Engineering Specification
for
Power-One SLI 1500W Inverter
Slim Line series

Document ID: ES SLI 1500

Rev.	Date	Author	Description	Approved by	Approval Date
0.0	February 24 2002	Sauro Macerini	Draft		
0.1	July 4, 2002	Paolo Casini	detailed description of signals and parallelability		
0.2	August 7, 2002	Paolo Casini	Added remote on/off description		
0.3	December 18, 2002	Sauro Macerini	Overall revision and parameters alignment to actual product		
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0.7	August 21, 2006	Paolo Casini	More accurate specification of general failure signal		
0.8	December 22, 2006	Guido Fiesoli	Miscellaneous		

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1. Introduction

1.1. General

The scope of this document is to specify the electrical and mechanical specification of a 1500W inverter family for telecom applications:

48Vdc Input, 230Vac Output SLI 48-230 1500W
48Vdc Input, 115Vac Output SLI 48-115 1500W
24Vdc Input, 230Vac Output SLI 24-230 1500W
24Vdc Input, 115Vac Output SLI 24-115 1500W

The unit is designed to be mounted in a 19" rack. The cooling of the unit is fan assisted by four internal, ball bearing, long life, fans.

The inverter should be installed via front access in a 19" shelf and the input/output voltages, from source and to load, are provided via input/output connectors in the back side of the unit.

In the figures below are shown the main parts in the inverter's front panel.

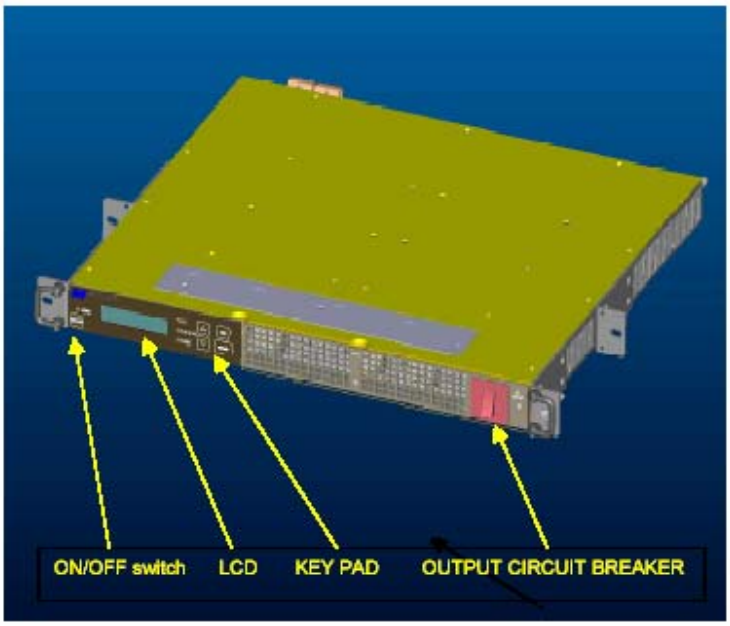


Figure 1 : Inverter front view

Details related to the input and output connectors are available at the chapter 3 in this specification.

1.2. Acronyms and Glossary

AC	Alternating Current
DC	Direct Current
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
GND	Ground
MTBF	Mean Time Before Failure
N/R	Not Required
OC	Over Current
OT	Over Temperature
OV	Over Voltage
TBD	To Be Defined
THD	Total Harmonic Distortion

1.3. Applicable documents

The following documents form a part of this specification:

UL 60950 3rd edition	Safety of Information Technology Equipment, including Electrical Business Equipment – Safety requirements.
EN 60950: 2000	Safety Standard for Information Technology Equipment.
CAN/CSA C22.2 No 60950-00	Safety of Information Technology Equipment, including Electrical Business Equipment – Safety requirements
IEC 60950:1999 3rd edition	Safety Standard for Information Technology Equipment.
EN 55022	Harmonised standard for conducted and radiated emissions.
EN 50082-1 (1997)	Electromagnetic Compatibility (EMC); Generic immunity standard. Part 1 – Residential, Commercial and light industry environment.
ETS 300 132	European Telecommunication Standard, Equipment engineering Power Supply interface at the input to telecommunication equipment, Stability & Safety requirements.
NEBS, GR-63-CORE	Bellcore, Network Equipment – Building System Requirements: Physical Protection – Environmental requirements part.
NEBS, GR-1089-CORE	Bellcore, Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment, EMC & Safety requirements.
ETS 300 019	European Telecommunication Standard, Environmental requirements for operation, transport and storage.
FCC Part 15	Federal Communication Commission, EMC, Conducted and Radiated Emission requirements

WARNING!
Figures between brackets refer to 24Vdc input models; underlined figures refer to 115Vac.

2. Electrical

2.1. Input Characteristics

2.1.1. Input Voltage Ratings

The unit is operational and turned-on over the following input voltages range:
40Vdc to 72Vdc (20Vdc to 36Vdc) at any load, from no load to full load. The unit is not damaged at any input voltage from 0Vdc to 75Vdc (0Vdc to 40Vdc).

A protection against input reverse polarity connection is provided via a diode, burning the input internal 70A (2 paralleled 70A) fuse.

2.1.2. Input Current

The maximum absorbed input current is 48A (100A) at full load and 36Vin (18Vin). Input Over Current protection is software controlled and can be changed from the front panel or remotely through RS485 port. The safety protection is provided by an internal 70A (2 paralleled 70A) Telpower® fuse. The rating of the fuse is such to guarantee that no hazardous conditions will be present in the case of a failure. The maximum RMS input ripple current generated by the inverter in the psophometric range is less than 1.5% of the DC average absorbed input current.

2.1.3. Input Over/Under Voltages

The unit is protected against Input OV and UV by an internal shutdown circuit. The unit switches off for input voltages lower than 36V (18V) +/- 1V and higher than 74V (37.5V) +/- 1.5V. An hysteresis of 3.5V (1.75V) is provided to prevent false triggering of the input UV threshold.

2.2. Output Characteristics

2.2.1. Voltage and Current Ratings

The Inverter has the following Output ratings: 230Vac *115Vac* -3%/+1% from Minimum Load to Full Load, 0 to 1500W resistive. Non resistive loads increase the regulation tolerance beyond 2%, specifically load with a power factor of 0.3 and/or crest factor 4 can results in the worst regulation of 4%. At no load condition the inverter works properly without damage.

2.2.2. Output Power

The maximum output Power is 1500W/1800VA *1500W/1600VA* at any input voltage value within the specified input voltage range and the ambient temperature within the range –25°C to +55°C. Between +55°C to +65°C, a 75W/°C linear thermal derating should applied to

the output load to avoid OT shutdown. The minimum output power at which the functionality of the unit is guaranteed is 0.0 VA.

2.2.3. Load Power Factor

The unit provide full power at any load with a power factor in the range from 0.33 to 1.

2.2.4. Crest Factor

The maximum allowed load crest factor is 4.

2.2.5. Ripple and Noise

The output voltage is provided, at minimum and maximum load, with the following peak to peak Ripple and Noise specifications: 2% of the nominal RMS output voltage including random and periodic deviations over the bandwidth 20Hz/20MHz.

2.2.6. Efficiency

The maximum peak efficiency of the inverter is typically greater than 93% for 48Vdc input and 230Vac version output, and 91% for 24Vdc input and 115Vac output version. The peak efficiency is available at maximum input voltage and approximately 75% of the output power on a resistive load.

2.2.7. Output Voltage and Frequency

The Inverter provides an Output Voltage of 230Vac *115Vac* at the frequency of 50Hz *60Hz* +/- 0,2%. The shape of the output voltage is a true Sine Wave with a Total Harmonic Distortion of 2% maximum (on a resistive load).

2.2.8. Inverter Protection Setup

Each type of protection can be customized from the front panel by the user. The protection mode are Latched, Autorestart “n” times, Autorestart Always . In the case of Autorestart, users can set the waiting time between each auto-restart tentative. The waiting time is an individual value for each protection.
The number of auto-restarts can be set in a range between 1 to 10 or Always. The internal controller considers a fault as part of a sequence if it occurs within 15 minutes from the first one.
All the protection settings are stored on a non volatile memory and automatically restored after each reset of the unit.
The default values are:
Autorestart 5 times, Wait time = 5s

2.2.9. Over Voltage Protection

The unit is equipped with two levels of Over Voltage protection. The higher threshold, Catastrophic OV, is set at 370Vpk *185Vpk* +/-2%. The catastrophic threshold is 2ms delayed and latches up the unit.

The lower threshold is set at 115% +/- 2% of the nominal RMS value and it is delayed 200msec. It turn-off the unit according to the inverter protection setup selected by the user (Latched or Autorestart).

2.2.10. Under Voltage Protection

The unit is equipped with Under Voltage protection. The threshold is set at 85% . +/- 2% of the nominal voltage, it is delayed 1sec and shutdown the unit according to the inverter protection setup selected by the user for the OV (Latched or Autorestart).

2.2.11. Short Circuit Protection

Short circuit protection is operated switching cycle by switching cycle by the current limit circuitry that limits the output current peak at 30A *60A* +/-10%. The over current protection will turn-off the unit if the short is longer than 200ms. An additional safety protection is provided by the 10A *15A* AC circuit-breaker that will disconnect both lines from the load in case of a catastrophic OC non controlled by the unit. At normal operation the OC protection acts faster than the circuit breaker in order to avoid manual intervention to restore the unit.

If the short circuit is removed, the unit returns to its normal operation according to the inverter protection setup selected by the user for the OC (Latched or Autorestart).

2.2.12. Over Current Protection

The Inverter is protected against Over Load. The Over current circuit will be active for loads of 8A *14A* +/-5% turning-off the unit. User can reduce this value from the front panel in the range between 1A and 8A *14A* . The OC is delayed 200ms.

At normal operation the OC protection acts faster than the circuit breaker in order to avoid manual intervention to restore the unit.

If the OC is removed, the unit returns to its normal operation according to the inverter protection setup selected by the user (Latched or Autorestart).

2.2.13. Over Temperature Protection

The unit shuts down if the inlet ambient temperature exceeds 67°C. An additional internal OT monitoring the power devices, avoids the components to exceed a safe temperature (100°C).

An acoustic and visual indication becomes active 5°C before having reached one of the two OT protections (int. or ext.) flashing the O.T. led and activating the internal buzzer with a 2s period signal. The acoustical indication can be disabled from the front panel.

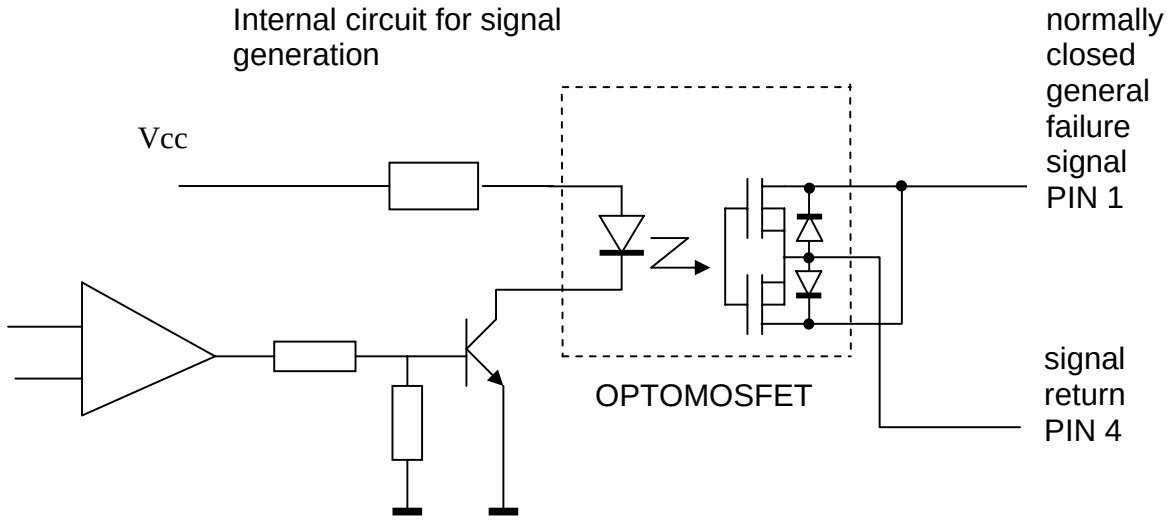
2.2.14. General failure Signal

This is a status mode upon occurrence of one of the following failures:

- Failure of at least 2 fans
- Over Temperature
- Output Over Current
- Output Over Voltage
- Output UV
- Input out of range
- (UV or OV)
- Input OC

2.2.15. General Failure alarm

This is a general failure indication related to any fault condition listed above present in the unit. The indication is provided by a visual indication (LED and display), by the low status (normally closed) of the pin "general failure" (pin 1 of the signal connector) and via RS485 port for a remote control. As all the signals the general failure signal is referred to pin 4, "signal return". A low impedence status between pin 1 and pin 4 is an indication of failure.



- The maximum current of the output mosfet is 100mA at 40°C ambient
- The alarm circuitry is galvanically isolated from the chassis GND. The dielectric strength is 500Vdc.
- The drain to source voltage rating of the opto-mosfet is 400V. The maximum R_{DSon} is 7 Ohm.

2.2.16. Fan Fail

This is an indication related to a fault on one or more internal FANs. The indication is provided by a visual indication (LED and display), and via RS485 port for a remote control. If one or more FAN fails, the unit continue to operate if the internal and external temperature are in a safe range. The fault of a single FAN is flagged only by the FAN FAULT LED visual indication and the RS485 port. In the case of two or more simultaneous faulty FANs , the general fault signal and the FAULT LED are activated while the system keeps running.

2.2.17. LEDs

A visual indication of the status of the inverter is provided by 4 LED's located on the front panel.

- Power (Green): lights up when the inverter is active
- Fault (Red): lights up when a general failure occurs.
- OT (Red): lights up when an OT condition (blink 5°C before the unit shut-down).

- Fan Fail (Red): lights up when one or more of the fans is detected as low speed rotating.

2.3. Other features

2.3.1. Protective output breaker

The output of the unit is equipped with a 10A *15A* thermal-magnetic circuit breaker for output disconnection and safety overload protection.
In case of a tripping of the circuit breaker, the system indicates a “Breaker Off” state on the front panel and shut-down immediately the power converters. Both the General Failure signal and the FAULT LED are activated. The fault is indicated also by the RS485 port.

2.3.2. Output Ctrl Signal (optional upon request)

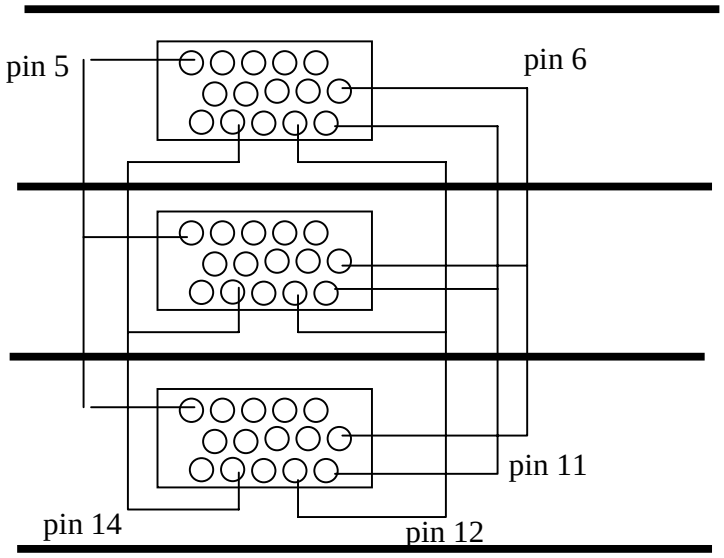
The invert offers the possibility of controlling the output voltage waveform or other customer requested parameter by an analog input signal. The analog voltage range is 0-10V.

2.3.3. Serial port and control.

The unit is equipped with 500Vdc isolated RS485 serial port for communication between inverters parallel connected and remote control unit. Specifically the RS485 communication is a master to multi-slave link where the external remote control unit is the master and inverters the slaves, the serial link is available at the signal connector, pin 2, 3 and 4 (respectively -TR, +TR and signal return).

2.3.4. Parallelability.

The inverter is designed to be parallelable to other identical units and load sharing with them. The maximum number of units that can be paralleled is 6. To guarantee the exclusion of a failing unit form the paralleled system each inverter is equipped with a relay series wired to the output. The maximum current difference between paralleled units is 0.35Arms provided equal cable length between each unit and point of load connection. The parallelability allows to configure the inverter system in N+1 redundancy or to upscale the system from 1.5KVA to 9KVA.
The load is shared by the paralleled units by voltage droop method that allows an output voltage variation with the output current of +0/-6% for the 230Vac, and +0/-8.5% for the 115Vac version. The first unit to power up (master unit) will generate a synch signal ("synch" at pin 14 of the signal connector) for the other paralleled units (slaves). At system power up the master unit, besides providing the synch signal, commands the engagements of all the output relays of each paralleled inverters by driving at low level the "output synch" signal (pin 12 of the signal connector). The synchronization of the relays that connect each inverter to the load avoids the current limitation of the first unit that would power up on a load exceeding its output current capacity.



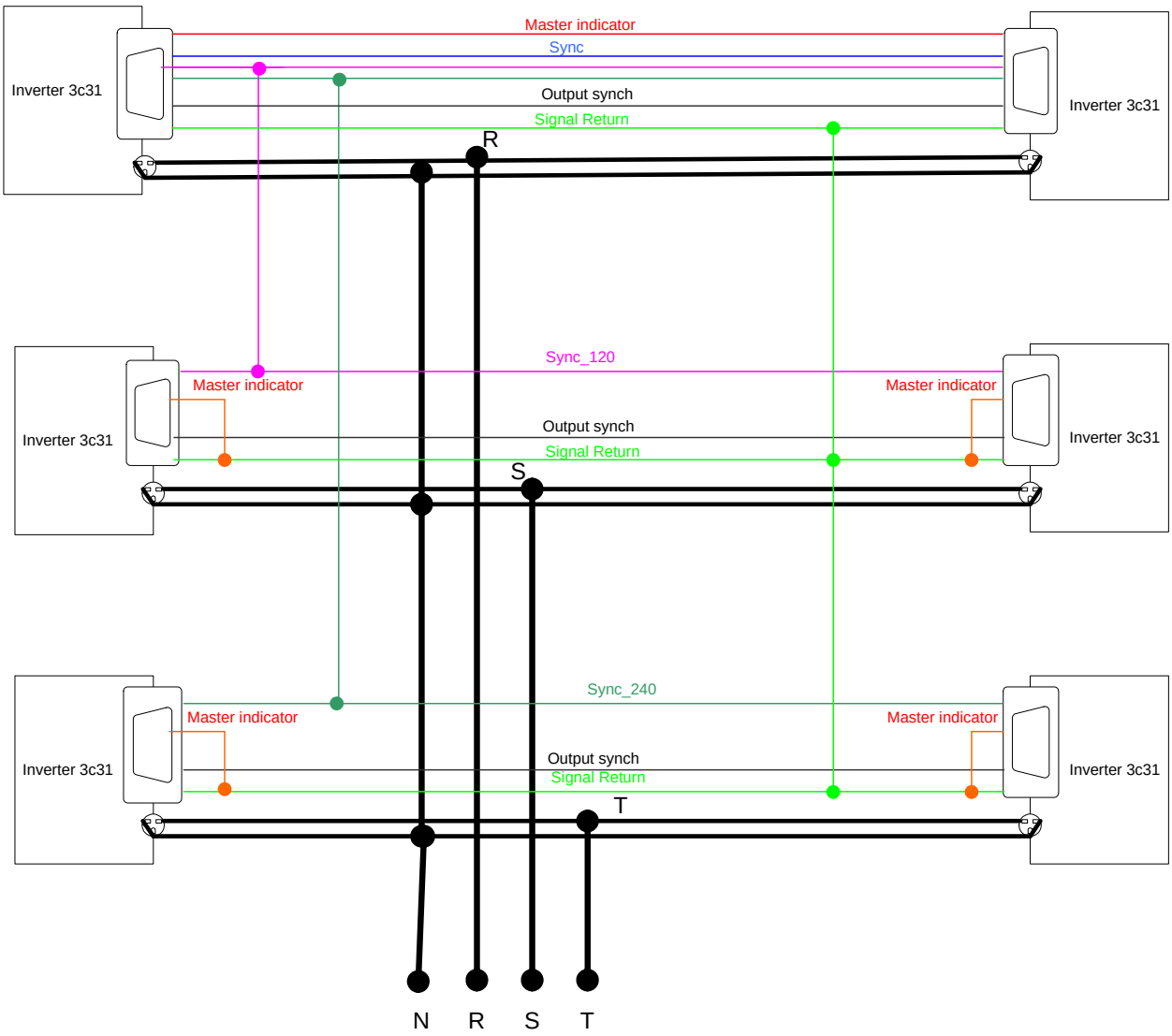
Parallel operation: connection scheme

2.3.5. 3-Phase generation

The inverter offers the possibility to generate a 3-phase voltage by connecting to a Y an equal number of inverters per each one of the three phases. The following diagram shows an example of the necessary connections. Be aware that the 3-phase configuration needs to be enabled by acting on the service menu of the unit.

By connecting the master indicator pins of the inverters on phase 1 (R) one of the units will prevail as master unit on the others connected on that phase and will provide 3 different synchronization signals displaced by 120° from each other, Synch, Synch_120, Synch_240 and Master indicator. These signal will be sensed by the other units, previously assigned to the other phases (S or T), that will generate output sine waves out of phase by 120° (units of phase S) or 240° (units on phase T) respect the master unit. There may be one or more unit per phase, we recommend not to exceed 2 units per phase, as long as they are in equal number. To complete the wiring it is necessary to connect the Output_synch and signal return pin of all the unit to guarantee proper signal exchange and synchronization of the output relays of all the units.

Inverter 3C3X
Additional wiring needed for three phase
voltage generation



2.3.6. Hot plugging.

The inverter is offered in two versions one of which can be hot plugged in a system where the AC bus already generated by other units.

2.3.7. Option

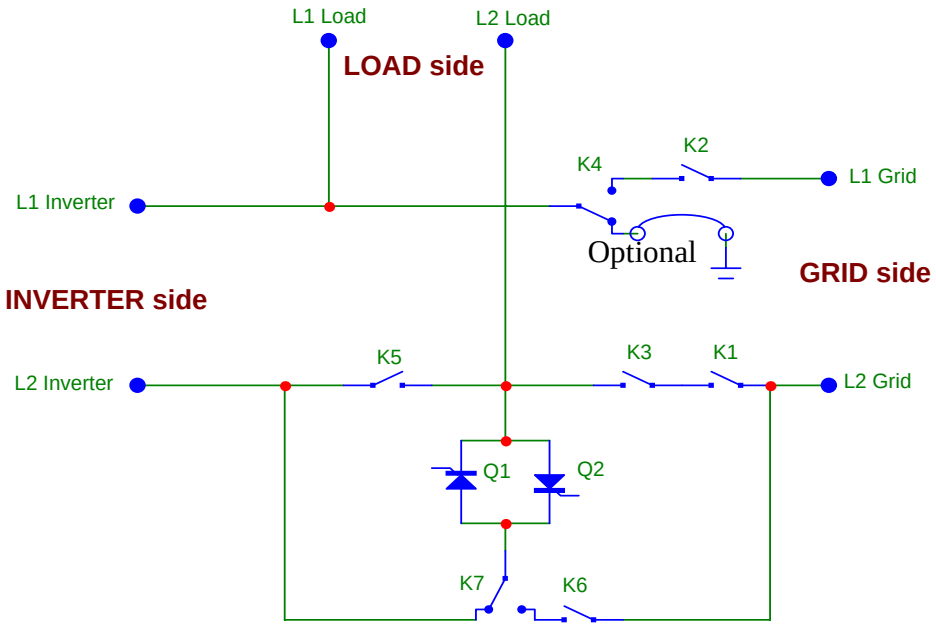
-The project will allow the introduction of a CAN bus for remote communication and control.

-Advanced load share method through optional internal RS485 serial link (+TR/I, -TR/I).

-An analogue auxiliary control input (0 to 10V at PIN 9) can set the reference for the output voltage waveform in a range between DC to 100Hz and –340V to +340V.

-Hybrid Transfer Switch add the UPS functionality to the inverter. This option allows transfers between sources without phase shift and is characterized by the following parameters:
Transfer Time <2.5mS
Switching Voltage < 250Vac
Current Capability =16A RMS
Inrush Current Capability < 90A for MAX 5ms

Hybrid Transfer Switch



Each unit with HTS option is individually equipped with the above sketched circuit. To allow scalability of the inverter system, the units' HTS needs to be synchronized by connecting the Transfer Synch signal at Pin 11.

The jumper between K4 and GND in the above picture is an optional and it is mounted on the non isolated units only.

Provisions on the signal connector are made to accommodate those options. Specifically pin 8 and 13 of the signal connector are dedicated to the CAN lines "H" and "L"; PIN 10, 15 and 4, respectively -TR/I, +TR/I and "common pin" will be used for the advance parallel method and pin 9 for auxiliary control input.

2.3.6.1 Grounding

The inverter offers the option to connect one of the output's rails (neutral) to GND. The grounding of the neutral can be done through an internal jumper on the inverter connector board if the inverter does not feature the transfer switch or on the transfer switch board if the transfer switch is present. The jumpers are to be mounted during manufacturing process at the factory and not added or removed after the unit left the factory. By default the inverter does not features anyone of the jumpers (isolated configuration).

When the transfer switch is installed the jumper on the inverter connector board have not to be present.

2.3.8. Remote on/off

This signal, pin 7, can be used for turning on/off the inverter remotely. The signal is active low, that is, it must be connected to pin 6 (signal return) for turning on the unit.
THE PIN MUST BE ENABLED FROM THE FRONT PANEL BY ACCEEDING TO THE SETTING MENU AND SETTING TO "ON" THE "REMOTE ON/OFF" OPTION.

3. Input and Output Connections

3.1. Input connector

The DC is connected to the unit through two bars located on the back side of the chassis. The bars can be mated with clips or bolted to bus bars. To facilitate the connection the bars feature threatened holes M6. Polarity identifiers are marked on the chassis.
The unit for hot-plug will have a special PCB connection to allow the input capacitors pre-charge during the hot-insertion.

3.2. Output connector(s)

The connector to the load is an IEC320 plug wall mounted on the back side of the chassis. This is also the sole point to parallel connect the inverter to other identical units. The IEC plug is marked “inverter output”
A second optional IEC320 socket is located nearby the plug and it is a point of entrance for the mains. The mains is internally directed to the load by the optional transfer switch. The optional IEC socket is marked “grid input”.

3.3. Signal connector

- Molex 89263-6062 or equivalent (female high density sub -D 15 pins)

Signal description	***Pin assignment***
General failure signal	1
+T/R	2
-T/R	3
Common pin for General failure signal and serial port signals (+/-T/R)	4
Master indicator	5
Signal return and common pin for synch signals and remote on/off	6
Remote ON/OFF	7
Synch_120 (Optional)	8
Output Ctrl Signal (Optional Upon Request)	9
-TR/I (Optional Upon Request)	10
Transfer synch (HTS option version only)	11
Output synch	12
Synch_240 (Optional)	13
Synch	14
+TR/I (Optional Upon Request)	15

4. Environmental

The Inverter module is capable of surviving in the environmental conditions described below.

4.1. Operating Temperature and Humidity

The Inverter is capable of operating in a temperature ambient of -25° C to +55°C (+65°C with power derating) with forced air cooling. The Inverter is also capable of operating with a relative humidity (non-condensing) of 0% to 90%.

4.2. Storage Temperature and Humidity

The storage temperature of the Inverter is -40° C to +85° C with a relative humidity of 0% to 90%.

4.3. Altitude

The unit operate normally at -200 to 13,000 feet, -61 to 3962 meters.

4.4. Audible Noise

When the inverter is operating the audible noise shall not exceed TBD (Sound Pressure) measured from 2 feet or 0.6 meters from the unit.

4.5. Cooling

The unit is fan assisted. The cooling is guaranteed by 4x40mm ball-bearing fans. The fans are in redundancy 3 + 1. The fans are located on the front side of the unit and the generated air flow is front to back. The fans speed is controlled by the internal logic circuitry accordingly

to the ambient temperature. In case of failure of one of the four fans, the fault led lights on. If the temperature is in a safe range, the unit continue to work.

4.6. Earthquake

The Inverter not prevent the end-use system from complying with the seismic requirements of Telcordia GR-63-CORE Issue 1, October 1995, Zone 4, upper floor requirements. Proper system design solution is required.

4.7. Shock

The Inverter withstands the shock involved when the packing container is dropped from a height of 36 inches (if shipped by mail services, 24 inches if transported commercially), and when the unit is dropped from a height of 4 inches (weight assumed to be less than 20 pounds). Per GR-63-CORE, Issue 1, October 1995.

4.8. Vibration

The Inverter withstands the vibration encountered in shipping without damage or degradation of performance. (Packaged: 0.5g from 5 to 50 Hz, 3g from 50 to 500 Hz. Unpackaged: 0.5g from 5 to 100 Hz, 1.5g for 100 to 500 Hz.). Per Telcordia TR-EOP-000063, Test 4.4, Par. 4.4.4

5. EMC

5.1. Emission

* EN 61000-6-4 Electromagnetic compatibility – Generic emission standard Part 1: Residential, Commercial and Light Industry.

* EN 55022: 1998 + A1:2000 Limits and methods of measurement of radio interference characteristics of ITE, class A.

5.2. Immunity

* EN 61000-6-1 Electromagnetic compatibility – Generic immunity standard -.Part 1: Residential, Commercial and Light Industry

* EN 61000-4-2: 1995 + A1:1998 + A2: 2001 Electromagnetic compatibility for industrial process measurements and control equipment – Electrostatic discharge requirements.

* EN 61000-4-3: 1996 + A1:1998 + A2:2001 Electromagnetic compatibility for industrial process measurements and control equipment – Radiated, radio-frequency, electromagnetic field immunity requirements.

* EN 61000-4-4: 1995 + A1:2001 + A2:2001 Electromagnetic compatibility for industrial process measurements and control equipment – Electrical fast transient/burst requirements.

* EN 61000-4-5: 1995 + A1:2001 Electromagnetic compatibility for industrial process measurements and control equipment – Surge immunity requirements

* EN 61000-4-6. 1996+ A1:2001 Immunity to conducted disturbances, induced by RF field.

* EN 61000-4-8: 1993 + A1:2001 Power frequency magnetic field.

6. Safety

6.1. Compliances

The unit is compliant with the following standards:

- IEC60950:1999, 3rd edition
- EN60950:2000
- UL60950, 3rd edition
- CSA Standard C22.2 No.60950-00, 3rd edition

6.2. Marking

The unit is marked with the followings marks:

- KEMA
- cCSAus

7. Mechanical

The size of the unit is 482.6mm wide (19"), 400mm long and 43.8mm high (1U) Tolerance: +/- 0,5mm mm. Weight: 7kg ca. The chassis of the unit is made of aluminium sheet finishing with Alodine. Front plate colour is RAL7032 with the exception of the LCD and key pad areas which is RAL7039.
Below are shown the four views of the inverter with evidence of the most important dimensions.

8. Reliability.

The calculated MTBF of the unit assessed accordingly to TR-TSY-000332 is >250.000 hours at 40°C (excluding fan) . The expected life of the unit is 15 years.
The product with Static Transfer Switch option has MTBF>200.000 hours in the same conditions as above.