

Syncrocloser® Digital Synchronizing System M-5625

Integrated Synchronizing System®
for Generator and Intertie Synchronizing



- Facilitates standardization for generator and system intertie sync check applications
- Assure safe and accurate connection of a generator to the power network
- Provides accuracy and independent controls; no additional instrumentation is required for field setting
- Breaker closing times are field programmable
- Local and remote serial communications (MODBUS protocol) capability for monitoring and control functions

Digital Synchronizing System

When the M-3410A relay is connected with Line-Line voltage input, the following functions are available (refer to Figure 7 for wiring connections).

- Sync-check with Phase Angle, ΔV and ΔF with dead line/dead bus options (25)
- Reconnect enable (79) for inertia application
- Phase undervoltage (27) detection
- Dual-setpoint, single or three phase, directional power monitoring that can be selected as over power or under power (32) detection (requires current transformer input)
- Negative sequence overvoltage (47) detection
- Phase overcurrent (51) detection (requires current transformer input)
- Phase overvoltage (59) detection
- VT fuse-loss detection and blocking (60FL)
- Four-step over/under frequency (81) detection

If a line-neutral is applied to the single VT input of the M-3410A only the Synch-Check (25) Function is viable. The (51) Function may also be active for this voltage configuration if current input is connected as well (refer to Figures 5 and 6).

Standard Features

- Selectable Anti-Motoring and Anti-Pump
- Adjustable Jog Durations, proportional to error, for Voltage and Speed Controls
- Time Between Jogs adjustments bring the generator to a matched condition in minimum time and eliminate overshoot and hunting by accounting for inertial and control lags
- Kicker Pulse brings phase angle around through zero if speed is matched but synchronism has not yet occurred. Adjustable pulse duration compensates for the sensitivity of the governor.
- One Auto-sync output, two Sync-check outputs, one self-test output, two enable inputs, and two control/status inputs
- Oscillographic recording (COMTRADE file format)
- Time-stamped sequence of events recording for 32 events
- Metering of Voltage, Delta Voltage, Frequency, Delta Frequency, Phase Angle, Current and Sync Scope indication
- One RS-232 port (COM1) on front and one RS-232 or 485 port (COM2) on rear
- M-3810A IPScom® For Windows™ Communications Software
- MODBUS protocol
- Supports both 50 and 60 Hz applications
- Accepts 1A or 5 A rated CT inputs
- Continuous Self-Diagnostics

Optional Features

- M-3801D IPSplot® PLUS Oscillograph Analysis Software
- Horizontal and Vertical panel mount versions available
- Standard 19" Rack Mount Available

SYNCHRONIZING SYSTEM FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy
Sync Check				
25	Phase Angle Window	0° to 90°	1°	±1°
	Upper Voltage Limit	100.0 to 120.0%*	0.1%	±0.5 V or ±0.5%
	Lower Voltage Limit	70.0 to 100.0%*	0.1%	±0.5 V or ±0.5%
	Delta Voltage Limit	1.0 to 50.0%*	0.1%	±0.5 V
	Delta Frequency Limit	0.001 to 0.500 Hz	0.001 Hz	±0.001 Hz or 5%
	Sync Check Time Delay	1 to 8160 Cycles	1 Cycle	
	Dead Voltage Limit	0.0 to 50.0%*	0.1%	±0.5 V or ±0.5%
	Dead Time Delay	1 to 8160 Cycles	1 Cycle	±2 Cycles

* Of nominal voltage.

Sync Check may be operated as a stand-alone function or supervised by 79 (reconnect). Various combinations of input supervised hot/dead closing schemes may be selected.

Phase Undervoltage				
27	Pickup #1, #2	4 to 100%*	0.1%	±0.5 V or ±0.5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles**

* Of nominal voltage.

** When DFT is selected, the time delay accuracy is ±2 cycles. When RMS magnitude is selected, an additional time delay from 0 to +20 cycles may occur.

Directional Power				
32	Pickup #1, #2	-3.00 to +3.00 PU	0.01 PU	±0.02 PU or ±2%*
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles

The per-unit pickup is based on nominal VT secondary voltage and nominal CT secondary current settings for currents less than 14 A (2.8 A). This function can be selected as overpower or underpower in the forward direction (positive setting) or reverse direction (negative setting). This function can also be selected for single phase detection for line-to-ground VT.

Minimum sensitivity of 100 mA for 5 A CT (real component of current).

* Accuracy applies for a nominal current range of 2.5 A to 6 A (5 A CT) or 0.5 A to 1.5 A (1 A CT).

Negative Sequence Overvoltage				
47	Pickup #1, #2	4 to 100%*	0.1%	±0.5 V or ±0.5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles

* Of nominal voltage.

Inverse Time Overcurrent				
51	Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±10%

Values in parentheses apply to 1 A CT secondary rating.

SYNCHRONIZING SYSTEM FUNCTIONS (cont.)

Device Number	Function	Setpoint Ranges	Increment	Accuracy
Phase Overvoltage				

59	Pickup #1, #2	100 to 150%*	0.1%	±0.5 V or ±0.5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles**

* Of nominal voltage.

** When DFT is selected, the time delay accuracy is ±2 cycles. When RMS magnitude is selected, an additional time delay from 0 to +20 cycles may occur.

VT Fuse-Loss Detection

60 FL	A VT fuse-loss condition is detected by using the positive and negative sequence components of the voltages and currents. VT fuse-loss output can be initiated from internally generated logic or from input contacts.			
	Time Delay	1 to 8160 Cycles	1 Cycle	±2 Cycles

Reconnect Enable Time Delay

79	Time Delay	2 to 65,500 Cycles	1 Cycle	±2 Cycles
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Reconnect timer starts when all outputs designated as trip outputs reset.

Over/UnderFrequency

81	Pickup #1, #2, #3, #4	50.00 to 67.00 Hz (40.00 to 57.00 Hz*)	0.01 Hz	±0.03 Hz
	Time Delay #1,#2, #3, #4	2 to 65,500 Cycles	1 Cycle	±2 Cycles or ±0.01%

*This range applies to 50 Hz nominal frequency models.

The pickup accuracy applies to 60 Hz models at a range of 57 to 63 Hz, and to 50 Hz models at a range of 47 to 53 Hz. The accuracy is ±0.15 Hz for a range of 52 to 57 Hz, and 63 to 67 Hz (for 60 Hz nominal) and 42 to 47 Hz and 53 to 57 Hz (for 50 Hz nominal).

Controls

Upper Voltage Limit (either input)	110 to 140 V ac	—	±1.5% of full scale
Lower Voltage Limit (either input)	90 to 120 V ac	—	±1.5% of full scale
Delta Voltage Limit	1 to 5 V ac ⁽¹⁾	—	±5% of full scale
Delta Frequency Limit	0.05 to 0.5 Hz ⁽²⁾	—	±3% of full scale

(1) Multiple times of this range (2 times to 10 times) are available.

(2) An additional range of 0.005 to 0.05 Hz is available.

SYNCHRONIZING SYSTEM FUNCTIONS (cont.)

Device Number	Function	Setpoint Ranges	Increment	Accuracy
Controls (cont.)				
Speed Control				
	Speed matching range of operation	30 to 85 Hz	—	—
	Time Between Jogs	2 to 30 seconds ⁽³⁾	—	±20% of setting
	Jog Duration	⁽⁴⁾	—	±20% of setting
	Kicker Pulse Rate ⁽⁵⁾		—	±20% of setting
	Kicker Pulse Duration	0.1 to 1.5 seconds	—	±20% of setting
Voltage Control				
	Voltage matching range of operation	30 to 200 V ac	—	—
	Time Between Jogs	1 to 15 seconds ⁽⁶⁾	—	±20% of setting
	Jog Duration	⁽⁷⁾	—	±20% of setting

(3) A 1 to 15 second range is available.

(4) Proportional to error. Proportional Jog Duration is 1 to 10 seconds per Hz of frequency mismatch, linear for ΔF (delta frequency) of 0.015 to 1.5 Hz of mismatch.

(5) One pulse per 6 to 120 seconds. A generator raise speed jog is produced in the time set on the Kicker Pulse Duration Dial if the speed matcher does not operate.

(6) A 2 to 30 second range is available.

(7) Proportional to error. Proportional Jog Duration is 0.1 to 1.0 second per volt of mismatch, linear for ΔV (delta voltage) of 1 to 20 V of mismatch.

Nominal Settings				
	Nominal Voltage	50 to 500 V*	1 V	—
	Nominal Current	0.50 to 6.00 A	0.01 A	—
	VT Configuration Line-Line	(For 25 Function)		
	Seal-in Delay	2 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%

* Maximum measured range for (25) function settings is ≤ 600 V.

Description

The M-5625 Syncrocloser® Digital Synchronizing System is suitable for the automatic synchronizing of a generator to the electric power network. The system provides speed and voltage “jogs” to bring a generator to proper conditions of matching voltage and frequency, prior to safely and accurately closing a breaker into a bus energized by an electric power network.

The Digital Synchronizing System is intended for three general classes of application:

- Initial connection of a generator to a power network as shown in Figure 1

- Closure of a network breaker where there is a possibility of a split of the system into two isolated networks having different frequencies
- Breaker closure applications with a static phase angle (see Figure 2 Automatic Synchronizing for Synchronous and Asynchronous lines and Busbars)

The system can also be used for manual synchronizing application. A typical Control Wiring Diagram of Generator Synchronizing System is illustrated in Figure 3.

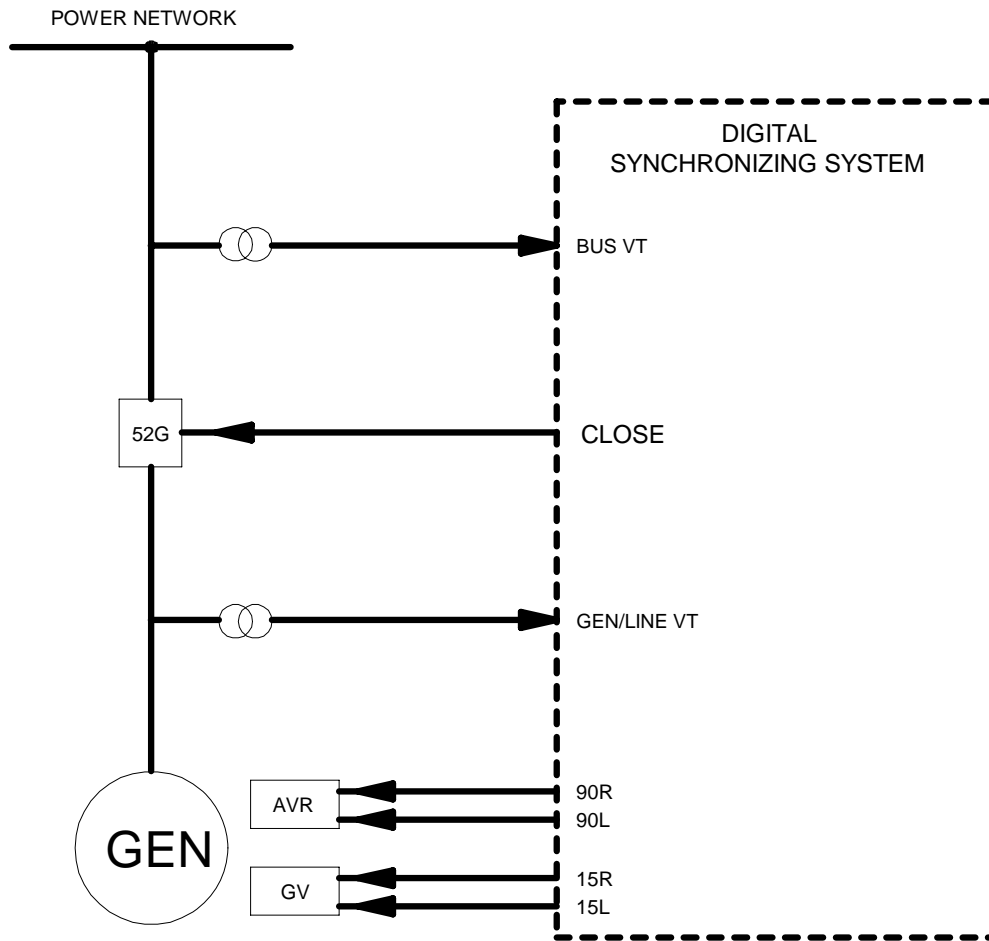


Figure 1 Automatic Synchronizing of a Generator to a Power Network

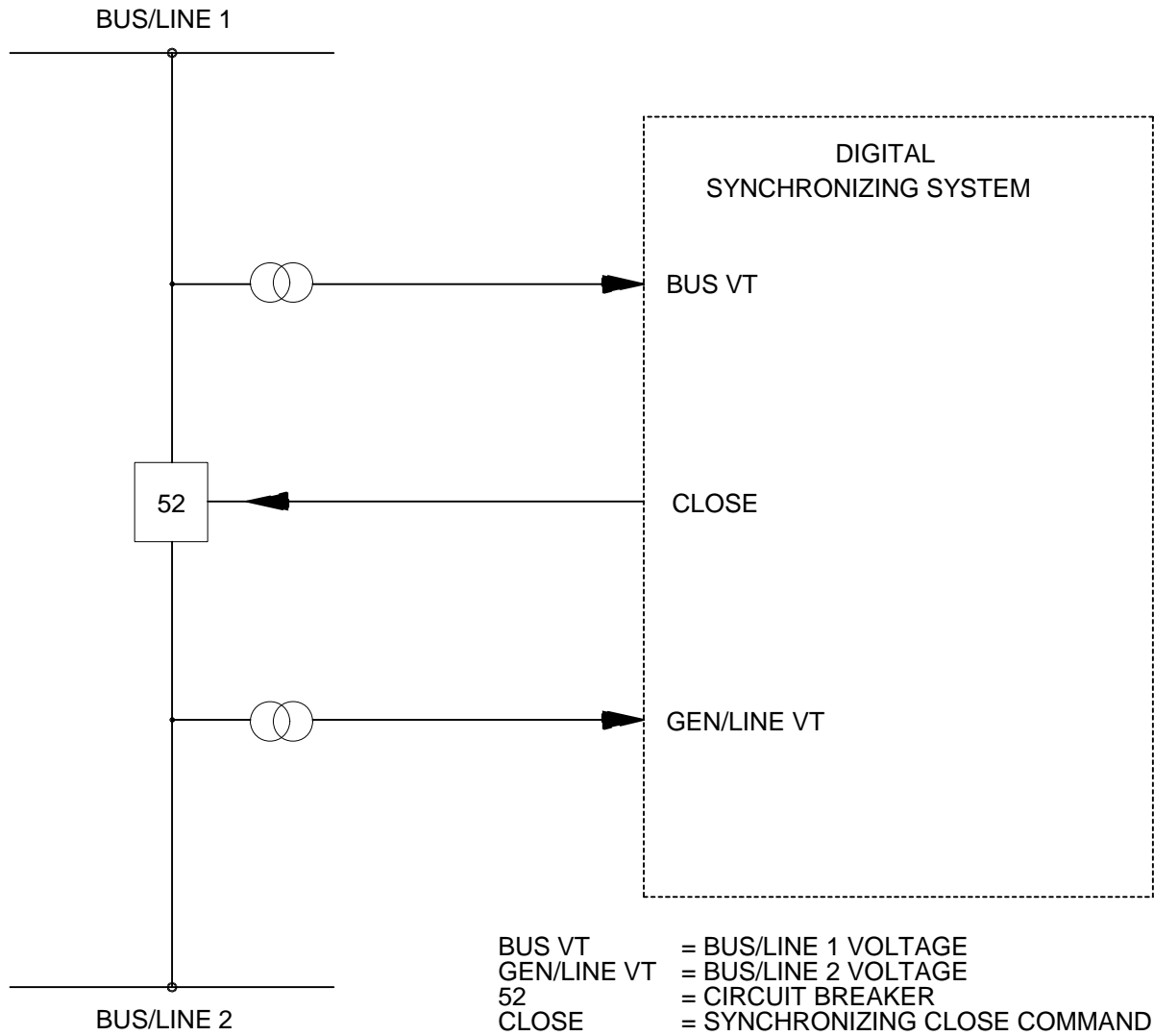


Figure 2 Automatic Synchronizing for Synchronous and Asynchronous Line and Busbars

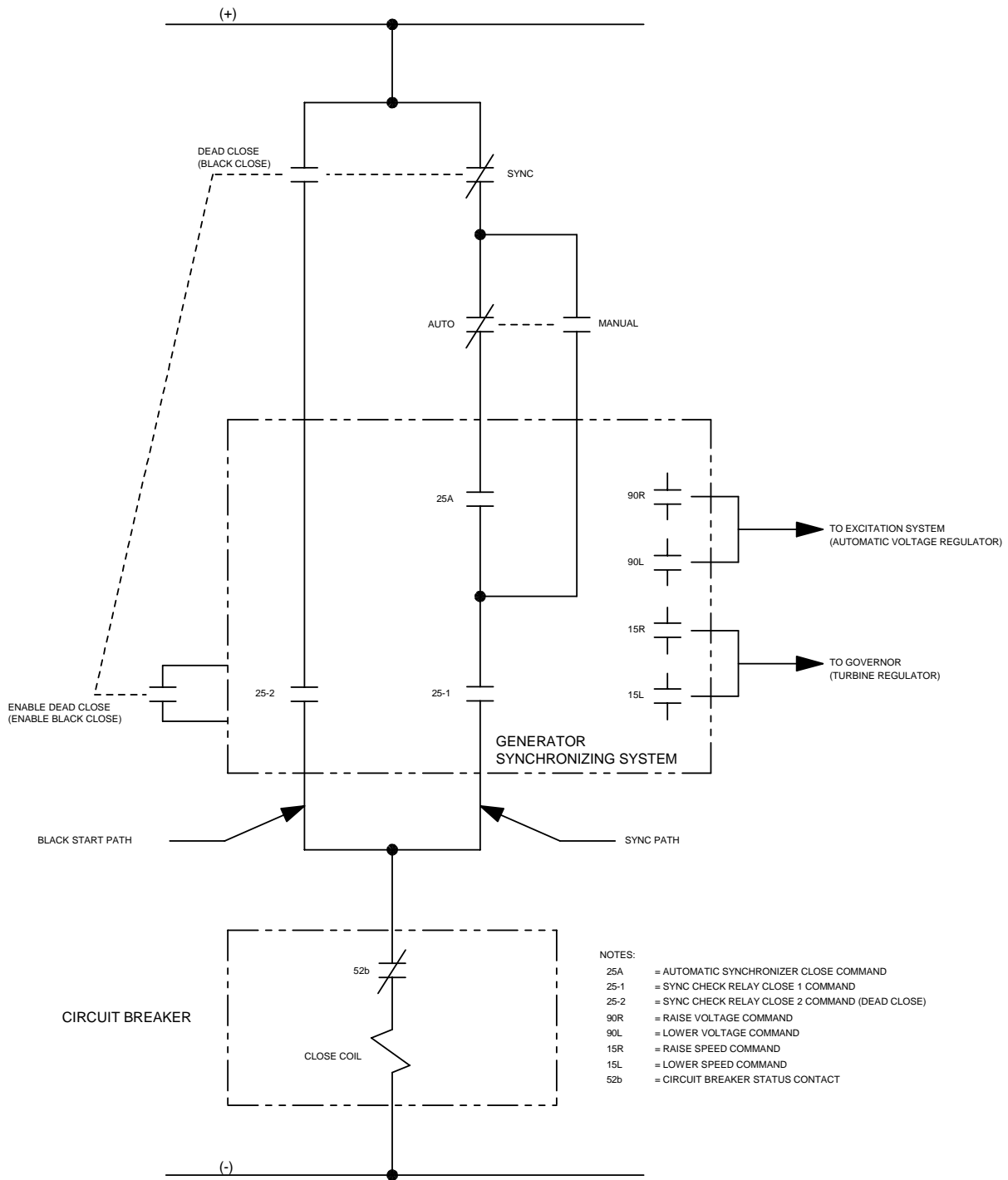


Figure 3 Typical Control Wiring Diagram of Generator Synchronizing System

Minimum Frequency Difference

The guaranteed minimum frequency difference for Auto-Sync operation is 0.0005 Hz. However, typical units consistently operate with frequency difference of 0.0001 Hz.

Zero Phase Prediction

Figure 4 illustrates the average closing phase error as a function of frequency difference for 80 ms, 100 ms, 200 ms, 400 ms and 800 ms breaker closing times. This data was taken under lab conditions with a constant frequency difference.

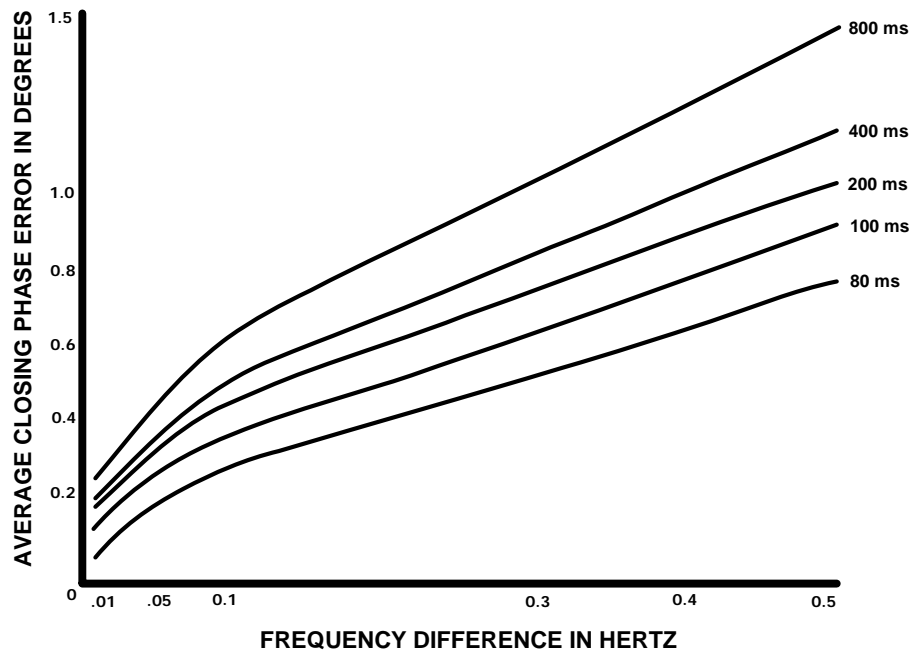


Figure 4 Zero Phase Prediction

Anti-Motoring

The Anti-Motoring feature prevents closing of the breaker when the generator frequency is slower than the line/system frequency, thus preventing motoring power from flowing into the generator. This function is enabled by an internal toggle switch.

Anti-Pump

The breaker close contact of the automatic synchronizer will close for approximately 0.5 second. Power supply to the automatic synchronizer must be removed for approximately 10 seconds before another closure is possible, regardless of the other inputs. A front panel LED (M-0193B READY) indicates that the automatic synchronizer is active and ready to operate, provide input conditions meet their respective limits. The automatic synchronizer can be ordered without the Anti-Pump Option. In this case, the automatic synchronizer will close once on each slip cycle when all input conditions are within their limits and the unit is enabled. The anti-pump option must be specified on order.

Operator Window Option

The Operator Window Option allows an operator to work in conjunction with the automatic synchronizer. The operator's contact must be closed within a variable time and phase angle "window", otherwise the automatic synchronizer will block closing of the breaker. The unit will then automatically reset for the next attempt to close. The operator window option must be specified on order.

Metering

The Digital Synchronizing System provides metering of voltages, currents, real power, reactive power, power factor, frequency and positive sequence impedance.

Metering Accuracies are:

- Voltage:** ± 0.5 V or $\pm 0.5\%$, whichever is greater (Range 0 to 600 V)
- Current:** 5 A rating, ± 0.1 A or $\pm 3\%$, whichever is greater (Range 0 to 14 A)
1 A rating, ± 0.02 A or $\pm 3\%$, whichever is greater (Range 0 to 2.8 A)
- Power:** ± 0.02 PU or $\pm 2\%$, whichever is greater
- Frequency:** ± 0.03 Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models)
- Sync Scope:** The Sync Scope screen displays a phasor representation, the phase angle, delta voltage and delta frequency of generator and incoming voltages. The display should not be used to determine in phase conditions for manual synchronizing because of communications time delay.

Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, input contacts and output contacts, storing up to 120 cycles of data. The total record length is configured for one or two partitions. A programmable post trigger delay (5 to 95%) is incorporated to capture breaker operation. The oscillograph is triggered either remotely using the serial interface, or designated status input signals or M-5625 programmable output operations. Storage of oscillographic records is nonvolatile, and will be retained even without power, as long as the on-board battery is healthy.

Oscillographic data can be downloaded using serial communication in Common Format For Transient Data Exchange (COMTRADE) format as specified by IEEE Standard C37.111-1999.

Sequence of Events

A total of 32 nonvolatile events can be stored. The recorded information includes the function(s) operated, the function(s) picked up, input/output contact status and time stamp. The events can be retrieved through the communications port. After the 32nd event is stored, additional events result in the oldest event being dropped (FIFO). The information is time-stamped to 1 ms resolution.

Calculations

Current and Voltage Values: Uses discrete Fourier transform (DFT) algorithm on sampled (32 times per cycle) voltage and current signals to extract fundamental frequency phasors for calculations. When set for RMS measurement, uses a time domain algorithm to calculate the voltage magnitude.

Power Input

Nominal 120 V ac, 50/60 Hz, 100 to a maximum of 140 V ac, 22 VA maximum burden at 120 V ac.

Other power input options are available for M-3410A only:

Nominal	Range	Burden
12/24 V dc	9 to 36 V dc	<5 VA
48 V dc	36 to 75 V dc	<5 VA
120 V ac/125 V dc	85 to 150 V ac/V dc	<5 VA

Sensing Inputs

2 Voltage Inputs: Gen/Line and Bus voltages, nominal 120 V ac, 60 Hz (Optional 50 Hz user configurable). Will withstand 145 V ac maximum continuous voltage, 200 V ac for 1 second. Voltage transformer burden less than 0.5 VA at 120 V ac.

3 Current Inputs: Rated current (I_R) of 5.0 A or 1.0 A, 60 Hz (50 Hz user configurable). Will withstand $2 I_R$ continuous current and $30 I_R$ for 2 seconds. Current transformer burden is less than 0.75 VA at 5 A for 5 A inputs, 0.3 A at 1 A for 1 A inputs.

Control/Status Inputs

- The status inputs, INPUT1 (breaker status 52) and INPUT2 (Auto-Sync close command), can be used to trigger the oscillograph recorder. The control status inputs accept only dry contacts and are internally wetted by the relay's power supply. A minimum current of 1.3 mA is required to avoid spurious triggering of the input.
- Enable Auto-Sync close
- Enable Generator Control Unit for speed and voltage matching
- Breaker closing time: field programmable from 20 to 800 ms

Output Contacts

Auto-Sync Close Output: Output will close for approximately 0.5 second. Normally-open dry output contact rated to make and carry 20 A up to 250 V dc, interrupt 0.9 A, 120 V dc inductive load; 0.4 A, 250 V dc inductive load.

Raise and Lower Voltage Jog Outputs, Raise and Lower Speed Jog Outputs: Normally-open dry output contact rated to make and carry 20 A up to 250 V dc, interrupt 0.9 A, 120 V dc inductive load; 0.4 A, 250 V dc inductive load.

Sync Check Close Outputs: Two programmable output relays, each with a contact are rated as per ANSI/IEEE C37.90-1989 for tripping: make 30 A for 0.2 seconds. Available hardware configurations include two normally open (Option B1), one normally open and one normally closed (Option B2), or two normally closed (Option B3) contacts. The contacts will carry 8 A, break 6 A at 120 V ac, break 0.1 A at 125 V dc, inductive break 0.1 A. Also provided is a self-test alarm output contact (form 'c') with a rating of 8 A at 120 V ac, 5 A at 30 V dc, 125 V dc 0.15 A resistive, 0.1 A inductive.

Any of the M-3410A protective functions can be individually programmed to activate the two programmable outputs. The user can configure the two programmable outputs to either energize or de-energize to issue an output command.

The outputs (excluding the self-test) can have two modes of operation, LATCHING and NORMAL. The LATCHING mode requires an operator intervention to deactivate the outputs after the condition for operation has been removed. In the NORMAL mode, when the condition for tripping has been removed, the output(s) will deactivate automatically after the corresponding seal-in timers have expired.

Status Output Contacts

ΔV Status Output: Closed when ΔV (delta voltage) is within limits. Normally-open dry output contact rated 0.5 A at 125 V dc resistive, 1 A at 120 V ac or 250 V dc across open contact.

ΔF Status Output: Closed when ΔF (delta frequency) is within limits. Normally-open dry output contact rated 0.5 A at 125 V dc resistive, 1 A at 120 V ac or 250 V dc across open contact.

Auto-Sync Close Status Output: Closed when Auto-Sync closed command is issued. Normally-open dry output contact rated 0.5 A at 125 V dc resistive, 1 A at 120 V ac or 250 V dc across open contact.

Self-Test Alarm Output: Form 'c' dry output contact with rating of 8 A at 120 V ac, 5 A at 30 V dc, 125 V dc 0.15 A resistive, 0.1 A inductive.

The Status Output Contacts are light duty contacts intended primarily for status interrogation by supervisory control. They can be used to illuminate local lamps within the above maximum ratings.

Target/Status Indicators (LEDs)

- UPPER VOLTAGE LIMIT BUS OK
- UPPER VOLTAGE LIMIT GEN/LINE OK
- LOWER VOLTAGE LIMIT BUS OK
- LOWER VOLTAGE LIMIT GEN/LINE OK
- ΔV LIMIT OK
- ΔF LIMIT OK
- M-0193B READY
- SENDING RAISE SPEED
- SENDING LOWER SPEED
- SENDING RAISE VOLTAGE
- SENDING LOWER VOLTAGE
- BUS FREQUENCY HIGH
- GENERATOR FREQUENCY HIGH
- PHASE UV 27
- DIRECTIONAL POWER 32
- VOLT. UNBALANCE 47
- OVERCURRENT 51
- PHASE OVERVOLTAGE
- 60FL FUSE LOSS
- 81 O/U FREQUENCY
- OSC TRIGGER (indicates that the oscillograph has been triggered)
- DIAGNOSTIC (provides indication of the error code when flashing)
- RELAY OK (reveals proper cycling of the Sync Check relay microprocessor)
- OUTPUT 1 and OUTPUT 2 are used to indicate the status of the Sync Check output contacts. The output LEDs will illuminate when the Sync Check output contacts are closed.

LED Test pushbutton resets the target LEDs of the Sync Check function if the conditions causing the operation have been removed. Holding the Target/Output Reset button displays the present status of the Sync Check function.

Communication

Communications ports include a front panel RS-232 port and a rear port user configurable to RS-232 or RS-485. The RS-232 ports are connected physically with a DB-9 connector and the RS-485 port utilizes 4-wire interface mounting screw terminals.

M-3810A IPScom[®] For Windows[™] Communications Software utilizing the MODBUS communications protocol in RTU mode, implements serial, byte-oriented asynchronous communication with the M-3410A and provides the following functions:

- Interrogation and modification of setpoints
- Time-stamped sequence of events information for the 32 most recent events
- Real-time metering of all quantities measured
- Downloading of recorded oscillographic data
- Sync Check Relay Setup

Tests and Standards

The M-5625 Digital Synchronizing System consists of the M-0193B, M-0194 and the M-3410A components. The M-3410A meets or exceeds the following Tests & Standards, the M-0193B and the M-0194 have not been tested to all of the Tests & Standards listed below. Please contact the factory for a complete listing of applicable Tests & Standards for each component.

The M-5625 Digital Synchronizing System complies with the following type tests and standards:

Voltage Withstand

Dielectric Withstand

IEC 60255-5 3,500 V dc for 1 minute applied to each independent circuit to earth
 3,500 V dc for 1 minute applied between each independent circuit

■ **NOTE:** 1,500 V dc for dc power supply options (12, 24, 48 V dc).

Impulse Voltage

Power Supply Input Voltages, 120 V ac/125 V dc:

IEC 60255-5 5,000 V pk, +/- polarity applied to each independent circuit to earth
 5,000 V pk, +/- polarity applied between independent circuits
 1.2 μ s by 50 μ s, 500 ohms impedance, three surges at every 5 second interval

Power Supply Input Voltages, 12, 24, 48 V dc:

IEC 60255-5 3,000 V pk, +/- polarity applied to each independent circuit to earth
 3,000 V pk, +/- polarity applied between independent circuits
 1.2 μ s by 50 μ s, 500 ohms impedance, three surges at every 5 second interval

Insulation Resistance

IEC 60255-5 > 100 Megaohms

Electrical Environment

Electrostatic Discharge Test

EN60255-22-2 Class 4 (8 KV) - Point contact discharge
 Class 4 (15 KV) - Air discharge

Fast Transient Disturbance Test

EN 60255-22-4 Class A (4KV, 2.5KHZ)

Surge Withstand Capability

ANSI/IEEE 2,500 V pk Oscillatory each independent circuit to earth
C37.90.1 2,500 V pk Oscillatory between each independent circuit
2002 4,000 V pk Fast Transient burst applied to each independent circuit to earth
 4,000 V pk Fast Transient burst applied between each independent circuit
 5,000 V pk Fast Transient each independent circuit to earth
 5,000 V pk Fast Transient between each independent circuit

■ **NOTE:** The signal is applied to the digital data circuits (RS-232, RS-485) communication ports through capacitive coupling clamp.

Radiated Susceptibility

ANSI/IEEE 80-1000 Mhz @ 35 V/m (with Keying test)
C37.90.2
2004

Output Contacts

ANSI/IEEE Make 30 A for 0.2 seconds, off for 15 seconds for 2,000 operations
C37.90.0 Section 6.7.1, Tripping Output Performance Requirements

Atmospheric Environment

Temperature

IEC 60068-2-1 Cold, -20° C
IEC 60068-2-2 Dry Heat, +70° C
IEC 60068-2-78 Damp Heat, +40° C @ 93% RH

Mechanical Environment

Vibration

IEC 60255-21-1 Vibration response Class 1, 0.5 g
Vibration endurance Class 1, 1.0 g

IEC 60255-21-2 Shock Response Class 1, 5.0 g
Shock Withstand Class 1, 15.0 g
Bump Endurance Class 1, 10.0 g

Compliance

cULus Listed per 508 – Industrial Control Equipment certified for Canada CAN/CSA C22.2 NO. 14-M91
cULus Listed Component per 508A Table SA1.1 Industrial Control Panels

Physical

19" Rack Mount

Size: 10.50" high x 19.0" wide x 14.00" deep (26.7 cm x 48.26 cm x 35.56 cm)
Approximate Weight: 36 lbs, (16.33 kg)
Approximate Shipping Weight: 53 lbs, (24.04 kg)

Vertical Panel Mount

Size: 19.00" high x 10.50" wide x 14.00" deep (48.26 cm x 26.7 cm x 35.56 cm)
Approximate Weight: 36 lbs, (16.33 kg)
Approximate Shipping Weight: 53 lbs, (24.04 kg)

Patent & Warranty

The M-5625 Syncrocloser® Digital Synchronizing System is covered by U.S. Patent 3,491,248.

The M-5625 Syncrocloser® Digital Synchronizing System is covered by a five year warranty from date of shipment.

External Connections

M-5625 external connection points are illustrated in Figure 5, External Connections.

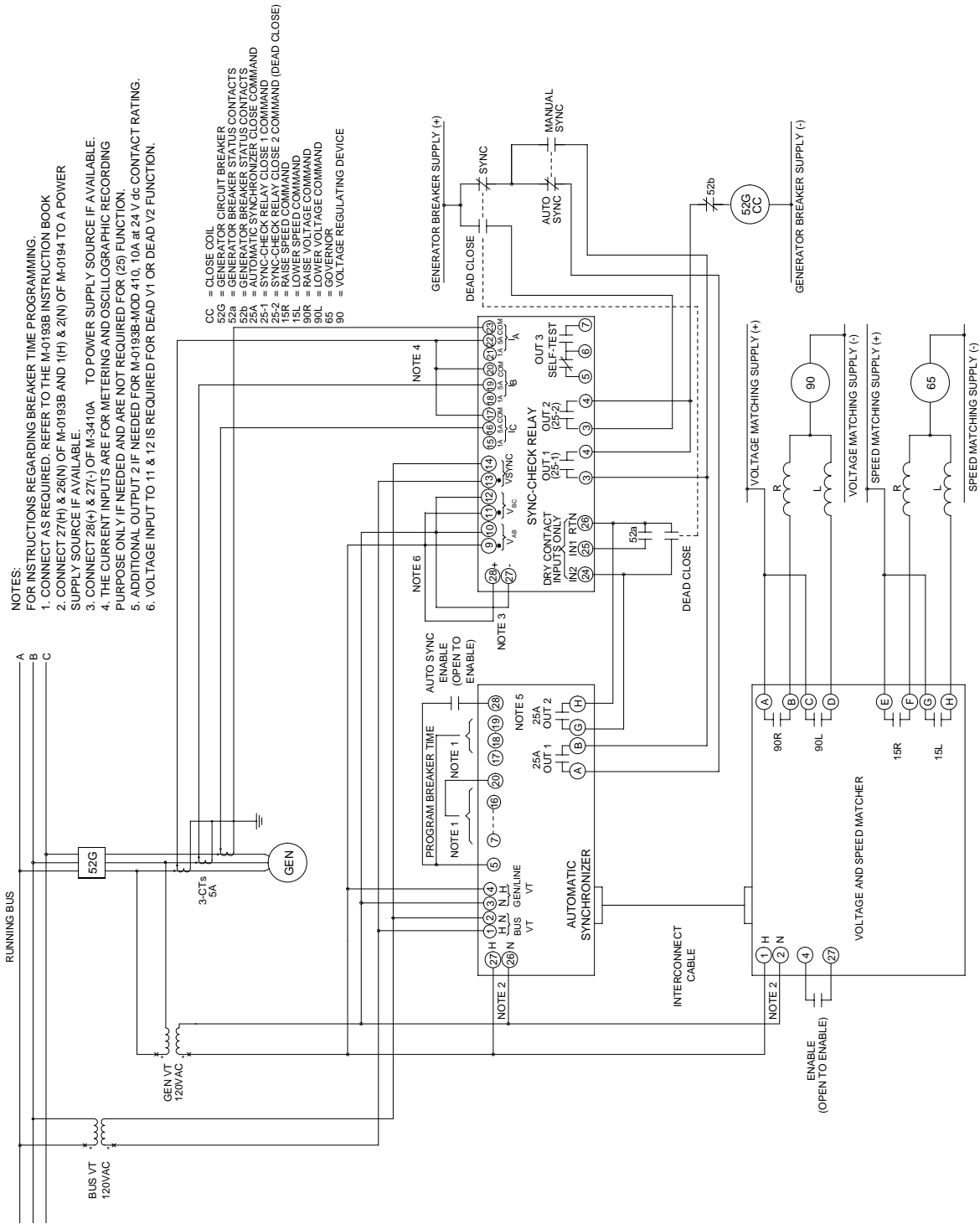


Figure 7 External Connections, Single Phase-Phase VTs

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