1 General

1.1 Summary

This specification describes the requirements for an automatic static transfer switch (STS). The PDI WaveStar® Static Transfer Switch shall be a three pole, two-position transfer device that both automatically and manually transfers a load between two three-phase, AC power sources. The input power shall be supplied by two different AC power sources, which are nominally of the same voltage, phase rotation, and frequency.

The STS shall transfer the load from one source to the alternate source when one source fails or when a transfer is manually initiated for testing or maintenance. The transfer shall be transparent to the load and shall be within CBEMA limits. The transfer action shall not connect the two sources, which would cause cross feeding of one source to the other.

The STS shall employ two user-selectable algorithms: a fast algorithm that transfers the load within1/4 cycle for in-phase conditions and a PDI-patented algorithm that slightly increases the transfer time to from approximately 1/2 cycle to a maximum of 3/4 cycle, while controlling in-rush to a downstream transformer. Both algorithms shall provide a transparent load transfer well within CBEMA limits.

The STS shall employ substantial redundancy in components to provide the high reliability and availability needed by data centers. To the fullest extent practicable, tri-redundant circuits with voting shall be used to eliminate single points of failure.

The STS shall also provide comprehensive operator support facilities, networking, and other options to facilitate the integration of the STS into a modern data center.

1.2 Standards

The Static Transfer Switch shall be ETL-listed to UL1008S, UL891, CSA 22.2, and IEC60947. The STS shall also be ETL-listed to the emission standards, EN61000-6-2 and EN61000-6-4.

In addition, the STS shall be designed, manufactured, tested, and installed in observance of the following standards:

- American National Standards Institute (ANSI)
- Canadian Standards Association (CSA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories Standards

- IBC 2010, seismic zone 4, California standard
- ISO 9001:2015

The STS shall safely withstand without mis-operation or damage:

- Transient voltage surges on either AC power input as defined by ANSI/IEEE C62.41 for Category B3 locations (high surge exposure industrial and commercial facilities)
- Electrostatic discharges (ESD) up to 10 kV at any point on the exterior of the unit
- Electromagnetic fields from portable transmitters within 3 feet (1 meter) of the unit

The STS shall comply with the latest FCC Part 15 EMI emission standard for Class A computing devices.

1.3 Definitions

STS – Static Transfer Switch

SCR – Silicon Controlled Rectifier

MTBF – Mean Time Between Failure is the actual arithmetic average time between failures of the critical AC output bus.

MCCB - Molded Case Circuit Breaker is an over current device which has automatic thermal and magnetic overload trip elements for overload and short-circuit/fault protection

MCSW – Molded Case Switch is a circuit breaker which has no automatic thermal overload trip element but does have a magnetic trip element for short-circuit/fault protection. Overload protection must be provided by an upstream over current device.

1.4 System Description

The STS shall be available in the following ratings:

- Current Ratings: 250, 400, 600, 800, 1000, 1200, or 1600A. The STS shall be rated to continuously carry a 100% full load.
- Input/Output Voltage: 208, 400, 480, or 600 volts three phase, 3-wire-plus-ground.
- Frequency: 60 Hz or 50 Hz

1.5 Documentation

1.5.1 Drawings

The manufacturer shall furnish as-built STS 1-line electrical drawings and outline or other mechanical drawings with the equipment delivery, if requested by the customer. For quoting, prospective sample preliminary submittal drawings shall be available.

1.5.2 Installation and Operations Documentation

A *Static Transfer Switch, Installation and Operations* manual shall be furnished. Points lists (Modbus register maps) for analog and digital points and an SNMP MIB shall be available for downloading from the manufacturer's website.

1.5.3 Spare Parts

A list of recommended spare parts shall be made available at customer request.

1.5.4 Contact List

The manufacturer shall provide a contact list for key functions, such as Service and Accounting.

1.6 Warranty

The manufacturer shall provide a 12-month warranty against defects in material and workmanship for 12 months after initial startup or 18 months after shipping date, whichever comes first.

1.7 Quality Assurance

The STS shall be designed and manufactured according to internationally recognized quality standards, including those listed in section **1.2 Standards**. The manufacturer shall be ISO 9001:2015 certified.

The STS shall be factory tested before shipment. Testing shall include at minimum all items listed in **Section 3.2 Factory Testing**.

1.8 Submittal Requirements

The information submitted with the seller's bid shall include the following items:

- Technical proposal, including STS one-line diagram, specification, unit ratings, transformer ratings, frame size and current ratings of circuit breakers.
- Prospective outline and installation drawings showing dimensions and weight of the equipment, service clearances, external power cable connections, and recommended cable entrances and exits.

2 Product

2.1 Electrical Requirements

Maximum continuous current ratings: 250, 400, 600, 800, 1000, 1200, or 1600A.

Nominal Input and Output Voltage: 208, 400, 480 or 600 volts

Voltage Range: ± 10% of nominal voltage

Source Voltage Distortion: Up to 15% THD plus notches, flat topping or/and ringing transients

Frequency: (60) Hz. +/-0.5 Hz or (50) Hz. +/-0.5 Hz

Load Power Factor Range: 0.5 to 1.0, leading or lagging

Load Crest Factor: Up to 3.5

Sense and Transfer Time:

- 1/4 cycle or less using POG algorithm.
- Approximately 1/2 to maximum 3/4 cycle using the VSS controlled-inrush algorithm.

Overload Capability:

- 100% continuously
- 125% for 30 minutes
- 150% for 2 minutes
- 300% for 30 seconds
- 500% for 10 seconds

Short Circuit Withstand Capability, Rated kAIC at ≤ 600 volts:

- 250-1600A units: 22 kAIC (65 kAIC and 100 kAIC optional)
- The STS withstand capability shall be in accordance with UL 1008S without SCR protective fusing.

2.2 Environmental Specifications

The STS shall have the following environmental specifications for operation and storage:

- Storage Temperature Range: -40° to +80°C B. Operating Temperature Range: 0° to 40°C
- Relative Humidity: 0 to 95% without condensation

- Operating Altitude:
    - Up to 5000 feet above sea level without derating
    - Above 5000 feet, current rating is de-rated by 6% per 1000 feet
- Storage and transport altitude: Up to 40,000 feet above sea level
- Audible noise: Less than 60 dBA at 5 feet without alarm activation

2.3 Components: Enclosure

2.3.1 Enclosure Construction

The STS enclosure shall be constructed to NEMA-1 standards.

The STS enclosure shall be designed for the data center or telecommunication environment.

All removable STS panels shall incorporate latches with ¼ turn screws.

STS units rated 250-800A shall have heavy-duty casters and stabilizing pads, which can be adjusted to stabilize the unit, once the STS is placed in its final position.

The STS cabinet can be tipped 15 degrees in any direction without damage.

Physical access controls The STS shall have the following physical access controls:

- Front doors shall be secured by latches and 2-position locks.
- All circuit breakers and switches (MCCBs and MCSWs) shall be mounted behind closed lockable doors. The doors must be opened to allow operators to manipulate MCCBs and MCSWs for bypass operations.

Enclosure dimensions. The cabinet enclosure dimensions shall be the following by unit rated amperage:

- 250-600A: 32.75"D x 36.50"W x 74.75"H
- 800A: 32.75"D x 48.00"W x 74.75"H
- 1000 -1200A: 43.00"D x 84.00"W x 74.75"H
- 1600A: 43.00"D x 84.00"W x 89.25"H

Enclosure Weights STS units shall have the following approximate weights by unit rated amperage:

- 250-600A: 900 lbs.
- 800A: 1,100 lbs.
- 1000-1200A: 3,600 lbs.
- 1600A: 4,000 lbs.

Paint The cabinet enclosure shall be primed and painted inside and out with a suitable powder coat enamel. The paint color shall be PDI Black or IBM Pearl White (or "computer hardware off-white") to match other PDI equipment in appearance. Customer may specify alternate color(s) that must be approved by PDI.

2.3.2 Mounting Options

The STS shall be suitable for installation on both fixed floor or on a floor stand in a raised floor environment.

Floor stands shall be available for 250-800A units in heights from 8" to 52". Floor stands shall be available for 1000-1200A units in heights from 32-40".

Seismic brackets shall be available to attach the STS to the floor or floor stand:

- STS units 250-1600A shall have optional brackets for attaching the STS to the floor.
- STS units 250-800A shall have built-in brackets for attaching the STS to a floor stand.
- STS units 1000A and 1200A shall have optional brackets for attaching the STS to a floor stand.

2.4 STS Cooling

STS 250 and 400A units shall use convection air-cooling and shall have no fans. Heat rejection shall be through ventilation openings. Convection cooling shall be sufficient for full load operation.

STS 600, 800, 1000, 1200, and 1600A units shall have redundant fans for cooling:

- STS 600 and 800A units shall have six (6) fans: three (3) active and three (3) reserve fans available for automatic start upon fan failure.
- STS 1000A – 1600A units shall have nine (9) fans: six (6) active fans and three (3) reserve fans available for automatic start upon fan failure.

No filters shall be provided in the STS.

2.5 STS Access

2.5.1 Service Access Clearances

The STS shall require the following service access clearances:

- STS 250-800A units: 36" front and 36" right side (minimum)
- STS 1000A-1600A units: 36" front and 36" rear (minimum)

The STS units shall require the following ventilations clearances:

- 6" all sides (minimum)

- 18" top (minimum)

2.6 Electrical Construction

2.6.1 Wiring

All wiring shall be rated per the National Electrical Code (NEC). All busses shall be rated per the UL or National Electric Code. All wiring and cables shall be copper or plated copper. Aluminum shall be used for heat sinks only.

2.6.2 Ground

The STS shall include a computer grade single point ground in accordance the requirements of the NEC. The STS shall be designed to operate from sources that are grounded in accordance with NEC requirements.

2.6.3 Cable Landing

The STS shall be constructed so that all input and output field power connections can be made as follows:

- STS 250-800A units: front and right side
- STS 1000-1600A units: front and rear

2.6.4 Power Junction Boxes for Input Sources (Optional)

The two input power sources shall be (optionally) connected to the STS via two power junction boxes. Each junction box is a NEMA 12 box with removable covers. Each box shall contains four (4) mechanical power terminal blocks for the connection of the DELTA-configured incoming power feeds to the STS.

Each power junction box shall be equipped with a 10-foot long STS main input power cable is provided with each STS. The cable consists of liquid-tight flexible metal conduit and contains the appropriate size and number of copper conductors to comply with NEC standards. This field-installed cable contains two (2) box connectors thus allowing ease of installation onto the power junction box and to the STS.

2.6.5 Hazardous Voltages Safety

To allow safe servicing of the unit while the load is energized, the STS shall be designed to minimize the exposure of hazardous voltages. Barriers shall be used on and around any exposed surface with more than 42 volts peak applied including connections, to protect personnel during maintenance.

2.6.6 Electrical Noise Immunity

Noise immune signal bus(s) shall be used; optical and/or Can Bus shall be used to route signals between logic PCBs.

2.6.7 Separation of Logic and Power

All control and logic components shall be separated from the power components.

2.6.8 Current Transformers

For monitoring, the STS shall have appropriately sized current transformers (CTs) installed on input power sources and output.

2.7 Static Transfer Switch Module Design

The Static Transfer Switch shall be a three-pole, double-throw; solid-state, automatic and manual transfer switch that is fed from two AC power sources. The three-phase, dual position design connects the load to Source 1 or Source 2. All transfers from one source to the other, regardless of direction, shall be a break-before-make with no overlap in conduction from one source to the other.

One source shall be designated as the preferred source while the other is the alternate source. Under normal conditions, power shall be provided by the preferred input. Either Source 1 or Source 2 can be designated preferred and shall be user-selectable from the operator control panel.

The STS shall include an automatic transfer mode so that upon the failure of the preferred power source, the load shall be automatically transferred to the alternate source. The transfer shall be transparent to the load.

2.7.1 Transfer Algorithms and Transfer Times

The STS shall have two transfer algorithms that each transfers the load between the two sources without connecting the sources together within CBEMA limits:

- The **Power or Gate** (POG) algorithm transfers the load to the alternate source as quickly as possible with the following transfer times:
    - Automatic transfers including sense time are ≤ 1/4 cycle for normal in-phase conditions.
    - Manual transfers are ≤ 1/8 cycle for normal in-phase conditions (phase-synchronized sources).
- The **Volt Second Synchronization** (VSS) algorithm is a PDI-patented controlled in-rush algorithm that transfers the load to the alternate source in approximately ½ cycle to a

maximum ¾ cycle and will balance the volt-seconds of any magnetic load so as to not draw in-rush current.

- Automatic transfers are approximately 1/2 cycle to ≤ 3/4 cycle for all phase conditions, including sense time.
- Manual transfers are ≤ 1/8 cycle for in-phase conditions.

The operator shall be able to select or toggle between these algorithms from the front operator panel.

2.7.2 Transfer Times

The POG (fast) algorithm transfers the load as quickly as possible from one source to another without connecting the sources together:

2.7.3 SCRs

The STS shall have of two solid-state switching elements with associated logic to control switching and sensing functions. The solid state switching elements shall be high speed Silicon Controlled Rectifiers (SCRs) connected in anti-parallel pairs to transfer the AC power.

Each solid-state switch element shall consist of three sets of three-phase "PUK" type SCRs connected in an AC switch configuration. The SCRs shall carry the full rated STS load.

"BRICK" OR "GEL FILLED" TYPE SCRs SHALL NOT BE ACCEPTABLE FOR STATIC TRANSFER SWITCH APPLICATIONS.

For 250-800A STS units, the SCRs shall be rated 2,880A RMS continuous.

For 1000-1600A STS units, the SCRs shall be rated 7,060A RMS continuous.

2.7.4 In-Rush Currents

The STS shall control transformer in-rush on initial power-up, on restart after shut down, and upon load transfers.

- At start-up or restart the STS shall use a special "soft startup" algorithm to control current in-rush. The inrush shall be less than 2 times the rated STS current.
- Using the VSS controlled in-rush algorithm, the current inrush for all transfers shall be less than 2 times the rated STS current. This PDI-patented algorithm increases the transfer time to synchronize the flux and/or volt- seconds. The transfer time shall be within the CBEMA limits, making the transfers transparent to the load.

2.7.5 MCSWs and MCCBs

Input source and bypass MCSWs (standard) or MCCBs (optional) shall be 100% rated for the STS's rated amperage as long as upstream over-current protection is sized correctly per UL circuit breaker standards.

The outputs of the two sets of MCSWs or MCCBs are connected to furnish power to the load through the isolation MCSW(s). The STS shall have one (1) or two (2) isolation MCSWs. Two isolation MCSWs shall be standard on units 1000A or greater.

Key interlocks shall be provided for the MCSWs and MCCBs to prevent the operator from closing both of the bypass MCSWs or MCCBs at the same time.

All MCSWs or non-auto circuit breakers shall be of a plug-in or draw-out type to allow easy replacement.

2.8 Redundancy

The STS shall be designed for high reliability and high availability with an MTBF exceeding 2,000,000 hours. To the fullest extent practicable, tri-redundant circuits with voting shall be used to eliminate single points of failure.

2.8.1 Redundant Logic

Triple redundant logic shall be standard with voting circuits.

The STS shall have a backup triple redundant simple logic voting PCB with voltage detection that is independent of the main logic PCB. Both logic PCBs shall monitor the voltage and current supplied to the load; if one PCB does not transfer the load within specification, the second PCB shall transfer the load within the limits of the CBEMA curve.

2.8.2 Redundant Signal Buses

All signal buses shall be redundant. Each signal bus shall continuously transmit "Bus Integrity" signals, when not transmitting true data. If all receivers do not receive the "Bus Integrity" signals, then the bus is considered discontinuous and is alarmed.

2.8.3 Redundant SCR Gate Drivers

Source 1 and Source 2 shall each have two isolated, independent gate drivers. Each gate driver can drive the SCRs by itself.

2.8.4 Redundant Power Supplies

The STS shall have triple redundant logic power supplies. The configuration of each DC logic power supply shall be such that a short circuit on one PCB cannot prevent the other PCBs from

receiving triple redundant power. This is accomplished by coordinated fusing in the DC distribution lines. Each PCB shall receive logic power via three isolated connectors.

The power supplies shall be mounted in separate modules so that a power supply module including its transformers can be replaced while the STS is powered.

2.8.5 Primary and Backup Operator Controls

There shall be two sets of operator controls and status displays:

- 10.4" Color Touch Screen Graphical Display providing full operator functionality.
- Redundant Operator Interface (ROI) providing a back-up operator interface in case the Graphical Display fails. The ROI shall allow the operator to control both automatic and manual transfer functions with toggle switches and while showing power source status on LEDs.

Each operator control/display PCB shall be replaceable while the STS is powered.

2.9 STS Operation

The STS shall automatically power up when connected to at least one power source. The STS shall have three operational modes: Normal, Bypass, and Redundant

2.9.1 Normal Mode Operation

The input of the STS shall be fed by two power sources with the STS output connected to the load. One source shall be designated the preferred source.

In normal operation, the load shall be connected to the designated preferred source as long as all phases of the preferred source are within the acceptable limits. When preferred source fails or is out of acceptable limits, the STS shall transfer the load to the alternate source. When the preferred source returns to acceptable limits, the STS may or may not retransfer the load back to the preferred source, depending on the setting of parameter “Retransfer = Yes/No”.

If “Retransfer = No”, the STS shall keep the load on the alternate source as long as the alternate source’s is within tolerance. If the alternate source goes out of tolerance, the unit will automatically retransfer back to the preferred source.

If Retransfer = Yes”, when the preferred source’s voltage returns to normal, the STS shall automatically retransfer the load back to the preferred source after a preset retransfer delay time. The retransfer delay can be set to between 4 seconds and 10 minutes on the Switch Settings operator screen.

2.9.2 Manual Transfers

The STS shall allow manually initiated transfers between the two sources providing the alternate source is within acceptable voltage limits and phase tolerances.

Allowable phase differences between the sources for manually initiated transfers shall be adjustable from the operator control panel. The user-adjustable phase synchronization window shall be by default +/- 20 degrees, but can be set as high as 180 degrees. When phase differences between sources is greater than allowed by the phase synchronization window, the operator shall be able to manually transfer the load by pressing the **override button** on the monitor's **Home** screen.

For manual override transfers, the operator shall be able to manually transfer the load with sources up to 180 degrees out of phase.

2.9.3 Special Conditions Affecting Transfers

The STS shall monitor for conditions that require special handling.

High Load Current Inhibit

If the load current exceeds a preset level, which is set at the factory to about three times the STS full load rating, the logic shall inhibit transfers even if the voltage on the active source exceeds the transfer limits. If the over-current condition subsides and the input voltage is still present, the transfer inhibit shall automatically be removed.

SCR Failure

The STS shall continuously monitor the status of each SCR and will respond to anomalous conditions as follows:

- If an SCR on the source powering the load is shorted, the logic shall automatically alarm and trip open the opposite source input breaker.
- If there is a shorted SCR on the non-conducting source and cross-current is detected, the logic shall automatically transfer the load to that source and alarm the condition and trip open the non-shorted source's input MCSW/MCCB.
- If an SCR is open, the logic shall automatically sense and alarm the condition and transfer to the other source.
- All open and shorted SCR alarm conditions shall be latched and require the system to be repaired and reset to restore normal operation.

2.9.4 Bypass Mode Operation

The STS shall have a Bypass Mode for maintenance. In Bypass Mode, all electronic components shall be isolated from the power sources to allow safe STS servicing. Transferring from Normal

mode to Bypass mode on the same source and retransfer back to Normal mode is transparent to the load.

The bypass MCSW's shall be operated manually. Going to the Bypass and returning from Bypass to Normal mode shall both require the operator to manipulate Kirk Keys and MCSWs or MCCBs.

To assist the operator, the **Help** screen shall have instructions for going to Bypass 1 or 2 and for returning from either Bypass 1 or 2 to Normal operation. The **Help** screen shall graphically show the progress of the bypass operation on the **Home** screen, coordinated with the status shown on the One-Line Mimic on the **Home** screen. When the STS senses a step has been completed, the **Help** screen shall proceed to the next step. The Voice Unit shall also call out instructions for each step as the operator executes the procedure.

2.9.5 Redundant Mode Operation

When the Mode of Operation toggle switch on the Redundant Operator Interface (ROI) panel is set to "REDUNDANT", the STS shall operate in Redundant Mode, as follows:

- Automatic transfers to the alternate source shall occur when the current source is out of tolerance.
- Manual transfers to the alternate source are made by setting the ROI SOURCE SELECTOR toggle switch to that source (if not already on that source).

2.10 Operator Interface

2.10.1 10.4-inch Color Touchscreen Monitor

The STS shall have a 10.4" diagonal color touchscreen monitor on the front of the STS. The monitor shall be accessible with the door closed or open.

The STS shall allow changes to controls or parameters to be made only from the touchscreen display. Controls or parameters shall not be modifiable remotely from a Building Management System (BMS), DCIM system, or from a web browser.

2.10.2 Redundant Operator Interface Panel

The STS shall have a backup operator interface mounted below the Color Touchscreen Monitor, the Redundant Operator Interface (ROI). The STS door must be unlocked and open to access the ROI.

2.10.3 Voice Unit

The STS shall have a Voice Unit. The Voice Unit shall provide short audible statements that supplement text or graphics in certain situations, such as "Static Switch, new alarm," or "Static Switch, alarm cleared." The Voice Unit also steps the operator through Bypass procedures in coordination with the Help screen for Bypass.

2.11 Operator Screens

The STS monitor shall have a comprehensive set of operator screens.

2.11.1 Home Screen

The Home screen shall provide a summary of STS system status, showing the following:

- Dynamic mimic 1-line display showing power flow, source and output status, measurements for sources and output, and status of MCSWs/MCCBs and SCRs.
- Preferred source
- Status of STS, including presence or absence of alarms
- Number of transfers that have occurred since the last reset.
- Current ID of logged-in operator.

From the **Home** screen the operator shall be able to

- Log in to the STS
- Select the preferred source
- Execute manual transfers

2.11.2 Administration and Configuration Screens

The **Users** screen shall allow an administrator to set up access classes, PINs, and passwords for operators.

The **Configuration** screen shall allow factory and service personnel to configure the STS. The Configuration screen shall be viewable by other users but the configuration shall not be modifiable.

The **Switch Settings** screen shall have transfer controls and optimization settings for the STS.

The **Settings** screen shall allow an operator to configure Ethernet and Modbus network settings and manually set time and date.

The **Time** screen shall allow an operator to set and synchronize time using Simple Network Time Protocol (SNTP). To use SNTP, the STS must be connected through its Ethernet port to a network with a reachable SNTP time server.

The **SNMP** screen shall allow an operator to configure an SNMP trap providing a summary alarm.

The **Email** screen shall allow an operator to configure an email summary alarm notification using Simple Mail Transfer Protocol (SMTP). The IP addresses of the SMTP server and recipients must be reachable by the network.

2.11.3 Monitored Values Screens

The **Analog Values** screen shall display points from the Analog points list, showing metered values such source voltage or current for each phase. Each point shall have a colored status indicator showing that it is in normal range, alarmed, or not a status point.

The **Digital Values** screen shall display status points from the Digital Values points list, such as Bypass 1 MCSW open or closed. Each point shall have a colored status indicator showing that its status is OK, alarmed, or not a status point.

2.11.4 Alarms and Events Screens

The **Alarms** screen shall display all alarms with date/time stamps and shall have a reset button to clear alarms from the log.

The **Event Log** screen shall display the 512 most recent events, which are recorded in nonvolatile memory including

- Alarms
- Outages
- User login and logout
- Changes in state for digital points (binary states) in the Digital Points list
- Crossed thresholds for analog points (measurements) in the Analog Points list

The Administrator shall be able to clear the Log.

The **Plots** screen shall show the waveform plots generated by

- Outages (automatic transfers due to a source going out of specification)
- Dual outages, where both sources fail
- Manual transfers
- Immediate operator-requested plots

The plots shall be associated on screen with the time-stamped event that caused the plot to be taken. The operator shall be able to generate an immediate plot by touching the **Now** button on the **Plot** screen.

The STS shall also have these additional screens:

- **Harmonics** screen, showing STS output harmonics for both voltage and current.
- **Load** screen, showing current for both sources and output, and kVA, peak kVA, and total KW for output.
- **Help** screen, providing interactive help for bypass operations.

2.12 Alarms

An alarm shall be signaled when any monitored condition is out of normal specification. The following alarm conditions shall be displayed and logged:

Source 1 out-of-tolerance	Source 1CB open	Power Supply Failed
Source 2 out-of-tolerance	Source 2 CB open	ID of failed power supply
Sources out of Sync	ISO #1 CB open	LCM voting disagreement
Source 1 over voltage	ISO #2 CB open	Simple logic voting disagreement
S1undervoltage (fast)	S1 Bypass CB closed	S1 & S2 sources failed
S1undervoltage RMS (slow)	S2 Bypass CB closed	S1 Gate drive module 1 failed
Source 2 over voltage	S1 SCR Open	S1 Gate drive module 2 failed
S2 under voltage (fast)	S2 SCR Open	S2 Gate drive module 1 failed
S2 under voltage RMS (slow)	S1 SCR Shorted	S2 Gate drive module 2 failed
Output over current	S2 SCR Shorted	STS Heat Sink Over-temp 1
Redundant display controls enabled	Power supply fuse blown	STS on alternate source
Source 1 Over/Under Frequency	REPO/EPO activated	STS Heat Sink Over-temp 2
Source 2 Over/Under Frequency	Control Module Fail	Source 2 Phase Rotation Error
Source 1 Phase Rotation Error	Maintenance Mode	Output under voltage
Auto Retransfer Inhibit	Manual Override	Loss of optical bus integrity signal
Output Over/Under Frequency	PDU Input CB Open	Loss of CAN bus integrity signal
Transfer Inhibit	Output over voltage	

The above conditions may put multiple analog and/or digital points in an alarm state. For example, the “Source 1 out-of-tolerance” condition may cause each phase of Source 1 to be marked in an alarm state.

2.12.1 Alarm Notification

Active alarms shall be signaled in the following ways:

- The **Home** screen shows Alarm status and gives an alarm count.
- The Voice Unit of the STS states, “Static Switch, new alarm.”
- The **Alarms** screen lists a new alarm.
- Each point in the **Analog Values** screen and **Digital Values** screen that is in alarm shall have a color-coded status dot showing that the point is in alarm.
- The **Event Log** screen adds an alarm.
- The **Alarms** or **Log** web page shows a new alarm.

2.12.2 Summary Alarm Notification

The STS shall issue a summary alarm when any alarm occurs by one or more of the following means, if the system is configured to do so:

- Dry contact
- SNMP trap
- Email notification

2.13 Networking

2.13.1 Protocols

For network communications upstream of the STS, the Monitor shall communicate using any of the following protocols, which can be used simultaneously:

- Modbus RTU (2-wire or 4-wire)
- Modbus TCP/IP
- SNMP Version 1
- TCP/IP (for STS web pages only)

Add-in cards shall not be necessary for the STS to communicate upstream in any of these protocols.

For other than Modbus RTU, the STS shall require a customer Ethernet connection to the customer network. An Ethernet connection shall be required for Modbus TCP/IP, TCP/IP for the web server, SNMP, SNTP for time synchronization, and SMTP for email summary alarm alerts.

A Java-enabled browser shall be required for some web pages.

2.13.2 Networking Connections

Customer Modbus RTU connections shall be made to a Contractor Board.

The optional customer Ethernet connection shall be made to the STS Monitor or to a RJ45-terminated cable attached to the STS Monitor.

2.13.3 Points Lists

STS points lists (Modbus register maps) shall be available for downloading from the manufacturer's website or by calling the manufacturer's service number.

2.14 Current Transformers

For monitoring, the STS shall mount appropriately sized current transformers (CTs) on input power sources and output.

2.15 Contractor Boards

The STS shall have a Contractor Board for customer communications connections. The STS shall have the Basic Contractor Board as standard and the Enhanced Contractor Board as an option.

2.15.1 Basic Contractor Board

The Basic Contractor Board shall contain the following:

- **Four (4) Relay Contacts**: Programmable NO dry contacts for external output of specific internal alarms or status, which are programmed by default as follows:
    - **Relay 1:** Summary Alarm – signals when there is any active alarm on the STS.
    - **Relay 2**: Load on S1
    - **Relay 3**: Load on S2
    - **Relay 4**: Output OK

    Note: Remote relays can accept dry contacts rated up to 2A/250V.
- **Four (4) Building Alarm Contacts** – Input terminal block to provide unit with input on four (4) external building alarms
- **Modbus RTU Connection** – 2-wire/4-wire configuration connection (RS-422/485)
- **Remote EPO (REPO)** –Dry contact connection point for remote EPO signal to system.

2.15.2 Enhanced Contractor Board (Optional)

The optional Enhanced Contractor Board shall contain the following:

- **Eight (8) Relay Contacts**: Programmable NO dry contacts for external output of specific internal alarms or status
- **Eight (8) Building Alarm Contacts**– Input terminal block to provide unit with input on eight (8) external building alarms
- **Modbus RTU Connection** – 2-wire/4-wire configuration connection (RS-422/485)
- **Remote EPO (REPO)** –Dry contact connection point for remote EPO signal to system.

2.15.3 Dry Contact Output Signals

Contractor Board remote relays shall signal status and alarms through closed dry contacts. Three (3) predefined relay lists shall be available as shown in the following table.

Table 1 Dry Contact Output Relays Predefined Signals

Remote Relays	Basic Contractor Board (Default List)	Enhanced Contractor Board	
		List 1	List 2
Relay 1	Summary Alarm	Summary Alarm	Summary Alarm
Relay 2	Load is on Source 1	Load is on Source 1	Load is on Source 1
Relay 3	Load is on Source 2	Load is on Source 2	Load is on Source 2
Relay 4	Output is OK	Source 1 is on Bypass	Source 1 is on Bypass
Relay 5	Not Available	Source 2 is on Bypass	Source 2 is on Bypass
Relay 6	Not Available	Source 1 is Available	STS cannot switch
Relay 7	Not Available	Source 2 is Available	Auto Retransfer is inhibited
Relay 8	Not Available	Output is OK	STS is on the Alternate Source (not the Preferred Source)
NOTE: Closed dry contacts signal the conditions shown in this table.			

2.15.4 Dry Contact Input Signals

Contractor Boards shall have connections for dry contact input signals from an external source. The following input signals shall be available:

- **Remote EPO** shuts down the STS.
- **Remote Select S1** or **Remote Select S2** causes the STS to switch to that designated source.
- **Building Alarm 1-8** are input signals for various building sensors, such as fire, temperature, cooling failure, or underfloor water. The name of the Building Alarm is specified in the points list. A building alarm shall cause a point to be activated in the points list, but shall cause no other action.

External Dry Contact Signal	Basic Contractor Board	Enhanced Contractor Board
Remote EPO	Available	Available
Remote Select S1	Not Available	Switch to Source 1
Remote Select S2	Not Available	Switch to Source 2
Building Alarm 1	Name Definable	Name Definable
Building Alarm 2	Name Definable	Name Definable
Building Alarm 3	Name Definable	Name Definable
Building Alarm 4	Name Definable	Name Definable

External Dry Contact Signal	Basic Contractor Board	Enhanced Contractor Board
Building Alarm 5	Not Available	Name Definable
Building Alarm 6	Not Available	Name Definable
Building Alarm 7	Not Available	Name Definable
Building Alarm 8	Not Available	Name Definable

2.15.5 Remote Source Select Option

The STS shall have a "Remote Source Select Option" that functions as follows:

Two external two dry contacts can be used to control the remote selection of the preferred source. Dry contact closures are generally used when two UPSs supply power to the system. If the preferred UPS goes to bypass mode, the "good" UPS becomes preferred:

- Signal 1 (Remote Select S1) dry contact closure will make Source 1 preferred.
- Signal 2 (Remote Select S2) dry contact closure will make Source 2 preferred.
- If both dry contacts closures are open, the preferred source control is returned to the system operator control panel.

Any remote control signal or closure puts the unit into a "Retransfer=Yes" mode to ensure system redundancy. Normally the closures are controlled by auxiliary contacts in the UPS bypass circuit breakers. If both dry contacts close, the first input to the STS is recognized.

2.15.6 Multi-Switch Link Option (N+1 UPS)

The STS shall have a "Multi-Switch Link Option (N+1 UPS)" that functions as follows:

In an N+1 UPS Configuration, there are multiple STS units, each with a preferred source fed by a separate UPS. The alternate source on all STSs is provided by a single backup UPS.

All STS units in an N+1 UPS configuration must have Enhanced Contractor Boards and the Multi-Switch Link Option installed, providing coordination among the STSs.

Because the backup UPS can only provide power through the STS to a single downstream load, when an STS transfers its load to the backup UPS, the STS must signal the other STS units that it is using the UPS. The other STS units are locked out and cannot transfer to the backup source.

An "Inhibit Transfer" alarm is signaled on each STS. The STSs are prevented from transferring until the Preferred Source on the STS using the backup UPS returns to normal and the STS retransfers the load back to the Preferred Source.

2.16 Web Pages

The STS shall be able to act as a web server to display STS status pages over an appropriately configured customer Ethernet connection using TCP/IP. For security reasons, web pages shall viewable, but no changes in STS parameters or controls can be made through the web server. For example, users shall not be able to reset alarms.

The following web pages shall be available:

- Home
- One-Line, showing one-line mimic view of power flow, MCCBs, and MCSWs.
- Analog, showing analog (metered) values
- Log, showing Event Log
- Alarms, showing outstanding alarms
- Waveforms, showing waveform plots, similar to Plots screen
- Service screen
- Contact PDI screen

Some web pages require a Java-enable browser.

3 Execution

3.1 Packing and Shipping

The STS shall be adequately packaged to prevent damage to the unit while in transit. Each STS shall be braced and strapped to a palette and enclosed in a protective covering.

3.2 Factory Testing

The complete STS shall be inspected and tested in the factory to demonstrate full compliance with manufacturer's standard test procedures and the purchase specification.

Factory testing shall include the following tests:

- A complete visual inspection of the equipment, both internally and externally.
- A complete test of the equipment including static switch transfers and operations.
- A complete test of all controls and control panel including verification of proper operation of all metering and monitoring parameters and alarm annunciation.
- A complete hi-pot test of the power components.
- Equipment load test.

3.3 Factory Witness Test

The manufacturer shall allow the customer to witness the factory testing of each unit. The factory shall perform its standard witness test to demonstrate that the unit meets PDI's STS specifications.

3.4 Certified Test Report

A certified factory test report shall be provided for each unit.

3.5 Installation

Customer shall be responsible for site preparation and correct installation of the STS in accordance with provided product data, final shop drawings, and manufacturer's written recommendations and installation instructions.

3.6 Start-Up

A PDI-authorized representative shall validate correct installation and operation of the STS at initial STS start-up. Validation shall be required to initiate warranty coverage.