Owner Manual

Installation/Operator

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Cummins® Power Generation

Controller

Control Kit 541–1359

SYNC 1320 Master Synchronizer

English – Original Instructions 11–2010 0900–0662 (Issue 3)

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Foreword

This manual provides information on the installation, operation, and fault diagnostics of the SYNC1320 Master Synchronizer. Refer to the switchboard manufacturer's product documentation for important safety precautions.

The purpose of this manual is to provide the users with general control operation and fault code information. Refer to the equipment manufacturer's product support manuals for important safety precautions.

Manufacturers applying this control are respectfully advised that it is their responsibility to employ competent persons to carry out any installation work in the interests of good practice and safety. It is essential that the utmost care is taken with the application of this control device.

Warranty

Warranty: This manual is published solely for information purposes and should not be considered all inclusive. Sale of product shown or described in this literature is subject to terms and conditions outlined in appropriate Cummins Power Generation selling policies or other contractual agreement between the parties. This literature is not intended to and does not enlarge or add to any such contract. The sole source governing the rights and remedies of any purchaser of this equipment is the contract between the purchaser and Cummins Power Generation.

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IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important information on the installation, operation, and fault diagnostics in the SYNC1320 master synchronizer.

The following symbols, found throughout this manual, alert you to potentially dangerous conditions to the operator, service personnel, or the equipment.

⚠ DANGER ***This symbol warns of immediate hazards which will result in severe personal injury or death.***

⚠ WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

Read this entire manual prior to initial installation of the SYNC1320 into a switchboard assembly. Be sure to also read all other manuals pertaining to the safety and operation of the switchboard in which it is installed prior to performing any service or adjustments. Comply with all switchboard manufacturers' instructions and precautions. Failure to follow instructions can cause property damage, personal injury, or death.

⚠ WARNING ***Interconnection with a utility system can cause electrocution and/or property damage. Do not connect to any building's electrical system except through an approved device or after the building main switch is open.***

⚠ CAUTION ***The SYNC1320 can be used to synchronize generator sets to a utility (mains) service. Do not initiate any connection of a generator set to a utility service without written approval of the service provider.***

HANDLING ELECTRONIC PARTS

Electronic controls contain static sensitive parts. Observe the following precautions to prevent damage to these parts:

- Discharge body static before handling the control. With no power supply connected to the control, contact a grounded surface and maintain contact while handling the control.
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around this product.
- Do not touch the components or conductors on this circuit board with your hands or conductive devices.
- When not installed, this component should be kept in the protective antistatic bag that it was shipped in.

INSTALLING ELECTRONIC PARTS

Proper operation of the device requires installation using the following general guidelines:

- Use interconnection wiring of the specific type specified on the interconnection drawing provided with the control.
- Make sure that all wiring shown as shielded on the interconnection drawings is in fact shielded, and that the cable shield(s) are connected at only one point in the circuit and as shown on the Cummins interconnection drawing.
- Where shielded wiring is passed over a terminal block assembly, verify that the integrity of the shield is maintained.
- Do not place shielded cable or analog signal cable in conduits with AC line voltage wiring.
- Use wiring rated for the ambient temperatures as installed. In general, wiring should not be subjected to temperatures in excess of 100° C.
- Avoid kinks or sharp bends in wiring.
- Make sure that all wiring connections are tight, and that proper strain relief is incorporated.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surface to be damp when handling electrical equipment. Do not wear jewelry. Jewelry can short out electrical contacts and cause shock or burning.
- Use extreme caution when working on electrical components. High voltages can cause injury or death. DO NOT tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag and lock open switches to avoid accidental closure.

GENERAL SAFETY PRECAUTIONS

- Keep multi-class ABC fire extinguishers handy. Class A fires involve ordinary combustible materials such as wood and cloth; Class B fires, combustible and flammable liquid fuels and gaseous fuels; Class C fires, live electrical equipment. (ref. NFPA No. 10).
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

KEEP THIS MANUAL NEAR THE EQUIPMENT FOR EASY REFERENCE

1. Introduction

ABOUT THIS MANUAL

This manual provides installation and operation information regarding the SYNC1320 master synchronizer.

This manual also includes fault code information and corrective steps.

This manual does not have instructions for servicing a printed circuit board assembly. After determining that a printed circuit board assembly is faulty, replace it. Do not repair it. Attempts to repair a printed circuit board can lead to costly equipment damage.

This manual contains basic (generic) wiring diagrams and schematics that are included to help in troubleshooting.

Read and carefully observe all instructions and precautions in the switchboard equipment Operator's Manual.

SYSTEM OVERVIEW

The SYNC1320 master synchronizer is a system component designed to interface with multiple PowerCommand digital paralleling controls operating on an common bus and provide a means to synchronize that bus with another live system bus. A common system configuration uses the master synchronize function to allow a generator system to synchronize to a utility (mains) service after a power failure, so that power transfer back to the utility can occur without a power interruption.

The master synchronizer adjusts the generator set bus frequency, phase angle, and voltage to the reference bus via the PowerCommand generator set load sharing lines. (See Figure 1-1) The system operates in a phase lock configuration as standard, and can be set up as a slip frequency configuration if desired. The PowerCommand generator set bus can be synchronized to a system bus operating in the range of plus or minus 1.5 hertz and 90–110% of nominal system voltage.

When the generator set bus is operating isolated from other sources, such as a utility service, the generator set fuel and excitation level are regulated by algorithms based on engine speed and alternator voltage level, and well as percent of generator set kW and kVAR output. When it is desired to synchronize the generator set bus to another source, the master synchronizer provides a bias signal to the load sharing lines to drive system voltage and frequency to the required level for safe and effective synchronizing of the two system buses. The master synchronizer cannot function when the generator sets are in the load govern (utility parallel) state.

The SYNC1320 master synchronizer is adjustable for a wide range of response characteristics and sync-check criteria. It provides a comprehensive series of diagnostics and display information. Discrete input and output signals allow the module to be controlled by an external device such as a programmable logic controller (PLC) in a desired sequence.

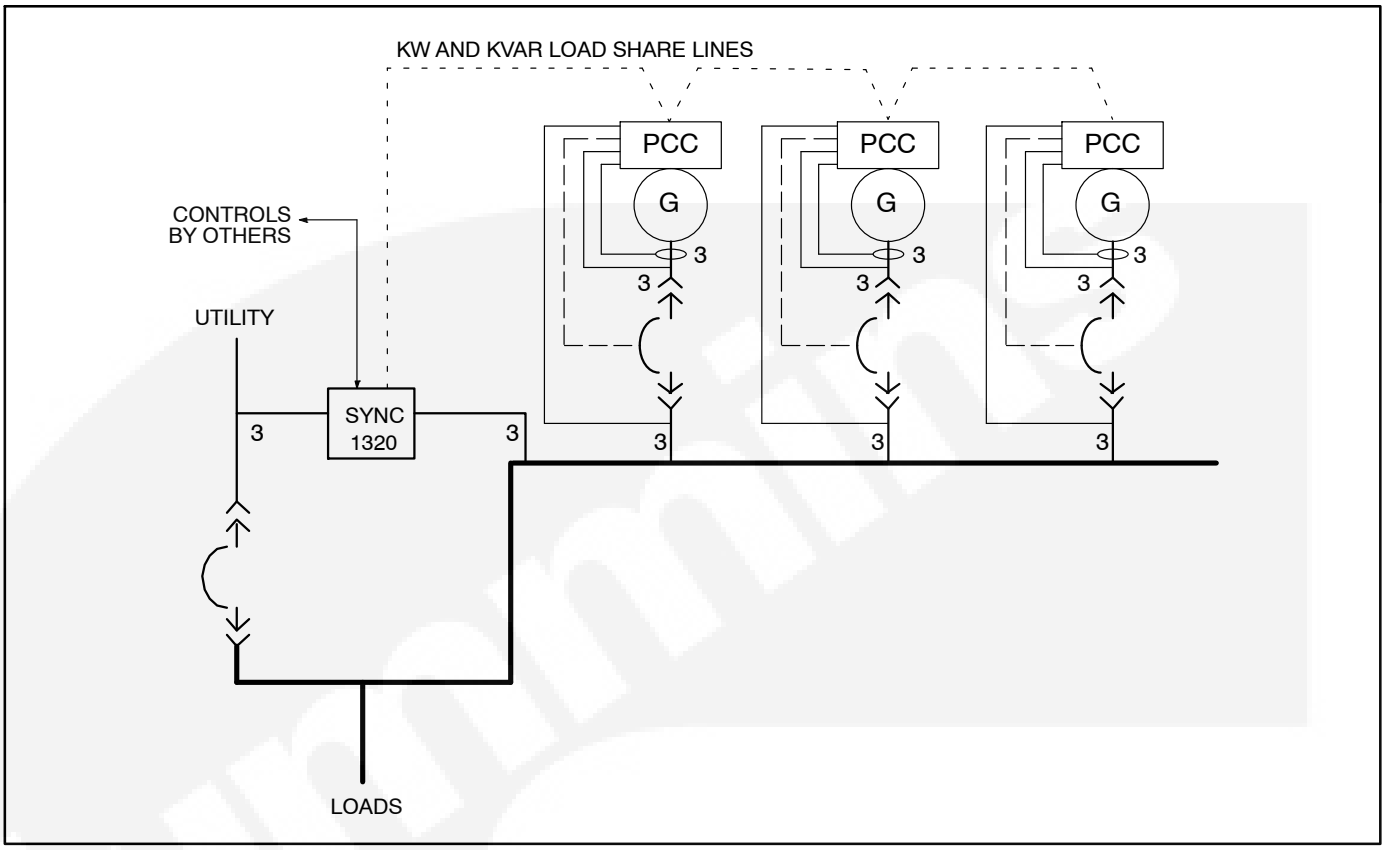

FIGURE 1-1. SYNC1320 MASTER SYNCHRONIZER

CERTIFICATIONS

The SYNC1320 master synchronizer meets or exceeds the requirements of the following codes and standards.

- UL508 Recognized
- CE Mark
- EN 61000-6-2
- EN 61000-6-4
- ISO 7637, pulses #2, 3a, 3b, 5, 7

PowerCommand control systems are designed and manufactured in ISO9001 certified facilities.

HOW TO OBTAIN SERVICE

Contact your Cummins Power Generation distributor when seeking additional service information or replacement parts.

⚠WARNING ***Incorrect service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.***

2. Installation

INSTALLATION

NOTE: When using any PCCNet device on a genset control application, the wiring used to connect ALL devices in the network must be Belden 9729 Two Pair, Stranded, Shielded Twisted Pair Cable (24 AWG).

The SYNC1320 master synchronizer is a UL-recognized component. It has an operating temperature range of –40 to +60 °C (–40 to 140 °F).

The control board is designed for panel mounting. It must be mounted in a dry location. Outline information, mounting dimensions, and hardware information is included in Figure 2-1.

The SYNC1320 master synchronizer should be mounted as shown in Figure 2-1, with TB7 toward the upper right of the installation. The panel should be mounted in a location so that the LED displays are easily visible for use by a technician, and so that TB15 is accessible for use by a technician to connect a PC-based service tool.

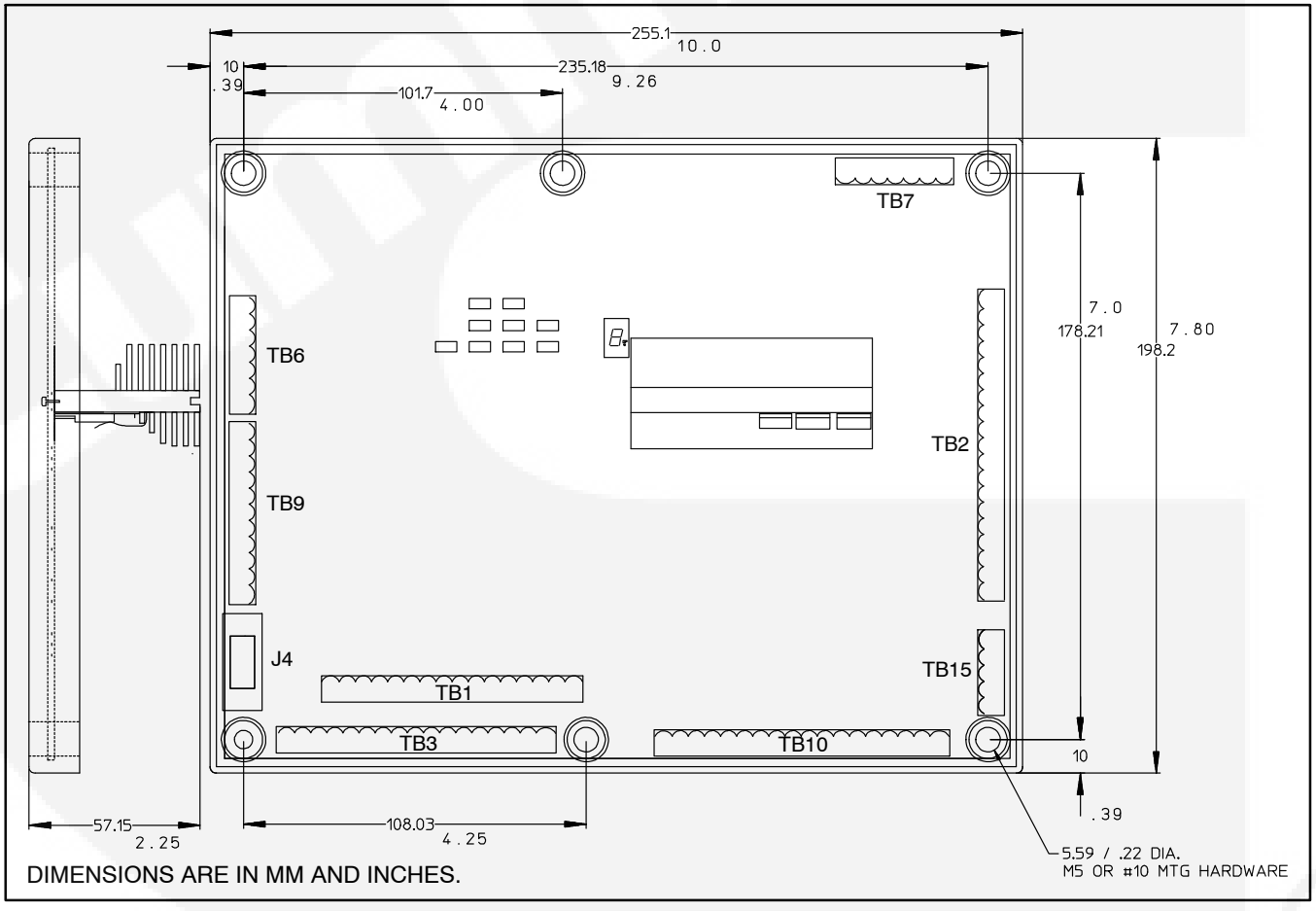

FIGURE 2-1. CONTROL DIMENSIONS

SYSTEM INTERCONNECTION

The SYNC1320 master synchronizer connects between PowerCommand generator set controls and a switchboard bus. It also provides status signals and accepts commands from external controls. Refer to the interconnection wiring diagram in Section 6 of this manual for specific interconnection information.

Battery Power

The SYNC1320 master synchronizer can be powered by a 12 or 24 V input. It has an operating range from 9–32 volts and has a 1 amp maximum current draw with no load on the auxiliary B+ (+9–32 VDC) outputs. The control is always awake when B+ is supplied. Control power is supplied by one or both of the B+ input power points on the board. The two supply inputs are isolated by diodes incorporated into the control board. If just one B+ source is used and that source is the genset starting batteries, the board rides through the starter dip if the distance/wire gauge between the SYNC1320 master synchronizer and the gensets is adequate. For a more robust system, it is recommended that both B+ inputs be used, with one of them supplied from a station battery.

Battery Power Fusing

The SYNC1320 master synchronizer must be fused externally with a 4 amp fuse wired to B+ (TB2-8, 9 or TB2-11, 12).

Voltage Transformer (VT) Inputs

The SYNC1320 master synchronizer voltage sensing input can be directly connected to 110 to 480 volts line-to-line (VLL). An external transformer can be used to connect to voltages up to 35 kVLL. 3-wire or 4-wire connections can be used.

A 2–wire (single phase) connection can also be used. Refer to section 2–5.

Genset Control Interfaces

The SYNC1320 master synchronizer uses the genset kW and kVAR load share lines that are compatible with the PCC3xxx load share lines to control the genset bus voltage and frequency. The Master Frequency Bias senses and drives the kW load share line to affect genset bus frequency and the Master Voltage Bias sense and drives the kVAR load share line to affect genset bus voltage. These bi-directional analog signals can drive up to 20 gensets simultaneously. Shielded, twisted pair cable should be used for these signals, twisting each of the two signals with its analog return. See the drawings in Section 6 for cable sizing recommendations.

Customer I/O Interfaces

Hardwired I/O

Discrete inputs are activated by current (opto coupled). To activate a switch input, connect it to a return (ground). To deactivate a switch input, open circuit that input. Use the ground connections on the SYNC1320 for ground reference.

The discrete outputs are low side relay drivers capable of sinking 200 mA.

Service Tool Connection

A PC-based service tool is provided with the SYNC1320. The control will communicate with a PC operating this software via a communication cable included in Cummins kit part number 541–1199.

The SYNC1320 can also be serviced using Cummins InPower software. For more information, refer to the SYNC1320 master synchronizer wiring diagram located in Section 6 of this manual.

TABLE 2-1. SYNC1320 MASTER SYNCHRONIZER TERMINAL BLOCK PIN DESCRIPTIONS

Connector Assignment	SYNC1320 Master Synchronizer Connection Name	Signal Type	Description
Switch I/O (TB1)			
TB1-10	Discrete Input Return	Return	Signal return for switch inputs
TB1-11	Synchronizer Enable	Switch Input	Use to manually enable synchronizing
Switch I/O / DC Power In (TB2)			
TB2-2	Battery –	Battery Ground	Ground return for either Battery 1 or Battery 2 DC power source
TB2-3	Battery –	Battery Ground	Ground return for either Battery 1 or Battery 2 DC power source
TB2-5	Battery –	Battery Ground	Ground return for either Battery 1 or Battery 2 DC power source
TB2-6	Discrete Input Return	Return	Signal return for switch inputs
TB2-7	Battery –	Battery Ground	Ground return for either Battery 1 or Battery 2 DC power source
TB2-8	Battery 1+	B+ Power Input	Battery 1 DC power input; diode or'd with Battery 2 DC power source
TB2-9	Battery 1+	B+ Power Input	Battery 1 DC power input; diode or'd with Battery 2 DC power source
TB2-10	Relay Coil B+ Supply (Fused 2A)	B+ Power Output	Use to supply high side of relay coils which are returned to a low-side output
TB2-11	Battery 2+	B+ Power Input	Battery 2 DC power input; diode or'd with Battery 1 DC power source
TB2-12	Battery 2+	B+ Power Input	Battery 2 DC power input; diode or'd with Battery 1 DC power source
TB2-14	Fault Reset	Switch Input	Used to reset faults and to activate fault flashout mode (activated when held for at least five seconds)
TB2-15	Configurable Output1 (Common Warning)	Low Side Output	Configurable output #1; intended to drive a relay coil; default is Common Warning
TB2-16	Configurable Output 2 (Fail to Sync)	Low Side Output	Configurable output #2; intended to drive a relay coil; default is Fail to Sync
TB2-17	Configurable Output 3 (Genset Available)	Low Side Output	Configurable output #3; intended to drive a relay coil; default is Genset Available
TB2-18	Configurable Output 4 (Utility Available)	Low Side Output	Configurable output #4; intended to drive a relay coil; default is Utility Available
TB2-19	Connect to Grounded Chassis	Chassis Ground	Must be connected via a short wire/strap to earth ground equipment chassis
Switch I/O (TB3)			
TB3-8	Discrete Input Return	Return	Signal return for switch inputs
TB3-12	Configurable Output 5	Low Side Output	Configurable output #5; intended to drive a relay coil; default is unassigned
TB3-13	Configurable Output 6 (Sync OK)	Low Side Output	Configurable output #6; intended to drive a relay coil; default is unassigned
TB3-14	Configurable Output 7 (Sync Output Limit)	Low Side Output	Configurable output #7; intended to drive a relay coil; default is unassigned
TB3-15	Configurable Output 8 (Hardware Failure)	Low Side Output	Configurable output #8; intended to drive a relay coil; default is unassigned

TABLE 2-1. SYNC1320 MASTER SYNCHRONIZER TERMINAL BLOCK PIN DESCRIPTIONS (CONTINUED)

Connector Assignment	SYNC1320 Master Synchronizer Connection Name	Signal Type	Description
Genset VT Inputs (TB6)			
TB6-1	Genset Bus Voltage L1	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB6-2	Genset Bus Voltage L2	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB6-3	Genset Bus Voltage L3	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB6-4	Genset Bus Voltage N	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
Utility VT Inputs (TB7)			
TB7-1	Utility Bus Voltage L1	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB7-2	Utility Bus Voltage L2	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB7-3	Utility Bus Voltage L3	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
TB7-4	Utility Bus Voltage N	AC Voltage Input	VT input connection; up to 480V L-L nominal direct connection
Analog I/O (TB9)			
TB9-8	Master Frequency Bias +	Bi-directional Analog	Connect to kW+ load share NOTE: PCC3100 diagrams have + and – reversed
TB9-9	Analog Return	Analog Return	Connect to kW– and kVAR– load share NOTE: PCC3100 diagrams have + and – reversed
TB9-10	Master Voltage Bias +	Bi-directional Analog	Connect to kVAR+ load share NOTE: PCC3100 diagrams have + and – reversed
Status Inputs (TB10)			
TB10-6	Auto/Manual	Switch Input	Puts the synchronizer control in manual mode
TB10-8	Discrete Input Return	Return	Signal return for switch inputs
RS-485 InPower Port (TB15)			
TB15–1	Service Tool RS-485 Gnd/Shield	RS-485 Port	Tool RS-485 GND/shield connection point
TB15-2	B+ Output (Fused 0.25A)	B+ Power Output	Auxiliary B+ output to power RS-232 to RS-485 converter or low cost display
TB15-3	Service Tool RS-485 A	RS-485 Port	Tool RS-485 port
TB15-4	Service Tool RS-485 B	RS-485 Port	Tool RS-485 port

SINGLE PHASE APPLICATIONS AND REPLACEMENT OF 0300−2014 AND 0300−2015

NOTE: Must order SYNC1320 kit part number 0541−1359 (contains SYNC1320 and manual).

Capabilities:

1. The SYNC1320 can be configured to synchronize single phase voltages.
2. The MCM3320 cannot be configured to synchronize single phase voltages. It must use three phase.
3. The single phase voltage must be nominal between 110 V and 480 V.
4. Sync Check output is availabe in single phase mode.
5. Must have V7.0 or greater InPower.
6. Controller must have V1.29 or greater.

Instructions:

1. Verify SYNC1320 controller has V1.29 firmware or greater. If not, update the firmware.
2. Connect the single phase voltage signal wires across the L1 and L2 terminal block inputs (TB 6−1, 2 and TB 7−1, 2).
3. The voltage signal can be any line−line or line−neutral signal whose nominal voltage is between 110 V and 480 V.
4. Do not connect anything to L3 or N terminal block inputs (TB 6−3, 4 and TB 7−3, 4). If feeding a line−neutral voltage use L1 and L2 inputs.
5. Set the variable Synchronizer Type (trim) = Single Phase from InPower browser or Setup screen. V7.0 or greater InPower is required.
6. Set the Nominal Voltage, PT Primary, and PT Secondary voltages according to the voltage setup as you normally would.
7. Save trims.
8. Apply the nominal voltage to the inputs and verify in InPower that the Utility Average Voltage % = 100% and the Genset Average Voltage % = 100%. If they are off by more than 1% and nominal voltage is applied, then increase or reduce the PT Secondary voltage setting(s) to get the number close to 100%. (Save Trims!)
9. Enable the synchronizer with live sources and verify performance.

Refer to the terminal board drawing on Page 6−4 of this manual for more information.

Important Notes:

1. If the voltage signal phasing is not the same for both source connections, the Sync Phase Offset trim will need to be adjusted. For example if L1−L2 are used on one side, but L1−N is used on the other side (both connected across the L1−L2 inputs per above instructions), a Sync Phase Offset of either +30 degree or −30 degrees will be required. Check with an independent sync check device to verify sync before allowing breaker closure.
2. Do not use an L1−L2 voltage on one source and an L2−L3 voltage on the other source. The Sync Phase Offset trim cannot accommodate 120 degrees. Limit is +/− 50 degrees.
3. If using in a Woodward governor application, it may require a 1 M Ohm potentiometer and a 5 K Ohm resistor added in series with the speed bias to allow for required tuning. Another solution with Woodward governor applications would be to use a Woodward Synchronizer.
4. If application requires Sync Check, an external pilot relay will be required.
5. For mounting hardware, it is recommended to use self−tapping machine screws.

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3. Description

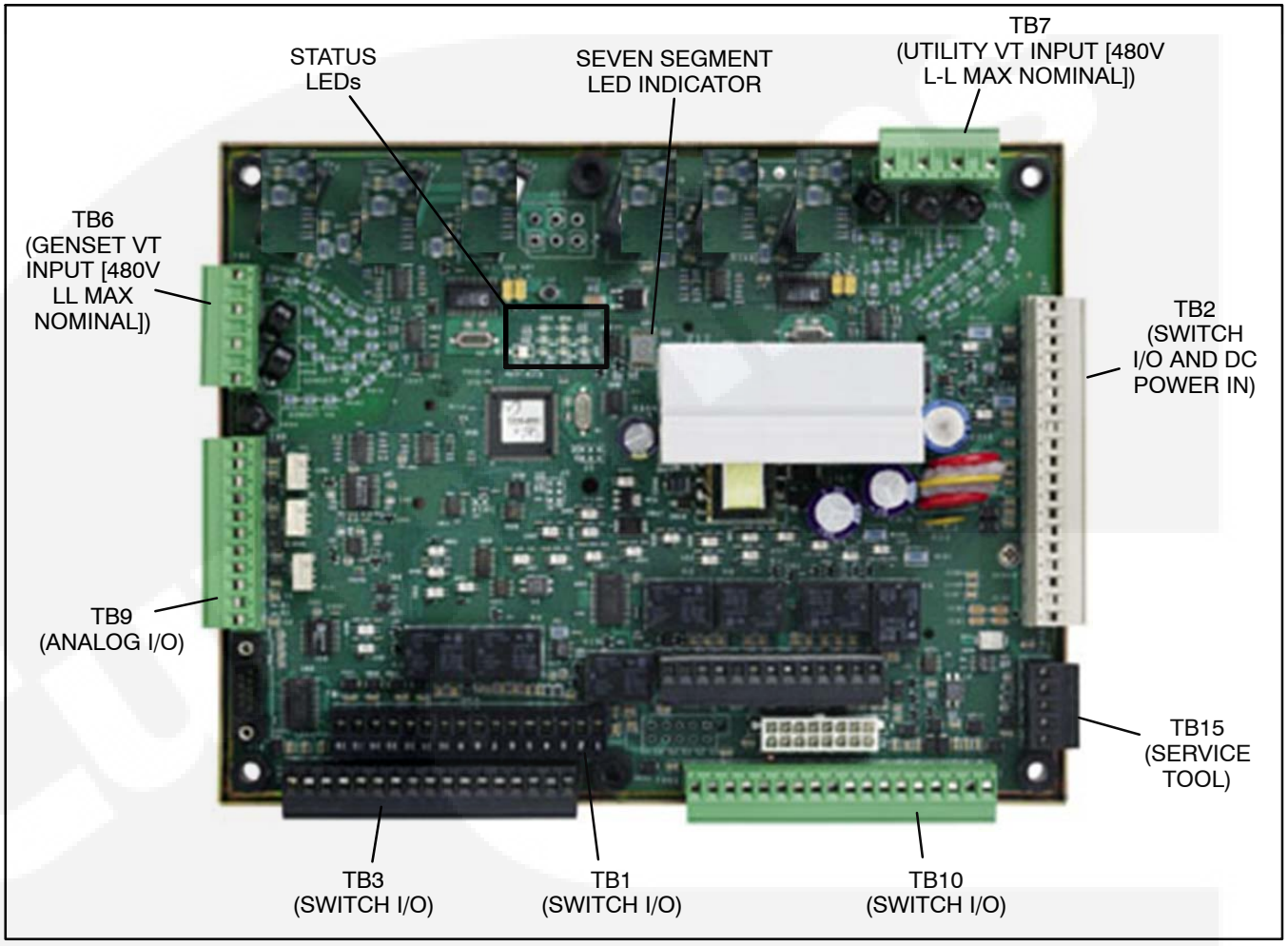

FIGURE 3-1. SYNC1320 CONTROL BOARD

OVERVIEW

The Master Synchronizer (SYNC1320) is a microprocessor–based control component designed for use with PowerCommand Digital Paralleling genset controls. The control can be used with generator sets that have various frequency (50 or 60 Hz operation), voltage, and power connection configurations from 120 to 35,000 VAC. It can be used for master synchronizing, voltage matching, and permissive sync check. The SYNC1320 simultaneously synchronizes multiple generator sets to a utility or other system bus. The SYNC1320 drives the genset bus to match the phase, frequency, and voltage of the reference bus.

The SYNC1320 master synchronizer includes onboard diagnostics and can be configured using the RS-485 interface for communicating with the InPower service tool. However, default settings will work for most applications.

The SYNC1320 master synchronizer is suitable for direct connection to alternators and system buses operating at up to 480VAC line-to-line. By default, the synchronizer is set up for nominal line-to-line voltages from 110–139VAC. The synchronizer can also be used in applications operating at up to 35kV by proper use of a voltage transformer (VT) to provide control signals to the device.

The control is designed for panel mounting, but can be mounted into a large number of physical locations due to its inherent environmental protection.

The SYNC1320 master synchronizer is usually powered from the generator set starting batteries.

The module can be connected to two independent DC sources for redundancy. The control functions over a voltage range from 9 to 32 VDC and requires less than 1 amp.

The SYNC1320 master synchronizer is designed for connection to a 12 or 24 VDC control system.

Figure 3-2 is a block diagram showing the SYNC1320 master synchronizer inputs and outputs. This I/O is described in Table 3-1. The SYNC1320 master synchronizer interfaces to external components through locking plug-in terminal blocks suitable for wiring up to 12 gauge (2.5 mm).

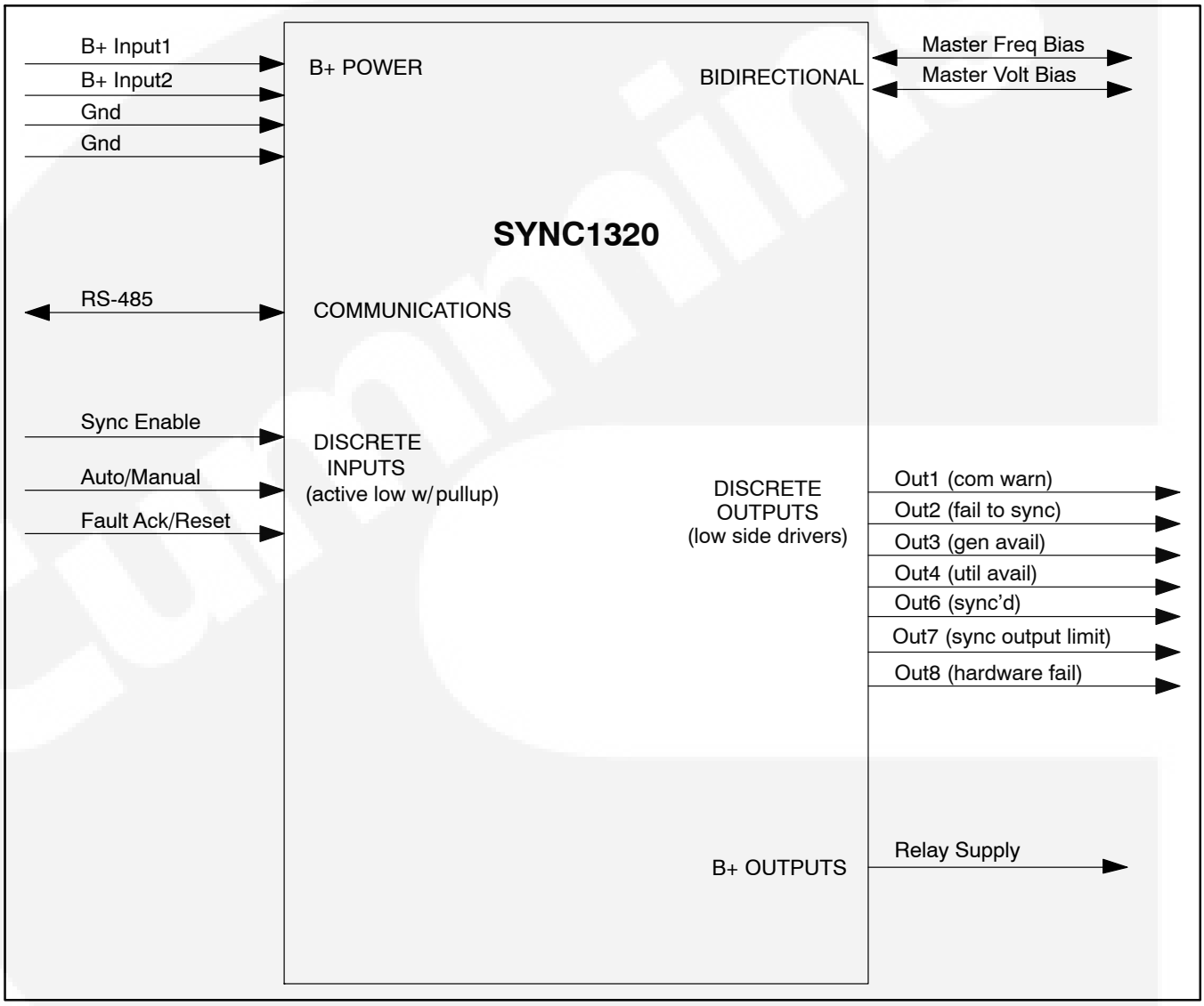

FIGURE 3-2. SYNC1320 MASTER SYNCHRONIZER I/O

TABLE 3-1. HARDWARE I/O

Hardware Signal	Active State*	Function
B+ Input1		Battery positive power input for the board. Diode OR'd on the board with B+ Input2. 9–32V range. Starter dip ride-through capable.
B+ Input2		Battery positive power input for the board. Diode OR'd on the board with B+ Input1. 9–32V range. Start dip ride-through capable.
Gnd		Battery negative connection for the board.
RS-485		Communications connection for tools
Sync Enable	Enable Sync	Input used to externally initiate synchronizing if the Auto/Manual input is in the Manual state.
Auto/Manual	Manual	Input used to put the control in the manual mode. Manual operation allows an external device to initiate synchronizing. In Auto mode, the control automatically synchronizes to a good source.
Master Frequency Bias	–2.5 to +5 V	This is a bi-directional analog signal which connects to the PowerCommand Control kW load share lines for master synchronizing. The SYNC1320 master synchronizer moves the voltage on the kW load share lines to affect the genset bus frequency for synchronizing.
Master Voltage Bias	–2.5 to +5V	This is a bi-directional analog signal which connects to the PowerCommand Control kVAR load share lines for master voltage matching. The SYNC1320 master synchronizer moves the voltage on the kVAR load share lines to affect the genset bus voltage for voltage matching.
Out1 (common warning)	Low	This is a low side driver output which is intended to drive a relay coil. It goes active on any warning condition.
Out2 (fail to sync)	Low	This is a low side driver output which is intended to drive a relay coil. It goes active on a fail to sync event.
Out3 (genset available)	Low	This is a low side driver output which is intended to drive a relay coil. It is active when the genset is available.
Out4 (utility available)	Low	This is a low side driver output which is intended to drive a relay coil. It is active when the utility is available.
Out6 (sync'd)	Low	This is a low side driver output which is intended to drive a relay coil. It is active when the two sources are in sync.
Out7 (sync output limit)	Low	This is a low side driver output which is intended to drive a relay coil. It is active when the sync output is being driven to its limit.
Out8 (hardware failure)	Low	This is a low side driver output which is intended to drive a relay coil. It is normally energized but becomes inactive when there is a hardware failure event.
Relay Supply	B+	This is a B+ output to be used to supply the high side of relay coils for the Out1–8 low side outputs.
Gen Bus VTs		Gen Bus voltage sensing inputs are 3 phase, 3 or 4 wire, and up to 480V nominal direct.
Utility Bus VTs		Utility Bus voltage sensing inputs are 3 phase, 3 or 4 wire, and up to 480V nominal direct.

* For discrete inputs, the active state is when the input is connected to a return (gnd). Inactive is when the input is open circuit. For discrete low side outputs, the active state is when the low side output is on (gnd), inactive state when low side output is off (float).

SYNC1320 MASTER SYNCHRONIZER FEATURES

Master Synchronizing and Voltage Matching

The following functions are available with the master synchronizing and the voltage matching features.

- Synchronizes up to a 20-genset bus to another source.
- Output frequency offset range: ±1.5 Hz minimum and up to ±3.0 Hz
- Output voltage offset range: ±6% minimum and up to ±10%
- Controls frequency and voltage via PowerCommand Control kW and kVAR load share lines.
- Performs both phase synchronization and voltage matching
- Includes selectable phase synchronization (default) or slip frequency synchronization methods.
- When the slip frequency synchronization method is selected, the slip amount is adjustable.
- Includes adjustable control loop gains, if needed.
- Includes a sync enable input for manual mode or sync only applications.
- Synchronizer output limit diagnostic

Permissive Sync Check

The following functions are available with the permissive sync check feature.

- The SYNC1320 Master Synchronizer continuously monitors for permissive sync conditions to be met when sources are considered acceptable.
- The permissive check feature includes adjustable frequency, phase, voltage, and time windows.
- Sync check output
- Fail to synchronize diagnostic
- Phase rotation mismatch diagnostic (Sync check OK is prevented if phase rotations are different.)
- Sync check may be configured for any combination of live-live, dead-live, live-dead, or dead-dead

On-Board Diagnostics

The SYNC1320 control board includes LEDs (see Figure 3-3) that indicate system status, events, and faults. The SYNC1320 control board also includes a seven segment LED (see Figure 3-3), used to indicate current activity or to view event and fault codes

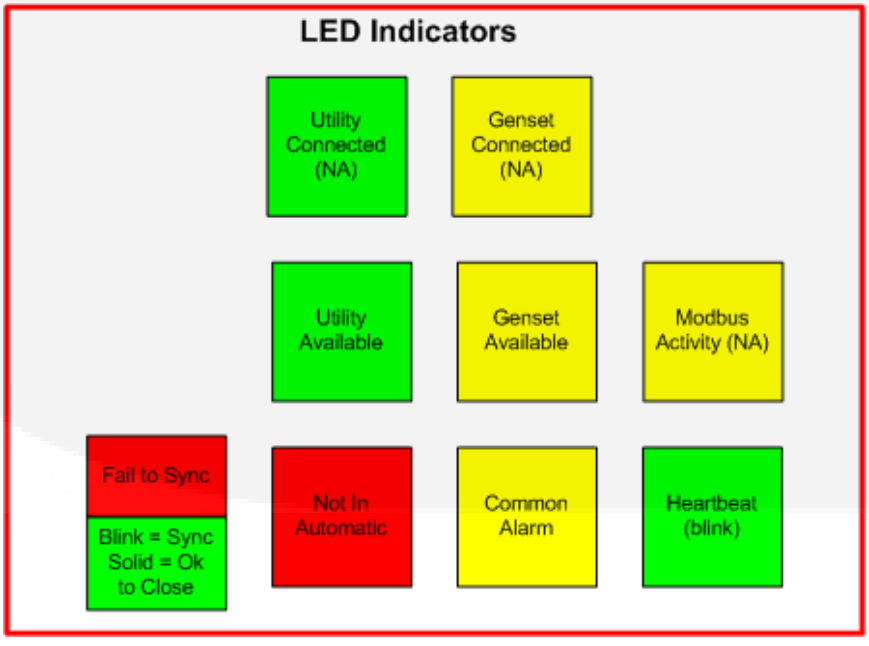

FIGURE 3-3. CONTROL BOARD LEDS

System Status Indicators

The SYNC1320 control board includes individual LEDs for the following:

- DS1 (Green) = Utility Available. When lit, the Utility Available LED indicates that the voltage sensed at the utility VT is within the range identified as acceptable within the controller.
- DS5 (Yellow) = Genset Available. When lit, the Genset Available LED indicates that the voltage sensed at the generator VT is within the range identified as acceptable within the controller.
- DS7 (Red) = Not in Auto Mode. When lit, the Not in Auto LED indicates that the control is not in Auto mode.
- DS6 (Yellow) = Common Warning. When lit, the Common Warning LED indicates that the control has detected a Warning fault.
- DS3 (Blinking Green) = Heartbeat. When lit, the Heartbeat LED indicates that power is available at the control board.
- DS8 (Blinking Green) = Synchronizing. When blinking green, the Synchronize LED indicates that a sync check is in progress to determine if both sources of power are within specified tolerances of frequency, voltage, and relative phase difference.
- DS8 (Green) = Synchronized. when lit, the Synchronize LED indicates that the control has determined that both power sources are synchronized.
- DS8 (Red) = Fail to Sync. When lit, the Fail to Sync LED indicates that the two power sources have failed to synchronize either voltage, phase, or frequency within the specified time limit.

System State and Diagnostic Indicators

The SYNC1320 control board also includes a seven-segment LED (U51 – see Figure 3-3), used to indicate the following:

- System State (default) – When in this mode, the LED displays a code to indicate current activity. See Table 3-9.
- Diagnostic State – A customer-supplied fault reset switch must be pressed for at least five seconds to switch to Diagnostic mode and view event and fault codes. The seven segment LED is in Diagnostic State mode when the dot on the lower right corner is lit. To return to System State mode, press the reset button.

For more information on faults and troubleshooting, see *Section 5*.

PC InPower Service Tool

InPower can be used for setup and service.

The PC InPower service tool used with the SYNC1320 master synchronizer includes the following features.

- An RS-485 interface
- Standard InPower software that includes Adjustments, Faults, Monitor, and Test folders
- The ability to create capture files
- The ability to download new firmware

For more information on using InPower, refer to the InPower User's Guides.

FUNCTIONS

Synchronizer

The SYNC1320 master synchronizer matches the frequency, phase, and voltage of a system of paralleled generator sets to a utility bus. It does this by driving the Kw and kVAR load share lines to adjust the generator set frequency and voltage. There are two synchronize method options – slip frequency or phase – which can be selected depending on the application.

The SYNC1320 master synchronizer is designed to synchronize gensets with PowerCommand controls. The SYNC1320 master synchronizer can be used with competitor gensets via an ILSI module but the voltage matching feature is not available with that application.

Ratings and Typical Performance

The SYNC1320 master synchronizer synchronizes up to a 20-genset bus to another source.

The output frequency offset range is ±1.5Hz minimum, up to ±3.0Hz.

The output voltage offset range is ±6% minimum and up to ±10%.

Table 3-2 shows the typical performance of the phase synchronizer with diesel engines.

TABLE 3-2. TYPICAL SYNCHRONIZER PERFORMANCE

Description	Typical Performance with Diesel Engines
Synchronize time with phase match	1–5 seconds
Synchronize time with slip frequency	3–10 seconds
Phase lock	Within +/– 5°
Maximum number of sets	20

Synchronizing Methods

The SYNC1320 master synchronizer has two methods of synchronizing: Phase Synchronizing and Slip Frequency Synchronizing. The default method is Phase Synchronizing and is suitable for most applications. This synchronizes the generator bus phase to the utility.

When using the Slip Frequency method, genset bus frequency is driven to be a fixed frequency higher or lower than utility bus (for example, 0.1Hz). The Slip Frequency option should be used with difficult-to-sync applications, such as natural gas.

Phase Synchronizing – The Synchronizer matches voltage, frequency, **and** phase angle of the genset bus to the utility bus. The phase match algorithm drives kW load share lines to match frequency/phase. It employs two PI loops. The faster frequency match PI loop drives the frequencies to match and then the slower phase match PI loop brings the two sources into phase.

Slip Frequency Synchronizing – The slip frequency method works by governing the generator bus frequency slightly off of the utility frequency. This frequency difference is called the slip frequency. The frequency difference produces a constantly changing phase difference between the two sources. If the frequencies are close enough periodically, the phase difference will be small enough that it will meet the permissive conditions for closing the circuit breaker. It is easier to govern frequency than match phase; therefore, systems that are difficult to phase match or where you would like to control the direction of power flow when the breaker closes, frequency synchronizing may be desirable. Since the permissive conditions occur periodically based on the slip frequency, the slip frequency method generally takes longer to synchronize than the phase match method. The phase gain has no effect when using the frequency synchronize method and when phase synchronizing is selected, the slip frequency has no effect.

Table 3-3 shows the recommended slip frequency settings. The recommended slip frequency setting = phase window / (360 * Time in window). By using the settings in the table, the phase difference at the end of the permissive time window (when the breaker is allowed to close) will be 0 degrees. (For example, at a 0.1 Hz slip it takes 0.5 seconds for the phase to change 20°; the phase difference would be in a +/– 20° window for 0.5 seconds.)

TABLE 3-3. RECOMMENDED SLIP FREQUENCY SETTINGS

Permissive Window	Recommended Slip Frequency in Hz	Time in Seconds Between When Permissive Window Conditions Are Met
20° 0.5 seconds	0.1	10
10° 0.5 seconds	0.05	20

Voltage Matching

The SYNC1320 master synchronizer matches the average of the three generator phases to the average to the three utility phases.

The SYNC1320 master synchronizer matches voltage in a similar way in which it matches frequency. There is a closed PI loop which drives kVAR load share lines to match voltage. Voltage matching is active in both the phase and frequency synchronize methods.

Tuning the voltage matching is done in a similar way to frequency matching. There is a proportional gain Kp and an integral gain Ki. Voltage matching gains are generally less critical than frequency or phase matching gains and typically do not need to be adjusted.

NOTE: If the genset voltage is increased by voltage matching, the load on the set will increase. If the voltage is raised to 6%, then the genset load increases by 12%.

Synchronizer Enabling Conditions

The SYNC1320 master synchronizer does not start synchronizing unless the following conditions are met:

1. The generator source is available – see the Sensors subsection on page 3-9 for determination of source availability.
2. The utility source is available – see the Sensors subsection on page 3-9 for determination of source availability.
3. The SYNC1320 master synchronizer is in Auto OR it is in Manual with the sync enable switch on.
4. The fail-to-synchronize fault is not active or the fail-to-sync lockout is disabled.
5. The generator and bus have the same phase rotation.

The synchronizer function requires both sources to be considered as “available” in order to be able to turn on synchronizing. A source is available when all enabled sensors are picked up.

Sync Enable Input

The sync enable input is used to enable synchronizing when in Manual or when the module is used only as a synchronizer. Pull to ground to activate (TB1–11).

Auto / Manual Synchronizer Operation

When the Auto / Manual input is an open circuit, the synchronizer is in automatic mode. It will start synchronizing whenever both sources are “available”.

When the Auto / Manual input is grounded, the synchronizer is in manual mode. It will start synchronizing when both sources are “available” and the Sync Enable input is grounded. It will not synchronize when Sync Enable is an open circuit.

Genset Sensor Operation During Synchronizing

When the synchronizer is running, the pickup and dropout thresholds for undervoltage, overvoltage, and frequency sensors for the genset bus are temporarily expanded in order to allow the synchronizer to change the bus voltage and frequency without dropping out a sensor. These sensors are the generator bus sensors internal to the SYNC1320 master synchronizer.

Maximum Allowable Synchronizer Range vs. Load Share Gains

The SYNC1320 master synchronizer drives the load share lines to synchronize system frequency/phase and voltage. In order for frequency and voltage matching to work properly, the kW and kVAR load share gains must be set properly so all the controls respond the same way to the voltage applied to the load share lines. If the system genset controls are all the same, the load share gains must be set to the same values. If PCC3100 and PCC3200 controls are mixed in the same system, they must be set up so their gains have the same effect. The load share gains affect the range of operation of the frequency and voltage matching and the synchronizer gain.

NOTE: The PCC3200 and PCC3201 controls are treated identically and are called out as 3200 (only) in this manual for simplicity.

The SYNC1320 master synchronizer default synchronizing range limits for frequency/phase and voltage matching are shown in Table 3-4. These limits are set so the SYNC1320 master synchronizer will work with the default load share gain settings of the PCC3100 and 3200 controls.

NOTE: The PCC3100 and PCC3200 controls have overvoltage shutdowns at 110%. The SYNC1320 master synchronizer voltage matching range should not be set to exceed this value.

If a wider range is desired, the load share gains can be increased. The Kw load share gain controls the frequency matching range and the kVAR load share gain controls the voltage matching range. The PCC3100 default gains will allow a +/– 2.5 Hz frequency match range. The maximum voltage and frequency synchronizing range is not available in the set up tool provided with the module. They must be changed using InPower.

NOTE: Higher gains may cause the load sharing to become unstable. If the gains are changed, stable load share operation should be verified.

TABLE 3-4. SYNCHRONIZING RANGE

	Synchronizer Default Range	Maximum Allowable Range	Comments
Frequency	±1 Hz	±3 Hz	The maximum range is only achievable by changing the Kw load share gain and trim settings
Voltage	±6 %	±10 %	The maximum range is only achievable by changing the kVAR load share gain setting

TABLE 3-5. PCC3100 MAXIMUM ALLOWABLE SYNCHRONIZE RANGE VS. LOAD SHARE GAINS

Kw Load Share Gain	Maximum Frequency Match Range		kVAR Load Share Gain	Maximum Voltage Match Range
3	±1.0 Hz		150	±4 %
6 (default)	±2.5 Hz		300(default)	±8 %
8	±3.5 Hz			

TABLE 3-6. PCC3200 MAXIMUM ALLOWABLE SYNCHRONIZE RANGE VS. LOAD SHARE GAINS

Kw Load Share Gain	Maximum Frequency Match Range		kVAR Load Share Gain	Maximum Voltage Match Range
0.5	±0.5 Hz		0.5	±4 %
1.0 (default)	±1.0 Hz		1.0 (default)	±8 %
2.0	±2.5 Hz			

Synchronizer Diagnostics

The SYNC1320 master synchronizer supports the following synchronizer diagnostics.

- *Fail-to-Synchronize Warning* – If the permissive conditions are not met in the time specified the fail-to-synchronize warning is activated. If the fail-to-synchronize lockout is disabled (default) synchronizing will continue while the fault is active. If it is enabled synchronizing will cease when the fault occurs. If a fail-to-sync fault occurs and the lockout is enabled

the fault must be reset before normal operation can occur.

- *Synchronizer Phase Rotation Warning* – If the phase rotation of the Utility bus does not match the phase rotation of the generator bus this fault is activated. Synchronizing will continue while this fault is active but the permissive conditions will not be met.
- *Synchronizer Output Limit Warning* – If the SYNC1320 master synchronizer drive on the load share lines has reached its maximum this fault is activated. This occurs if the SYNC1320 master synchronizer is trying to match voltage or frequency and cannot reach the desired level.

Synchronizer Tuning and Adjustments

Control loop gains and other setup parameters are adjustable through the tool.

Sync Check

The SYNC1320 Sync Check function runs independently of the synchronizer. Sync check output is mapped to configurable output 6 by default.

Sync Check Adjustments

The following trims are available for the permissive window.

Trim	Default
Voltage window	5%
Phase window	10 degrees
Time window	0.5 seconds
Frequency window	1.0 Hz

Permissive Close Conditions

The follow conditions must be met for a permissive close is allowed:

- The utility source is available.
- The generator source is available.
- The utility and generator phase rotation are the same.
- The highest difference of all the generator phase voltages, minus the utility phases, is less than the voltage window.
- The phase difference is less than the phase window degrees and is decreasing or it is less than 10 degrees and the phase difference is less than the phase window.
- The frequency difference between the sources is less than the frequency window.
- Permissive conditions are met for the time window.

The board LEDs display the status of the sync check.

NOTE: The permissive close is removed when any of the criteria fall outside of the window.

Dead Bus Close

In synchronizer only applications, sync check can be enabled individually for the following dead bus scenarios.

- Dead utility dead genset
- Live utility dead genset
- Dead utility live genset

Dead bus thresholds for both the utility bus and the genset bus are adjustable. The default for both busses is 25% of nominal.

Sensors

The generator and utility bus sensors determine if the bus voltages and frequencies are in an acceptable operating range. When they are in this range, the source is considered to be available.

Both sources have the following sensors:

- Undervoltage
- Overvoltage *
- Under/Over Frequency *
- Phase Rotation *
- Loss of Phase *

* Optionally enabled

The undervoltage sensor is always enabled. Other sensors may be enabled as desired.

If any sensor is dropped out, the source is considered not available.

Undervoltage Sensor – At a minimum, source availability is determined by the undervoltage sensor. The sensor drops out when the voltage falls below the drop-out threshold, and picks up when the voltage rises above the pick-up threshold setting. The time delay is for the drop-out time. Pick up is immediate.

Overvoltage Sensor – If enabled, this sensor drops out when voltage exceeds the drop-out threshold and picks up when the voltage falls below the pick-up threshold. The time delay is for the drop-out time. Pick up is immediate.

Frequency Sensor – If enabled, this sensor drops out when the frequency goes beyond the drop-out thresholds, and picks up when the frequency falls within the pick-up thresholds. The time delay is for the drop-out time. Pick up is immediate.

Phase Rotation Sensor – If enabled, this sensor drops out if the phase rotation of the source does not match the system phase rotation setting.

Loss of Phase Sensor – If enabled, this sensor detects if the line-to-line voltages are more than 30 degrees away from 120 degrees. The time delay is for the drop-out time. Pick up is immediate.

Discrete Inputs

There are three discrete inputs labeled as switches (see Table 3-7). These inputs are optically coupled so they are activated by current. To activate an input, connect it to one of the discrete input return connections or to a local B– connection. The inactive state for these inputs should be an open circuit. Do not connect to B+.

Synchronizer Enable Switch

The synchronizer enable switch input is used to turn the synchronizer on and off only when the control is in Manual mode. The synchronizer automatically turns on if the control is in Auto mode and the two power sources are good (TB1-11).

Fault Reset

The fault reset input acknowledges and resets faults. It is also used to activate the fault flash out on the seven segment display on the board (hold active for >5 seconds to activate this mode; hold active again momentarily to leave this mode) (TB2–14).

Discrete Outputs

There are two different types of discrete outputs. There are the seven Low Side Outputs capable of sinking 200 mA each and the Relay Supply (see Table 3-8).

There are seven low side outputs.

- Output 1 (Common Warning) – Output #1 is intended to drive a relay coil and is activated by a Common Warning.
- Output 2 (Fail to Synchronize – Output #2 is intended to drive a relay coil and is activated by a Fail-to-Sync event.
- Output 3 (Genset Available) – Output #3 is intended to drive a relay coil and is activated when the genset is available.
- Output 4 (Utility Available) – Output #4 is intended to drive a relay coil and is activated when the utility is available.
- Output 6 (Synchronized) – Output #6 is intended to drive a relay coil and is activated by a Synchronized event.
- Output 7 (Synch Output Limit) – Output #7 is intended to drive a relay coil and is activated by a Synch Output Limit event.
- Output 8 (Hardware Failure) – Output #8 is intended to drive a relay coil and is activated by a hardware failure event.

TABLE 3-7. SYNC1320 MASTER SYNCHRONIZER DISCRETE INPUTS

Discrete Input	Active State (to Gnd)	Inactive State (open circuit)	Description
Fault Reset	Reset	Not Reset	Reset faults; engage fault readout
Auto/Manual	Manual	Auto	Manual or auto breaker / sync operation
Synchronizer Enable	Active	Inactive	Sync enable (applies in manual only)

TABLE 3-8. PCC3200 DISCRETE OUTPUTS

Output Signal Name (Hardware)	Active State (Low / Energized)	Inactive State (High Impedance / De-energized)	Description
Output1 Driver	Driver On	Driver Off	Activated by a common warning
Output2 Driver	Driver On	Driver Off	Activated by a fail-to-sync event
Output3 Driver	Driver On	Driver Off	Activated by a genset available event
Output4 Driver	Driver On	Driver Off	Activated by a utility available event
Output6 Driver	Driver On	Driver Off	Activated by a sync'd event
Output7 Driver	Driver On	Driver Off	Activated by a sync output limit event
Output8 Driver	Driver On	Driver Off	Deactivated by a hardware failure event
Relay Supply	B+ Output	B + Output	B+ output for supplying relay coil high side; the low side is connected to a low side driver output

Analog Inputs

Genset Bus Voltages

VT Input Connection; up to 480VLL nominal direct connection or higher with external VT, 3-wire or 4-wire.

Utility Bus Voltage

VT Input Connection; up to 480VLL nominal direct connection or higher with external VT, 3-wire or 4-wire.

Bidirectional Analog Signal

Master Frequency Bias

Connect to kW load share; Note PCC3100 wiring diagrams have + and – reversed.

Master Voltage Bias

Connect to kVAR load share; Note PCC3100 wiring diagrams have + and – reversed.

SYSTEM STATE VARIABLE

This variable is intended to give an indication of the most relevant thing that is going on the controller at the present time. This is displayed on the 7-segment LED when the controller is not in fault readout mode.

NOTE: If the decimal point is ON, then the 7-segment LED is in fault readout mode; otherwise, it shows the system state.

TABLE NO TAG3-9. SYSTEM STATE VARIABLE

System State	Description	7-Segment LED Output Character
Not Available	Controller state is not available at present.	– (center segment)
Synchronizing	Synchronizer is on.	6
Sync Check OK	Sync Check is OK.	7
Manual	Auto/Manual switch is in Manual mode	C
Standby	Normal	J

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4. Setup

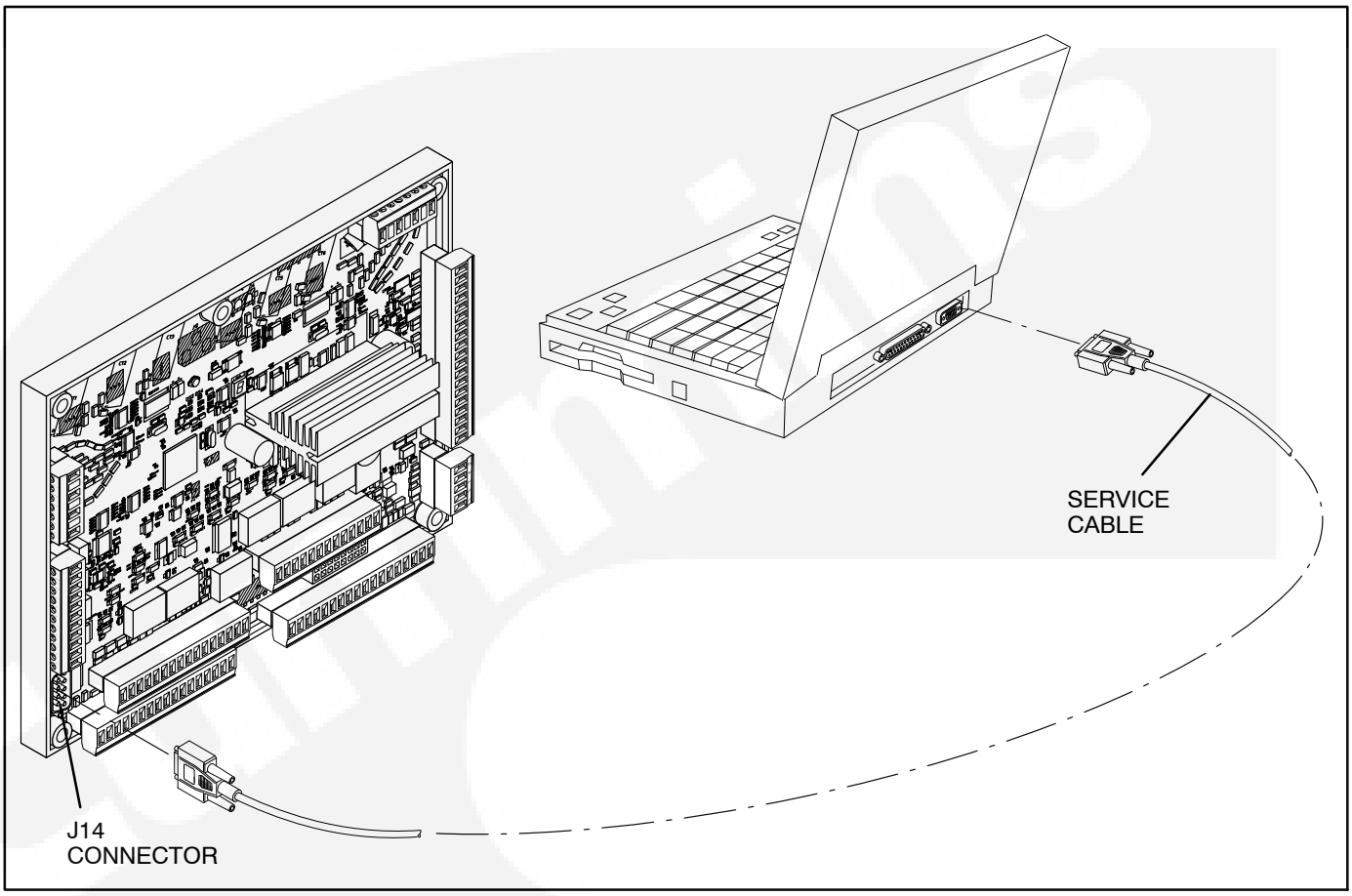


FIGURE 4-2. CONNECTING TO THE SYNC1320

METERING

After InPower has connected to the Synch1320, select MCM3320 Setup from the device menu in the menu bar.

To set up the SYNC1320 master synchronizer metering, first select the Voltage Setup tab. Then select the wye or delta configuration for the generator and utility at the top of the screen (see the connection options below).

Enter the system nominal voltage for the system in the “Nominal generator system LL voltage” text box. The “Nominal utility system LL voltage” box displays the same value. This is the voltage that will equal the 100% value referred to in the generator and utility bus sensor setup screens.

If an external step down potential transformer is used, then click on the Enable check box in the External transformer frame and enter the data for the transformer. In all the text boxes, the data can either be selected from the drop down menu or entered in directly.

To save the adjustments permanently, click the Save Adjustment button.

To verify the meter readings, go to the Voltage Calibration tab (see Figure 4-4). The voltages will be displayed there and can be calibrated if desired.

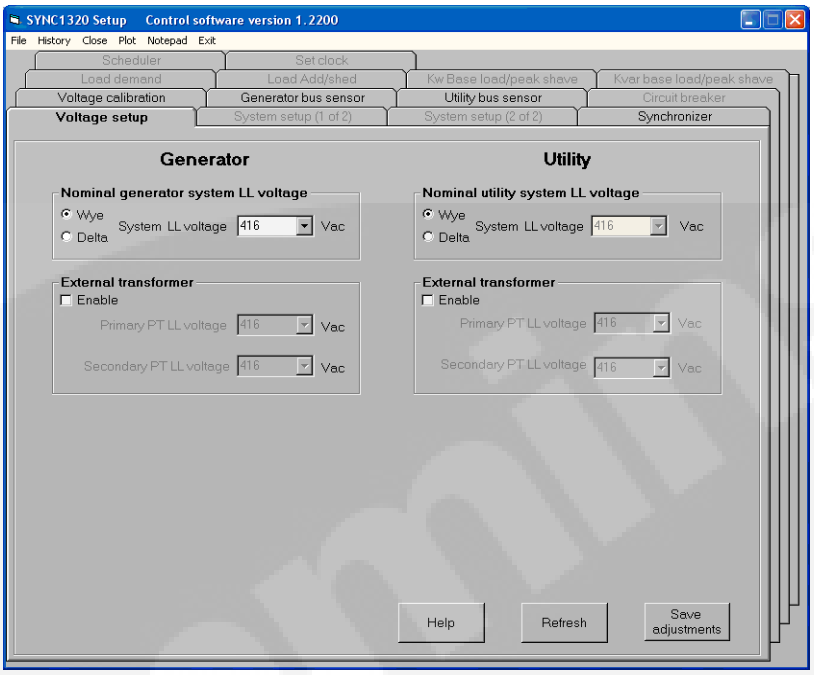


FIGURE 4-3. GENERATOR AND UTILITY VOLTAGE SETTINGS

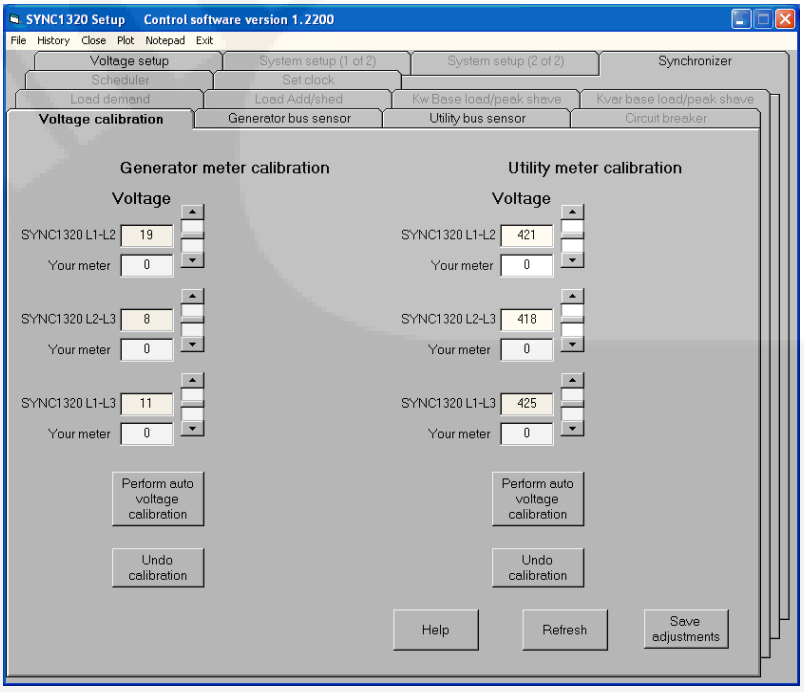


FIGURE 4-4. GENERATOR AND UTILITY METER CALIBRATION

Voltage Calibration

The SYNC1320 master synchronizer is calibrated at the factory and normally does not require calibration in the field. If it is necessary to have the SYNC1320 master synchronizer metering match another metering instrument, a provision is provided for calibrating the voltage. Always make sure that the source you would like to calibrate is live before attempting to calibrate.

The setup program allows for an automatic calibration of the SYNC1320 master synchronizer through the Voltage Calibration tab. The shaded blocks display the voltage readings of the SYNC1320 master synchronizer. Below each of the shaded boxes is a box labeled **Your meter**. This is where you enter the

reading from an external meter that you would like the SYNC1320 master synchronizer to match. When you click on the **perform auto voltage calibration** button, the setup program will match the SYNC1320 master synchronizer reading to the value entered in the **Your meter** box. The scroll bars to the right of the meter boxes allow an option to manually calibrate the voltages and current.

NOTE: The voltage cannot be calibrated while the SYNC1320 master synchronizer is synchronizing.

VOLTAGE AND FREQUENCY SENSORS

The generator and utility bus sensors determine if the bus voltages and frequencies are in an acceptable operating range. When they are in this range, the source is considerable available. The text boxes with the white background are used to enter the desired range. The shaded boxes display the voltage or frequency those values correspond to.

NOTE: The setup process is identical for both the utility and generator bus sensors. Utility bus sensor information is shown in Figure 4-5 and generator bus sensor information is shown in Figure 4-6.

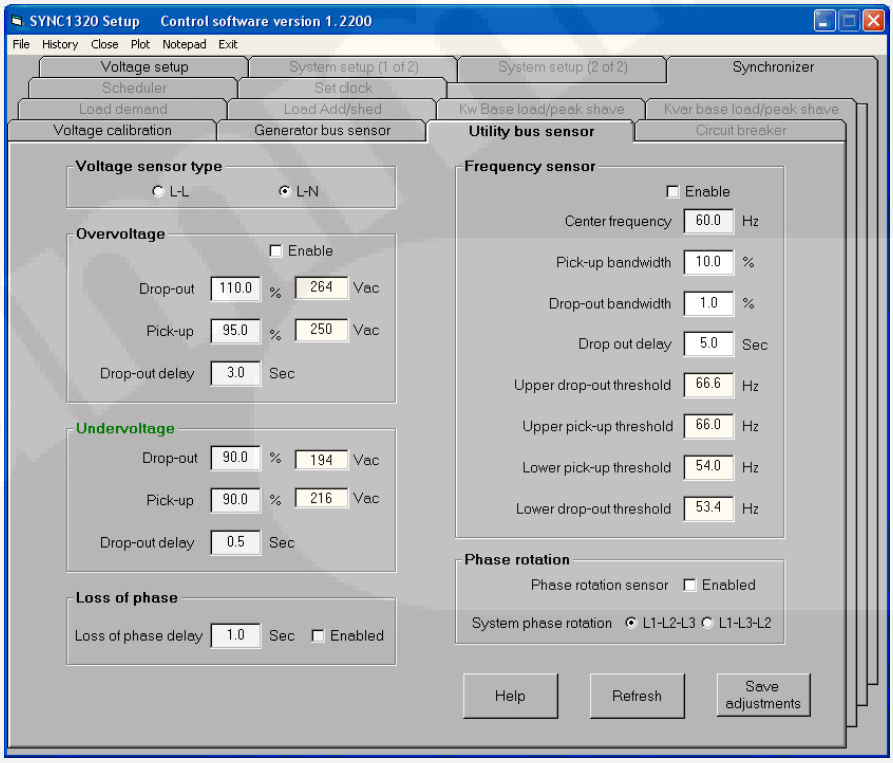


FIGURE 4-5. UTILITY BUS SENSOR INFORMATION

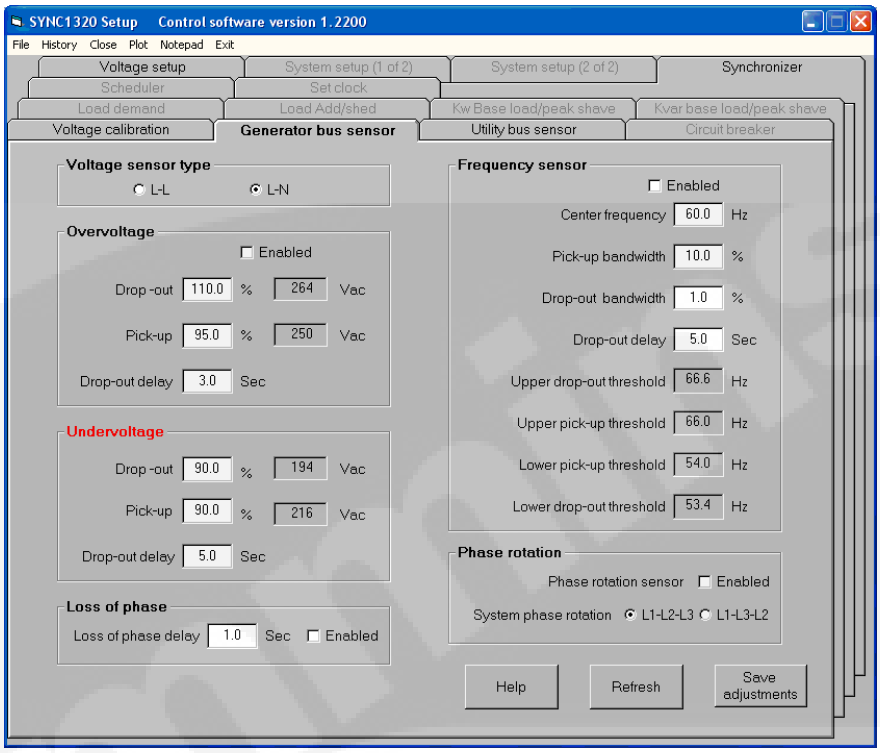


FIGURE 4-6. GENERATOR BUS SENSOR INFORMATION

Undervoltage Sensor

At a minimum, source availability is determined by the undervoltage sensor. The sensor will drop out when the voltage falls below the drop-out threshold, and will pick up when the voltage rises above the pick-up threshold setting. The time delay is for the drop-out time. Pick up is immediate.

Pick up is % of nominal.

Drop out is % of pickup.

Overvoltage Sensor

If enabled, this sensor will drop out when the voltage exceeds the drop-out threshold and will pick up when the voltage falls below the pick-up threshold. The time delay is for the drop-out time. Pick up is immediate.

Drop out is % on nominal.

Pick up is % of drop out.

Frequency Sensor

If enabled, this sensor will drop out when the frequency goes beyond the drop-out thresholds, and will pick up when frequency falls within the pick-up thresholds. The time delay is for the drop-out time. Pick up is immediate.

Phase Rotation Sensor

If enabled, this sensor will drop out if the phase rotation of the source does not match the phase rotation setting.

Loss of Phase Sensor

If enabled, this sensor will detect if the line-to-line voltages are more than 30 degrees away from 120 degrees. The time delay is for the drop-out time. Pick up is immediate.

SYNCHRONIZING

Genset and Utility Bus Sensors Settings for Synchronizer Applications

The synchronizer function requires both sources to be considered as “available” in order to be able to turn on synchronizing. A source is available when all enabled sensors are picked up. The undervoltage sensor is always enabled. Other sensors may be enabled as desired.

Auto / Manual Synchronizer Operation

When the Auto / Manual input is an open circuit, the synchronizer is in Automatic. It will start synchronizing whenever both sources are “available.”

When the Auto / Manual input is grounded, the synchronizer is in Manual. It will start synchronizing

when both sources are “available” and the Sync Enable input is grounded. It will not synchronize when Sync Enable is an open circuit.

Genset Sensor Operation During Synchronizing

When the synchronizer is running, the pick-up and drop-out thresholds for undervoltage, overvoltage, and frequency sensors for the genset bus are temporarily expanded in order to allow the synchronizer to change the bus voltage and frequency without dropping out a sensor. When the synchronizer is running, these temporary expanded voltage thresholds are displayed in red on the Generator Bus Sensor tab (see Figure 4-6).

Synchronizing Methods

The SYNC1320 master synchronizer has two methods of synchronizing: phase synchronizing and slip frequency synchronizing. The default method is phase synchronizing and is suitable for most applications. This synchronizes the generator bus phase to the utility.

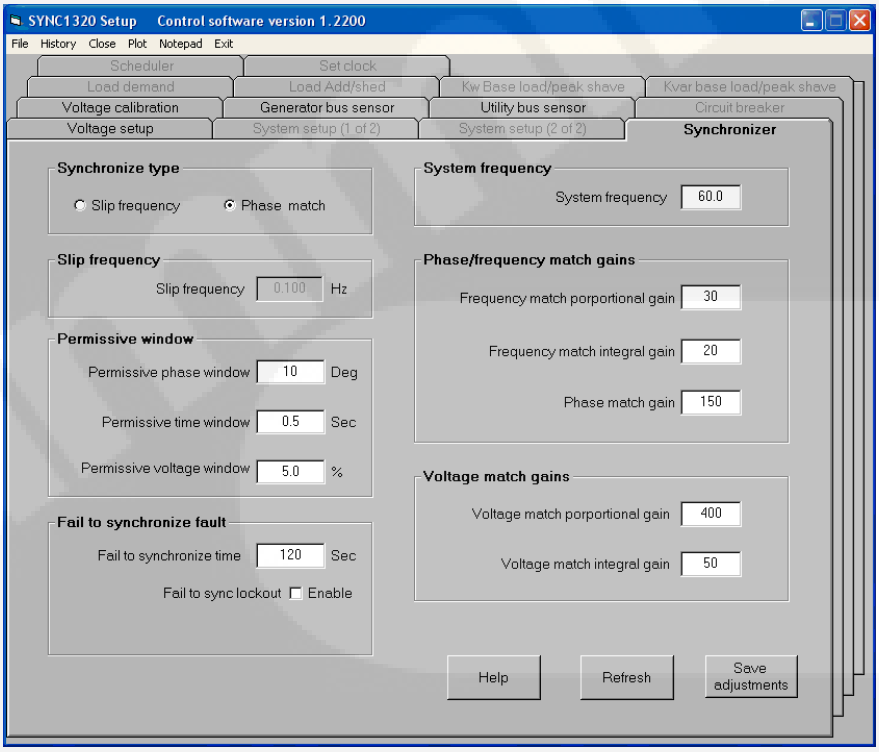


FIGURE 4-7. SYNCHRONIZER INFORMATION

Voltage Matching

The SYNC1320 master synchronizer matches the average of the three generator phases to the average to the three utility phases. The SYNC1320 master synchronizer matches voltage in a similar way in which it matches frequency. Voltage matching is active in both the phase and frequency synchronize methods.

Tuning the voltage matching is done in a similar way to frequency matching. There is a proportional gain and an integral gain. Voltage matching gains are generally less critical than frequency or phase matching gains and typically do not need to be adjusted.

NOTE: If the genset voltage is increased by voltage matching, the load on the genset will increase. If the voltage is raised to 6%, then the genset load increases by 12%.

Slip Frequency Synchronizing

The slip frequency method works by governing the generator bus frequency slightly off of the utility frequency. This frequency difference is called the slip frequency. The frequency difference produces a constantly changing phase difference between the two sources. If the frequencies are close enough periodically, the phase difference will be small enough that it will meet the permissive conditions for closing the circuit breaker. It is easier to govern frequency than match phase; therefore, on systems

that are difficult to phase match or where you would like to control the direction of power flow when the breaker closes, frequency synchronizing may be desirable. Since the permissive conditions occur periodically, based on the slip frequency, the slip frequency method generally takes longer to synchronize than the phase match method. The phase gain has no effect when using the frequency synchronize method and when phase synchronizing is selected, the slip frequency has no effect. Table 4-1 shows the recommended slip frequency settings. The recommended slip frequency setting = phase window / (360 * Time in window). By using the settings in the table, the phase difference at the end of permissive time window (when the breaker is allowed to close) will be 0 degrees. (For example, with a 0.1 Hz slip, it takes 0.5 seconds for the phase to change 20°. The phase difference would be in a +/– 20° window for 0.5 seconds.)

Adjusting the Synchronizer Gain Values

⚠ CAUTION ***The SYNC1320 master synchronizer is factory-configured for gains that are most appropriate for typical applications. Adjustment of the gains by non-qualified persons can result in misoperation of the system when the synchronizer is enabled. Defer settings to a qualified Cummins service technician.***

Normally the synchronizer works properly with the default gain settings and does not need to be adjusted. If the frequency/phase synchronizing is unstable, the frequency match proportional gain can be reduced. This may be necessary with gas or other gensets that have slow response times.

The synchronizer gains can be set using the values in Table 4-2, based on the control and engine. These gain values apply with the genset controls set to their default load share gain values. If the load share gain values are changed, the frequency match proportional gain will need to change. If the load share gains are increased, the frequency match proportional gains may need to be decreased. Generally the voltage matching gains can be set the same for all gensets and can be left at their defaults.

The frequency matching gains will vary, depending on the control and engine. For diesel engines with PCC3100 and PCC3200 controls, the frequency match gains should be set to the standard values listed in the table. Gas gensets are much more stable when running with load.

NOTE: The stability of the synchronizing improves when more gensets are paralleled.

TABLE 4-1. RECOMMENDED SLIP FREQUENCY SETTINGS

Permissive Window	Recommended Slip Frequency in Hz	Time in seconds between when permissive window conditions are met
20° 0.5 seconds	0.1	10
10° 0.5 seconds	0.05	20

TABLE 4-2. SUGGESTED SYNCHRONIZER GAIN VALUES

Control/Set	Frequency Match Proportional	Frequency Match Integral	Phase Match Proportional	Voltage Match Proportional	Voltage Match Integral
Default gains	30	20	160	400	50
PCC3200 – standard	50	20	160	400	50
PCC3100 – standard	50	20	160	400	50
PCC3100 – QSM11	25	20	160	400	50
PCC3100 – 1250 gas	9	20	160	400	50

5. Testing and Troubleshooting

SYSTEM STATE AND DIAGNOSTIC INDICATORS

This section includes troubleshooting information for the SYNC1320 master synchronizer. Refer to Section 3 for information on the LED status display.

The SYNC1320 master synchronizer also includes a system status and alarm readout 7-segment LED. This section describes troubleshooting based on information displayed by that device.

On-Board Diagnostics

The SYNC1320 control board includes LEDs (see Figure 5-1) that indicate system status, events, and faults. Section 3 describes functions of the LED display.

NOTE: DS2, DS4, and DS9 are not used.

System Status Indicators

The SYNC1320 control board includes individual LEDs for the following:

- DS1 (Green) = Utility Available
- DS5 (Yellow) = Genset Available
- DS7 (Red) = Not in Auto Mode
- DS6 (Yellow) = Common Warning
- DS3 (Blinking Green) = Heartbeat
- DS8 (Blinking Green) = Synchronizing
- DS8 (Green) = Synchronized
- DS8 (Red) = Fail to Sync

System State and Diagnostic Indicators

The SYNC1320 control board also includes a seven-segment LED (U51 – see Figure 5-1), used to indicate the following:

- System State – When in this mode, the LED displays a code to indicate current activity.
- Diagnostic State – A customer-supplied fault reset switch must be pressed for at least five seconds to switch to Diagnostic mode and view event and fault codes.

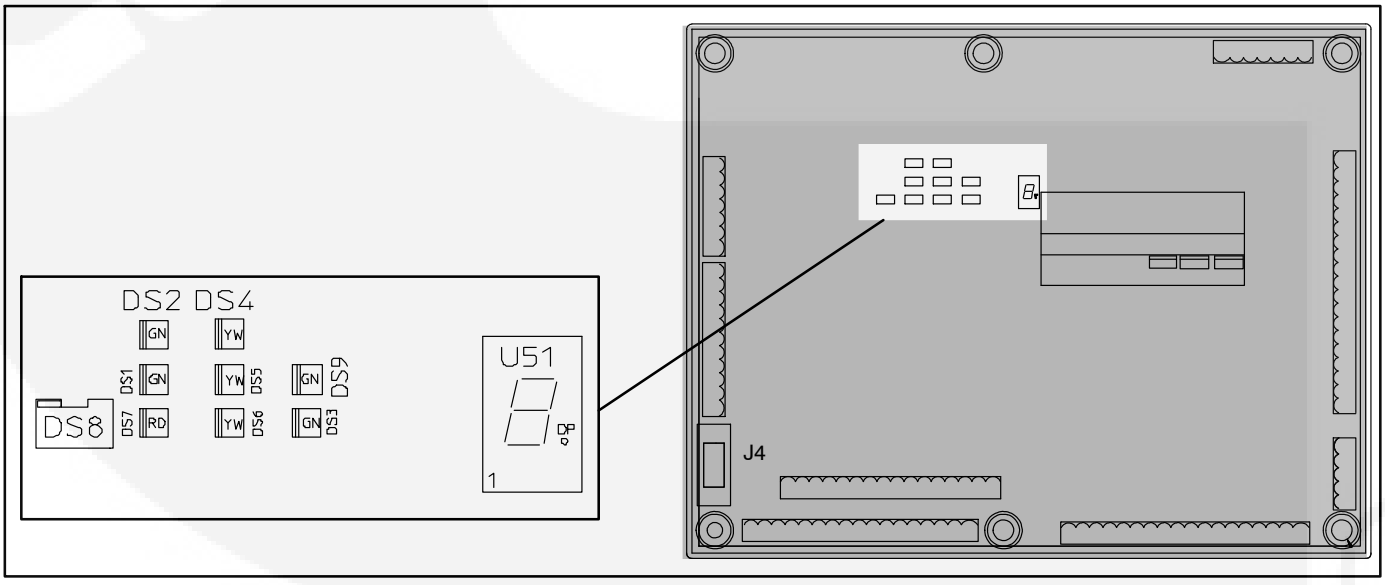


FIGURE 5-1. SYNC1320 CONTROL BOARD LEDS

The control is normally in the System State mode. When in System State mode, the decimal point near the bottom right corner of the seven-segment LED is off and the LED displays a code to indicate current activity. When in this mode, the characters listed in Table 5-1 can be displayed.

TABLE 5-1. SYSTEM STATE LED CHARACTERS

LED Output Character	System State
– (Center Segment)	Not available
6	Synchronizing
7	Sync Check OK
C	Manual
J	Standby

To switch to Diagnostic mode and view event and fault codes, a customer-supplied fault reset switch connected to TB2-14 must be pressed for at least five seconds. When in Diagnostic mode, the decimal point near the bottom right corner of the seven-segment LED is lit.

Some diagnostics are mapped to low side driver outputs.

Warnings are latched until the user does a fault reset using the customer-supplied fault reset switch.

When in Diagnostic mode, the control flashes each digit of the fault/event code, with a pause between digits and a longer pause between repetitions.

TEST AND ADJUSTMENT

Basic Configuration

Before any testing of the SYNC1320 master synchronizer can be done, the basic configuration of the board must be set up and verified using InPower. (See Section 4.)

⚠ CAUTION ***The SYNC1320 master synchronizer is factory-configured for gains that are most appropriate for typical applications. Adjustment of the gains by non-qualified persons can result in misoperation of the system when the synchronizer is enabled. Defer settings to a qualified Cummins service technician.***

Bench Tests

Connect a 12 or 24VDC control power source to one of the control power inputs (TB2-7 and TB2-8, 9, 11 or 12). Verify that the control is operating by viewing DS3 blinking green.

If an AC power source of an acceptable magnitude and number of phases is available, the board can verify that proper voltage is sensed at each voltage reference point, again by verifying that the appropriate LED (DS1–green for utility side and DS5–amber for generator bus side) operates when the source is connected. Note that in the default configuration, the utility available and generator bus available relay drivers should also operate during this test (TB2-17 and 18).

If both sources are connected simultaneously and the sources are synchronized the board should display a ”synchronized” indication by lighting DS8 continuously. If the synchronizer is enabled (TB1-10 to 11) and DS8 is flashing both sources are available and the device is attempting to synchronize them.

Commissioning

Commissioning of Cummins PowerCommand generator sets and SYNC1320 master synchronizers should be supervised by a qualified Cummins service technician.

⚠ WARNING ***Do not allow connection of an operating generator bus to a utility service without explicit written permission of the utility service provider. Improper settings and practices can result in personal injury, death, or serious equipment damage.***

The commissioning process can result in power outages of varying duration and/or voltage and frequency disturbances to loads connected to the generator set or utility buses.

The actual commissioning process for any system is dependent on the specific characteristics of that system. The follow points provide only guidelines for proper system commissioning. A qualified system designer should provide specific commissioning instructions to validate proper system operation and settings.

1. Generator sets that are used in conjunction with a SYNC1320 master synchronizer must be fully commissioned as described in the Cummins generator set installation manual prior to commissioning of the SYNC1320 functions in the system.
2. Verify that all wiring is installed as required by the system control drawings and the Cummins interconnecting drawings for the SYNC1320 master synchronizer.
3. Set the system up for manual operation so that the system does not attempt to switch power to

loads. Check the source availability set points in the SYNC1320 master synchronizer for proper settings.

4. Verify that DC control power is available at the master synchronizer. DS3 should be flashing green to indicate that the control is ready to operate.
5. Verify that the sources are connected properly to the master synchronizer. Energize each source individually, and verify that the voltage of a calibrated meter, the SYNC1320 metering, and the switchboard metering (if provided) is consistently operating. Make calibration adjustments on the SYNC1320 master synchronizer as necessary.
6. Verify proper connections to the generator sets from the master synchronizer. With system loads connected to the utility, the synchronizer not enabled, and a generator set running, adjust the generator set frequency and voltage to a value that is different from utility frequency by 1 hertz, and utility voltage by approximately 3%. Enable the synchronizer and observe that the generator set correctly matches the utility frequency and voltage without connecting the generator set to the utility source. If desired, the settings can be done in each direction to verify the capabilities of the device to drive adjustments in both directions. Reset generator set frequency and voltage to levels to those prior to running test. Repeat this test for each generator set in the system.
7. Verify that the generator sets synchronize properly as a group. With the utility source available, the generator sets operating with system loads connected and load properly balanced between all machines, enable the master synchronizer and verify that the generator sets synchronize as a group without disrupting load sharing, and to within the sync check parameters set into the SYNC1320 master synchronizer. The “SYNC OK” output of the master synchronizer can be used to signal that the control considers the generator bus to be synchronized. An external device should be used to validate the synchronizing accuracy of the system. The Cummins service technician may make adjustments necessary to optimize synchronizing speed.
8. Complete the balance of system operation tests in manual state, then repeat system testing in all automatic modes, to totally verify system operation.

TROUBLESHOOTING

Table 5-2 lists the possible fault/event codes that are available with the SYNC1320 master synchronizer. This table also lists the possible cause(s) and provides corrective actions.

To reset faults,

1. Correct the fault condition.
2. Make sure the control is not in Diagnostic mode (decimal point is not lit). If in Diagnostic mode, press the reset switch for at least five seconds.
3. Activate a Reset input momentarily (less than 5 seconds).

TABLE 5-2. CONTROL TROUBLESHOOTING

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
343	Hardware Failure Warning	1. At least one of the following faults is active. • Calibration Checksum Warning (Fault Code 2416) • EEPROM Write Failure Warning (Fault Code 353) • Utility Bus AC Metering Failure (Fault Code 1335) • Generator Bus AC Metering Failure (Fault Code 1335) 2. The hardware version is not compatible with the software version.	1. Identify which of the faults is active by observing the fault displayed on the control panel or observing the lamps on the SYNC1320 control board, or by using InPower. 2. Take corrective steps for the active specific faults, as described in this section. 3. Cycle power to the SYNC1320 master synchronizer. 4. If the problem continues, replace the control board.
353	EEPROM Write Failure Warning	The current value in RAM memory (to-be-written value) does not match its post-written value in EEPROM. This problem occurs when you attempt to save a trim by using either InPower or the LCD display and it is not successful. This problem may also occur when the SYNC1320 master synchronizer tries to automatically save data on a periodic basis.	Clear the fault either by cycling power to the SYNC1320 master synchronizer or by resetting the processor via an InPower initial calibration.
1222	Not in Auto Event	The Synchronizing System is not in Auto mode.	1. Make sure you want to work in this mode. If you do not, check relevant terminal blocks (TB10-6) on the SYNC1320 master synchronizer and related switches for misoperation. 2. Check cabling from the switches to the terminal blocks. 3. Make sure the control switch operation is OK. 4. Use InPower to verify that the SYNC1320 master synchronizer is properly processing contact data.

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
1223	Utility Frequency Warning	The Utility frequency is greater than the upper drop-out threshold or it is less than the lower drop-out threshold and it stays there for a time period that is greater than the drop-out time delay.	1. Check the lower and upper utility frequency drop-out settings on the SYNC1320 master synchronizer. To determine if you are trying to synchronize to a dependable source, create a sensible bandwidth that tells you how good the Utility is. InPower or the set-up tool can be used to accomplish this. 2. To avoid lengthy synchronizing operation, make sure the Utility frequency is not varying a lot all of the time. 3. Make sure the SYNC1320 master synchronizer is measuring frequency correctly.
1224	Generator Bus Overvoltage Warning	The generator bus voltage is greater than the Genset overvoltage drop-out threshold and it stays there for a time period that is greater than the drop-out time delay.	1. Make sure the Genset overvoltage threshold is safe for the connected load and make sure that this value is not too close to the rated voltage. 2. Make sure that the drop-out time delay for this fault is not set too low. 3. Check the AVR system operation of each individual genset. 4. Make sure all AC voltage sensors are properly calibrated at the SYNC1320 master synchronizer and the gensets. 5. Use InPower to monitor and make any necessary adjustments. 6. If used, check external transformer connections.
1225	Generator Bus Undervoltage Warning	The generator bus voltage is less than the Genset undervoltage drop-out threshold and it stays there for a time period that is greater than the drop-out time delay.	1. Make sure the Genset undervoltage threshold is safe for the connected load and make that this value is not too close to the rated voltage. 2. Make sure that the drop-out time delay for this fault is not set too low. 3. Check the AVR system operation of each individual genset. 4. Make sure all AC voltage sensors are properly calibrated at the SYNC1320 master synchronizer and the gensets. 5. Use InPower to monitor and make any necessary adjustments. 6. Make sure the wire size and distance is correct and check for loose connections.

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
1226	Genset Frequency Warning	The generator bus frequency is greater than the upper drop-out threshold or it is less than the lower drop-out threshold and it stays there for a time period that is greater than the drop-out time delay.	1. Verify that the lower and upper generator bus frequency drop-out settings on the SYNC1320 master synchronizer create a sensible bandwidth that makes load-feeding a safe activity. InPower can be used to accomplish this. Be aware that the generator bus settings harmonize with the genset settings. 2. To avoid lengthy synchronizing operation, make sure the Utility frequency is not varying a lot all of the time. 3. Verify that the SYNC1320 master synchronizer is measuring frequency correctly. 4. Verify that the genset control is correctly calibrated.
1335	AC Metering Out of Range Warning	At least one of the following variables are out of range in utility bus and/or generator bus analog measurements. • Voltage • Current • kW • kVAR • kVA • Power Factor	1. Use Inpower to determine if the generator bus or the utility bus is the source of the problem. 2. Verify that the meter calibration is okay. 3. Verify that the SYNC1320 master synchronizer VT and CT ratios are correctly set. 4. Verify that the VT and CT rated values match the ones set in the SYNC1320 master synchronizer. 5. Check the number of turns on each of the built-in CTs to verify that they comply with requirements regarding 5A-secondary and 1A-secondary. 6. Verify that the CT and VT polarities and connections are okay.
1456	Synchronizer Output Limit Warning	The synchronizer fails to achieve a match point when it puts the voltage and/or frequency at their extreme values (lowest, highest) of the allowed bandwidth for a time period that is greater than the fail-to-synchronize time period. This diagnostic logic is shown below.	1. Verify that the Failure to Synchronize time is not too low. 2. Verify that the Permissive Phase Window is not too tight. 3. Verify that the Permissive Voltage Window is not too tight. 4. Check to see that the Permissive Window time is not too high.
		If: Frequency match is at the high or low limit, or Voltage match is at the high or low limit, or Voltage match has failed, Then a synchronizer output warning is initiated.	

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
1457	Fail to Synchronize Warning	This warning is displayed when the synchronizer is ON **AND** Permissive Close is Not Allowed. Permissive Close Not Allowed is true continuously for a Failure to Synchronize time period.	1. Verify that the voltage bias and frequency bias signals to the gensets are arriving at the correct terminals. 2. Verify that the SYNC1320 master synchronizer is sending bias signals to the gensets. 3. Check the speed-governing system of each genset. 4. Check the fuel quality. 5. Make sure that all SYNC1320 master synchronizer and genset meters are properly calibrated.
1458	Synchronizer Phase Rotation Mismatch Warning	This warning is displayed when the synchronizer is ON **AND** the Utility Phase Rotation is different from the Genset Phase Rotation and this status is true continuously for a Fail-to- Synchronize time period.	1. Use InPower to observe data processing on the SYNC1320 master synchronizer. 2. Verify that Genset and Utility input voltage lines to the SYNC1320 master synchronizer match the ones shown on the terminal block as to Phase Rotation and line-to-line match. 3. Make sure the Genset and Utility power lines are properly connected to relevant breakers. Improper connections can result in a catastrophic breaker closure. 4. Check the Genset and Utility VT connections and polarities, if used.
1483	Common Warning Event	This warning is active whenever any other warning fault state is active.	Search for the active warning and follow the appropriate relevant troubleshooting procedures elsewhere in this document.
1912	Utility Loss of Phase Warning	The phase difference in electrical degrees between adjacent phase utility bus voltage phasors is greater than 150 degrees OR less than 90 degrees and this is true continuously for a Utility Loss of Phase Drop-Out Delay.	1. Check to see that there is no incoming missing line at the SYNC1320 master synchronizer relevant Utility voltage inputs. 2. Make sure there are no loose connections. 3. Since there is little chance that there is a real phase difference in Utility voltage phasors, focus on bad connections.

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
1913	Genset Loss of Phase Warning	This warning is active if the phase difference in electrical degrees between adjacent phase generator bus voltage phasors is greater than 150 degrees OR less than 90 degrees and this remains true continuously for the Utility Loss-of-Phase Drop-Out Delay.	1. Verify that there is no missing incoming line at the SYNC1320 master synchronizer relevant to the generator bus voltage inputs. 2. Make sure there are no loose connections. 3. Since there is little chance that there is a real phase difference in Utility voltage phasors, focus on bad connections.
1914	Utility Phase Rotation Warning	This warning is active whenever the Utility Phase Rotation mismatches the System Phase Rotation for at least one second.	1. Use InPower to verify data processing on the SYNC1320 master synchronizer. 2. Use InPower to check the System Phase Rotation setting. 3. Verify that he Utility input voltage lines to the SYNC1320 master synchronizer match the ones shown on the terminal block as to phase rotation and line-to-line voltage. 4. To avoid the possibility of a catastrophic breaker closure, make sure your genset and utility power lines are properly connected to relevant breakers. 5. Check the genset and utility VT connections and polarities, if used.
1915	Genset Phase Rotation Warning	This warning is active whenever the Genset Phase Rotation mismatches the System Phase Rotation for at least one second.	1. Use InPower to verify data processing on the SYNC1320 master synchronizer. 2. Use InPower to check the System Phase Rotation setting. 3. Verify that he Genset input voltage lines to the SYNC1320 master synchronizer match the ones shown on the terminal block as to phase rotation and line-to-line voltage. 4. To avoid the possibility of a catastrophic breaker closure, make sure your genset and utility power lines are properly connected to relevant breakers. 5. Check the genset and utility VT connections and polarities, if used.
1916	Sync Check OK Event	This event is for information purposes only. It is active whenever a Sync Check Close Allowed event is active.	This event can be mapped to a programmable output.

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

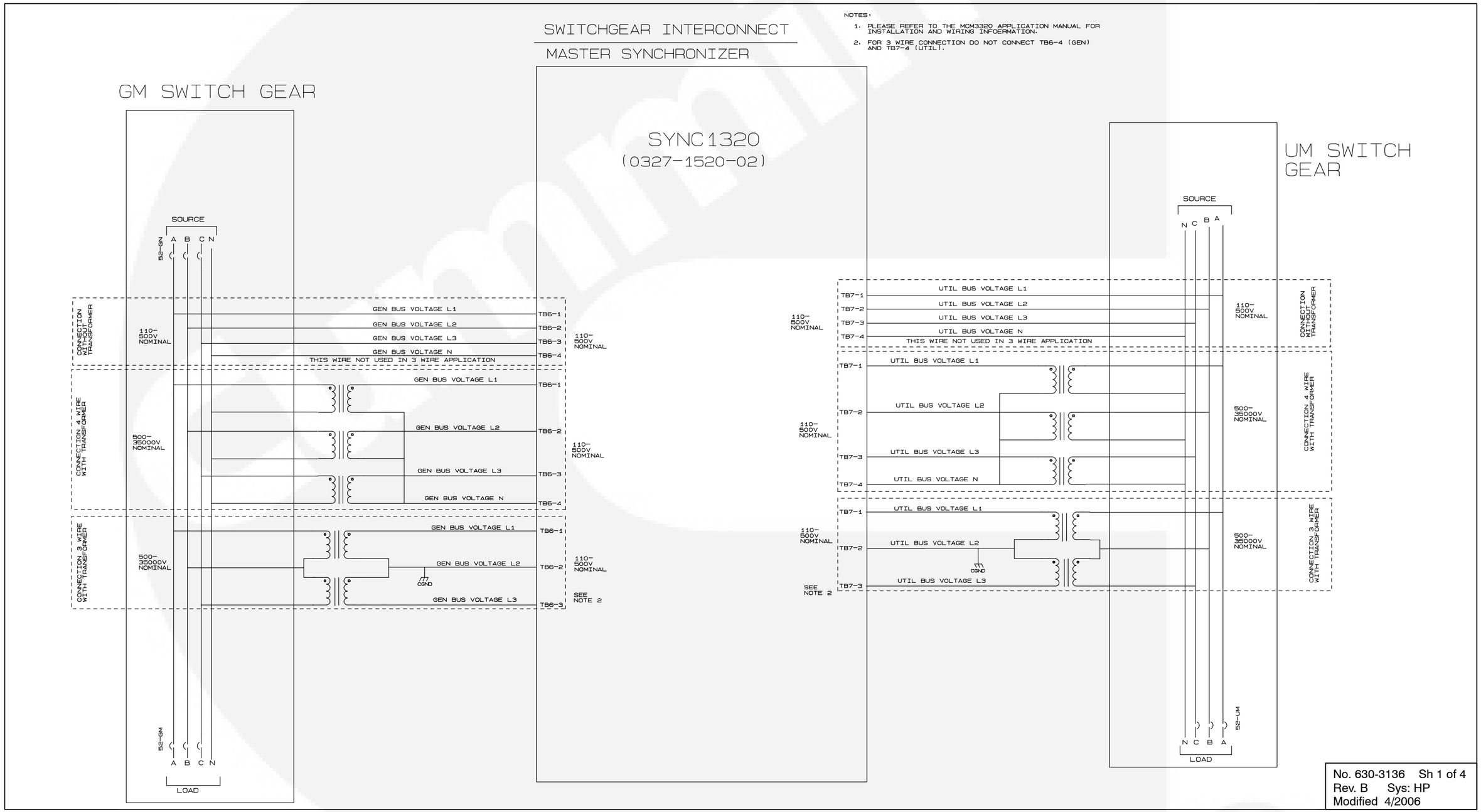
⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.***			
CODE	**DESCRIPTION**	**POSSIBLE CAUSE**	**CORRECTIVE ACTION**
2328	Utility Bus Available Event	This event is for information purposes only. This event is active if the faults/events listed below are inactive **simultaneously**. If a sensor is disabled, the fault is considered inactive. • Fault 2331 – Utility Undervoltage Warning • Fault 2358 – Utility Overvoltage Warning • Fault 1223 – Utility Frequency Warning • Fault 1912 – Utility Loss of Phase Warning • Fault 1915 – Genset Phase Rotation Warning • Fault 1914 – Utility Phase Rotation Warning	This event can be mapped to a programmable output.
2331	Utility Undervoltage Warning	The utility bus voltage is less than the Undervoltage Drop-Out Threshold and it stays there for a time period greater than the Undervoltage Drop-Out Delay.	1. Make sure the Utility Undervoltage Threshold is safe for the connected load. 2. Verify that this value is not too close to the rated voltage. 3. Make sure that the time delay for this fault is not set too low. 4. Check the AVR system operation at each individual genset. 5. Make sure that all AC voltage sensors are properly calibrated at the SYNC1320 master synchronizer and the Utility. 6. Use InPower to monitor and make any necessary adjustment. 7. Check the wire size, distance, and loose connections.

TABLE 5-2. CONTROL TROUBLESHOOTING (CONT.)

⚠WARNING Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions at the front of this manual.

CODE	DESCRIPTION	POSSIBLE CAUSE	CORRECTIVE ACTION
2358	Utility Overvoltage Warning	The utility bus voltage is greater than the Utility Overvoltage Drop-Out Threshold and it stays there for a time period greater than the Drop-Out Delay.	1. Make sure the Utility Undervoltage Threshold is safe for the connected load. 2. Make sure the Utility Overvoltage Threshold is safe for the connected load. 3. Verify that this value is not too close to the rated voltage. 4. Make sure that the time delay for this fault is not set too low. 5. Make sure that all AC voltage sensors are properly calibrated in the SYNC1320 master synchronizer. 6. Use InPower to monitor and make any necessary adjustment. 7. Check VT connections, if used.
2416	Calibration Checksum Error Warning	This warning is displayed whenever there is a specific mismatch regarding comparison of some internal data on the microprocessor.	1. Cycle power to the SYNC1320 master synchronizer. 2. If the fault persists, use InPower to perform an Initial Calibration. 3. If the problem continues, replace the control board.
2965	Genset Bus Available Event	This event is for information purposes only. This event is active if the faults/events listed below are inactive **simultaneously**. If a sensor is disabled, the fault is considered inactive. • Fault 1328 Generator Bus Breaker Tripped Warning • Fault 1452 – Generator Bus Breaker Fail-To-Close Warning • Genset Stop Command must be inactive and Gen CB can be open or closed • Fault 1225 – Generator Bus Undervoltage Warning • Fault 1224 – Generator Bus Overvoltage Warning • Fault 1226 – Generator Bus Frequency Warning • Fault 1913 – Generator Bus Loss of Phase Warning • Fault 1915 – Generator Bus Phase Rotation Warning	This event can be mapped to a programmable output.

6. Wiring Diagrams



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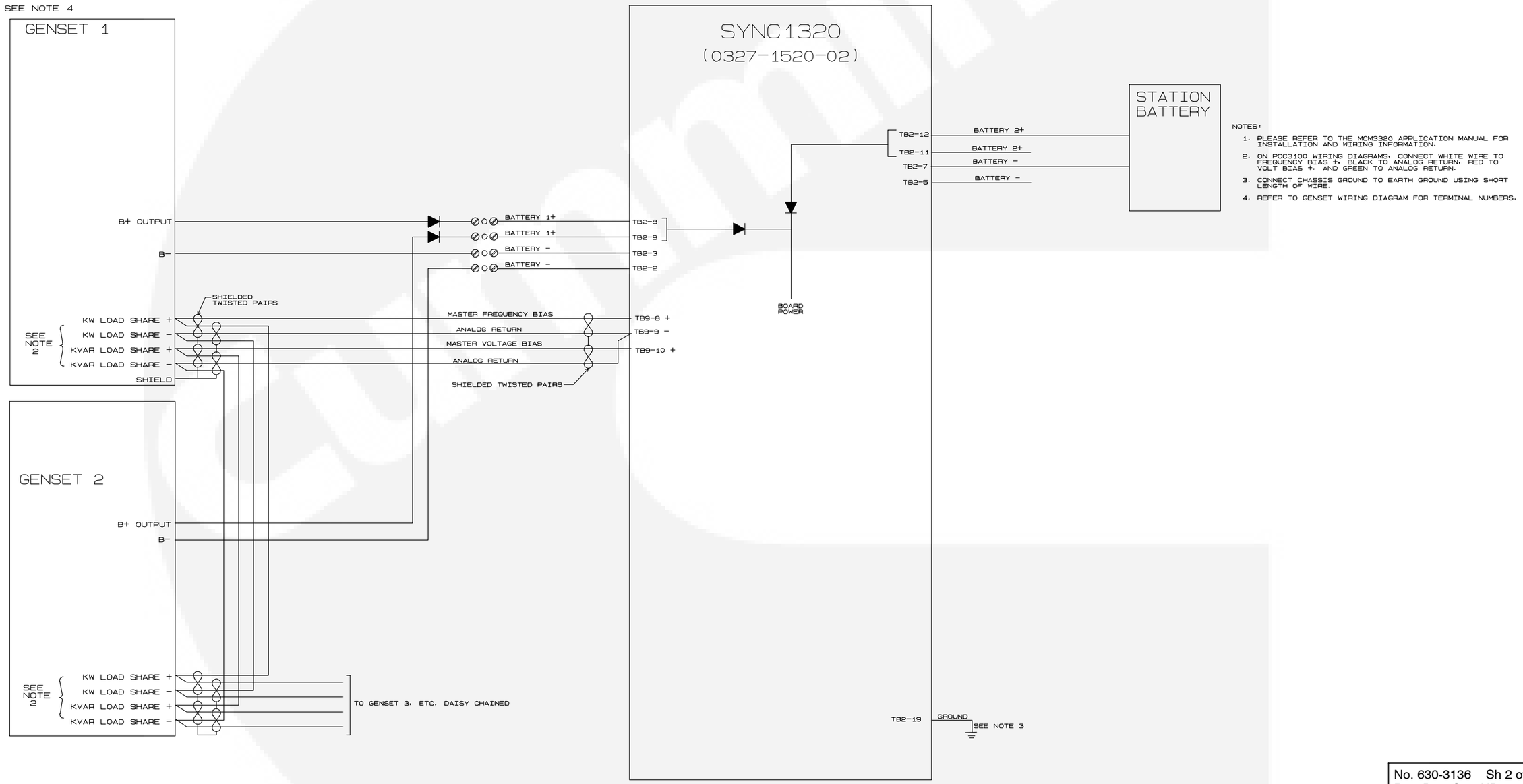
SYNC1320 WIRING DIAGRAM (SHEET 1 OF 4)

GENSET INTERCONNECT
MASTER SYNCHRONIZER



NOTES:

1. PLEASE REFER TO THE MCM3320 APPLICATION MANUAL FOR INSTALLATION AND WIRING INFORMATION.
2. ON PCC3100 WIRING DIAGRAMS, CONNECT WHITE WIRE TO FREQUENCY BIAS +, BLACK TO ANALOG RETURN, RED TO VOLT BIAS +, AND GREEN TO ANALOG RETURN.
3. CONNECT CHASSIS GROUND TO EARTH GROUND USING SHORT LENGTH OF WIRE.
4. REFER TO GENSET WIRING DIAGRAM FOR TERMINAL NUMBERS.

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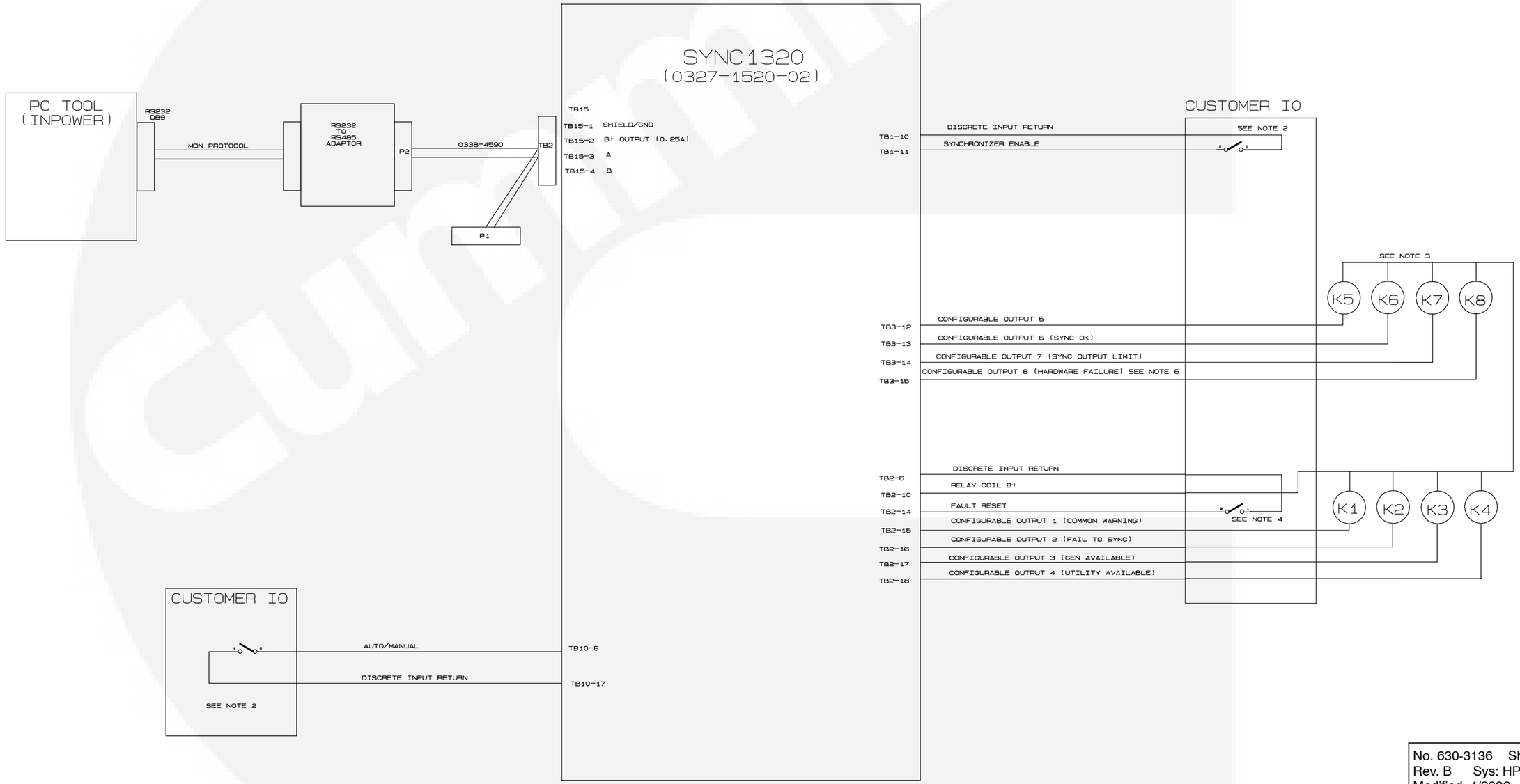
SYNC1320 WIRING DIAGRAM (SHEET 2 OF 4)

NOTES:

1. PLEASE REFER TO THE MCM3320 APPLICATION MANUAL FOR INSTALLATION AND WIRING INFORMATION.
2. SWITCH INPUTS ARE ACTIVATED BY CURRENT. TO ACTIVATE A SWITCH INPUT, CONNECT IT TO A RETURN (GROUND). TO DEACTIVATE A SWITCH INPUT, OPEN CIRCUIT THAT INPUT. ANY OTHER METHOD OF CONTROLLING THESE INPUTS MAY RESULT IN UNINTENDED OPERATION. ALL SWITCHES ARE SHOWN IN THEIR INACTIVE POSITION.
3. RELAY COILS RATED 24V: DRAWING 200mA MAX EACH.
4. FOR FAULT RESET USE MOMENTARY SWITCH.
5. CABLE OR CUSTOMER DEVICE MUST JUMPER RTS AND CTS.
6. HARDWARE FAILURE TURNS OFF TO INDICATE A PROBLEM.

CUSTOMER I/O INTERCONNECT

MASTER SYNCHRONIZER



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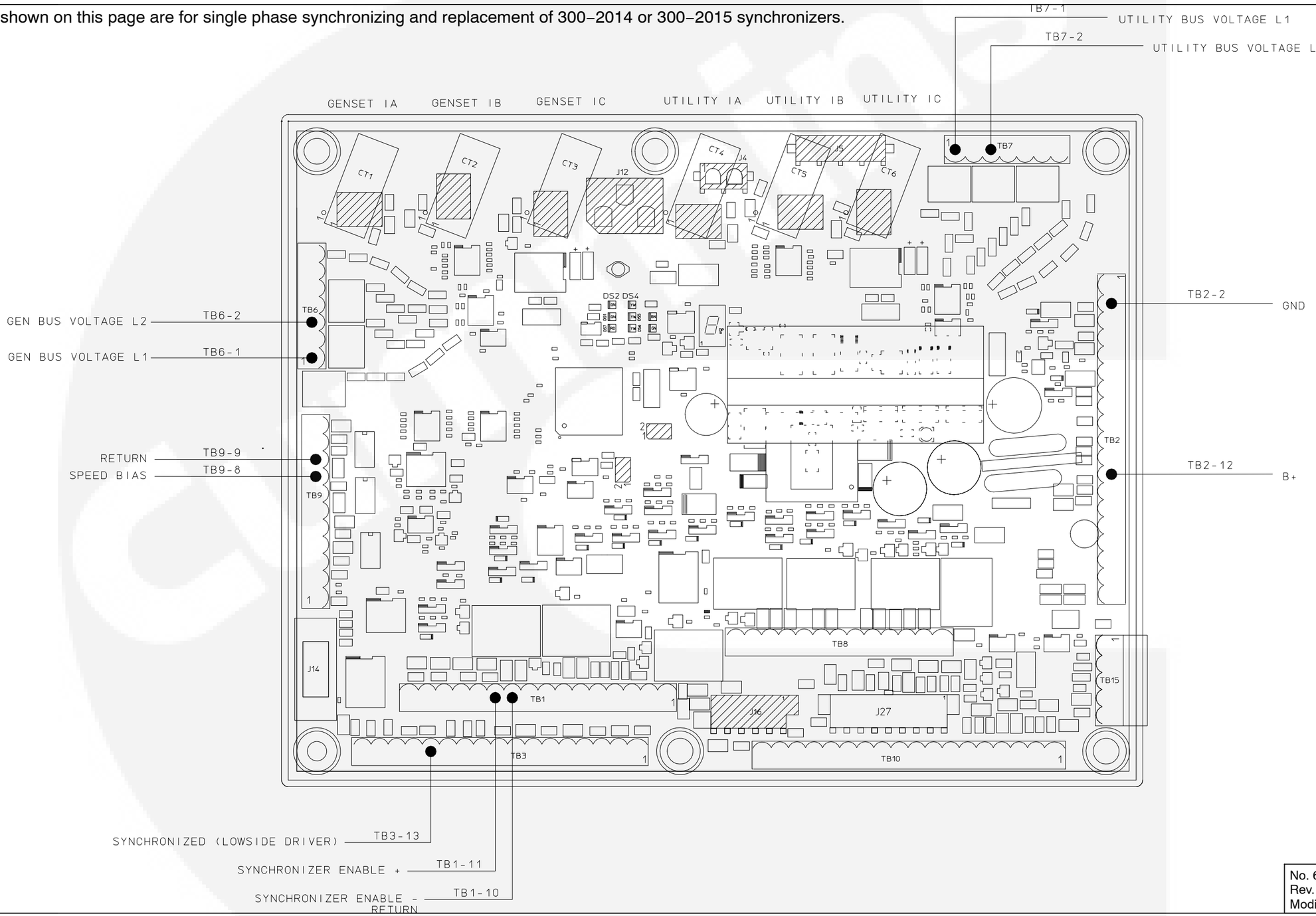
SYNC1320 WIRING DIAGRAM (SHEET 3 OF 4)

Connections shown on this page are for single phase synchronizing and replacement of 300–2014 or 300–2015 synchronizers.



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SYNC1320 WIRING DIAGRAM (SHEET 4 OF 4)

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