

Engineering Specification

SLI 50 - 5kW Inverter Slim Line series

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1. Introduction

1.1. General

The scope of this document is to specify the electrical and mechanical specification of a hot pluggable 5KW (7kVA) Inverter for telecom applications.

Input 48Vdc, Output 230Vac, 50Hz or 60Hz.

The unit is designed to be mounted in a 19" chassis or in its two positions subrack available as individual product.

The cooling of the unit is fan assisted by internal fans, ball bearing, long life type, front to rear air flow.

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

The analog and digital behaviour is completely managed by DSP and microprocessor devices.

The unit may be configured alternatively with hot pluggable Display Unit or LED's Unit.

Base Inverter front slot



Display Unit



LED unit

1.2. Part Numbers

SLI 50 48-230	Base + LEDs Unit
SLI 50 48-230-CTRL	Base + Display Unit
SLI 50 LEDs Unit	LEDs Unit for spare
SLI 50 Display Unit	Display Unit for spare

In multiple inverter systems just one Display Unit is allowed.

1.3. 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
THD	Total Harmonic Distortion

1.4. Applicable documents

The following documents form a part of this specification:

UL 60950-1 (1 st edition)	Standard for Information Technology Equipment - Safety Part 1: General Requirements
EN 60950-1: 2001 + A11 :2004	Information Technology Equipment - Safety Part 1: General Requirements
CAN/CSA C22.2 No.60950-1-03 (1 st edition)	Standard for Information Technology Equipment - Safety Part 1: General Requirements
IEC 60950-1: 2001 (1 st edition)	Information Technology Equipment - Safety Part 1: General Requirements
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

NEBS, GR-63-CORE	requirements. 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

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 60Vdc, from no load to full load. The unit is not damaged at any input voltage from 0Vdc to 65Vdc at any voltage variation rate.

Start up from stand by condition is for $V_{in} > 43V_{dc}$ in order to provide hysteresis enough for not having on/off bouncing when powered from batteries. The 43V threshold is provided by factory and is adjustable down to 40V.

A protection against input reverse polarity connection is provided via an internal diode that in case of input reverse polarization clears the internal input circuit breaker.

2.1.2. Inrush Current

The inrush current is compliant with the ETSI EN 300-132-2 v2.1.2

2.1.3. Input current

The maximum sunk input current is 150A.

The safety protection is provided by an internal circuit breaker. The rating of the circuit breaker is such to guarantee that no hazardous conditions will be present in case of a failure.

Input current surges allowed by the circuit breaker are up to 200A for maximum 2s allowed by the unit for power output surges.

The maximum RMS input ripple current generated by the inverter in the psophometric range is less than 0,15% of the maximum DC input current.

2.1.4. 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 +/-1V and higher than 65V +/-1V. No damage occurs below 40V nor fuse or circuit breaker clearing.

The units starts up for $V_{in} > 43V$ (adjustable down to 40V) to prevent false triggering of the input UV threshold.

2.2. Isolation

PRI-SEC	3000Vac
PRI-GND	500Vdc
SEC-GND	1500Vrms or 2121Vdc (tested 100% for safety)
GR1 – GR2	500Vdc
GR1 – GND	500Vdc
GR2 – GND	500Vdc
Form-C – GND	500Vdc
Form-C – GR2	functional
Form-C – GR1	500Vdc

2.3. Output Characteristics

2.3.1. Voltage and Current Ratings

The SLI 50 Inverter can be set in the following output voltages range: 200Vac to 240Vac. The output cross regulation is $\pm 0,5\%$ from minimum resistive load to full load, 0 to 5kW. Non resistive loads increase the regulation tolerance beyond 2%, specifically load with a power factor of 0.3 and/or crest factor 3 can results in the worst regulation of 4%. At no load condition the inverter works properly without damage.

2.3.2. Output Power

The maximum output Power is 5000W (7000VA) at any input voltage value within the specified input voltage range and the ambient temperature within the range $-25^{\circ}C$ to $+55^{\circ}C$. Between $+55^{\circ}C$ to $+65^{\circ}C$, a $150W/^{\circ}C$ linear thermal derating have to be applied to the output load to avoid OT shutdown. At $65^{\circ}C$ maximum output power is reduced and limited to 3500W. The minimum output power at which the functionality of the unit is guaranteed is 0.

2.3.3. Load Power Factor

The unit provides full power (7kVA) at any load with a power factor in the range from 0.33 to 1 leading or lagging.

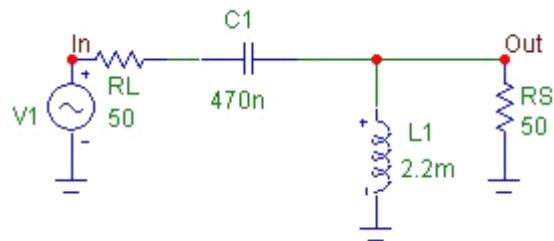
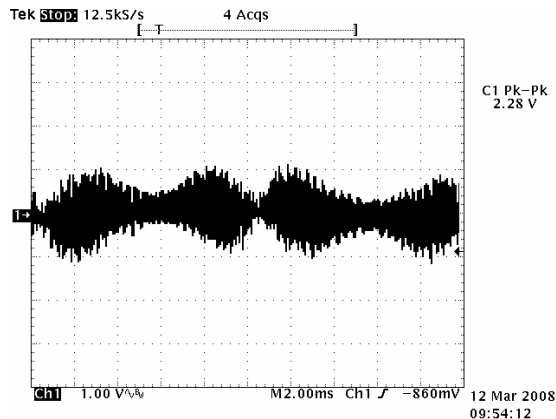
2.3.4. Crest Factor

The maximum allowed load crest factor is 3.

2.3.5. Ripple and Noise

The output voltage is provided, at minimum and maximum resistive load, with the following peak to peak Ripple and Noise specifications: 3% of the nominal RMS output voltage over the bandwidth 3kHz/20MHz. Typically 5Vpp over 230Vac.

The following filter is used to evaluate the output Ripple (scope reading shall be multiplied by a factor 2 in order to get proper figure).



2.3.6. Efficiency

The maximum peak efficiency of the inverter is typically higher than 93% at nominal input voltage. The peak efficiency is available at maximum input voltage and approximately 75% of the output power on a resistive load.

2.3.7. Output Voltage and Frequency

The Inverter provides an Output Voltage of 230Vac at the frequency of 50Hz \pm 0,2%. Frequency is adjustable between 47Hz and 63Hz. The shape of the output voltage is a true Sine Wave with a Total Harmonic Distortion <0,5% with resistive load or R/C or R/L, any PF. THD remains <8% in case of crest factor up to 3.

2.3.8. 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 unit resets restart counting after 15min of normal operation.

All the protection settings are stored on a non volatile memory and kept also after a reset of the unit.

The default values are: Autorestart 5 times, Wait time = 10s

2.3.9. Over Voltage Protection

The unit is equipped with an output Over Voltage protection. The threshold is set at 260Vac \pm 2% and it is delayed 100msec. It turns off the unit according to the inverter protection setup selected by the user (Latched or Autorestart).

2.3.10. Under Voltage Protection

The unit is equipped with output Under Voltage protection. The threshold is set at 195Vac \pm 2% of the nominal voltage, it is delayed 2,5sec and shuts down the unit according to the inverter protection setup selected by the user (Latched or Autorestart).

2.3.11. Short Circuit Protection

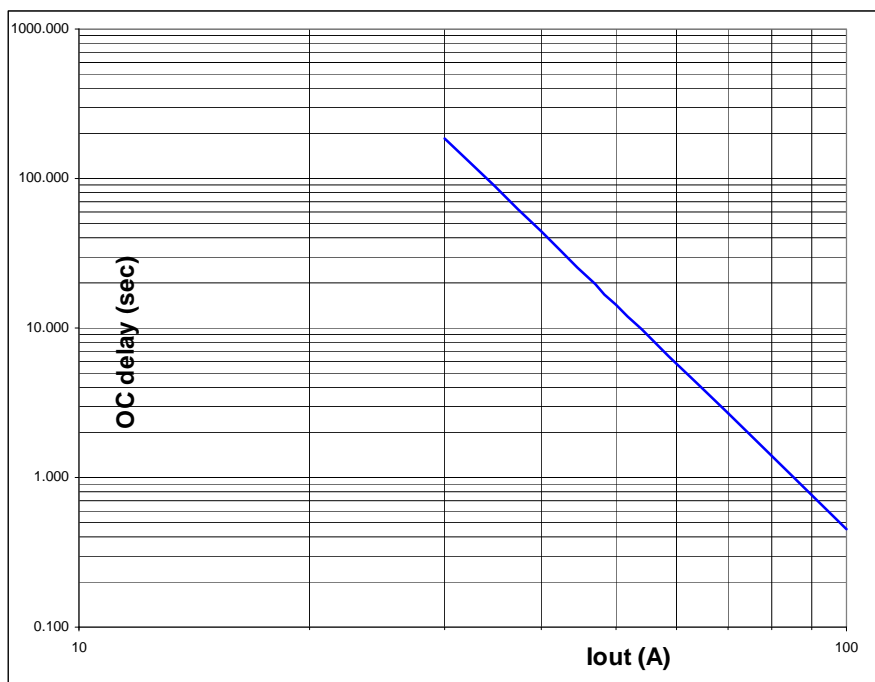
Short circuit protection is operated “switching cycle” by “switching cycle” by the current limit circuitry that limits the output current peak to 95A +/-5%. The over current protection will turn-off the unit if the short is longer than 1sec. An additional safety protection is provided by two fuses rated 30Aac placed on both lines working in case of a catastrophic OC non controlled by the unit. At normal operation the OC protection acts faster than the output fuses in order to avoid their intervention.

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).

2.3.12. Over Current Protection

The Inverter is protected against Over Load. The Over current circuit will be active for loads higher than 30A +/-5% turning-off the unit. User can reduce this value from the front panel in the range between 15A and 30A in 1A steps. The OC delayed is according to the below figure.

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).



2.3.13. Over Temperature Protection

The unit shuts down if the inlet ambient temperature exceeds 67°C. An additional internal temperature sensor monitors the power devices, avoiding the components to exceed a safe temperature.

An acoustic and visual indication becomes active 5°C before having reached one of the two OT protections (int. or ext.) making flash the O.T. led.

2.3.14. General Failure conditions

General Failure status is reached 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
- Input OC
- System error (typically related to internal parameters)

2.3.15. 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 if present) and by the Form-C output available at signal connector (max 1A-30Vdc).

This alarm is available also via RS485 port for a remote control.

2.3.16. Fan Fail

This is an indication related to a fault of one or more internal FANs. The indication is provided by a visual indication (LED and display if present), and via RS485 port for a remote control. If one (or more) FAN fails, the unit continues to operate if the internal and external temperatures 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.

2.3.17. LED's

A visual indication of the status of the inverter is provided by 5 LED's located on the front panel.



Display Unit



LED unit

- Power (Green): blinks in stand by; lights up when the inverter is active;
- Fan Fail (Yellow): lights up when one or more of the fans is detected rotating at lower speed than normal;

- OT (Red): lights up when an OT condition is detected and unit is off (it blinks 5°C before the unit shut-down);
- Fault (Red): lights up when a general failure occurs;
- Address (Yellow): lights up when the unit is master or working in stand alone; off is slave; low frequency blinking when polled by a display unit in a multiple inverter system; fast frequency blinking when polled by a RS485 port.

2.4. Other features

2.4.1. Input breaker

The input of the unit is equipped with a 150A magnetic circuit breaker for input disconnection.

With breaker off any part of the unit is not powered.

With breaker on, the start up happens if the hot plug jumper is in place (or the unit is plugged into its subrack) AND a remote on/off valid signal is issued.

A remote on/off valid signal is depending on how the on/off mode of the unit is set:

- Hardware on/off (default): unit configured by factory or by a display unit or by a RS485 signal + electrical connection at the remote on/off pins of the signal connector, see pinout chapter.
- RS485 on/off: unit configured by a display unit or by a RS485 signal + RS485 control command

In case of tripping of the circuit breaker, check input polarity first and if this is ok it is very probable a permanent failure.

2.4.2. Serial port and control

The unit is equipped with a 500Vdc isolated RS485 serial port for communication with a user device. Available to the user is present a +5V output rated 50mA (in case of paralleled inverters, 50mA is multiplied by the inverters number).

This 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.

A CAN interface, system reserved, is used for internal communication between paralleled units and display unit (max one) and for master slave management.

Two additional RS485 ports are dedicated to internal fast communication between paralleled inverters for current sharing information; the second is for redundancy.

2.4.3. 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 12. To guarantee the exclusion of a failing unit from the paralleled system each inverter is equipped with two relays, one per line, series wired to the output. The maximum current difference between paralleled units is 1,5Arms 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 5kW to 60kW.

The load is shared by the paralleled units by a digital control via fast RS485 with the output current share typically of +/-3% of the maximum output current for load higher than 20%.

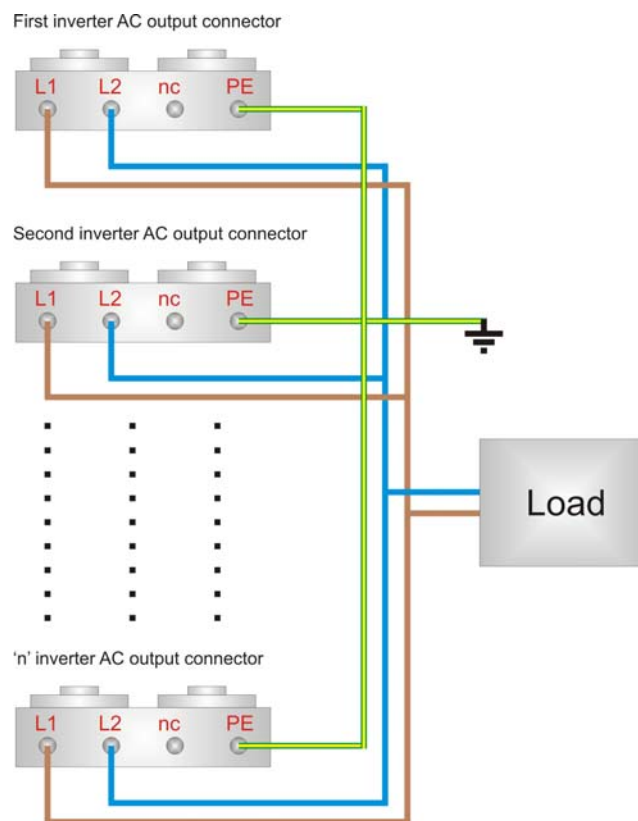
Before having Vout available, powering on all paralleled units simultaneously will define as master the unit with lower S/N that will update all the others with its own working parameters.

In order to force as master a specific unit, this has to be powered up before. The following slaves powered up will assume the same working parameters of the master.

When remote on/off is issued, the master unit will generate a synch signal ("PHASE SYNC" at the signal connector) for the other paralleled units (slaves) and via fast RS485 all the output relays of each paralleled inverters is simultaneously driven to engage. The synchronization of the output 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.

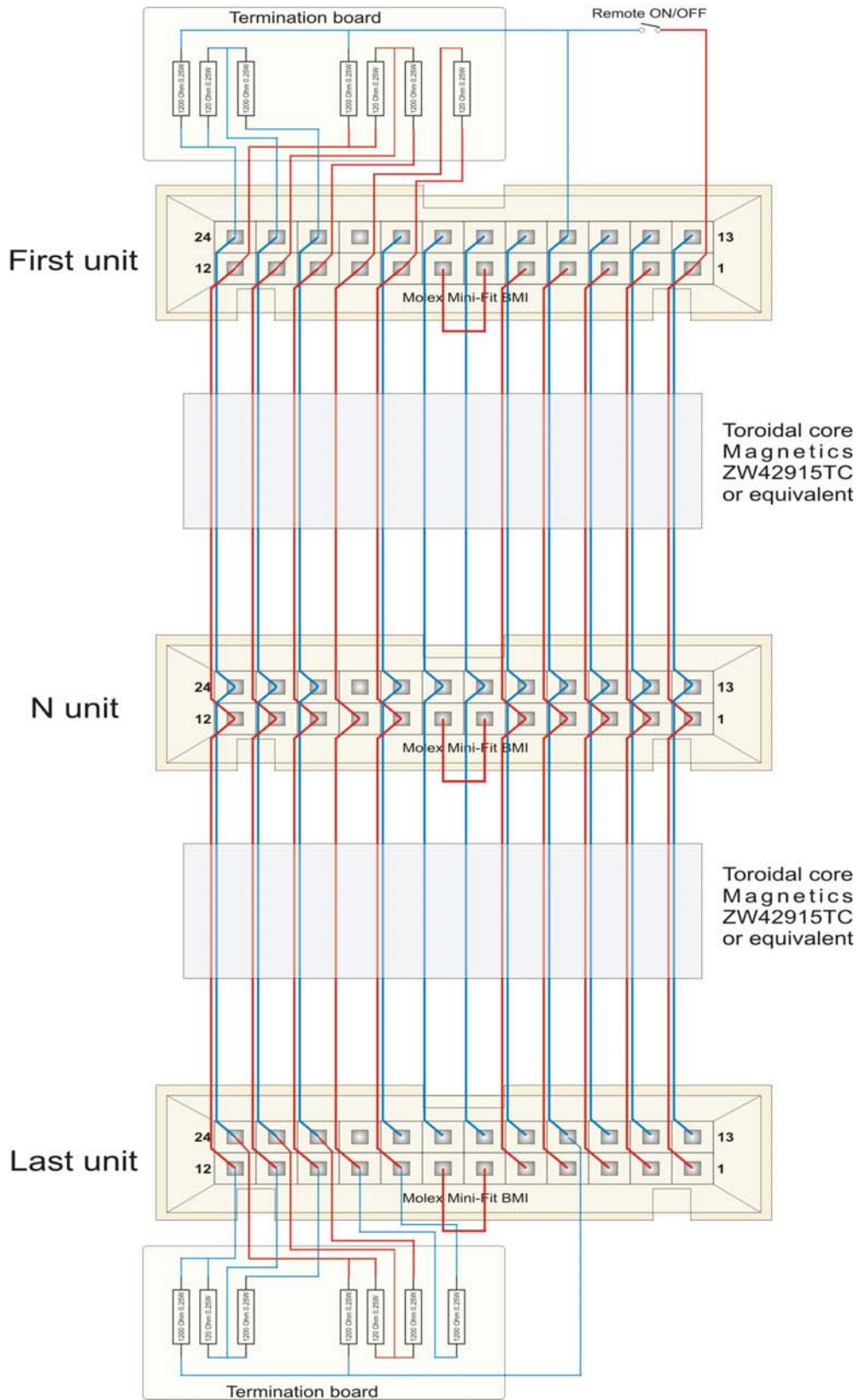
In case of failure of the master unit, a new master unit is automatically elected keeping all the same previous working parameters.

Connect all units at the same DC source (it is not mandatory).
Connect the AC output following the below schematic.



Connect the signal connectors following the below schematic (this connection is available purchasing the two positions subrack).

Single-Phase parallel cabling

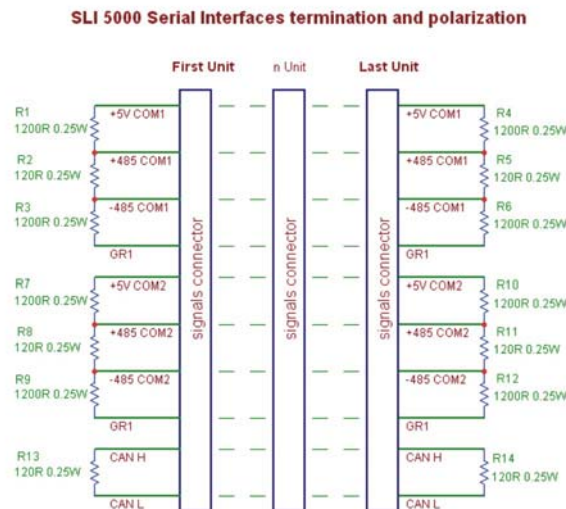


Pins 1,2,3,4,5,8,9,10,11,12,13,14,15,16,17,18,19,20,22,23,24 of each unit are connected pin to pin to the other signal connectors.

Every unit must have a jumper from pin 6 and pin 7, module presence.

Remote ON/OFF switch may be one for all the paralleled units.

The lines have to be terminated and polarized by the network detailed in the figure below.



⚠ Warning: changing the ON/OFF mode from RS485 to Hardware may result into an immediate turning ON of the units if the remote on/off signal is switched ON (closed).

2.4.4. 3-Phase generation

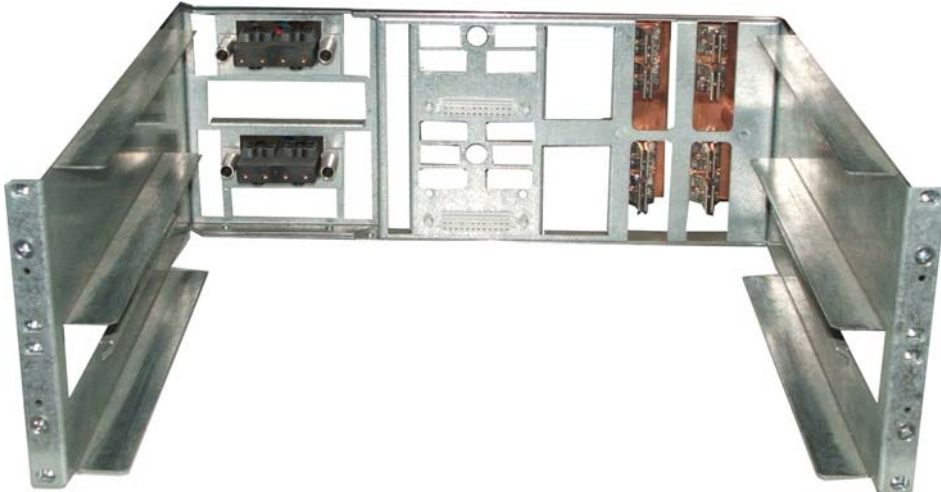
The SLI 50 inverter offers the possibility to generate a 3-phase system voltage by connecting an equal number of inverters per each one of the three branches. The inverter module remains the same as for stand alone or parallel applications. The mating signal connector will bear the information concerning what phase lag the plugged inverter module will have to assume.

2.4.5. Hot plugging.

The inverter is hot pluggable in a system where the AC bus is already generated by other units. In this case the plugged unit will assume all the working parameters of the others. Power-One's two position subrack is prepared with AC mating connectors, prewired signal mating connectors with termination board, possible expansion connector to other subracks and user interface board.

Eight power clips will be provided together with the subrack; these will have to be assembled to proper copper bus bar not provided.

This subrack is provided in a kit box, mechanical side walls separated from back plane. Here below a picture of the 2 positions subrack.



2.4.6. Grounding

The inverter has floating output with respect to ground. One of the output's rails can be connected to GND.

3. Input and Output Connections

3.1. Input DC connection

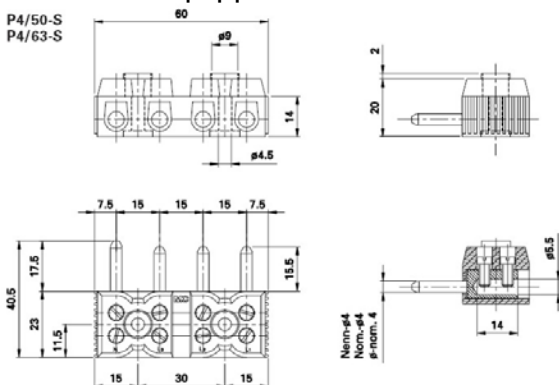
Positive (+) and Negative (-) input terminals consist of two bars located on the backside of the chassis. The bars can be mated with power clips or bolted to bus bars or cables. To facilitate the connection for Stand Alone system the input bars have M8 holes. Polarity identifiers are labeled on the chassis.

Mating part clip is ILSCO M-165 type, 100A or similar

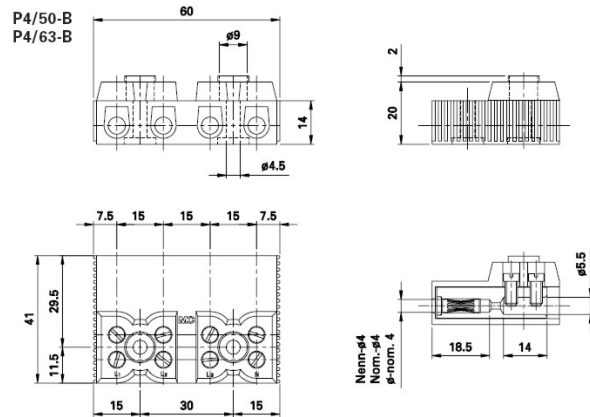


3.2. Output connector(s)

The unit is equipped with MULTICONTACT P4/63-S-PCD connector (order code 15.0117)

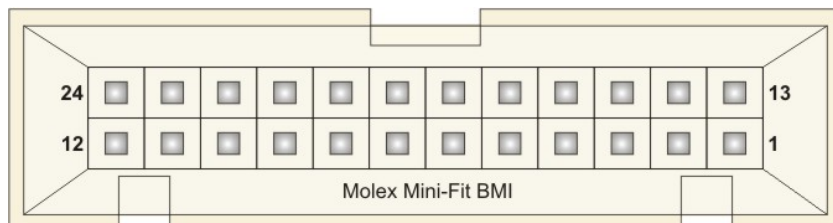


The mating part for this connector is
MULTICONTACT P4/63-B-PCD
(order code 15.0118)



3.3. Signal connector

The unit is equipped with a 24 poles Molex Mini-Fit BMI connector (order number 15-24-9245)



The mating part is:

Molex Mini-Fit BMI panel mount (order number 15-06-0241)

The crimp terminals are series 5556-T, for AWG18 to 24 wires, (order number 39-00-0038)

Pin	Signal description	Referred to
1	- Remote ON	GR2 User Return (pin 16)
2	Fault NC	Floating
3	Fault COM	Floating
4	Fault NO	Floating
5	-PH2	GR1 System Communication Return (pin 6 & 18)
6	GR1 Common return for system communication	
7	-INS	GR1 System Communication Return (pin 6 & 18)
8	CAN L	GR1 System Communication Return (pin 6 & 18)
9	CAN H	GR1 System Communication Return (pin 6 & 18)
10	+5V COM1	GR1 System Communication Return (pin 6 & 18)
11	+485 COM1	GR1 System Communication Return (pin 6 & 18)
12	-485 COM1	GR1 System Communication Return (pin 6 & 18)
13	-485 user	GR2 User Return (pin 16)
14	+485 user	GR2 User Return (pin 16)
15	+5V user	GR2 User Return (pin 16)
16	GR2 Common return for user signals	
17	-PH1	GR1 System Communication Return (pin 6 & 18)
18	GR1 Common return for system communication	
19	PHASE SYNC	GR1 System Communication Return (pin 6 & 18)

Pin	Signal description	Referred to
20	-GRID SYNC	GR1 System Communication Return (pin 6 & 18)
21	Not Connected	
22	+5V COM2	GR1 System Communication Return (pin 6 & 18)
23	+485 COM2	GR1 System Communication Return (pin 6 & 18)
24	-485 COM2	GR1 System Communication Return (pin 6 & 18)

Grounding detail:

GR1 = 500 Vdc insulation from earth ground (PE) and from GR2

GR2 = 500 Vdc insulation from earth ground (PE) and from GR1

Signal description:

- Pin 1 Remote ON/OFF.
Turn ON Active low.
The units are configured by factory in Hardware on/off mode.
Turn on happens connecting this pin to pin 16 (through a switch or relay).
Note: the on/off mode can be configured by a control display unit, menu Settings / on-off Mode, to operate via a RS485 serial interface software command. This RS485 on/off mode disables the hardware signal.
- Pin 2, 3, 4 Fault signal.
Low voltage relay contacts that provides a general failure indication related to any fault condition of the unit.
Form-C contacts, rated 1A at 30Vdc.
- Pin 5, 17 Used to configure three-phase system via external jumpers to GR1.
No jumper = single phase configuration or first phase in a three-phase system
-PH1 jumper to GR1 = second phase of three-phase system (120°)
-PH2 jumper to GR1 = third phase of three-phase system (240°)
- Pin 7 -INS signal, presence signal, to control the hot plug of the unit in the system. It must be connected to GR1 to turn ON the unit.
- Pin 8, 9 Serial CAN interface (System Reserved for communication between units)
This line must be terminated according to related chapter.
- Pin 10,11,12 Serial RS485 # 1 hi-speed (System Reserved for paralleled units load sharing). This line must be terminated according to related chapter.
- Pin 22,23,24 Serial RS485 # 2 hi-speed (System Reserved for paralleled units load sharing redundancy). This line must be terminated according to related chapter.
- Pin 13, 14 User side serial RS485

Pin 15	User auxiliary voltage 5V 50mA referred to GR2
Pin 19	PHASE SYNC (System reserved) bidirectional signal generated by the Master unit to synchronize the phase of the Slave units.
Pin 20	GRID SYNC (System reserved) input signal received from the Static Transfer Switch to synchronize the inverter system with the distribution grid.

4. Environmental

The Inverter module is fulfilling the following environmental conditions

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 self-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 operates normally from -200 to 13,000 feet, -61 to 3962 meters above sea level.

4.4. *Audible Noise*

When the inverter is operating the audible noise shall not exceed 60dBa (Sound Pressure) measured at 4 feet or 1.2meters from the unit with meter on "A" weighting position with 40dBa environment.

4.5. *Cooling*

The unit is fan assisted. The cooling is guaranteed by three 80x80mm ball-bearing fans. The fans are in redundancy 2+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 three fans, the Fan Fail led lights on. If the temperature is in a safe range, the unit continues to work. In case of fail of more than one fan, the unit is switched off and Fault led is lighted.

4.6. *Earthquake*

The Inverter doesn't 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 80cm, and when the unpacked unit is dropped from a height of 75mm per GR-63-CORE, Issue 3, March 2006.

4.8. Vibration

The Inverter withstands the vibration encountered in shipping without damage or degradation of performance. (Packed: 0.5g from 5 to 50 Hz, 3g from 50 to 500 Hz. Unpacked: 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: 2001 - ITE/ L - Electromagnetic compatibility – Generic emission Electromagnetic compatibility (EMC) - Part 6-4: Generic standards- Emission standard for industrial environments.

EN 55022: 1998 A1:2000 + A2:2003 - Limits and methods of measurement of radio interference characteristics of ITE. Level fulfilled: class B.

5.2. Immunity

EN 61000-6-2: 1999 - Electromagnetic compatibility – Part 6-2: Generic Standards - Immunity standard for Industrial environments.

EN 61000-4-2: 1995 + A1:1998 + A2: 2001 - ITE/ L - Electromagnetic compatibility - Electrostatic discharge requirements. Level fulfilled: 8kVcontact and 15kVair; criteria A.

EN 61000-4-3: 2006 - (ENV 50140) – ITE/ L - Electromagnetic compatibility – Radiated, radio-frequency, electromagnetic field immunity requirements. Level fulfilled: 10V/m, criteria A.

EN 61000-4-4: 2004 – ITE/ L - Electromagnetic compatibility - Electrical fast transient/burst requirements. Level fulfilled: +/-2kV; criteria A.

EN 61000-4-5: 2006 – ITE/ L - Electromagnetic compatibility - Surge immunity requirements. Level fulfilled: 500V crtA, 2kVCM 1kV DM low Z.

EN 61000-4-6. 1996 + A1:2001 – (ENV 50141) – ITE/ L - Electromagnetic compatibility - Immunity to conducted disturbances, induced by RF field. Level fulfilled: 10Vrms crit A.

EN 61000-4-8: 1993 + A1:2001 – ITE - Electromagnetic compatibility - Power frequency magnetic field. Level fulfilled: 30A/m crit a.

ETSI EN 300-132-2 – Conducted emissions of the telecom equipment - Level fulfilled: 44dBrc, A criteria.

6. Safety

6.1. Compliances

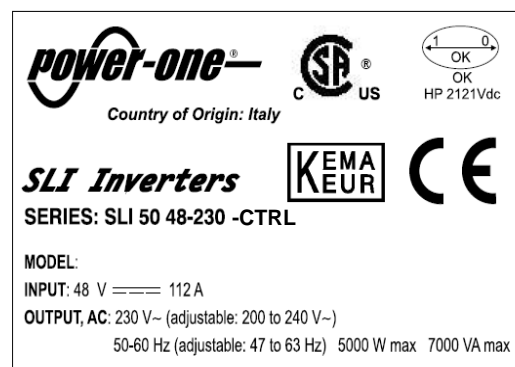
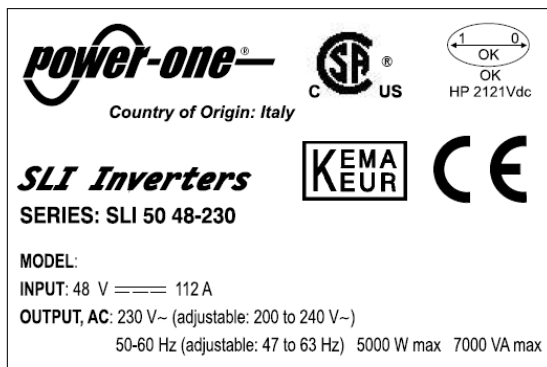
The unit is compliant with the following standards:

- IEC 60950-1: 2001, 1st edition
- EN 60950-1: 2001 + A11: 2004
- UL 60950-1, 1st edition
- CAN/CSA-C22.2 No.60950-1-03, 1st edition
- CE according to Low Voltage Directive and EMC Directive

6.2. Marking

The unit is marked with the followings marks:

- KEMA
- cCSAus
- CE



7. Mechanical

The size of the unit is 482.6mm wide (19"), 400mm long and 85 mm high (2U) Tolerance: +/- 0,5mm mm. Weight: 14,5 kg. The enclosure of the unit is made of steel.

Front plate colour is Cardinal reference number C241-GR663 with the exception of the LED or Display Units which PC/ABC Cycology C6600 black, GE Plastics E121563.

Below is shown a mechanical drawing 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 >200.000 hours at 40°C (excluding fan). The expected life of the unit is 15 years.

