Side
0	Output 5
1	Output 6
2	Output 5 common
3	Output 6 common
4	Output 7
5	Output 8
6	Output 7 common
7	Output 8 common

9.3 BIPC-300103-01 filter card



The Filter Card filters the feedbacks from the VFD and line potential transformers before sending them to the IC694ACC200 PSM terminal assembly.

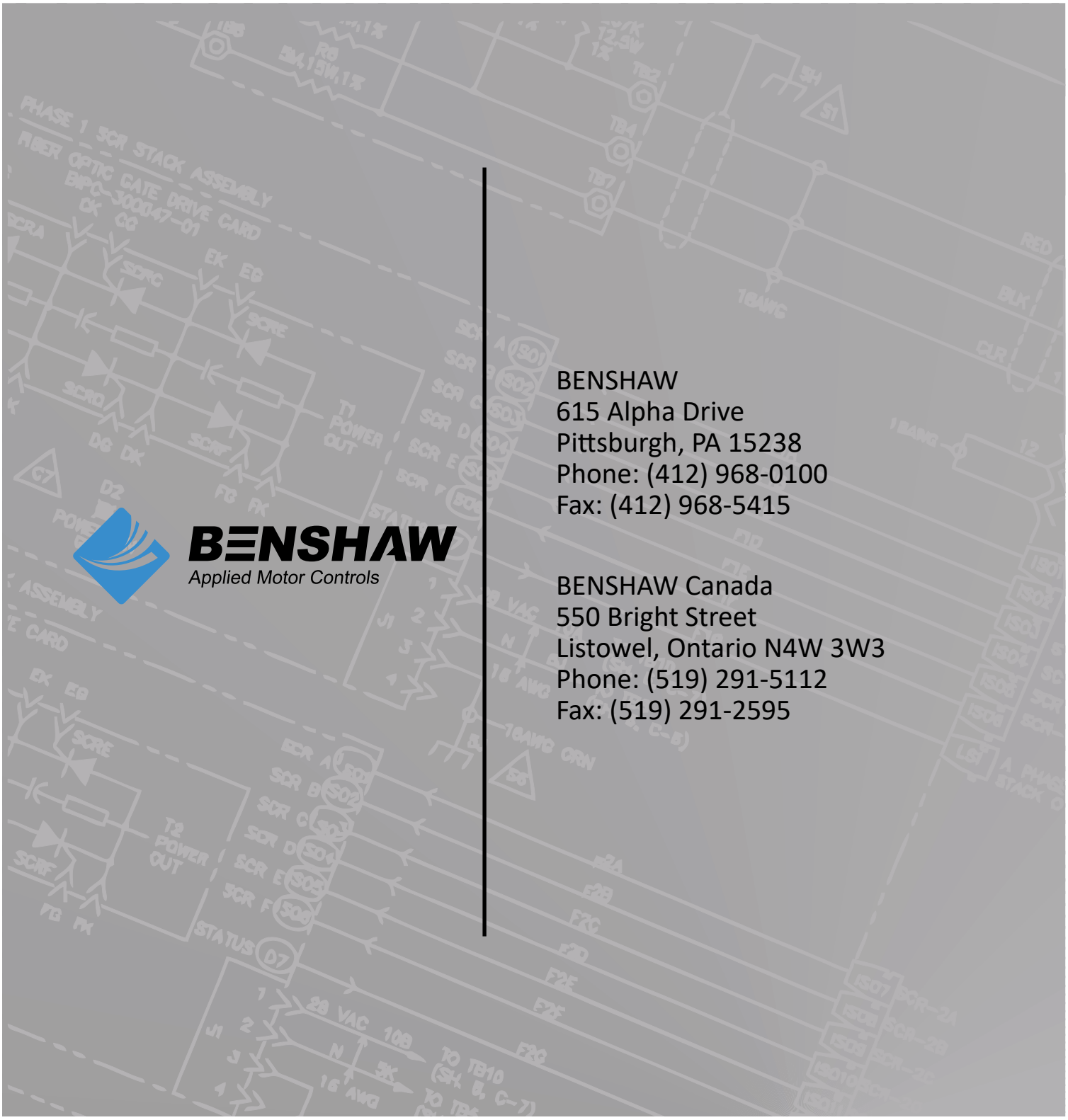
- **Terminals**

TB1	
1	Line phase A input
2	Line phase B input
3	Line phase C input
4	Shield

TB1A	
1	Line phase A output
2	Line phase B output
3	Line phase C output

TB2	
1	VFD phase A input
2	VFD phase B input
3	VFD phase C input
4	Shield

TB2A	
1	VFD phase A output
2	VFD phase B output
3	VFD phase C output



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