Operation/Installation/Service

DETROIT DIESEL

mtu

Automatic Transfer Switches

Models:

TSC 80

Transfer Switch Controller
Software Version 1.3

DETROIT DIESEL ISO CERTIFIED ORGANIZATION 9001 CORPORATION

MP-6296 1/06a

Product Identification Information

Transfer Switch Identification Numbers

Record the product identification numbers from the transfer switch nameplate.

Product Code ________________________________

Serial Number ________________________________

Accessory	Accessory Description

Table of Contents

Table of Contents, continued

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

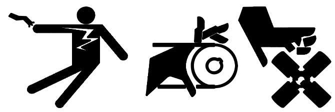
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



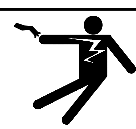
Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (–) lead first when disconnecting the battery. Reconnect the negative (–) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Hazardous Voltage/ Electrical Shock

DANGER



Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

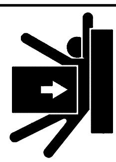
Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Making line or auxiliary connections. Hazardous voltage can cause severe injury or death. To prevent electrical shock deenergize the normal power source before making any line or auxiliary connections.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Heavy Equipment

WARNING

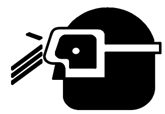


Unbalanced weight.
Improper lifting can cause severe injury or death and equipment damage.

Use adequate lifting capacity.
Never leave the transfer switch standing upright unless it is securely bolted in place or stabilized.

Moving Parts

WARNING



Airborne particles.
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Notice

NOTICE

Hardware damage. The transfer switch may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Foreign material contamination. Cover the transfer switch during installation to keep dirt, grit, metal drill chips, and other debris out of the components. Cover the solenoid mechanism during installation. After installation, use the manual operating handle to cycle the contactor to verify that it operates freely. Do not use a screwdriver to force the contactor mechanism.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

This manual provides operation and installation instructions for TSC 80 automatic transfer switch controllers.

DDC/MTU Power Generation transfer switches are used to provide a continuous source of power for lighting and other critical loads by automatically transferring from Source 1 power to Source 2 power in the event that Source 1 voltage falls below preset limits.

Voltage sensing and system control is performed via a state-of-the-art microcontroller located on the cabinet door. It is designed to give highly accurate control of the transfer switch system.

DDC/MTU Power Generation transfer switches are designed for use on emergency or standby systems and are rated for total system or motor loads. Transfer switches are UL listed under Standard 1008 and CSA certified under Standard C22.2 No. 178.

Information in this publication represents data available at the time of print. The manufacturer of DDC/MTU Power Generation products reserves the right to change this literature and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect parts often and perform required service at the prescribed intervals. Obtain service from an authorized service distributor/dealer to keep equipment in top condition.

List of Related Materials

This manual covers operation and installation information for the transfer switch's electrical controls. Verify that the transfer switch model and electrical controls match the models shown on the front cover of this manual before proceeding with operation or installation.

A separate operation and installation manual that covers the transfer switch's power switching device completes the operation and installation instructions for the transfer switch. The following table lists the related operation and installation manual part numbers and other related literature part numbers.

Document Description	Part Number
TS 840 Operation/Installation/Service Manual	MP-6294
TS 870 Operation/Installation/Service Manual	MP-6295
Service Display Module Instructions	TT-1408

Product Revision History

The following information provides a summary of changes made to this product.

Software Version, Date	Description
1.0 11/19/04	Original version.
1.1 5/10/05	Software updates incorporating the following: • Revise potentiometer control directions to match revised printed circuit board silkscreen text. • Change operation associated to secure configuration jumper. Enable remote load test to be activated if secure jumper is ON.
1.2 10/31/05	Beta test version. Not released for production.
1.3 11/05/05	Software updated to change some internal default timer settings.

Service Assistance

For professional advice on generator power requirements and conscientious service, please contact your nearest DDC/MTU Power Generation distributor.

- Consult the Yellow Pages under the heading Generators—Electric
- Visit the DDC/MTU Power Generation website at ddcmtupowergeneration.com
- Look at the labels and stickers on your DDC/MTU Power Generation product or review the appropriate literature or documents included with the product

1.1 General Information

Note: Installations must comply with the NEC and all applicable electrical regulation codes.

The following installation guidelines are provided for general information only pertaining to typical site installations. For specific site installation information, consult the factory as required.

Note: Factory installations of supplied transfer switches that have been tested and proven may deviate from these recommendations.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

This equipment contains static-sensitive parts. Please observe the following anti-static precautions at all times when handling this equipment. Failure to observe these precautions may cause equipment failure and/or damage.

- Discharge body static charge *before* handling the equipment. (Contact a grounded surface and maintain contact while handling the equipment. Use a grounded wrist strap.)
- Do not touch any components on the printed circuit board with your hands or any other conductive equipment.
- Do not place the equipment on or near materials such as Styrofoam, plastic and vinyl. Place the equipment on grounded surfaces and only use an anti-static bag for transporting the equipment.

1.2 Service Display Module (SDM)

An optional hand held, plug-in Service Display Module (SDM) is available for the TSC 80 Transfer Controller. The SDM module provides an LCD screen to display additional detailed information on the operation and settings of the TSC 80 controller for simplified servicing/troubleshooting procedures. For detailed information, refer to the separate SDM module instruction manual.

1.3 Notes to Installer

DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

Note: Qualified personnel only must perform installation and/or service work.

1.3.1 System Voltage

If the transfer switch has programmable/multi-tap system voltage capability (refer to electrical schematic), confirm the transfer switch has been configured for the system voltage. If the transfer switch requires reconfiguring, the controller will require configuration as well.

Note: Failure to confirm and match transfer switch voltage with the system voltage could cause serious equipment damage.

1.3.2 System Phasing, High Leg Delta Systems

When the transfer switch is connected to 3-phase 4-wire delta systems, connect the high leg (Phase B, colored orange), to Phase B of the utility and/or generator set supply. This will ensure the ATS control power that is internally connected between phase A and neutral is maintained at 120 VAC. See Figure 1-1.

Note: Failure to match correct system phasing will result in serious damage to the TSC 80 controller.

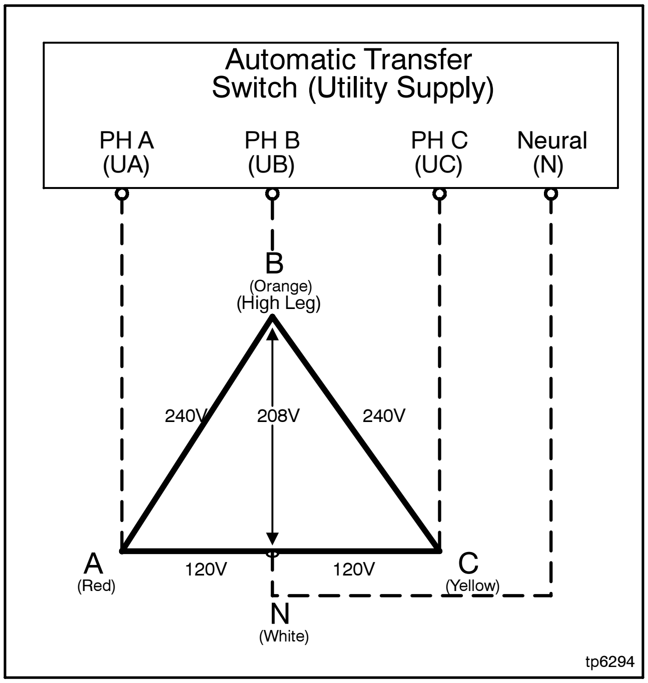
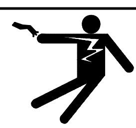


Figure 1-1 System Phasing

DANGER



Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

Note: Qualified personnel only must perform installation and/or service work.

Remote Start Contact Field Wiring

As a minimum, the remote engine start control field wiring must conform to the local regulatory authority on electrical installations. Field wiring of a remote start contact from a transfer switch to a control panel should conform to the following guidelines to avoid possible controller malfunction and/or damage.

1. Minimum #14 AWG wire size shall be used for distances up to 30 m (100 ft.). For distances exceeding 30 m (100 ft.), consult the factory.

2. Remote start contact wires should be run in a separate conduit.

3. Avoid wiring near AC power cables to prevent pickup of induced voltages.

4. An interposing relay may be required if field-wiring distance is excessively long, i.e. greater than 30 m (100 ft.), and/or if a remote contact has a resistance of greater than 5.0 ohms.

5. The remote start contact must be voltage free (i.e. dry contact). The use of a powered contact will damage the transfer controller.

Dielectric Testing

Do not perform high voltage dielectric testing on the transfer switch with the TSC 80 controller connected into the circuit as serious damage will occur to the controller. Remove AC control fuses and control circuit isolation plugs connected to the TSC 80 if high voltage dielectric testing is performed on the transfer switch.

The controller utilizes microprocessor-based design technology that provides high accuracy for all voltage sensing and timing functions. The controller is factory-configured to control all the operational functions and display features of the automatic transfer switch.

The controller consists of two parts; a faceplate mounted externally on the transfer switch door and a printed circuit board (PCB) mounted inside the transfer switch door.

2.1 Faceplate

The faceplate is shown in Figure 2-1. The faceplate pushbuttons are connected to the main circuit board via plug-in ribbon cable.

2.2 Printed Circuit Board

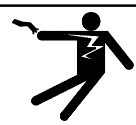
The printed circuit board (PCB) is shown in Figure 2-2. The PCB contains user interface items listed in Sections 2.2.1 through 2.2.5.

2.2.1 Voltage Selection

The voltage selection is made via two selector switches that are located on the PCB and are identified as S1 and S2.

The TSC 80 is factory-configured for specific power supply voltage inputs according to the ATS application.

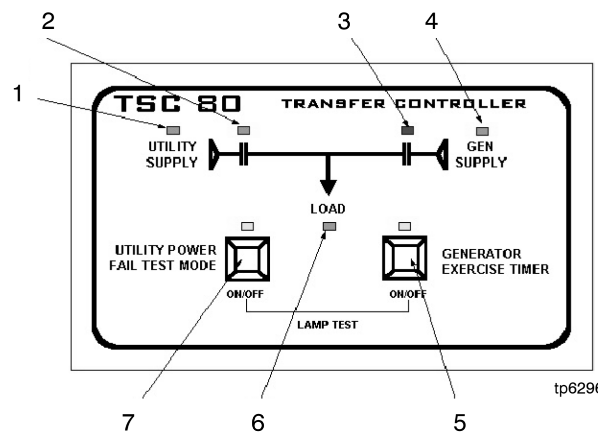
⚠ DANGER



Hazardous voltage.
Will cause severe injury or death.

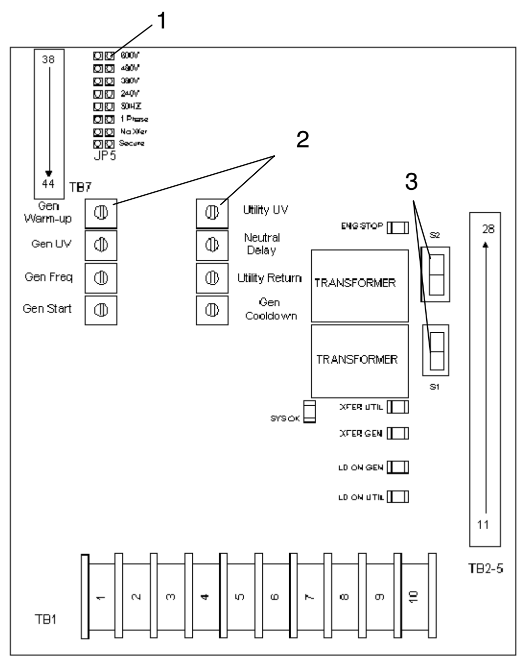
Disconnect all power sources before opening the enclosure.

Note: Switches S1 and S2 are factory-set to match system application voltage. Do not change the position of selector switch S1 or S2 while the TSC 80 is energized. Contact the factory for further information.



1. Utility supply available LED light
2. Load on utility supply LED light
3. Load on generator set supply LED light
4. Generator set supply available LED light
5. Generator set exercise mode pushbutton and LED light
6. ATS load bus energized LED light
7. Utility power fail test mode pushbutton and LED light

Figure 2-1 Controller Faceplate



1. Configuration jumpers
2. Adjustment potentiometers
3. Voltage selection switches. Disconnect power before adjusting.

Figure 2-2 Printed Circuit Board

2.2.2 Terminal Blocks

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

Note: Voltage sensing circuits are capable of lethal voltages while energized. Follow standard safety procedures. Qualified personnel only must perform work.

Terminal blocks are located on the PCB as follows:

- TB1: high voltage sensing terminal block (120–600 VAC).
- TB2-6: transfer control terminal block for 115/230 V control power and input/output circuits.
- TB7: low voltage (5 VDC) control inputs.

2.2.3 Diagnostic LED's

The TSC 80 controller provides diagnostic LED lights mounted on the printed circuit board. Their functions are described as follows:

- SYS OK. This LED flashes on and off at irregular intervals, which indicates the microprocessor is functioning normally.
- TRANSFER TO UTILITY. This LED is illuminated whenever the TSC 80 is initiating a signal to transfer to the utility supply.
- TRANSFER TO GEN. This LED is illuminated whenever the TSC 80 is initiating a signal to transfer to the generator set supply.
- ENGINE STOP. This LED is illuminated whenever the TSC 80 is initiating an engine stop signal.

2.2.4 Adjustment Potentiometers

The TSC 80 controller provides eight adjustment potentiometers mounted on the printed circuit board as shown in Figure 2-2. They are used to adjust time delays, voltage, and frequency setpoints. All potentiometers will be set to factory default values. See Section 4, Configuration Instructions, for further information.

2.2.5 Configuration Jumpers

The TSC 80 controller provides eight configuration jumpers mounted on the printed circuit board as shown in Figure 2-2. They are used to program main system operating parameters such as voltage, frequency, and phases. See Section 4, Configuration Instructions, for further information.

2.3 Controller Features

The transfer switch controller utilizes the latest advancements in microprocessor technology, printed circuit board assembly, and software for control of automatic transfer switches. The TSC 80 is factory-configured to monitor, display, and control all operational functions of the automatic transfer switch. All voltage sensors and timers are fully user-adjustable utilizing potentiometers, which requires no software configuration. The microprocessor design provides high accuracy for all voltage sensing and timing functions as well as providing many standard features.

- Utility AC voltage sensing (true RMS): 120–600 V single phase or 3 phase.
- Generator set AC voltage sensing (true RMS): 120–600 V single phase or 3 phase.
- Generator set AC frequency sensing.
- Utility undervoltage control setpoint 70%–95% (adjustable).
- Generator set undervoltage control setpoint 70%–95% (adjustable).
- Generator set underfrequency control setpoint 70%–90% (adjustable).
- Engine warmup timer 0–60 second (adjustable).
- Utility return timer 0–30 min. (adjustable).
- Engine start timer 0–60 second (adjustable).
- Engine cooldown timer 0–30 min. (adjustable).
- Neutral position delay timer 0–60 second (adjustable).
- Local utility power fail simulation test pushbutton and LED, door-mounted.
- Remote utility power fail simulation test pushbutton input (via terminal block).
- Load on utility supply and load on generator set supply LED's, door- mounted.

- Utility and generator set source available LED's, door-mounted.
- Weekly plant exercise timer (30 minutes on load) manually initiated.
- Local plant exercise initiate pushbutton and LED, door mounted.
- Engine start contact (10 A, 120/240 VAC resistive maximum).
- Load on utility auxiliary contact (one only, 10 A, 120/240 VAC, Form C).
- Load on generator set auxiliary contact (one only, 10 A, 120/240 VAC, Form C).
- Transfer fail/forced transfer logic.
- Automatic force transfer to alternate supply should load voltage become deenergized.
- 50 or 60 Hz capable (115 V or 230 V control power).
- Remote load test/peak shave input.

2.4 Application Information

2.4.1 AC Voltage Sensing Input

The TSC 80 can accept direct AC voltage sensing inputs on the generator set and utility supplies from 120-600 VAC (nominal).

Note: Direct input voltage sensing can only be used when the system utilizes a 3-phase, 4-wire distribution system which has the neutral conductor *solidly* grounded. For 3-phase, 3-wire systems (i.e. no neutral) or high voltage systems, potential transformers must be used. Refer to Figure 2-4 for voltage sensing connections.

2.4.2 AC Control Power Input

The TSC 80 is factory-supplied for either 115 VAC or 230 VAC (nominal) control power input voltage. Independent AC control power is required from both utility and generator supplies. AC control power is utilized for internal TSC 80 control circuits and external control device loads. The TSC 80 requires approximately 6 VA power for internal control circuits. The maximum external load is limited by output contact ratings (i.e. 10 A resistive, 120 VAC). Total AC control power requirements for each supply must be determined by adding both internal and external load requirements.

2.4.3 Outputs

The TSC 80 provides the types of output circuits shown in Figure 2-3. Interposing relays are required between the TSC 80 outputs and the end device if loads exceed the output current rating.

Output Circuit	Description
Engine Start Contact	Isolated Form B contact (10 A, 120 VAC resistive)
Load on Utility	Isolated Form C contact (10 A, 120 VAC/250 VAC resistive)
Load on Generator	Isolated Form C contact (10 A, 120 VAC/250 VAC resistive)
Transfer to Utility Output	120 VAC*, 10 A (resistive) powered output contact
Transfer to Generator Output	120 VAC*, 10 A (resistive) powered output contact
* Output voltage is dependent upon AC control power input voltage (i.e. 120 VAC or 230 VAC nominal).	

Figure 2-3 Output Circuit Types

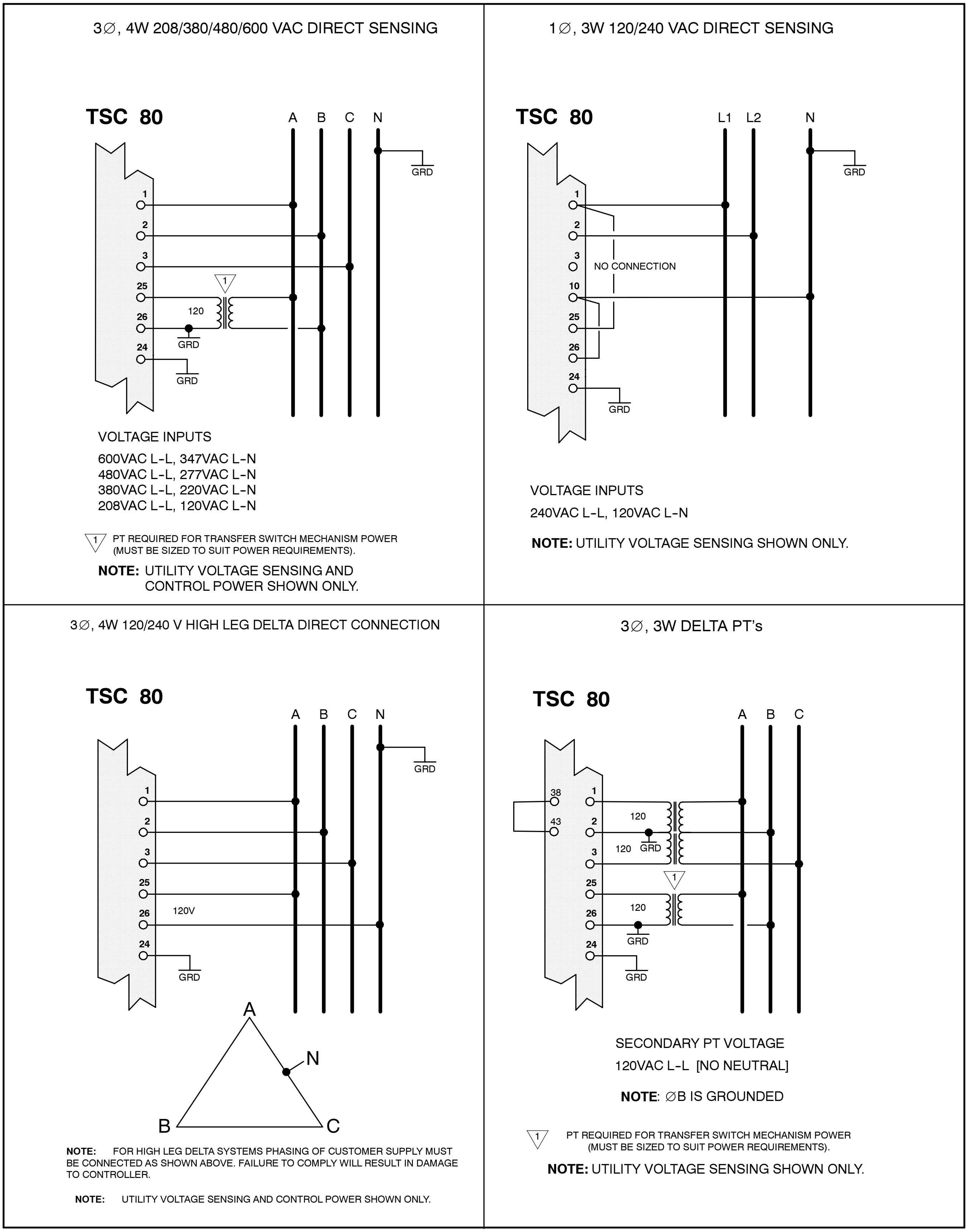


Figure 2-4 Voltage Sensing Connections

2.5 Specifications

Item	Description
Power Supply	• 115 or 230 VAC nominal (+10% -30%) • 50/60 Hz • 6 VA nominal (no external load connected)
Voltage Sensing	• Direct 120-600 VAC nominal, single or three phase • 50/60 Hz • ±1.0% accuracy of setting @ 25°C (77°F)
Operating Temperature	• -40°C to 50°C (-40°F to 122°F)
Output Contacts (Form C, 10 A, 120/240 VAC resistive)	• Engine start • Load on utility • Load on generator set
Output Signals (120/240 VAC resistive load)	• Transfer to utility 10 A • Transfer to generator set 10 A

Figure 2-5 Specifications

Notes

To operate the controller and the associated transfer switch using the front faceplate pushbuttons, refer to the following detailed operating instruction descriptions.

3.1 Automatic Operation Sequence

3.1.1 Normal Operation

Under normal operating conditions, the transfer switch operates automatically during a failure and restoration of utility power and does not require operator intervention.

When utility supply voltage drops below a preset nominal value (70%-95% of rated adjustable) on any phase, an engine start delay circuit will be initiated and the transfer to utility supply signal will be removed (i.e. contact opening). Following expiration of the engine start delay period (0-60 second adjustable), an engine start signal (contact closure) will be given.

After the engine starts, the transfer switch controller will monitor the generator set's voltage and frequency levels. When the generator set voltage and frequency rises above preset values (70%-95% nominal adjustable) the engine warmup timer will be initiated. When the engine warmup timer expires (0-60 second adjustable), the transfer to generator supply signal (contact closure) will be given to the transfer switch mechanism. The load will then transfer from the utility supply to the generator supply via motor driven mechanism.

The generator set will continue to supply the load until the utility supply has returned and the retransfer sequence is completed as follows:

When the utility supply voltage is restored to above the preset values (70%-95% of rated adjustable) on all phases, a transfer return delay circuit will be initiated. Following expiration of the utility transfer return timer (0-30 minute adjustable), the transfer to generator supply signal will be removed (contact opening), then the transfer to utility supply signal (contact closure) will be given to the transfer switch mechanism. The load will then be transferred from the generator supply back to the utility supply.

During the utility retransfer sequence, a neutral position delay circuit will cause the transfer mechanism to pause in the neutral position (i.e. with both transfer power switching devices open) for the duration of the neutral delay timer (0-30 second adjustable) setting. When the time delay expires, the retransfer sequence will be completed.

An engine cooldown timer circuit will be initiated when the load is transferred from the generator supply. Following expiration of the cooldown delay period (0-30 minute adjustable), the engine start signal will be removed (contact opening) to initiate stopping of the generator set.

3.1.2 Abnormal Operation

1. Test Condition. A test pushbutton on the transfer switch signals a simulated utility power fail signal to the transfer switch controller. The transfer switch operates as per a normal utility power fail condition. The neutral delay circuit logic is active during transfer to and from the generator supply (i.e. when both sources of power are available).

   The transfer switch remains on the generator set supply until the test mode is terminated. It then retransfers back to the utility supply following the transfer return timer and then continues to operate the generator set during its cooldown period and stops.

2. Generator Set Failure On Load. If the generator set fails while on load, the transfer switch retransfers the load back to the utility supply if within nominal limits. The utility return timer is bypassed in this condition.

   Note: This operating condition applies to a normal utility failure as well as any test condition.

3. Transfer Switch Fail Alarm Logic. The TSC 80 controller contains logic to detect a transfer mechanism failure. If a failure is detected, a forced transfer to the alternate supply is initiated. Detailed logic operation is as follows:

   Note: The TRANSFER SWITCH FAIL feature can be disabled by activating the Service Entrance Mode by jumpering terminal numbers 38 and 42. The TS 80 controller will not verify that the transfer mechanism has operated correctly.

4. Transfer Fail Detection, Normal Steady State Condition (Non-Transferring).

   a. Limit Switch Failure (i.e. open contact). Transfer Fail Alarm is initiated (load on source flashing LED) after a 9 second delay, and then a forced transfer to the alternate source is initiated. Retransfer back to the original source will not occur until the transfer fail alarm condition is reset. See Section 3.3, Transfer Fail Fault Reset.

   b. Loss of Load Voltage (<80 VAC) (i.e. power switching device tripped condition). Transfer Fail Alarm is initiated (load source flashing LED) after 5 second delay, then a forced transfer to the alternate source is initiated. Retransfer back to the original source will not occur until the transfer fail alarm condition is reset. See Section 3.3, Transfer Fail Fault Reset.

   c. Limit Switch Failure and Loss of Load Voltage <80 VAC. Transfer Fail Alarm is initiated (load source flashing LED) after 11 second delay, then a forced transfer to the alternate source is initiated. Retransfer back to the original source will not occur until the transfer fail alarm condition is reset. See Section 3.3, Transfer Fail Fault Reset.

5. Transfer Fail Detection, Transferring Condition.

   a. Transfer Source to Neutral. Find Neutral/ Source Timer (10 second fixed) starts timing as soon as a transfer to the alternate source is initiated. During this period, the ATS motor is energized and moves the mechanism from the original source to neutral. The power to the motor will be deenergized when either the Find Neutral/Source Timer times out or the load voltage drops below 80 VAC on all phases (whichever occurs first). After the ATS motor is deenergized, the neutral delay timer starts timing. When the neutral delay timer times out, the motor reenergizes to continue the transfer (see step 5.b.).

      Note: Normally the load voltage will drop below the setpoint within 1 second when the source power switching device opens and, therefore, the find neutral/source timer never times out. The default setting of this timer (10 seconds) is intentionally set long so that it will not prematurely stop the ATS mechanism.

   b. Transfer Neutral to Source. Find Neutral/ Source Timer starts timing as soon as the neutral delay timer times out. During this period, the motor is energized and moves the mechanism from the neutral to the alternate source. The power to the ATS motor will be deenergized when either the mechanism's limit switch activates (i.e. external logic to the TSC 80) or the Find Neutral/Source Timer times out (whichever occurs first).

      Note: During the above two sequences, the transfer fail alarm logic is inhibited. After the two sequences have been completed, the transfer fail alarm logic will be reenabled and will only be triggered if conditions as described in item 4. (normal steady state condition) are sensed (limit switch and/or loss of load voltage).

   For example, if the ATS mechanism fails to move (i.e. due to broken rod, motor failure, or manual release plunger not reengaged), the total time before a transfer fail will be initiated is 31 seconds (i.e. Find Neutral/Source Timer [10 sec.] + Find Neutral/Source Timer [10 sec.] + Limit Switch Failure and Loss of Load Voltage <80 VAC [11 sec.] = 31 sec.).

6. Service Entrance ATS. For service entrance rated transfer switch applications, the transfer switch control logic includes external wiring to signal the transfer switch mechanism to move to the service disconnected position. In this mode, the TSC 80's transfer control outputs and transfer fail feature are disabled.

3.2 Test Modes

3.2.1 Utility Power Fail Simulation (Load Test)

To simulate a utility power failure condition, press the UTILITY POWER FAIL SIMULATE pushbutton on the faceplate. Hold the pushbutton for approximately 5 seconds until the LED light above the pushbutton changes state. After the mode is initiated, the engine start will be activated. After the engine accelerates to nominal voltage and frequency levels, the load will automatically transfer to the generator supply. To terminate the utility power fail test mode, the test pushbutton must be held for approximately 5 seconds until the LED light above the pushbutton changes state. When the pushbutton is released, the LED light will go out and the load will retransfer back to the utility supply following expiration of the utility return delay timer.

Note: The load will automatically retransfer to the utility supply if the generator set fails while on load.

3.2.2 Automatic Plant Exercise Load Test

To initiate a 30 minute/7 day weekly automatic plant exercise mode, press the GENERATOR EXERCISE mode pushbutton on the faceplate. Hold the pushbutton for approximately 5 seconds until the LED light above the pushbutton changes state. When the mode is initiated, the engine will immediately start and transfer on load after nominal voltage and frequency levels have been obtained. The engine will remain operating on load until the plant exercise time delay period of 30 minutes expires, then the load will retransfer back to the utility supply. The engine will be automatically retested on load every week (e.g. 7 days) at the same time of day.

Note: The load will automatically retransfer to the utility supply if the generator set fails while in the test mode.

Note: To bypass a 30 minute exercise run period, press and hold the exercise pushbutton for 5 seconds until the LED remains on.

The generator exercise LED light will operate as follows:

- LED ON—Exercise timer is initiated, the 7 day timer is active, and the generator set is in the off state.
- LED FLASHING—Exercise timer is initiated, the 30 minute run timer is active, and the generator set is running on loads.
- LED OFF—Exercise timer is not initiated and the 7 day timer is not active.

To terminate the generator set exercise mode, the exercise pushbutton must be held for approximately 5 seconds until the LED light above the pushbutton starts flashing. When the pushbutton is released, the LED light will go out and the system will return to normal operation.

3.2.3 Four Function Remote Test (FTS4 Option)

The function of the four position test switch input is to allow operators to select various operating scenarios for test or maintenance purposes, in addition to the use of the faceplate-mounted pushbuttons.

Note: When an external FTS4 switch is used, the TSC 80 operation as selected from the faceplate pushbuttons will be overridden.

OFF: Disables the engine start output from the transfer switch. If the primary source is available, and within normal limits, the TSC 80 will initiate a transfer to the primary source. The transfer switch will not automatically transfer to the secondary (alternate) source if the primary source fails.

AUTO: All automatic functions are enabled.

ENGINE START: (No load test) An engine start signal is initiated and remains on until the FTS4 is placed in another position. The engine will start if the engine's auto start controller is in the Auto mode. If the primary source fails in this mode and the secondary source is within parameters, the TSC 80 will initiate a transfer to the secondary source. When the engine start input is removed, the generator set will continue to run if it has not operated for a time equal to or greater than the minimum run time (i.e. based on the engine cooldown timer setting).

TEST: (Full load test) A primary source failure is simulated and an engine start signal is initiated. When the secondary source is within normal limits, the TSC 80 initiates a transfer to the secondary source. The system remains in this state until the FTS4 is placed in another position or the secondary supply fails. Upon a secondary supply failure, if the primary supply is available, the TSC 80 will initiate a transfer to the primary supply. The engine cooldown time sequence will be initiated when the test mode is terminated.

3.2.4 Remote Test

To activate a remote load test, close a remote contact between terminal #44 and terminal #38. When the contact closes, an engine start will be activated. When the engine accelerates to nominal voltage and frequency levels, the load automatically transfers to the generator supply. When the remote contact opens, the load will retransfer back to the utility supply following expiration of the utility return delay timer. The engine cooldown time sequence will be initiated when the test mode is terminated.

Note: The load will automatically retransfer to the utility supply if the generator set fails while on load.

3.3 Transfer Fail Fault Reset

To reset a transfer fail condition (i.e. when either the Load on Gen or Load on Utility LEDs are flashing and the ATS load is transferred to the alternate source), hold both the UTILITY POWER FAIL SIMULATE and GENERATOR EXERCISE MODE pushbuttons for approximately 5 seconds until all LEDs on the faceplate start flashing and the UTILITY POWER FAIL SIMULATE LED flashes in opposition. After the alarm condition is reset, the load will automatically retransfer back to the original source if within normal limits.

3.4 Lamp Test

To initiate a Lamp Test, hold the UTILITY POWER FAIL SIMULATE and GENERATOR EXERCISE MODE pushbuttons longer than 5 seconds until all LEDs on the faceplate illuminate in a flashing mode.

Note: The lamp test function will also clear a transfer failure alarm and will allow active timers to be bypassed if the lamp test is held for longer than 5 seconds.

3.5 Timer Bypass

To bypass an active timing sequence (e.g. utility return timer, cooldown timer, warmup timer) during operation, hold the UTILITY POWER FAIL SIMULATE and GENERATOR EXERCISE MODE pushbuttons for approximately 5 seconds until all LEDs on the faceplate start flashing and the UTILITY POWER FAIL SIMULATE LED flashes in opposition.

Section 4 Configuration Instructions

All user configuration of the TSC 80 controller is accomplished using either hardware jumpers or potentiometers located on the printed circuit board as shown in Figure 2-2. No software configuration is required. The hardware jumpers and potentiometers are used for configuration of main operating parameters such as system voltage, frequency, phases, adjustable time delays, voltage sensor settings, and frequency sensor settings. All configuration jumpers and potentiometers are set to factory default values as required for the transfer switch and should not require further setting.

4.1 Configuration Jumpers

The following configuration jumpers are provided on the printed circuit board to program the TSC 80 controller:

DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

Note: The configuration jumper settings must not be changed while the transfer switch and TSC 80 controller are energized. All sources of power to the transfer switch must be deenergized prior to changing any configuration jumper settings.

4.1.1 System Voltage

Four jumpers are provided to set the required system operating voltage of the TSC 80 controller. Jumpers are provided for each typical system phase-to-phase voltage (i.e. 600 V, 480 V, 380 V, 240 V). See Figure 2-2.

To activate the required system voltage setting, place a jumper across the two pins, adjacent to the text on the PCB. Place only *one* jumper on the voltage selection jumpers. Failure to do so will cause improper operation.

Note: For 208 V nominal system voltage, no jumpers are required on any of the voltage jumper pins.

Note: For 3-phase, 3-wire, or high voltage applications utilizing 120 V sensing input voltage, no jumpers are required on any of the voltage jumper pins *and* Terminal #43 must be jumpered to terminal #38.

Note: For nominal system voltages that are not provided by specific configuration jumper pins, contact the factory for further information.

Note: If multiple jumpers are incorrectly left on the voltage selection pins, the highest voltage selected will have precedence.

When a system voltage is selected, the TSC 80's utility and generator undervoltage setpoint percentage setting will be automatically programmed to correspond to the sensing input voltage (e.g. with a 600 V system voltage selected and an 80% undervoltage potentiometer setting, the undervoltage sensor will be activated below 540 VAC).

Note: When a configuration jumper is not required, connect the jumper to only one pin of the header to conveniently store it for future use.

4.1.2 Undervoltage Setpoints with Non-Standard System Voltages

When the Transfer Switch and TSC 80 transfer controller is applied to non-standard system voltages, the TSC 80 undervoltage potentiometer setting percentages on the printed circuit board *will not* correspond to the correct voltage drop out setting.

To obtain the correct dropout voltages using non-standard system voltages, the TSC 80 potentiometers need to have an *offset* percentage adjustment with the corresponding voltage jumper settings. These are shown in Figure 4-1 for typical 85% dropout under voltage setpoints.

For other non-standard system voltages, the following formula can be used:

A) Desired Dropout Voltage=
Dropout% x System Voltage

B) TSC 80 POT Setting =
(Desired Dropout Voltage x 100) ÷
(TSC 80 Voltage Jumper Setting)

Example:

For a 440V system, 85% of 440V = 0 .85 x 400V = 374V

TSC 80 POT Setting = (374 x 100) ÷ 480

TSC 80 POT Setting = **78%**

Note: The TSC 80 voltage jumper setting must be set to be equal to the nominal system voltage level or the next highest setting available (e.g. 440V system voltage must use 480V jumper setting).

System Voltage	ATS Transformer Tap Setting, Volts	TSC 80 Voltage Jumper Setting	85% Dropout Voltage	TSC 80 Undervoltage Potentiometer Setting, % *
208	208	208 (no jumper)	177	**85**
220	240	240	187	**78**
230	240	240	195	**81**
240	240	240	204	**85**
440	480	480	374	**78**
460	480	480	391	**81**
480	480	480	408	**85**
575	600	600	489	**82**
380V/50 Hz	392 (use 208V to 600V primary connection)	380	323	**85**
400V/50Hz	392 (use 208V to 600V primary connection)	480	340	**71**

* To obtain the most accurate setting of the potentiometer (other than visually on the printed circuit board), a Service Display Module (SDM) is recommended.

Figure 4-1 Offset Percentage Adjustment for Typical 85% Dropout Undervoltage Setpoints

4.1.3 System Frequency

One jumper is provided to set the required system operating frequency of the TSC 80 controller. See Figure 2-2.

- For 60 Hz applications, no configuration jumper is required.
- For 50 Hz applications, place a jumper across the two pins labelled 50 HZ on the PCB.

When a system frequency is selected, the TSC 80's generator frequency setpoint percentage setting will be automatically programmed to correspond to the sensing input frequency (e.g. with a 60 Hz system frequency and a 90% underfrequency potentiometer setting, the underfrequency sensor will be activated below 54.0 Hz).

Note: When a configuration jumper is not required, connect the jumper to only one pin of the header to conveniently store it for future use.

4.1.4 System Phases

One jumper is provided to set the required number of system phases for the TSC 80 controller. See Figure 2-2.

- For 3-phase applications, no configuration jumper is required.
- For single-phase applications, place a jumper across the two pins labelled 1 Phase on the PCB. Phase C voltage sensing input is ignored in the single-phase mode.

Note: When a configuration jumper is not required, connect the jumper to only one pin of the header to conveniently store it for future use.

4.1.5 Gen Exercise Load Test Mode (No XFER)

A configuration jumper is provided to select the desired testing mode (i.e. load test with transfer or no-load test) for the 7 day/30 minute generator exercise function or for a remotely initiated test mode. See Figure 2-2. One jumper is provided to set the desired test mode as follows:

- Load Test Gen Exercise Test Mode: no program jumper is required.

  Note: The load test mode is the factory default setting.

- No-Load Gen Exercise Test Mode: program jumper is required to be placed across the two pins labeld No Xfer on the PCB.

  Note: If utility power fails during a no-load test operation, the load will automatically transfer to the generator and will retransfer back when utility power is restored to within normal conditions. The engine will continue to run until the 30 minute exercise time delay period expires.

  Note: When a configuration jumper is not required, connect the jumper to only one pin of the header to conveniently store it for future use.

4.1.6 Secure

A configuration jumper is provided to inhibit the test pushbuttons on the faceplate for security purposes. See Figure 2-2.

- For normal automatic transfer switch operation, no configuration jumper is required.
- To inhibit the test pushbuttons on the faceplate for security purposes, place a jumper across the two pins labelled Secure on the PCB.

If the jumper is placed to inhibit the test pushbuttons after the exercise test mode was activated, the Gen Exercise test mode is immediately terminated. If utility power fail test mode is selected prior to placing the inhibit configuration jumper on, the test will continue to operate until manually terminated by pressing the test pushbutton for 5 seconds.

Note: When a configuration jumper is not required, connect the jumper to only one pin of the header to conveniently store it for future use.

4.2 Adjustment Potentiometers

Eight adjustment potentiometers are provided on the TSC 80 controller printed circuit board. See Figure 2-2, which illustrates how the potentiometers are arranged on the printed circuit board. A listing of available features that are user-adjustable via the PCB potentiometers is shown in Figure 4-2. A small flat blade screwdriver is required to adjust the potentiometers. Turning the potentiometerclockwise will cause an increase in the function setting. Turning the potentiometer counterclockwise decreases the setting.

Function	Factory Default Setting	Range
Engine Start Timer	3 sec.	0-60 sec.
Engine Warmup Timer	2 sec.	0-60 sec.
Engine Cooldown Timer	2 min.	0-30 min.
Utility Return Timer	2 min.	0-30 min.
Neutral Delay Timer	3 sec.	0-60 sec.
Utility Undervoltage Sensor (Dropout Setting)	85%	70-95%
Generator Undervoltage Sensor (Dropout Setting)	85%	70-95%
Generator Frequency Sensor	90%	70-90%

Figure 4-2 Adjustment Potentiometers

4.2.1 Utility Undervoltage Setpoint

A potentiometer is provided to adjust the setpoint of the TSC 80's utility undervoltage sensor. The undervoltage setting is expressed in percentage of system voltage setting with an adjustable range of 70%-95% (e.g. if system voltage configuration jumper is set for 600 V, an 80% undervoltage setting will correspond to an actual 540 VAC setpoint.)

Note: The actual undervoltage setpoint voltage is calculated based on the TSC 80 voltage configuration jumper setting (i.e. *nominal* system voltage) and the potentiometer setting. Actual system operating voltage should *not* be used to calculate the undervoltage setpoint.

The undervoltage setting is for a falling utility voltage (i.e. dropout setting) on any one phase. The undervoltage sensor will reset to normal when the utility voltage rises 5% above the dropout setting (i.e. differential value). *Example*: If undervoltage is adjusted to an 80% dropout value, it will reset at 85% voltage. The 5% differential value is not programmable.

Note: To override momentary undervoltage fluctuations, the TSC 80's Engine Start Delay Timer feature is used.

See Figure 4-2 for the factory default settings of the utility undervoltage sensor.

4.2.2 Generator Set Undervoltage Setpoint

A potentiometer is provided to adjust the setpoint of the TSC 80's generator undervoltage sensor. The undervoltage setting is expressed in percentage of system voltage setting with an adjustable range of 70%-95% (e.g. If system voltage configuration jumper is set for 600 V, an 80% undervoltage setting will correspond to an actual 540 VAC setpoint.)

Note: The actual undervoltage setpoint voltage is calculated based on the TSC 80 voltage configuration jumper setting (i.e. *nominal* system voltage) and the potentiometer setting. Actual system operating voltage should *not* be used to calculate the undervoltage setpoint.

The undervoltage setting is for a falling generator voltage (i.e. dropout setting) on any one phase. The undervoltage sensor will reset to normal when the generator voltage rises 5% above the dropout setting (i.e. differential value). *Example*: If undervoltage is adjusted to an 80% dropout value, it will reset at 85% voltage. The 5% differential value is not programmable.

Note: To override momentary undervoltage fluctuations, the undervoltage sensor is provided with a transient time delay period of 3 seconds that is nonadjustable.

See Figure 4-2 for the factory default settings of the generator undervoltage sensor.

4.2.3 Generator Set Underfrequency Setpoint

A potentiometer is provided to adjust the setpoint of the TSC 80's generator underfrequency sensor. The underfrequency setting is expressed in percentage of system frequency setting with an adjustable range of 70-90% (e.g. if system frequency configuration jumper is set for 60 Hz, an 90% underfrequency setting will correspond to an actual 54 Hz setpoint.).

Note: The actual underfrequency setpoint voltage is calculated based on the TSC 80 voltage configuration jumper setting (i.e. nominal system frequency) and the potentiometer setting. Do not use the actual system operating frequency to calculate the underfrequency setpoint.

The underfrequency setting is for a falling generator frequency (i.e. dropout setting) on any one phase. The underfrequency sensor will reset to normal when the generator frequency rises 0.5% above the dropout setting (i.e. differential value). *Example:* if underfrequency is adjusted to an 80% dropout value (i.e. 48.0 Hz), it will reset at 48.3 Hz. The 0.5% differential value is not programmable.

Note: To override momentary underfrequency fluctuations, the underfrequency sensor is provided with a transient time delay period of 3 seconds that is nonadjustable.

See Figure 4-2 for the factory default settings of the generator underfrequency sensor.

4.2.4 Engine Start Delay

A potentiometer is provided to adjust the TSC 80's engine start delay timer. The engine start signal will be initiated following expiration of the start delay timer. Select desired engine start time delay in seconds. The range of setting is 0-60 seconds. If no delay is required, set this time delay to zero.

Note: The output relay is normally energized when the utility power is within limits and deenergizes to start the engine.

See Figure 4-2 for the factory default settings of the engine start delay timer.

4.2.5 Engine Warmup Delay

A potentiometer is provided to adjust the TSC 80's engine warmup delay timer. A transfer to the generator supply will be initiated when the voltage and frequency are within limits and upon expiration of the engine warmup delay timer. The range of setting is 0-60 seconds. If no delay is required, set this time delay to zero.

See Figure 4-2 for the factory default settings of the engine warmup delay timer.

4.2.6 Engine Cooldown Delay

A potentiometer is provided to adjust the TSC 80's engine cooldown delay timer. The engine cooldown period will be initiated once the load has transferred from the generator supply. The engine start signal will be maintained until expiration of the cooldown delay timer. The range of setting is 0-120 seconds. If no delay is required, set this time delay to zero.

See Figure 4-2 for the factory default settings of the engine cooldown delay timer.

4.2.7 Utility Return Delay

A potentiometer is provided to adjust the TSC 80's utility return delay timer. The utility return delay period will be initiated once the utility supply has returned within limits following a utility power failure condition. The range of settings is 0-30 minutes. If no delay is required, set this time delay to zero.

Note: The utility return delay will be bypassed should the generator fail during the time delay period.

See Figure 4-2 for the factory default settings of the utility return delay timer.

4.2.8 Neutral Delay

A potentiometer is provided to adjust the TSC 80's neutral delay timer. The neutral delay time period will be initiated once the load bus voltage drops below the dead-bus threshold value when both of the supply power switching devices are open during a transfer sequence. Select desired neutral delay time in seconds. The range of settings is 0-60 seconds. If no delay is required, set this time delay to zero.

Note: The neutral delay will be bypassed should the operating power fail for longer than the timer setting.

See Figure 4-2 for the factory default settings of the neutral delay timer.

Notes

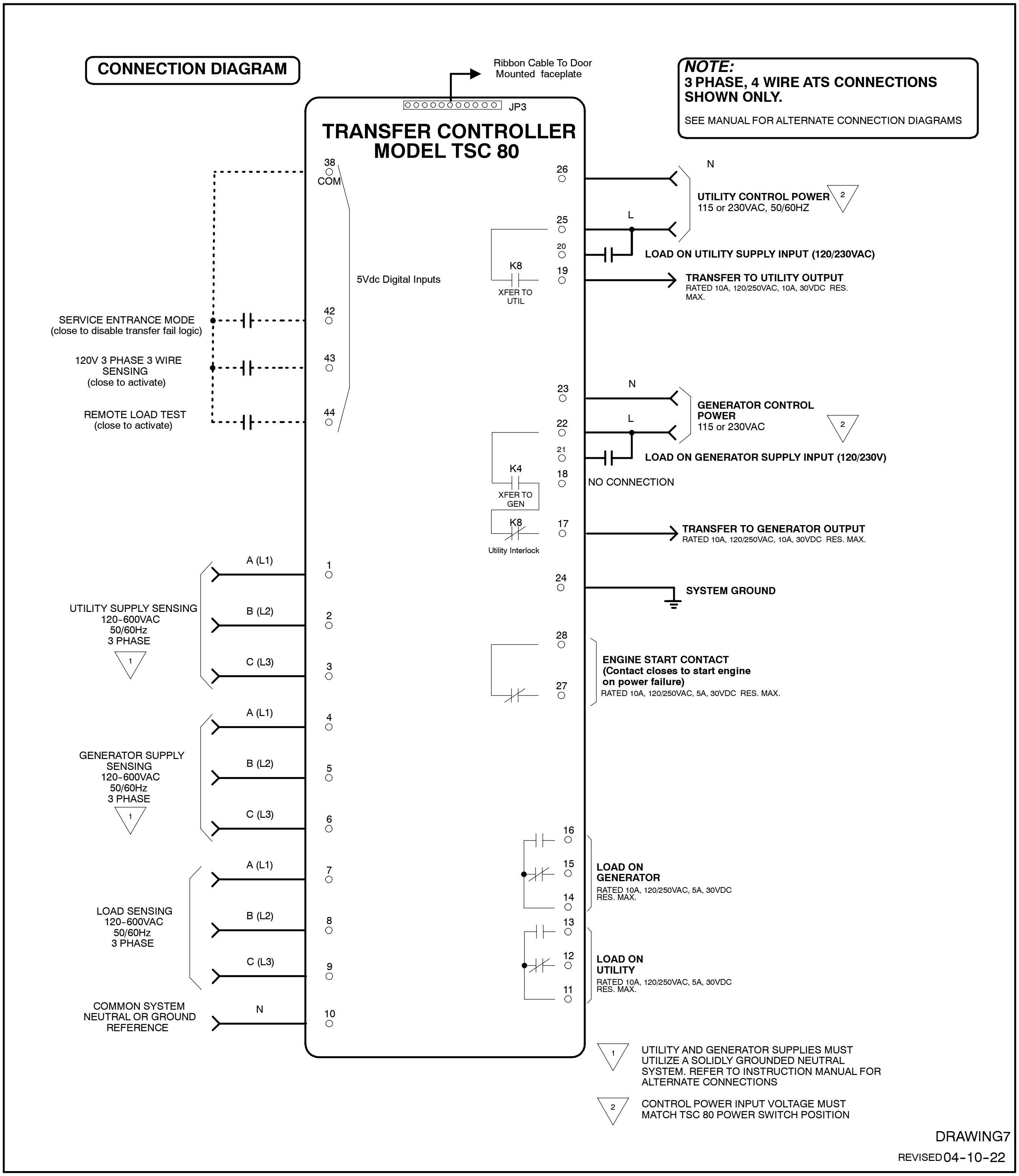


Figure 5-1 Typical Connection Diagram

Notes

Section 6 Service Parts and Troubleshooting

DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before servicing. Install the barrier after adjustments, maintenance, or servicing.

DANGER

Hazardous voltage.
Will cause severe injury or death.

Only authorized personnel should open the enclosure.

Servicing the transfer switch. Hazardous voltage can cause severe injury or death. Deenergize all power sources before servicing. Open the main circuit breakers of all transfer switch power sources and disable all generator sets as follows: (1) Move all generator set master controller switches to the OFF position. (2) Disconnect power to all battery chargers. (3) Disconnect all battery cables, negative (–) leads first. Reconnect negative (–) leads last when reconnecting the battery cables after servicing. Follow these precautions to prevent the starting of generator sets by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer. Before servicing any components inside the enclosure: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Test circuits with a voltmeter to verify that they are deenergized.

6.1 Service Parts

The TSC 80 controller is composed of 3 pieces that can be ordered as replacement parts. See the transfer switch Operation/Installation/Service manual for part numbers. See the List of Related Materials for manual part numbers.

When ordering replacement parts, please provide the following information:

- Transfer switch product (model) code (e.g. TS 843AA0200AS).
- Transfer switch serial number (e.g. W-022345).

Note: The above information can be found on the transfer switch equipment rating plate located on the outside of the ATS door.

6.2 Troubleshooting

Refer to the list of typical problems in Figure 6-1. Consult the factory for any detailed information or for any problems not listed.

Note: There are no user-serviceable components located on the TSC 80 printed circuit board. If the TSC 80 controller is defective, return it to the factory for repair or replacement.

Symptom	Possible Causes
Will not retransfer to utility source upon restoration	A test mode has been activated.
	Utility voltage is outside the preprogrammed limits (check utility source for adequate voltage).
	A loose control connection.
	Faulty auxiliary contact in the ATS motor circuit.
	Defective ATS motor.
	Defective TSC 80 controller (verify output signals with circuit board-mounted diagnostic LEDs).
	TSC 80 has transfer fail alarm activated, which is indicated by a flashing load on utility LED, located on the Lexan faceplate. Determine cause of alarm and rectify before TSC 80 is reset.
Will not transfer to generator source upon failure of utility source	Generator set not producing enough voltage/frequency or output circuit power switching device open.
	Warmup time delay function has not timed out (verify TSC 80 timer setting).
	A loose control connection.
	Faulty auxiliary contact in the ATS motor circuit.
	Defective ATS motor.
	Defective TSC 80 controller (verify output signals with circuit board-mounted diagnostic LEDs).
	TSC 80 has transfer fail alarm activated, which is indicated by a flashing load on generator LED, located on the Lexan faceplate. Determine cause of alarm and rectify before TSC 80 is reset.
Transfer to generator source without a power failure in the utility source	A test mode has been activated. Defective TSC 80 controller. Verify output signals with circuit-board-mounted diagnostic LEDs.
	Loose or broken wire to the utility voltage sensing terminals on the TSC 80 controller.
	Utility supply voltage is slightly below voltage sensing setpoints. Compare TSC 80 program voltage setpoints with actual utility voltage.
	Utility power switching device has tripped due to an overcurrent condition (service entrance type ATS) and TSC 80 Transfer fail alarm activated. Determine cause of alarm and rectify before TSC 80 is reset.
Generator does not start or stop when it should	Verify remote engine control panel is set for automatic mode. Verify the FTS4 selector is not in the off, engine start, or test positions.
No time delay when there should be	Verify time delay function setting of TSC 80 potentiometer. Verify load bus voltage decay during transfer to enable neutral delay timer.
Power is not available at the load terminals but the utility or generator power switching device appears to be closed to a live source	The power switching device's trip unit (service entrance type ATS) has tripped on a fault on the system. Correct the fault and manually reset the power switching device in the transfer switch by moving it off and then on again with the manual operating handle.
Engine runs for no apparent reason	Verify the TSC 80 has not been set for test operation.

Figure 6-1 Troubleshooting

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audiovisual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example *(exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lb.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature, high engine temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin

kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
MCCB	molded-case circuit breaker
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent-magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Notes

Notes

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