Operation Manual

12 kW Single-Phase Wind/Solar Hybrid Input Utility-Interactive IGBT Inverter

Model No. I12-60

(Version 3.02)

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1. Technical Specifications

This inverter is a 12 kW single-phase output, wind/solar hybrid input, dual peak power tracking, forced-commutated, auto synchronization, utility-interactive, space vector PWM IGBT inverter. It is exclusively designed and manufactured for the Ventera wind turbine VT10-240.

The maximum continuous output power rating is 12 kW, it can operate at 12.5kW for a short time (1 minute). The inverter's maximum continuous output current is 50A. The rated input line-to-line voltage from the wind turbine is 3-phase 280Vrms, corresponding to a dc-link voltage of 390V, while the rated input DC voltage from the solar panel is 192Vdc. The maximum input line-to-line voltage from the wind turbine is 350Vrms, corresponding to a dc link voltage of 490V, and the maximum input voltage from solar panel is 340Vdc. The nominal grid voltage is 240Vrms. The nominal grid frequency is factory-adjusted to 60Hz. This inverter is designed for variable speed wind turbines with a wide range of speeds and generator voltage levels, and the firmware of the inverter is coded to extract maximum power from both the wind and solar energy. The inverter is equipped with software and hardware protections including over-current of dc link and inverter output, over-temperature, over-voltage of the grid, dc link, PV input and generator, under-voltage of the grid, over-frequency and under-frequency of the grid, and the islanding operation of inverter. Table 1 lists the major specifications of the inverter.

Table 1 Electrical Specifications

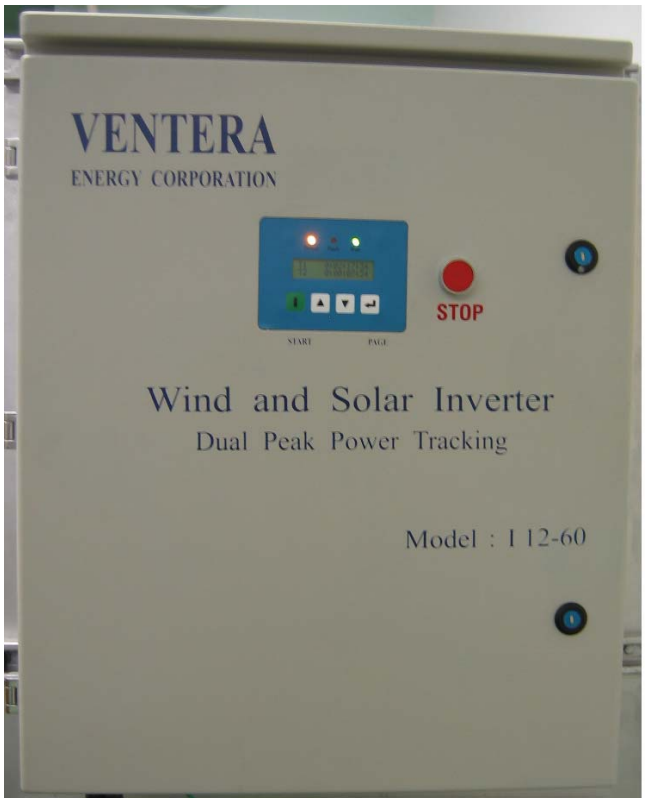
Specified Parameters	Values	Units
Rated Maximum Continuous AC Output Power	12	kW
Maximum Continuous Output Current	50	A
Output Power Factor	> 0.95 for 10% load and up	
Maximum Short Time AC Output Power, 1 minute	12.5	kW
Current THD at Rated Output Current	< 2	%
Nominal Single-Phase Grid Voltage (rms)	240	V
Operating Grid Voltage Range (V)	211~264	V
Nominal Grid Frequency (factory adjusted)	60	Hz
Operating Grid Frequency Range	59.3~60.5	Hz

Nominal Line-to-Line Voltage of 3-Phase AC Input from Wind Generator (rms)	280	V
Maximum Line-to-Line Voltage of 3-Phase AC Input from Wind Generator (rms)	350	V
Line-to-Line Voltage range of 3-Phase AC Input from Wind Generator (rms)	100~320	V
Maximum AC Input Current from Generator (rms)	33	A
Nominal Input DC Voltage from Solar Panel	192	V
PV Input DC Voltage Range	170-340	V
Maximum PV Input Current	12	A
Rated DC Link Voltage	390	V
Maximum DC Link Voltage	560	V
Maximum Utility Feed Back Current	56	A
Maximum Output Over-Current Protection	56	A
Maximum Output Fault Current	100A peak	A
Maximum Operating Ambient Temperature	40	deg. C

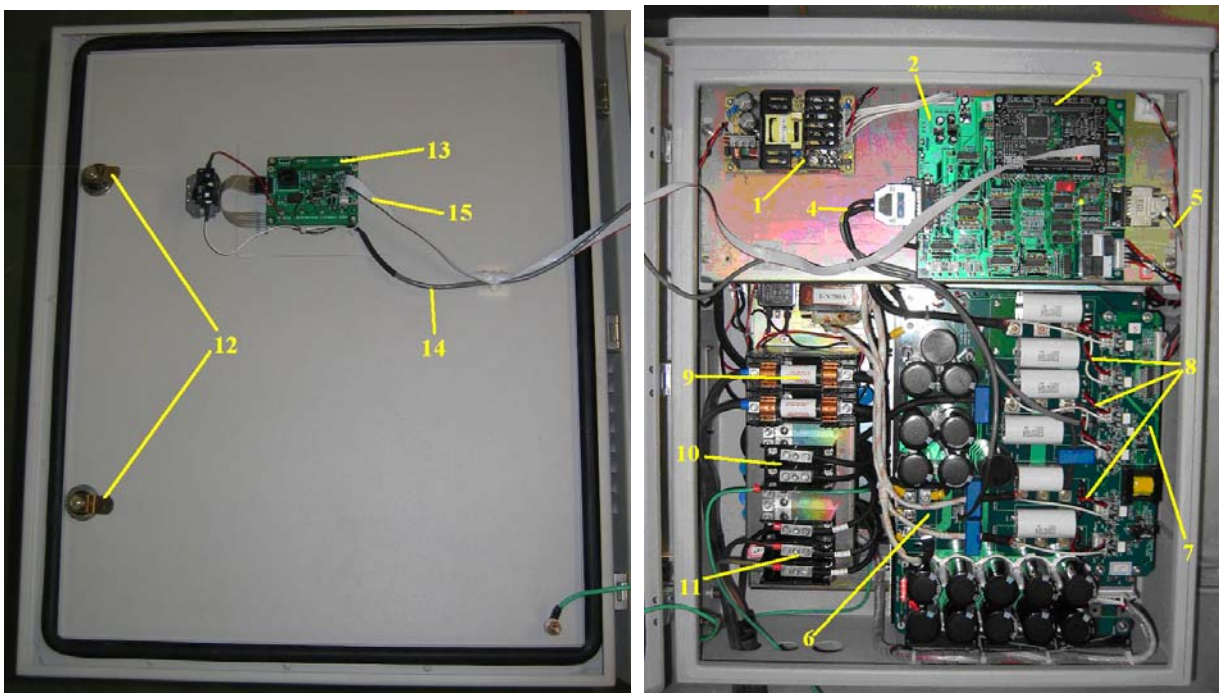
2. Inverter Layout and Power Circuit Schematics

Fig. 1 shows Model I12-60 inverter's pictures with the inverter door closed (a) and inside layout (b). The main parts/modules in Fig. 1 can be explained as following: 1- Control power supply, which supplies the sensors, interface board, DSP board and driver board; 2- Interface board; 3- DSP board, in which the control program is installed; 4- Current/voltage/temperature sensor cables; 5- Driver board signal cable; 6- DC-link printed circuit board; 7- Driver board; 8- IGBT driving signal wires; 9- Fuses; 10- Terminal block for PV input; 11- Terminal block for wind turbine generator input; 12- Inverter enclosure door locks; 13- LCD display module; 14- Inverter Start/Stop control cable; 15- Communication cable between DSP and display module.

Fig. 2 illustrates the schematic diagram of the power circuit of Model I12-60 inverter.



(a) Front view of inverter



(b) Front view of inverter

Fig. 1 Layout/arrangement of Model I12-60 inverter

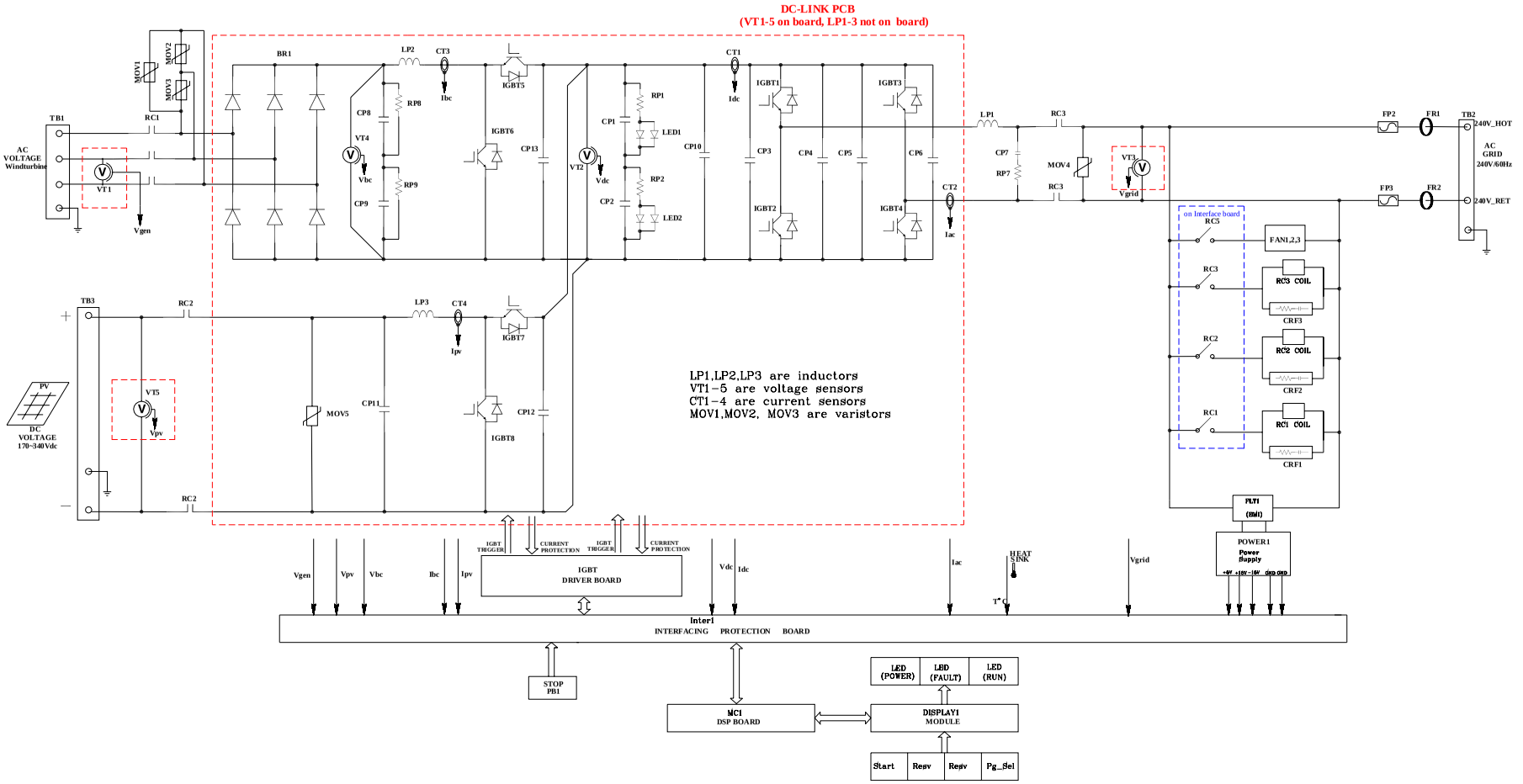


Fig. 2 Power circuit of Model I12-60 dual-input single phase IGBT inverter

3. Before Startup

Before the installation of the 12 kW IGBT inverter, the user should familiarize himself with the major inverter components as shown in Fig. 1 and Fig. 2 for the layout and power circuit of the inverter.

The Model I12-60 inverter is model of indoor inverter. If the inverter is to be installed outside, there should be suitable shield for the inverter. The inverter shall be securely mounted upright on the wall or on a suitable support. For necessary and suitable ventilation, the inverter requires no less than one foot space in the bottom, left side and right side. If the inverter is mounted in a wooden crate, in addition to the required margin of the inverter, the crate must have good ventilation as well.

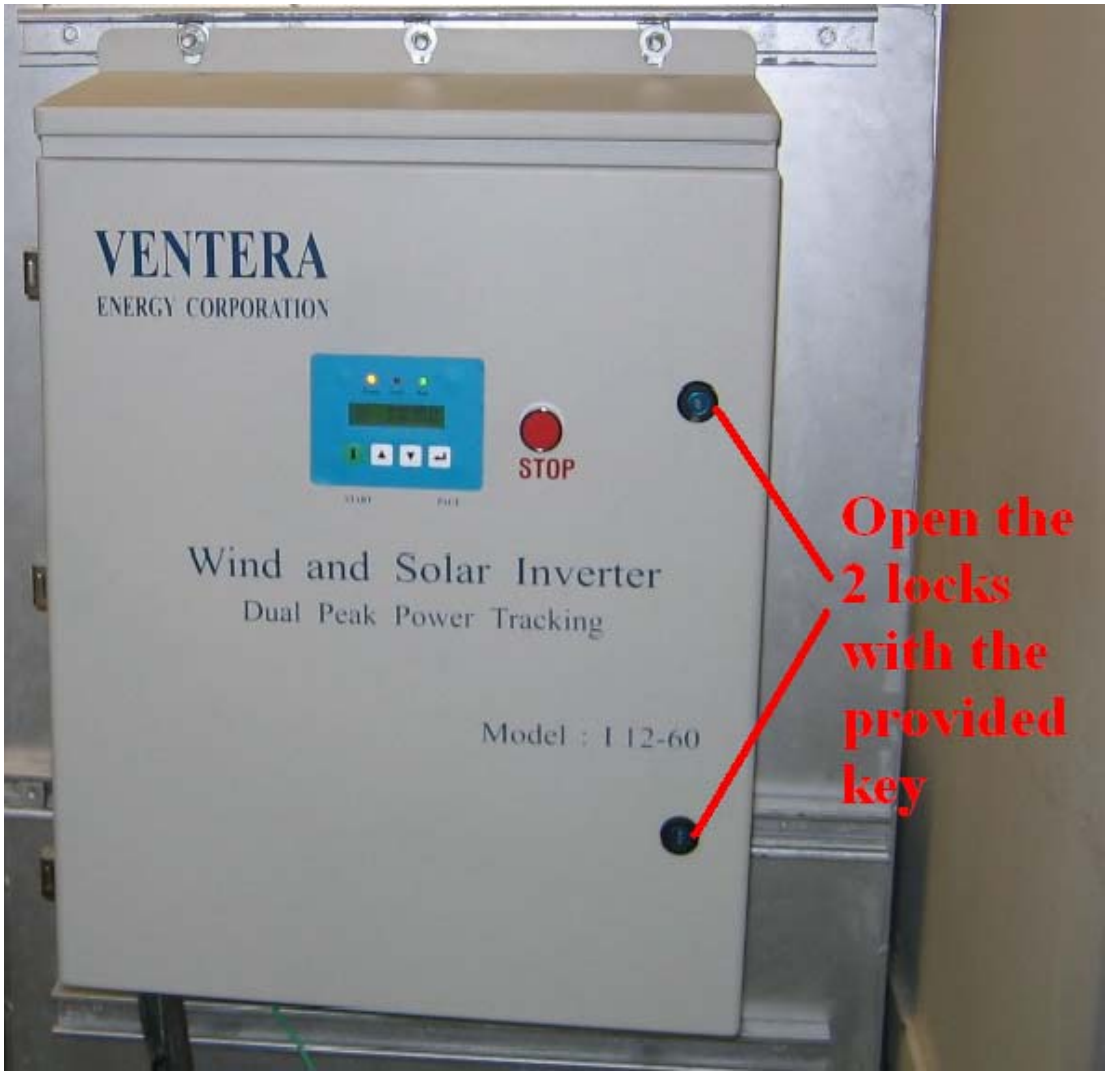


Fig. 3 Open the inverter door

To open the inverter, first unlock the two locks with the provided key (the two locks can be unlocked and locked with the same key), as shown in Fig. 3, then pull the right edge of the inverter door to open the inverter. In normal operation mode, the two locks of the inverter enclosure should be locked with the provided key all the time.

When connecting the inverter to the grid or doing maintenance on the inverter the grid power MUST be disconnected at the INVERTER TO GRID SHUT OFF SWITCH (supplied) and the dedicated 60amp breaker.

There are two main control buttons to control the operation of the inverter: the emergency “STOP” red push button, and the “START” green touch button locating at the display/touch pad, as shown in Fig. 4.

Fig. 4 Inverter Display/Control Panel and Emergency Stop Button

The inverter is controlled by a microcontroller (i.e. the DSP target board), which is located on the top of the interface board. The interface board is mounted on the power supply/interface board support locating at the top part of the inverter, as shown in Fig. 1(b).

The status/fault conditions are displayed by the 7-segment LED display mounted on the interface board, as shown in Fig. 5. The definitions of the LEDs are shown in Fig. 6. The status/fault information can also be read through the LCD display as shown in Fig. 4. The meanings of 7-segment LED display are listed in Table 2.

Fig. 5 Seven-segment LED display mounted on interface board

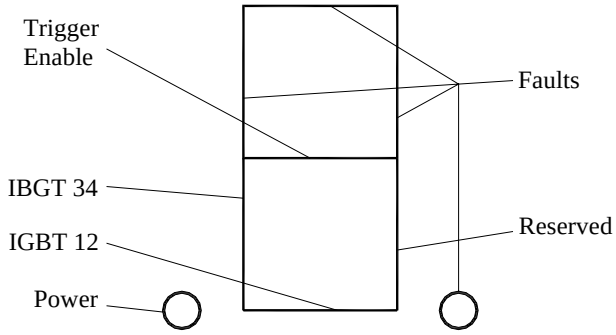


Fig. 6 Definitions of the LEDs

When the LCD display shown in Fig. 4 indicates "**SPI Fault**", this means there is a failure of the running of the inverter, disconnect the inverter from the grid (through the circuit breaker/disconnect) and re-connect it again may remove this fault, if **SPI Fault** persists, please consult the supplier.

There is no required operation inside the inverter enclosure for the user/customer of the inverter. There are no serviceable parts inside the inverter for the user/customer.

Only certified electricians are allowed to do the inverter wiring according to the corresponding electrical code. Only authorized persons (by Ventera or Novelek) can do the site repair or regular check.

Table 2 Inverter status/fault display LEDs (black indicates LIT-ON)

STATUS	DSP Values	LED Display
Wait to start	0000 1000	
Stop	0111 1000	
Running	0000 0xxx	
Over Current	0010 1000	
Over Voltage	0001 1000	
Grid Frequency Fault	1110 1000	
Over Temperature	1000 1000	
Grid Over Voltage	1010 1000	
Grid Under Voltage	1100 1000	
IGBT Fault	0011 1000	
VCC Fault	0101 1000	
No/Low Input	1101 1000	
Unknown Fault	1001 1000	
Other Fault		Display other than above status

The input wires from the wind turbine generator, i.e., the 3 phase-wires from the generator, are connected to the “WIND TURBINE” terminal block; the input wires from the PV arrays, the positive and negative wires, are to be connected to the PV+ and PV- terminals of the 2-pos terminal block, as shown in Fig. 7; the output wires which are connected to the grid in another end are connected directly to the lugs of the fuse holder. There are 3 ground lugs that can be used to connect the grounding wires, they are marked with “GND”.

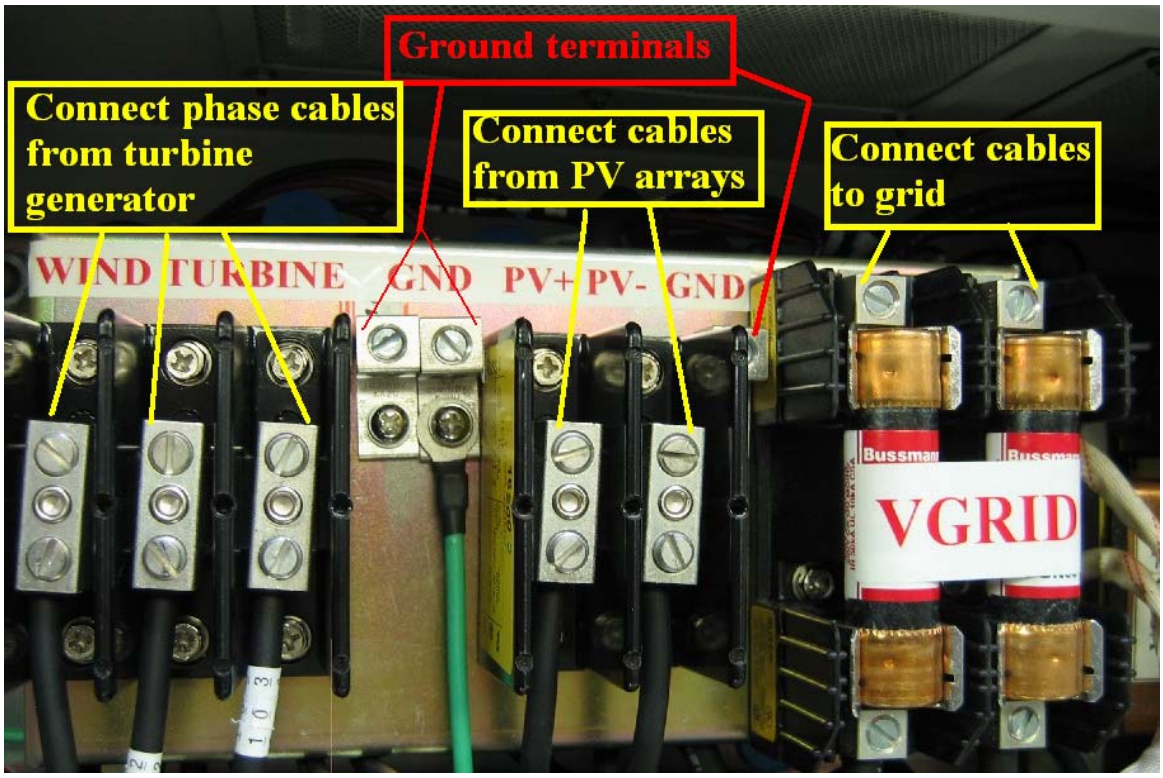


Fig. 7 Cable connection

Normally the AC power source is a 3-phase wind turbine and the DC source is a solar panel array. The wind turbine power source disconnect is a source shorting switch labelled, WIND TURBINE BRAKE SWITCH, and the solar panel source disconnect is labelled, SOLAR DISCONNECT. The two disconnects are shipped with the wind turbine and should be mounted near the inverter. There is no order to the three wires from the wind turbine. Any wire may be connected to any of the three inverter input terminals. No neutral connection is available or required for the wind turbine source.

For the output connection, wires of proper size shall be used, depending of the length of the wires. AWG #8 size is sufficient for connection of the 240v single phase grid up to 50ft one way. If the inverter is installed further from the dedicated 60amp breaker in the electrical panel, please consult the factory.

The inverter must be properly grounded for safety purposes. A properly sized wire should be used. Please consult electrical codes or an electrician if you are uncertain of the grounding procedure.

When the PV input is used, **GFCI as required by National Electric Code must be installed in line with photovoltaic input of inverter.**

For all wiring (I/P and O/P), use conduits suitable for applications.

4. Inverter Startup

First review that all connections to the inverter are correct and that the grid voltage is 240vac. The input power from the wind generator and solar panels should be OFF. Apply grid power by turning on the dedicated 60amp breaker and the INVERTER TO GRID SHUT OFF SWITCH. Press the green START button on the front of the inverter. The relays should be heard to close and the green light should come on. Now wind power and solar power can be applied to the inverter by turning OFF the WIND TURBINE BRAKE SWITCH and turning ON the SOLAR DISCONNECT SWITCH for normal operation of your wind and solar hybrid system. If a fault occurs, remove all powers going to the inverter and check the troubleshooting section. The inverter can be stopped at any time by pressing the STOP pushbutton shown in Fig. 4.

The inverter display panel is shown in Fig. 4. There are 4 Touch buttons (START, UP, DOWN, PAGE), one (1) Emergency Stop button (STOP), three (3) indicating LEDs (Power, Fault, Run), and one (1) LCD display. To start the inverter manually (after connecting all the inputs and output), press the START button. To stop the inverter operation at any time, press the STOP button. After the STOP button is pressed, the inverter can’t start automatically, and in order to restart the inverter, the START button must be pressed. The UP and DOWN buttons are reserved for other operations, they are no meaning to the Model I12-60 inverter.

The LCD on the front cover displays the following information: 1) Grid voltage (top line), output current (top line), output power (bottom line), and power factor (bottom line); 2) Total running time (top line) and running time (bottom line); 3) Total output energy (top line) and output energy (bottom line) in kWh. Use PAGE button to toggle between display 1 through display 3). If fault occurs, the LCD will display the fault message and the fault indicating LED will blink.

5. Detailed operation of the inverter

(1). **To start the inverter manually the first time**, (a) make sure procedure introduced in part 4 has been followed, (b) switch on the disconnect installed between the inverter and the grid,

(c) wait for the inverter to start automatically after 5 minutes, or (d) to manually start immediately, press the most-left square green button (START button) on the touch panel on the inverter door.

(2). **To restart the inverter manually after any fault**: (a) press the STOP push button (the RED pushbutton on the door of the inverter), (b) press the most-left square green button (START button) on the touch panel on the inverter door.

(3). **If the procedure described in (2) can not restart the inverter**, (a) switch off the disconnect installed between the inverter and the grid, (b) switch on the disconnect installed between the inverter and the grid, (c) press STOP (red) button on the door, (d) press START button on the touch panel on the inverter door.

(4). **Procedure to stop and disconnect the inverter**: (a) Press STOP (red) button on the door, (b) switch off the circuit breaker/disconnect that connects the inverter and the wind turbine generator, (c) switch off the disconnect/circuit breaker that connects the inverter and the grid, and (d), wait sufficient time (at least 5 minutes) for the discharging of capacitors inside the inverter enclosure, or **until all LEDs are OFF**, (e) disconnect the connected wires of the inverter.

6. Inverter Troubleshooting

This section helps to resolve some of the faults the inverters generated. The inverter is equipped with two tiers of protections from over-current of dc link and inverter output, over-temperature, over-voltage of the grid, dc link, generator and solar panel, under-voltage of the grid, over-frequency of the grid, under-frequency of the grid. These two tiers of protections are achieved by the control software and hardware.

After a shut-down at a fault condition, the inverter will automatically resume operation after the fault is cleared.

Below is a list of faults and possible solutions for the inverter. **When a serious fault occurs, disconnect all the powers from the inverter immediately. Do not work on the inverter when high voltages are present.**

When the inverter is connected to wind turbine and solar panel, the inverter will shut down after a fault condition is detected, and will resume operation when the fault is cleared. **If faults occur very often, the supplier may be consulted to determine the possible causes.**

Table 3 Troubleshooting Guide

Fault Type	**Grid Inverter**
No control Power	- Make sure there is a voltage source of 240Vrms on the grid terminals. Check the disconnect switch and fuses.
IGBT Fault	-There has been a very large current through the IGBTs. The IGBTs should be checked for damage. You should get technical assistance before powering the inverter again.
Over - Current	-The IGBT inverter was overloaded. Reduce the load on the inverter by reducing the current demand. (Factory adjusted) - The inverter will start automatically after 5 minutes if the fault is removed. - If this occurs very often, there may be a problem in the rectifier or IGBTs, in this case, consult the supplier.
Over - Voltage	-The voltage at the inputs of the inverter may be too high. The generator may be turning too fast, and PV arrays may generate too high voltage.
Frequency Fault	-The grid frequency has changed. Wait for a few minutes and restart the grid inverter. If this occurs very often at a normal grid, there may be a problem in the grid voltage sensor which is used to calaculate the frequency. The inverter will start automatically after 5 minute if the fault is removed.
Over - Temperature	-The temperature on the heat sink is too high. Check to see if the heat sink fans are running. If they are turning, the inverter was probably overloaded for a long period of time. The inverter should start automatically after the inverter is cooled down.

Low Control Power (VCC Fault)	-The control power is too low. This may be caused by a too low voltage supply (control voltage much less than 240V) or a problem with the internal power supply. Check the grid voltage.
Grid Over Voltage	-The grid voltage is too high. The inverter will start automatically after 5 minute if the fault is removed.
Grid Under Voltage	-The grid voltage is too low. The inverter will start automatically after 5 minute if the fault is removed.

The inverter should be able to resume automatically after the fault has been removed and after certain delay time, if not, consult the supplier for assistance. If the fault occurs frequently/always, consult the supplier for assistance.

Warning:

To prevent electric shock, **Never touch** any part inside the enclosure.