

# **EPSILON**

## **STATIC TRANSFER SWITCH**

**100 A - 600 A Three Phase Static Transfer Switch**

### **TECHNICAL SPECIFICATION**

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## **1.0 INTRODUCTION**

### **1.1 SCOPE**

This Technical Specification for the EPSILON Static Transfer Switch provides the technical details of the design for a line of digital, solid-state, three-phase transfer switches to be used for connecting critical loads to one of two independent sources in redundant power supply systems. In addition to hardware and software design criteria, the theory of normal operation and operation under various other conditions (fault included) are specified for the STS design.

### **1.2 DEFINITIONS, ACRONYMS & ABBREVIATIONS**

STS: Static Transfer Switch  
SCR: Silicon Controlled Rectifier  
FPGA: Field Programmable Gate Array  
UL: Underwriters' Laboratory  
PMM: Power Management Module  
MTBF: Mean Time Before Failure  
MTTR: Mean Time To Replace

### **1.3 REFERENCES**

UL1008 (5<sup>th</sup> Edition-11/96) : Safety Standard for Transfer Switch Equipment.  
IEEE 446 (1987) : Power Quality requirements prescribed by CBEMA.

### **1.4 OVERVIEW**

The EPSILON100 STS design shall be used for stand-alone units or for attachment to PMM's in the PMM Plus and PMM Ultra configurations, which requires that the STS enclosure matches the PMM in height and depth. Future projects may include integrating the STS into the PMM and developing a separate stand-alone STS line with increased height and smaller footprint.

## **2.0 PRODUCT DESCRIPTION**

### **2.1 GENERAL TOPOLOGY**

The MGE Digital Static Transfer Switch is a solid state, three-phase, break-before make, dual position switch designed to connect a critical three-phase load to one of two separate, independent, synchronized sources of three-phase power and provide voltage to its output terminals for any load from 0-100% of its rating. The STS shall consist of six pairs of SCR's connected in an AC switch configuration. Each 3-phase input shall be fed through a molded case automatic switch which provides short circuit protection by means of a magnetic trip only. The switch shall then feed three pairs of "hockey-puck" SCR's, each pair consisting of two SCR's in an anti-parallel arrangement. The SCR outputs for each corresponding phase from both inputs will then be connected and fed through an output isolation molded case switch to the output terminals. These SCR's shall be rated to carry the full 100% load (continuous rated) while operated as stipulated herein and at the maximum ambient temperature specified.

The source to which the load is normally connected to shall be designated as the "Preferred" source, and the other redundant, standby source as the "Alternate" source. Selection of which input source is preferred is user selectable from the operator control panel, by control contact inputs, or through the communications port(s).

In normal operation, the load shall be connected to the preferred source as long as all phases of the preferred source are within the acceptable limits. Upon failure of the preferred source (more degraded than the alternate source), the load will be transferred to the alternate source until such time as the preferred source returns to within acceptable limits. If while on the preferred source, the

alternate source falls outside acceptable limits (out of tolerance), then automatic transfer will be inhibited until the alternate source returns to within acceptable limits.

The STS solid-state switching devices will be “hockey-puck” type SCR’s with a minimum peak inverse voltage rating of 1800 volts continuous at 125° junction temperature and open gate conditions for reliability. The thermal margin on junction temperature at full load current will be at least 25°C below maximum junction temperature for an ambient temperature of 40°C. Cooling shall be natural convection two-sided cooling with heatsinks on models rated 200A and lower. Forced air-cooling using fans (with one redundant fan) will be used on models rated 400A and higher.

SCR’s will have a rupture rating or be protected in a manner compatible with the specified fault current availability. Rupture protection may be eliminated if the SCR overload capability can sustain a dead short on the load side. Fuses will not be used on the SCR’s if possible. Molded case switches with magnetic trips will be used to provide short circuit protection only. Upstream and/or downstream devices must provide over-current protection.

Transfers and re-transfers between sources shall be break-before-make and control logic will have protective sensing circuits to ensure that there is no cross-connection between the two sources.

A separate redundant circuit for backfeed protection shall be provided to ensure that there is no cross-connection between the two sources in the event of a shorted SCR on the inactive side with the upstream circuit breaker open.

Keyed interlocks shall be provided on the two bypass switches to prevent closure of both at the same time. An optional interlocking scheme will be offered for additional keyed interlocks on the source isolation switches to ensure that prior to bypassing to a particular source, the STS transfers the load to that source (if the load is not already being powered by that source). On closure of a bypass switch, the control logic will also shunt trip opposite bypass and input isolation switches if necessary to prevent cross-connection of the two sources.

The microprocessor-based core control will use FPGA’s for input and output signal processing and control sequencing. Separate analog-to-digital (A/D) circuits will allow selection of faster and more accurate devices to optimize sensing time.

The STS will be certified to the UL1008 Standard and C-UL certified for Canada.

## **2.2 ELECTRONIC CONSTRUCTION**

All active electronic devices will be solid-state. All relays will be sealed with covers. All capacitors will be non-PCB type and internally protected in accordance with applicable UL standards. All circuit boards and relays will have mechanical restraints designed to prevent loosening of these devices while in transit, being relocated or in service.

The design shall allow a minimum of 25°C operating margin from the maximum allowable junction temperature of all solid-state semiconductor devices.

Subassemblies will be constructed for ease of access and replacement of parts. All subassemblies will be front, top or side accessible. Circuit boards will use industry-accepted connectors. The equipment will be constructed so that each power component can be replaced without soldering. MTTR for any assembly will not exceed 15 minutes.

All internal circuit cards will employ connectors with corrosion-resistant pins for reliability. Some circuit boards will have LED indicators to annunciate critical board functions for ease of troubleshooting and maintenance.

All circuit cards will be screened against premature failure and have the ability to report diagnostics and failures to the central display.

**3.0 PRODUCT SPECIFICATIONS**

**3.1 TECHNICAL RATINGS**

<b>Nominal Input Voltage:</b>	208, 220, 240, 440, 480, 575, 600 VAC ± 15%, three (3) phase, three (3) wire plus ground.
<b>Nominal Output Voltage:</b>	208, 220, 240, 440, 480, 575, 600 VAC ± 15%, three (3) phase, three (3) wire plus ground to correspond with input voltage.
<b>Maximum Continuous Current:</b>	100, 200, 400, 600 Amps.
<b>Molded Case Switch Rating:</b>	250, 400, 600 Amps.
<b>Input/Output Frequency:</b>	50/60 Hz ± 5 Hz.
<b>Load Power Factor:</b>	Unity to 0.60 lagging or leading.
<b>Non-Linear Loads Capability:</b>	100% of its rating up to maximum crest factor of 3.5.
<b>Overload Rating:</b>	150% for 15 minutes; 1000% for three(3) cycles.
<b>Source Voltage Distortion:</b>	Up to 10% THD with notching and ringing transients.
<b>Output Voltage Distortion:</b>	Less than 1% added.
<b>Voltage Transient Withstand:</b>	Up to 6 kV (6000 volt spike) per IEEE C62.41 for Cat. B3. Meets EN 50082-1(with optional TVSS installed). Such transient levels shall not effect the operation of the STS. The STS may transfer on over-voltage conditions.
<b>Short Circuit Withstand:</b>	Up to 100kA.
<b>Harmonic Current Feedback from the Load:</b>	Unlimited.
<b>Emission Limits:</b>	Meets FCC Part 15 Class A, EN 50081-2
<b>Sense and Transfer Time:</b>	¼ cycle (4.17 milliseconds) total sense and transfer time maximum.
<b>Control Power Supplies:</b>	Triple redundant with failure alarm.
<b>SCR Detection:</b>	Open and shorted SCR detection.
<b>Cooling and Fans:</b>	Convection Cooling on 200A model. Forced air cooling with redundant fan(s) on 400A and 600A models.
<b>MTBF:</b>	>400,000 hours per MIL 217F.

**3.2 PHYSICAL SPECIFICATIONS**

<b>Enclosure Type:</b>	NEMA 1, Free-standing, modular configured with hinged dead front construction protecting high voltage areas.
<b>Enclosure Dimensions:</b>	<b>Depth:</b> 30" to match existing PMM line. System shall pass through standard 36" wide door. <b>Height:</b> 72". <b>Width:</b> 24" or less for 200A STS; 42" or less for 400A and 600A STS. (Future optional configurations for integration with the PMM or for stand-alone STS's may offer different dimensions).

<b>Accessibility:</b>	Front access for operation and maintenance. Front or side access for customer power connection points.
<b>Power Connections/Busbars:</b>	All power connections and terminations to be solid copper braced rated for 100KAIC. (400/600A models may be a combination of copper bus bars and cables).
<b>Cable Entry:</b>	Top and Bottom.
<b>Mounting:</b>	360° Casters and Leveling Jacks with 1” minimum adjustment.

**3.3 ENVIRONMENTAL CHARACTERISTICS**

<b>Operating Temperature:</b>	+10°C to +40°C.
<b>Storage Temperature:</b>	-10°C to +60°C.
<b>Relative Humidity:</b>	10% to 95% non-condensing.
<b>Operating Altitude (above sea level):</b>	0 to 8,500 feet.
<b>Non-Operating Storage/Transport Altitude:</b>	-150 to 50,000 feet.
<b>Audible Noise:</b>	Less than 65 dBA at 5 feet (with audible alarm off) or as appropriate for kVA rating per NEMA ST-20.

**3.4 AGENCY STANDARDS, APPROVALS & COMPLIANCES**

The STS system shall be designed, manufactured, tested, and installed in accordance with:

- American National Standards Institute (ANSI)
- Underwriters Laboratories (UL) 1008 (5<sup>th</sup> Edition-11/96) : Safety Standard for Transfer Switch Equipment.
- Underwriters Laboratories (UL) 1950: Safety of Information Technology Equipment, including electrical business equipment
- C-UL (UL Certified for Canada)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Electric Code (Article 702, NEC - NFPA 70-1996)
- National Electrical Manufacturers Association (NEMA) – ST-1; ST-20; AB1
- National Fire Protection Association (NFPA)
- International Organization for Standardization (ISO 9001 Quality Assurance)
- FCC Part 15 Class A (47 CFR 0-19)
- Federal Information Processing Standards (FIPS)

The STS system shall be certified by a national testing laboratory: Underwriters Laboratories(UL).

**4.0 THEORY OF OPERATION**

**4.1 Automatic Transfers**

Automatic “fast” transfer of the load from one source to the other shall be accomplished by turning off the “active” source SCR’s and turning on the “inactive” source SCR’s in a sequence and timing that allows a combined sense and transfer time of less than one quarter cycle (4.17ms).

Automatic transfer will be initiated under any of the following conditions, provided transfer is authorized and the “inactive” source is not more degraded than the “active” source:

- a) Under-voltage (Fast or Slow) on any phase of the “active” source. On sensing a Peak Current Overload condition, a check will be made for an undervoltage condition indicating that the under-

voltage condition caused the overload. In this case, automatic transfer will be inhibited, the fault is memorized (manual reset required) and the load will stay on the “active” source until the overload condition is cleared and the system is reset.

- b) Over-voltage (Slow) on any phase of the “active” source.
- c) Under-frequency of the “active” source.
- d) Over-frequency of the “active” source.
- e) Open SCR on the “active” side (transfer to “inactive” side, then shunt trip “active” CB and inhibit re-transfer until repair is made and the system is reset).
- f) Shorted SCR on the “inactive” side (transfer to shorted “inactive” side, then shunt trip previously “active” CB to prevent retransfer. Inhibit transfers and re-transfer until repair is made and the system is reset).
- g) SCR Over-temperature on the “active” side (if there are no current overload faults, transfer to “inactive” side and inhibit re-transfer until repair is made and the system is reset. If “inactive” side subsequently fails, transfer back to the “active” side if it is within acceptable limits, including over-temperature limits).
- h) SCR Gate Drive power supply failure on the “active” side (transfer to “inactive” side and inhibit re-transfer until repair is made and the system is reset).
- i) MOV (TVSS) failure on the “active” side.

## **4.2 Manual Transfers**

The STS can be operated as a manual switch when the “Manual Control” keyed switch on the front panel is in the ON position, enabling the manual control pushbuttons and some setpoint changes, for the following manual operations:

- a) Manual “Change Preferred Source” Pushbutton – Selects other source as preferred, causing a transfer (without break) to the selected source if it is available and within acceptable limits and is not the active source. If the two sources are outside the preset “in sync” phase window, a transfer (with break) can be made by pressing the manual “Override Limits” pushbutton simultaneously. (Pre-conditions: “Manual Control” switch in ON position; “inactive “ source is available and within acceptable limits).
- b) Manual “Return to Preferred Source” Pushbutton - If auto-re-transfer is disabled, pressing this pushbutton will temporarily enable auto-retransfer and initiate a re-transfer back to the preferred source, overriding owner selected auto retransfer time delay. Then auto-retransfer will again be disabled after this manual retransfer.

To prevent normal automatic transfers, the operator can use the “Change Preferred Source” pushbutton to transfer to the desired source, and then shut down the feeder to the other “inactive” source.

## **4.3 Automatic Re-transfers**

Automatic re-transfer of the load from the alternate source back to the preferred is accomplished by turning off the “active” alternate source SCR’s and turning on the “inactive” preferred source SCR’s. This is done in a sequence and timing that allows a combined sense and transfer time of less than one quarter cycle (4.17ms). Providing the “inactive” preferred source is not more degraded than the “active” alternate source, re-transfer will occur under the following conditions:

- a) If re-transfer is not prohibited, re-transfer will occur after an owner selected time delay after the preferred source becomes available and within acceptable limits.
- b) If re-transfer is prohibited, re-transfer can be manually initiated by pressing the manual “Return to Preferred Source” Pushbutton (Pre-conditions: “Manual Control” switch in ON position; “inactive “ preferred source is available and within acceptable limits). Transfer is temporarily authorized for a preset time.

#### **4.4 Transfer Authorization/Prohibition**

Transfer is prohibited under the following conditions (memorized conditions require manual system reset):

- a) Transfer Prohibit Input from the operator control panel, control contact input, or communications port
- b) Peak Current Overload
- c) External Power Fault (peak current overload caused by undervoltage) - Memorized
- d) Over-temperature (active or inactive switch) - Memorized
- e) Shorted SCR (active or inactive switch) – Memorized
- f) Open SCR (active switch) – Memorized
- g) Reverse Power
- h) Inactive source Out-of-Tolerance
- i) Inactive source Power Supply Fault
- j) Phase Rotation Fault
- k) Inactive input isolation switch open

#### **4.5 Maintenance Bypass / Molded Case Switches / Live System Test**

##### **4.5.1 Switch Arrangement**

A manually operated maintenance bypass switching arrangement shall be included to permit complete isolation of the static switch SCR assemblies for servicing without disrupting power to the critical loads.

The maintenance bypass shall consist of:

- a) STS input isolation switch. One for each static switch SCR assembly (two total - CB1, CB2).
- b) STS output isolation switch. One for both static switch SCR assemblies (one total - CB3A). (A second redundant output isolation switch (CB3B) is available as an option).
- c) Maintenance bypass switch. One for each static switch SCR assembly (two total – CB4, CB5).

All STS circuit breakers will be automatic switches with magnetic trip only with plug-in bases for ease of removal for replacement, calibration or testing, without interruption of power to the critical load. All switches shall be equipped with shunt trips and auxiliary contacts. Continuously activated shunt trips will not allow closing of the switch (not even as much as a contact to contact touch).

##### **4.5.2 Electrical Bypass Switch Interlock**

If either maintenance bypass switch is closed, the opposite maintenance bypass switch will be electrically shunt tripped.

##### **4.5.3 Electric Input-Bypass Switch Interlock**

If the output switch and either maintenance bypass switch are closed, the opposite input isolation switch will be electrically shunt tripped.

##### **4.5.4 Mechanical Key Interlocks**

Mechanical Kirk key interlocks will be provided on the two maintenance bypass switches (CB4 and CB5) to prevent an operator from closing both bypass switches at the same time. A single key will allow closure of one switch at a time. Additional key interlocks on the two STS input isolation switches (CB1, CB2) to ensure that the STS is on the source that the operator intends to bypass to, are available as an option.

##### **4.5.5 Live System Test**

While in maintenance bypass, and with the STS output isolation switch off, the STS can be tested with both sources connected to the STS through the input isolation switches (using the SCR's to make actual transfers).

##### **4.5.6 EPO**

In the event of an Emergency Power Off (EPO) condition, all switches shall be shunt tripped.

**4.6 Preferred Source Selection (Symmetrical Operation)**

At the operator's option and without any degradation of performances or loss of protective features, the unit may be operated with either source designated as the "preferred" source. Also, the current "alternate" source can be switched to be the "preferred" source (using LCD screen, the manual hard key, comm. port or remote input contact).

**4.7 Sensing and Transfer Times**

Voltage and/or current sensing using fast digital conversion techniques shall be employed for both sources to meet a maximum 2 milliseconds sensing time requirement (to sense a deviation of power quality outside of user parameters).

Total sense and transfer time shall be ¼ cycle (4.17 milliseconds) maximum.

**4.8 Overload Operation**

On sensing a Peak Current Overload (Crest factor setting: 3.5 maximum.), automatic transfers will be inhibited and the load will stay on the "active" source until the overload condition is cleared. On sensing Peak Current Overload condition, a check is made for an under-voltage condition indicating that the under-voltage condition caused the overload. Automatic transfer is inhibited and the load will stay on the "active" source until the overload condition is cleared and the system is reset (this fault condition is memorized).

An "Overload" alarm will be given if the load current exceeds the RMS current overload setting for more than 30 seconds. This overload condition will not cause an automatic transfer.

**4.9 Shorted SCR Protection (including Backfeed Protection)**

The STS design shall include sensing circuits to detect a shorted SCR and in addition to the following actions, will initiate audible and visual alarms:

- a) In the event of a shorted SCR in the active side powering the load, the unit will alarm, and stay on the active side. Then the SCR isolation switch on the inactive side will be shunt tripped to prevent transferring to the "inactive" source. Automatic transfer and re-transfer will be inhibited until repair is made and the system is reset.
- b) In the event of a shorted SCR in the non-conducting SCR in the in-active side that is not powering the load at the time, the unit will alarm. The STS will immediately transfer the load to the inactive side to eliminate cross-connect current between the shorted sources. The SCR isolation switch in the previously active side will be shunt tripped to prevent re-transfer. Automatic transfer and re-transfer will be inhibited until repair is made and the system is reset. A separate redundant backfeed protection circuit will be provided.

**4.10 Open SCR Protection**

The STS design shall include sensing circuits to detect an open SCR and in addition to the following actions, will initiate audible and visual alarms:

- a) In the event of an open SCR in the active side powering the load, the unit will alarm and immediately transfer to the inactive side. Then the SCR isolation switch on the previously active side will be shunt tripped. Automatic retransfer will be inhibited under such conditions until repair is made and the system is reset.

**4.11 Source Cross-Connection Protection**

The STS transfer logic will check that the two input sources, of any combinations, are never connected in a fashion to allow current flow from one source to the other without first passing through the load. The logic circuitry will have protective sensing circuits that prohibit this conduction. Transfers and re-transfers between sources will be break-before-make to prevent any cross-conduction, even in out-of-phase conditions.

4.12 Settings – Fixed and Adjustable

**Voltage Rating:** 208V 220V 240V 440V 480V  
**Current Rating:** 100A 200A  
**Frequency Rating:** 50Hz 60 Hz (Default: 60 Hz)

Table of personalization accessible via front panel display

Parameter (Configuration)	Setting Range	Default Setting
Nominal Voltage Rating	208V, 220V, 240V, 440V, 480V, 575V, 600V	480V
Nominal Frequency Rating	50 Hz, 60 Hz	60 Hz
Maintenance Mode	0: inactive / 1: active	0
Parameter (Transfer)	Setting Range	Default Setting
Automatic Re-transfer Authorization	0: authorized / 1: forbidden	0
Auto-Re-transfer Delay (Tret)	1 second to 5 minutes (1 sec. steps)	1 sec.
Transfer Break Time Delay (Ttrou)	0 second to 3 seconds (10 msec. steps)	0 msec.

Table of personalization accessible via J-BUS

Parameter (Advanced Configuration)	Setting Range	Default Setting
Zone	E: EMOA / N: NASA	N
Nominal Current Rating	100A, 200A, 400A, 600A	200A
Neutral Present	0: No / 1: Yes	0
Supply starting from the load	0: No / 1: Yes	0
Transfer Abort Delay (Tno_trans)	10 seconds to 30 minutes (1 sec. steps)	60 sec.
Operating Time		0
Automatic Transfer Authorization	0: authorized / 1: forbidden	0
Slow Under/Over-Voltage Delay (Tcdult)	1 msec. to 20 msec. (1 msec. steps)	10 msec.
RMS Under/Over-Voltage Delay (Tcdurms)	200 msec. to 5 seconds (100 msec. steps)	1 sec.
Detection of UV w/Overload Delay (Tcdcc)	1 msec. to 20 msec. (1 msec. steps)	5 msec.
RMS Current Overload Delay (Tcsi110)	-	30 sec.
Regular Out-of-Sync Delay (Tdph12)	5 periods to 15 periods (1 period steps)	10 periods
Rolling Out-of-Sync Delay (Tdph12p)	1 period to 5 periods (1 period steps)	2 periods
SCR Queue Delay (Tqueue)	100 µsec. to 500µsec. (50µsec. steps)	300µsec.
Parameter (Tolerances)	Setting Range	Default Setting
Fast Over-Voltage	+20% to +32% (1% steps)	+25%
Fast Under-Voltage	-20% to -32% (1% steps)	-25%
Slow Over-Voltage	+5% to +20% (1% steps)	+10%
Slow Under-Voltage	-5% to -20% (1% steps)	-10%
RMS Over-Voltage	+5% to +20% (1% steps)	+15%
RMS Under-Voltage	-5% to -20% (1% steps)	-15%
Over-Frequency	+1% to +10% (1% steps)	+5%
Under-Frequency	-1% to -10% (1% steps)	-5%
In Phase Window	0° to ±45° (5° steps)	±15°
Peak Current Overload (I <sub>rms</sub> x Crest Factor)	(x 3.5) fixed	3500
Parameter (Hysteresis)	Setting Range	Default Setting
Fast Over/Under-Voltage Hysteresis	0% to 6% (1% steps)	3%
Slow Over/Under-Voltage Hysteresis	0% to 6% (1% steps)	3%
RMS Over/Under-Voltage Hysteresis	0% to 3% (1% steps)	1%
Over/Under-Frequency Hysteresis	0% to 5% (1% steps)	2%

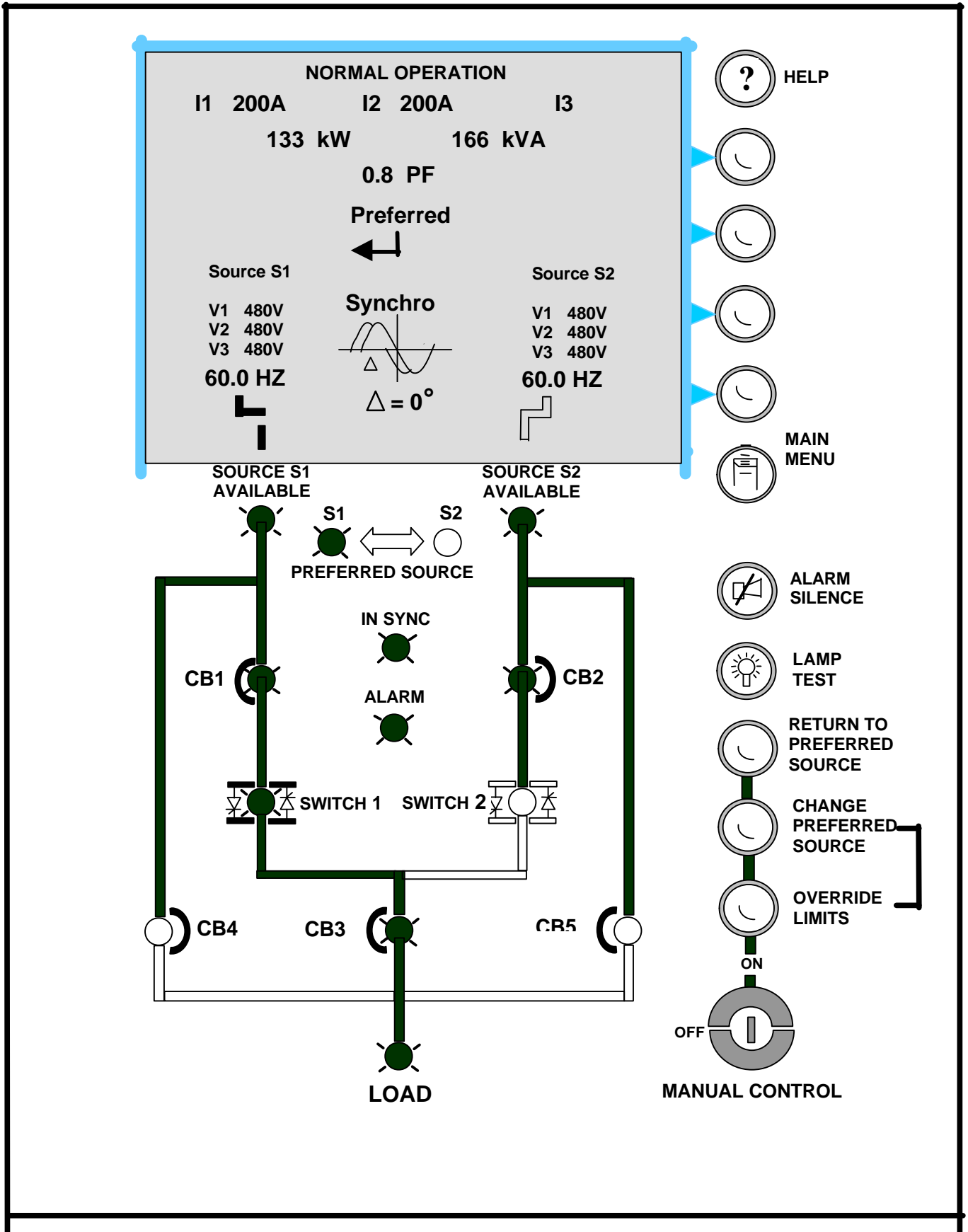
Table of Industrialization personalization

<b>Parameter (Sensor)</b>	<b>Setting Range</b>	<b>Default Setting</b>
Technical Voltage Gauge : CteU	208V, 220V, 240V, 440V, 480V, 575V, 600V	600V
Technical Sensor Voltage Gauge : CaptV	132V, 140V, 152V, 279V, 305V, 365V, 381V	381V
Technical Current Gauge : Cte I	100A, 200A, 400A, 600A	600A
Technical Sensor Current Gauge : Capt I	100A, 200A, 400A, 600A	600A
Output Voltage of Sensor V @ Vn : VsV	7.09V	7090
Output Voltage of Sensor I @ In : Vsl	2.857V	2857
Time Base of FPGA: Tb in second	Base_Temps_fpga	100
<b>Parameter (Application)</b>	<b>Setting Range</b>	<b>Default Setting</b>
Serial Number of STS	Num_serie	00000000

Missing:

Preferred Source selection	0: S1 / 1: S2	0
Phase Rotation	0: ABC / 1: CBA	0

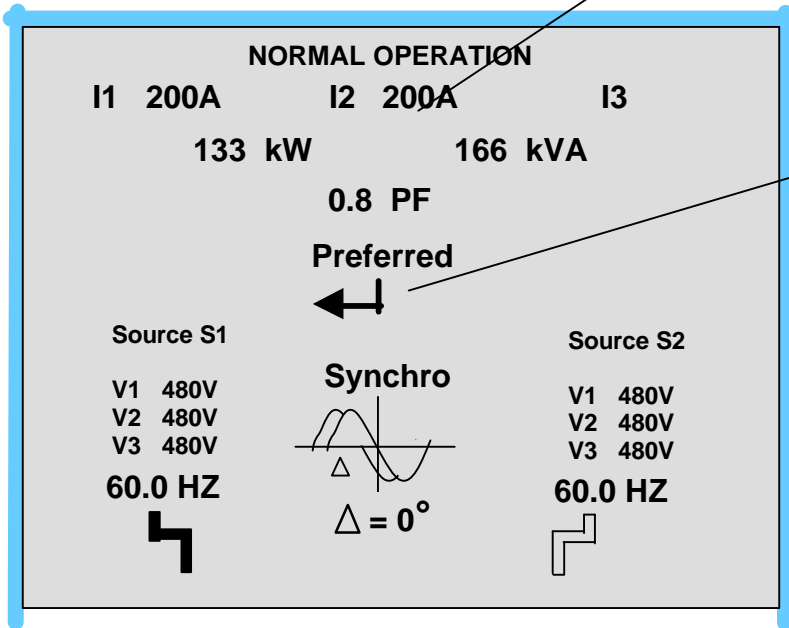
4.13 Front Control Panel Description/Operation



**LCD SCREEN:**

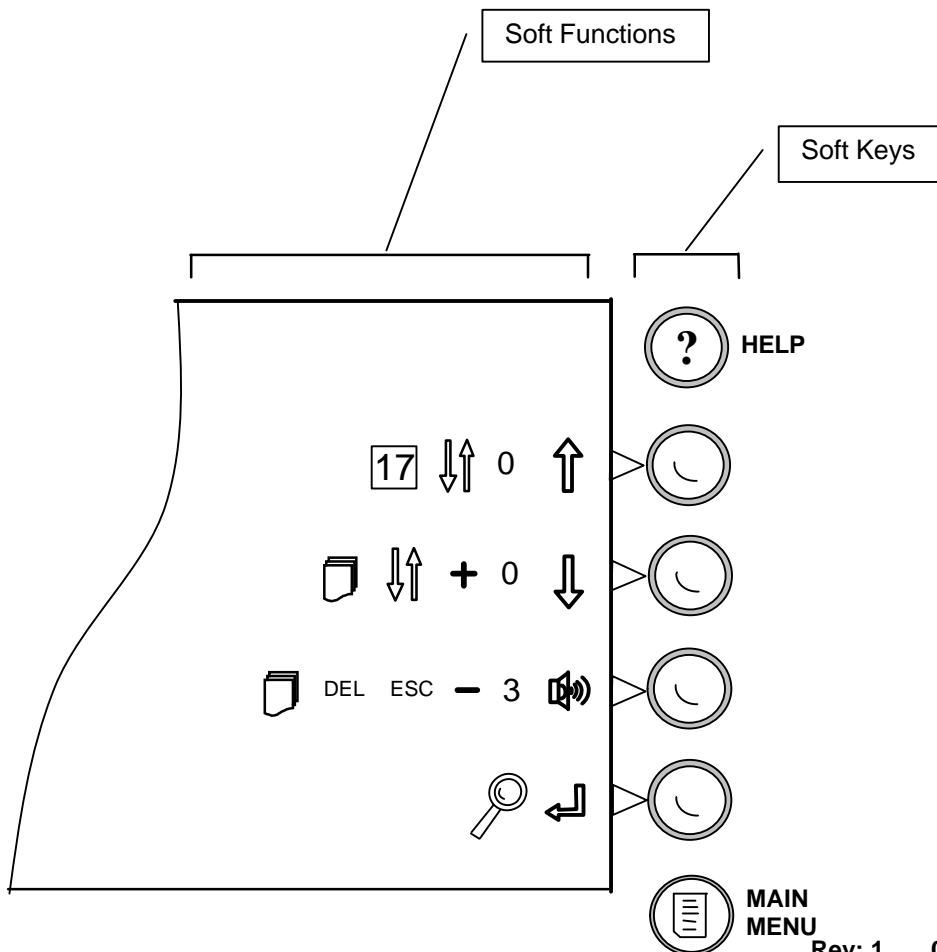
**Visual/Audible Alarms**

- access separate screen to view alarms.
- see alarm message table.

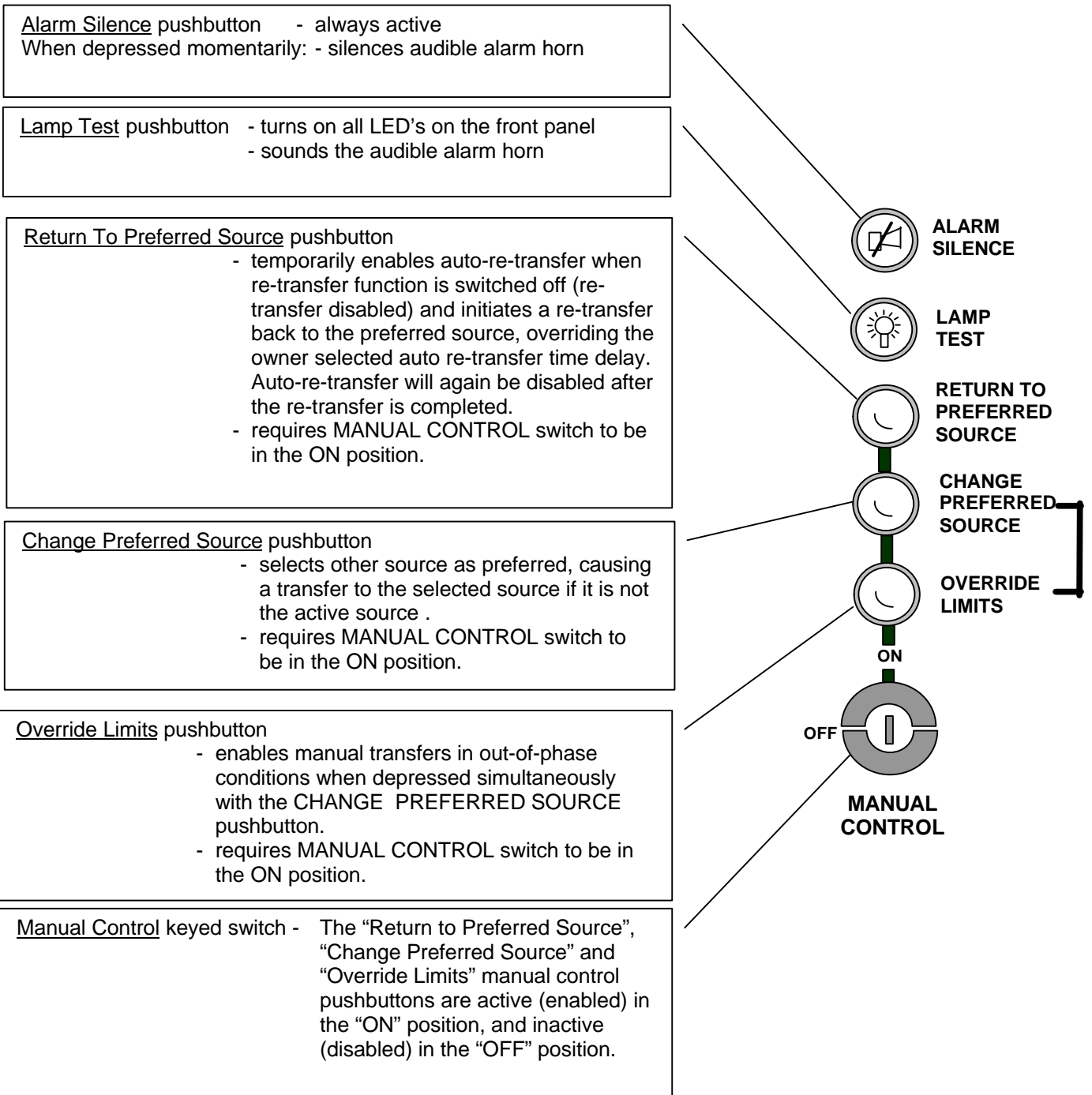


**Preferred Source Indication**

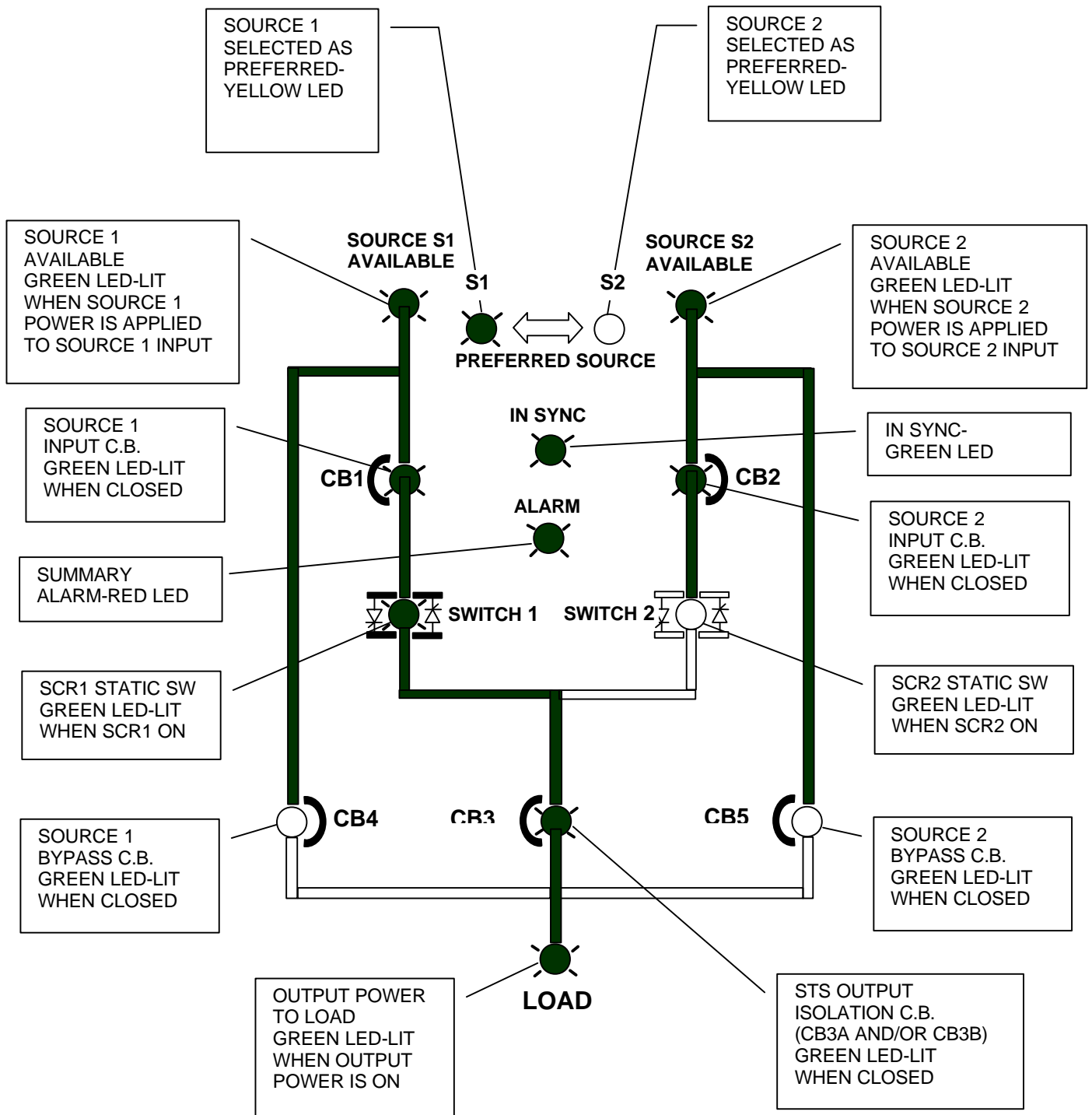
**SOFT KEYS:**



**HARD KEYS:**



**MIMIC DIAGRAM:**



#### 4.14 Alarms – Visual and Audible

Alarm Event	Visual (LCD)	Audible (Horn)	Latched	Auto Dial	Snap-Shot	Summary Alarm
Source 1 Phase Sequence	Yes	Yes	Yes			Yes
Source 2 Phase Sequence	Yes	Yes	Yes			Yes
Source 1 Over-Voltage	Yes	Yes	Yes	Yes	Yes	Yes
Source 2 Over-Voltage	Yes	Yes	Yes	Yes	Yes	Yes
Source 1 Under-Voltage	Yes	Yes	Yes	Yes	Yes	Yes
Source 2 Under-Voltage	Yes	Yes	Yes	Yes	Yes	Yes
Source 1 Over-Frequency	Yes	Yes	Yes	Yes	Yes	Yes
Source 2 Over-Frequency	Yes	Yes	Yes	Yes	Yes	Yes
Source 1 Under-Frequency	Yes	Yes	Yes	Yes	Yes	Yes
Source 2 Under-Frequency	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR1A	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR1B	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR1C	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR2A	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR2B	Yes	Yes	Yes	Yes	Yes	Yes
Open SCR2C	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR1A	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR1B	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR1C	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR2A	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR2B	Yes	Yes	Yes	Yes	Yes	Yes
Shorted SCR2C	Yes	Yes	Yes	Yes	Yes	Yes
Source 1 Peak Current Overload	Yes	Yes	Yes	Yes	Yes	Yes
Source 2 Peak Current Overload	Yes	Yes	Yes	Yes	Yes	Yes
Current Overload(>110% >30 sec. warning)	Yes	Yes	Yes	Yes	Yes	Yes
Source 1 Blown MOV Fuse	Yes	Yes	Yes			Yes
Source 2 Blown MOV Fuse	Yes	Yes	Yes			Yes
Source 1 CB1 Open	Yes	Yes				Yes
Source 2 CB2 Open	Yes	Yes				Yes
Bypass 1 CB4 Closed	Yes	Yes				Yes
Bypass 2 CB5 Closed	Yes	Yes				Yes
Output CB3A Open	Yes	Yes				Yes
Output CB3B Open	Yes	Yes				Yes
Auto Transfer Inhibited	Yes	Yes	Yes			Yes
Out of Sync	Yes	Yes				Yes
Auto Re-Transfer Disabled	Yes	Yes	Yes			Yes
Auto Re-Transfer Failed	Yes	Yes	Yes			Yes
Control Pwr Supply 1 (S1) Failure	Yes	Yes	Yes	Yes	Yes	Yes
Control Pwr Supply 2 (S2) Failure	Yes	Yes	Yes	Yes	Yes	Yes
Control Pwr Supply 3 (Output) Failure	Yes	Yes	Yes	Yes	Yes	Yes
Control Pwr Supply 4 (EPO) Failure	Yes	Yes	Yes	Yes	Yes	Yes
Control Logic (FPGA) Failure	Yes	Yes	Yes	Yes	Yes	Yes
SCR1 Over-Temperature	Yes	Yes	Yes	Yes	Yes	Yes
SCR2 Over-Temperature	Yes	Yes	Yes	Yes	Yes	Yes
Fan Failure	Yes	Yes	Yes	Yes		Yes
SCR1 Gate Power Supply Warning(+24V)	Yes	Yes	Yes	Yes	Yes	Yes
SCR2 Gate Power Supply Warning(+24V)	Yes	Yes	Yes	Yes	Yes	Yes
SCR1 Gate Power Supply Failure(+5,±15V)	Yes	Yes	Yes	Yes	Yes	Yes
SCR2 Gate Power Supply Failure(+5,±15V)	Yes	Yes	Yes	Yes	Yes	Yes
In Manual Control Mode	Yes	Yes				Yes

4.15 Status Indications

Condition	Visual (LCD)	Visual (Mimic)	Output Contact	Latched	Auto Dial	Snap-Shot	Summary Alarm
STS on Source 1	Yes	Yes	Yes				
STS on Source 2	Yes	Yes	Yes				
Source 1 Available	Yes	Yes	Yes				
Source 2 Available	Yes	Yes	Yes				
Summary Alarm	Yes	Yes	Yes				
In Sync	Yes	Yes	Yes				
Overload	Yes	No	Yes				
STS Auto Transfer Inhibited	Yes	No	Yes				
Source 1 is Preferred	Yes	Yes	No				
Source 2 is Preferred	Yes	Yes	No				
Source 1 ØA-B Voltage Meter	Yes	No	No				
Source 1 ØB-C Voltage Meter	Yes	No	No				
Source 1 ØC-A Voltage Meter	Yes	No	No				
Source 2 ØA-B Voltage Meter	Yes	No	No				
Source 2 ØB-C Voltage Meter	Yes	No	No				
Source 2 ØC-A Voltage Meter	Yes	No	No				
Load ØA Current Meter	Yes	No	No				
Load ØB Current Meter	Yes	No	No				
Load ØC Current Meter	Yes	No	No				
Output Load KVA Meter	Yes	No	No				
Output Load KW Meter	Yes	No	No				
Output Load PF Meter	Yes	No	No				
Phase Difference Meter	Yes	No	No				
PMM ØA-B Voltmeter	Yes	No	No				
PMM ØB-C Voltmeter	Yes	No	No				
PMM ØC-A Voltmeter	Yes	No	No				
PMM ØA-N Voltmeter	Yes	No	No				
PMM ØB-N Voltmeter	Yes	No	No				
PMM ØC-N Voltmeter	Yes	No	No				
PMM ØA Current meter	Yes	No	No				
PMM ØB Current meter	Yes	No	No				
PMM ØC Current meter	Yes	No	No				
PMM Neutral Current meter	Yes	No	No				
PMM KVA meter	Yes	No	No				

4.16 Event Log

Chronology shall be recorded of at least the last 2000 events including alarms, date and time stamped by an on-board real time clock, in the order of occurrence, with one resolution. Data is to be displayed on an alphanumeric LCD display with a text description of the alarm next to the event time. Data shall be retrievable via an RS-232 / RS-485 port for customer collection. The data logger shall function in a first-in first-out mode and shall be equipped with an internal battery connected to protect data in the event both power supplies experience an outage. Data shall remain in the log indefinitely for future review or evaluation.

4.17 Transfer Counter

The transfer counter shall be based on: 1) from first day use; and 2) since last reset, and will be date and time stamped.

4.18 Customer Interface / Connections

**Isolated Form C Relay Output Contacts (from core control output status signals):**

Indication						
STS on Source 1						
STS on Source 2						
Source 1 Available						
Source 2 Available						
Summary Alarm						
In Sync						
Overload						
STS Auto Transfer Inhibited						
PMM Overload Alarm						
Spare						
Spare						
Spare						

**Customer Control / Alarm Inputs (to core control input control signals):**

Condition						
Select Source 1 as Preferred						
Select Source 2 as Preferred						
Inhibit Auto Transfers						
Remote Emergency Power Off (REPO)						

**Standard Communications Port: RS232 / RS485 Serial Port**

**Options:**

- Dual Output Isolation Circuit Breaker.
- 4 Keyed Interlocks (Bypass & Source Isolation C.B.'s).
- Current-limiting circuit breakers (CB's w/thermal-magnetic trips) (instead of switches w/magnetic trips only).
- Transient Voltage Surge Suppression (TVSS) on each input source
- Up to two (2) optional communications cards (an additional RS232/RS485 communication port and / or and addition six relay dry contact alarm array) may be installed on the STS.