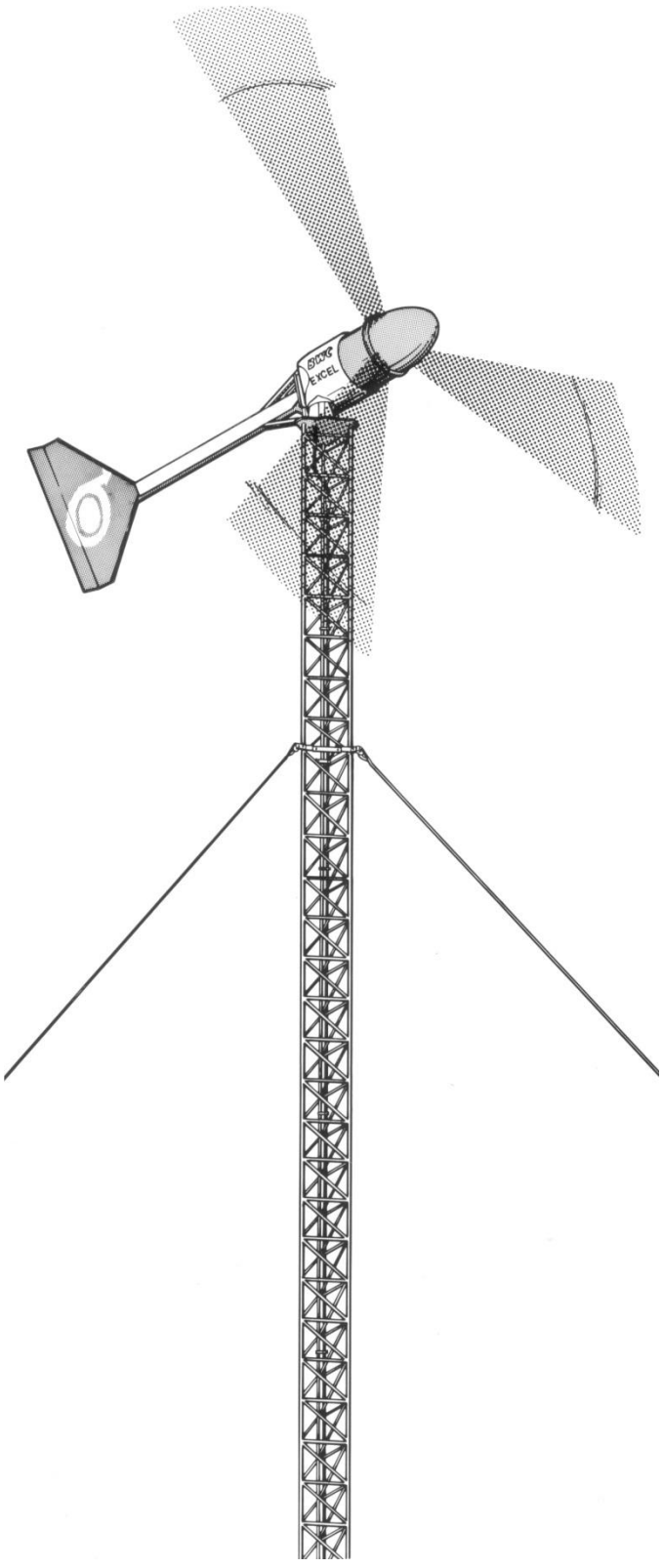
Owner's Manual

BWC EXCEL 10

Wind Turbine &
Powersync II
Grid-Intertie Inverter



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Part # MANXLS

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Contents

I. INTRODUCTION

This manual contains important information concerning your Bergey EXCEL 10 wind turbine system and its operational characteristics. We strongly recommend that you read and familiarize yourself with its contents.

At several points in this manual items of special interest or significant impact are highlighted by one of the following symbols:

	**DANGER:**	Hazards or unsafe practices that could cause personal injury or death.
	**WARNING**:	Hazards or unsafe practices which could cause product damage.
	NOTE	Significant points of interest.

Serial Numbers

Each Bergey EXCEL 10 wind turbine has a serial number located on the tower adapter. The turbine serial number can also be found on the outside of the shipping crate and on the warranty registration card. The blade serial numbers are located on the root pad and also the shipping crate. We recommend that the serial number be copied to this manual for possible future reference.

Bergey EXCEL 10 Serial No.: _____

Bergey EXCEL 10 BLADES Serial No.: _____

The Powersync II inverter has a serial number label on its right side. We recommend that this serial number also be copied to this manual.

Powersync II Serial No.: _____

II. EXCEL 10 SPECIFICATIONS

PERFORMANCE

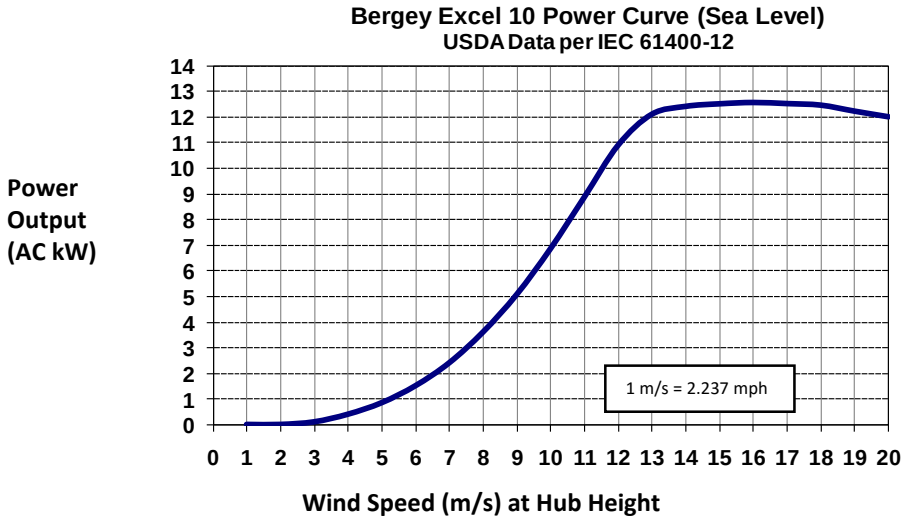
START-UP WIND SPEED	5 mph (2.2 m/s)
CUT-IN WIND SPEED	5 mph (2.2 m/s)
RATED WIND SPEED	26 mph (11.6 m/s)
AWEA RATED POWER (at 11 m/s or 25 mph)	8.9 kW
AWEA ANNUAL ENERGY (at 5 m/s average	13,600 kWh
CUT-OUT WIND SPEED	none
FURLING WIND SPEED	36-40 mph (16-18 m/s)
MAXIMUM DESIGN WIND SPEED	134 mph (60m/s)
RATED POWER	10 kW
ROTOR SPEED	0-400 RPM

MECHANICAL

TYPE	3-Blade Upwind, Horizontal-Axis
ROTOR DIAMETER	23 ft. (7.0m)
WEIGHT	1020 lb. (460 kg)
GEARBOX	none
BLADE PITCH CONTROL	none
OVERSPEED PROTECTION	AUTOFURL®
TEMPERATURE RANGE	-40 to 140 deg. F (-40 to 60deg. C)

ELECTRICAL

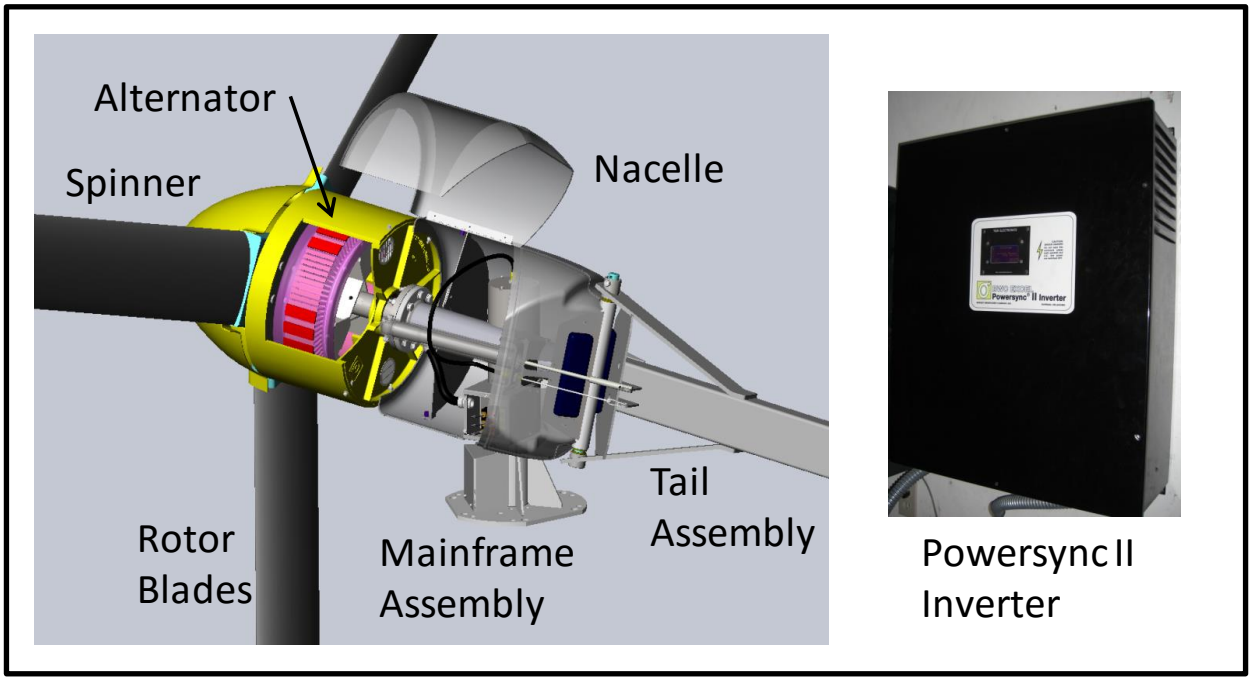
OUTPUT FORM	240VAC, 1-Phase, 60Hz
GENERATOR	
Permanent Magnet Alternator	
POWER PROCESSOR	Powersync II Inverter



III. SYSTEM DESCRIPTION

The Bergey EXCEL 10 is an upwind horizontal-axis wind turbine designed for distributed generation applications, connected to the power grid on the customer's side of the utility meter. The complete unit consists of the following major components, as shown in the figure below:

1. Spinner
2. PowerFlex® Blades
3. Alternator
4. Mainframe
5. Yaw Bearing
6. Slip-ring and Brushes
7. Tail Assembly
8. Nacelle Assembly
9. Furling Winch
10. Powersync II Inverter



A. ROTOR SYSTEM

The rotor system consists of three PowerFlex® fiberglass blades. Acting like aircraft wings, the blades convert the energy of the wind into rotational forces that drive the alternator. The PowerFlex® blades are rigidly attached to the alternator and they are fixed pitch. The Excel 10 rotor blades have a proprietary airfoil, the BWC-7, which was custom designed to provide high efficiency and low noise.

The blades for the EXCEL 10 are extremely strong because they are made in a "pultrusion" process that puts more high-strength glass fibers in the structure than any other molding technique. This contributes to their long life and toughness. Blade sets are carefully matched for balance at the factory to ensure smooth operation of the wind turbine. Each blade has a serial number inscribed on its root pad at the inboard end.

B. ALTERNATOR

The alternator converts the rotational energy of the rotor into electricity. The alternator utilizes permanent magnets and has an inverted configuration in that the outside housing rotates, while the internal windings are stationary. It was specifically designed for the Bergey EXCEL 10 and produces power at low speeds, eliminating the need for a speed-increasing gearbox. Since it uses permanent magnets, the alternator is generating voltage whenever the rotor is turning.

DANGER The output wiring of the BWC EXCEL presents shock hazard whenever the rotor is turning. Caution must be exercised at all times to avoid electrical shock.

C. MAINFRAME

The mainframe is the structural backbone of the wind turbine. It serves as the attachment point for the yaw bearing and the housing for the yaw-axis slip-ring brushes. The yaw-axis is the full 360 degree pivot that allows the turbine to freely align itself to the wind direction.

D. SLIP-RINGS AND BRUSHES

The slip-rings and brushes conduct the electricity generated in the alternator from the moving (as it orients with the direction) wind turbine to the fixed tower wiring. The slip-rings are enclosed in a metallic housing to help protect them from lightning.

E. TAIL ASSEMBLY AND AUTOFURL OPERATION

The tail assembly keeps the rotor aligned into the wind at wind speeds below approximately 35 miles per hour (16 m/s). At about 35 mph the AutoFurl® action turns the rotor away from the wind to limit the rotor speed in high winds. The tail appears to fold, but in reality the tail stays stationary as the rotor turns sideways to the wind. The rotor furls to a maximum angle of 75 degrees (limited by rubber tail stops), so that the unit continues to produce power in high winds. When the high winds subside, the AutoFurl® system automatically restores the turbine into the normal straight position.

The rotor continues to spin even in very high winds and this actually makes the blades stiffer. The AutoFurl® system works whether or not the Powersync II inverter is on or not. Unlike many other turbines designs, the Bergey EXCEL 10 can operate safely without an electrical load connected to the turbine.

F. SPINNER AND NACELLE

The spinner (nose cone) and nacelle provide additional weather protection for the bearings and the slip-ring assembly. The nacelle also improves lightning protection.

G. Powersync II Inverter

The ETL-approved Powersync II inverter converts the "variable AC" from the Bergey EXCEL 10 turbine into utility grade electricity so that it can be connected to the wiring in your home. This conversion requires sophisticated electronics and is designed to operate automatically. The Powersync II has a digital display that provides information on the status of the system, its current output power, and its cumulative energy production.

IV. SYSTEM OPERATION

A. NORMAL OPERATION

The Bergey EXCEL 10 produces utility compatible power in the form of 240VAC, 60 Hz, single phase electricity (other voltage options are available). It is connected through the Powersync II inverter to the utility distribution network in the same manner as household appliances. When the wind speed is too low to operate the wind turbine, all of the electrical power needed for the home will be supplied by the utility company. During these idle periods the Powersync II will consume approximately 0.3 kilowatt-hours of electricity per day.

When the system begins producing power, the amount of power which must be purchased from the utility is reduced by an amount equal to the output of the wind system. From the perspective of the utility company the wind system output reduces the electrical load they have to supply, just as if you turned off lights and appliances. The output of the wind system fluctuates with the speed of the wind so the instantaneous amount of electricity being saved will be constantly changing. Quite often your home will be served simultaneously by the utility and your Bergey wind turbine.

When the output of the wind system exceeds the power requirements of the house the excess electricity is sold back to the utility. Both the consumer's right to interconnect a wind system and the utilities obligation to purchase excess power are prescribed by federal law (PURPA, Section 210). The amount you will be credited or paid for this excess production varies state-to-state and sometimes utility-to-utility. If your utility company offers "net metering" then your meter is allowed to turn backwards so that you essentially bank energy, at full value, for less windy periods. This banking can be done over a month or over a year depending on the policy of your state or your utility. If you do not get "net metering" then you will have a second utility meter to register excess production and your utility will pay or credit you for this, typically at less than full value.

If your utility experiences an outage (blackout) the wind system will cease to produce power so that it does not present an electrical safety hazard to utility repair crews. Although the wind turbine will continue to operate, no power will be transferred from the Powersync II inverter to your circuit breaker panel. When utility power is restored, the Powersync II will automatically return the wind system to full working status following a five minute delay and then a two minute countdown. These time delays are dictated in the UL standards required by the utilities.

The rotor of the EXCEL 10 should begin to rotate when the wind speed reaches approximately 8 mph (3.6 m/s). Once started, the rotor may continue to turn in winds below 5 mph (2.2 m/s), but the system will not be producing power below this wind speed.

NOTE All operational wind speeds given assume steady winds, sea-level conditions and moderate temperatures. Hot weather, high altitude, turbulence and gusting winds will reduce system performance.

The rotor speed will increase with increasing wind speed and the system will produce a higher output. This output increases rapidly because the energy available in the wind varies as the third power (cube) of the wind speed. For example, if the wind speed increased form 5 mph to 10 mph, a factor of two, the energy in the wind would increase from one unit to eight units, a factor of eight (2 to the 3rd power). One result of this relationship is that there is very little energy available in light winds. For the average site, winds in the range of 12-20 mph (5.5 – 9 m/s) will provide most of the system's energy production on an annual basis.

B. HIGH WINDS - AUTOFURL®

During periods of high wind speeds the AutoFurl® system will automatically protect the wind turbine. Furling means that the rotor is turned away from the wind. When furled, the power output of the turbine will be reduced. In winds between 33 mph (15 m/s) and 45 mph (20 m/s) it is normal for the turbine to repeatedly furl and then unfurl and then furl again. During intermittent cycling the turbine may produce output surges up to 13,000 watts.

C. UNLOADED OPERATION

If an abnormal condition occurs on the utility line, such as a voltage fluctuation or a complete interruption, the Powersync II inverter will automatically disconnect the wind turbine from the power grid. If sufficient wind is present, the rotor will continue to operate. Since it is unloaded it will spin at a higher speed and some increase in blade sound is to be expected. This is a perfectly safe and permissible condition as the AutoFurl system will continue to protect the turbine.

DANGER During unloaded operation the alternator can still generate high voltages, so the EXCEL 10 electrical system should be handled with the same caution used during normal operation.

In order to enhance the systems reliability, the power output of the Excel is limited to approximately 12.5 kilowatts. Since this output is reached at 31 mph (14 m/s), the rotor will become progressively unloaded as wind speeds increase up to the furling point at approximately 35 mph (15.6 m/s).

D. MANUAL FURLING

The Bergey EXCEL 10 is designed for unattended operation over an extended period of time. Exceptional situations may occur, however, in which the wind turbine should be manually furled. These situations include:

1. **EXCESSIVE VIBRATION -** Uneven ice build-up, ice shedding, or blade damage may cause the wind turbine to experience excessive vibration. Always furl the turbine as soon as an increase in vibration is detected. Any new or excessive vibration in the turbine when ice is not present should be investigated immediately.

2. **UNUSUAL SOUND -** If the turbine begins making clinking, growling, or other unusual sound it should be furled and fully inspected as soon as possible.

3. **INSPECTION AND MAINTENANCE -** Whenever someone has to climb the tower the wind turbine must be manually furled, and the alternator dynamically braked (ie. electrically shorted), even if the wind speed is very low.

Manual furling of the EXCEL 10 is accomplished by operating the furling winch located at the base of the tower. The winch cable is connected to the tail boom such that as the cable is tightened the tail "folds" and the rotor is pulled away form the wind. Furling the wind turbine will not stop the rotor completely and it may take some time for the rotor to be pulled around away from the wind. Fully furled the rotor will still be partly facing into the wind and will normally turn at a reduced rate. The rotor can only be brought to a complete stop by shorting the output leads of the turbine.

DANGER Do not attempt to furl the wind turbine or approach any part of the tower when there is lightning in the area.

E. FURLING PROCEDURE

The furling winch is located at the base of the wind turbine tower. To furl the wind turbine, first make sure that the winch ratchet is engaged (a strong clicking sound should be heard as the handle is turned). The winch handle may then be turned until the tail comes to rest against its rubber stop. When the stop is reached the tail will stop rotating towards the blades and the force required to turn the handle will greatly increase. When fully furled, the tail will have come around approximately 70 degrees: *it does not come around parallel to the blades.*

The turbine may not come out of the wind immediately because the rotor forces will sometimes resist the sideways force acting of the tail. This situation will correct itself after a short time.

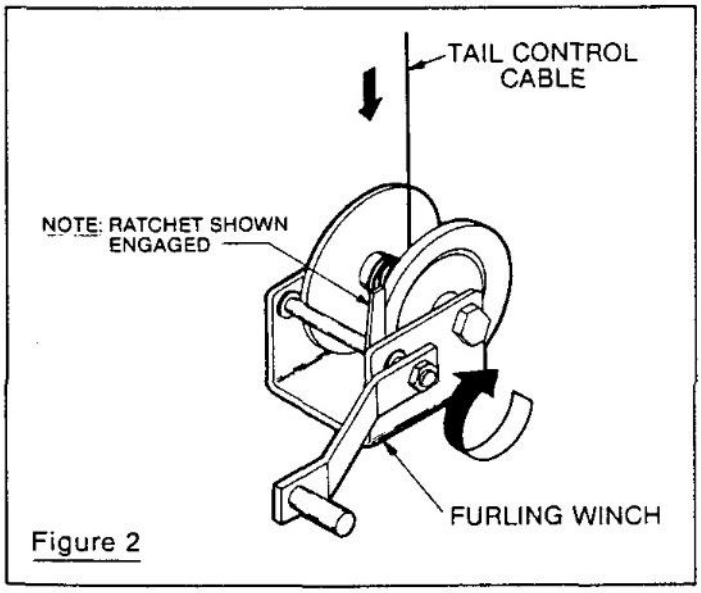


Figure 2

CAUTION Do not over tension the furling cable. Tightening the cable beyond the amount required to furl the wind turbine will reduce its ability to track the wind and may damage the furling system.

To return the turbine to the straight, normal operation, position, grasp the winch handle firmly and then release the ratchet mechanism. The cable can now be slowly unwound until the turbine has fully straightened out and the cable is slightly slack. It is a good idea to then reengage the ratchet.

DANGER Hold the winch handle *firmly* before the ratchet is released and until all tension is removed from the cable. The winch handle could whirl dangerously if it is released before the cable tension is reduced.

V. POWERSYNC II INVERTER

The Powersync II inverter is connected to the household circuit through a dedicated circuit breaker. Before opening the Powersync II enclosure, the breaker must be turned off and the turbine disconnect switch must be switched OFF, to avoid electrical shock.

DANGER Electric Shock Hazard. Failure to comply will result in death or serious injury. Disconnect all power to the inverter before servicing. Wait at least 5 minutes before opening the inverter door.

Using the utility grid as a reference, the Powersync II inverter converts the output of the wind turbine into utility-compatible power (AC). The Powersync II inverter has been designed for automatic, unattended operation and it is programmed to provide maximum performance from your Bergey EXCEL 10 wind turbine. It is also programmed to safely disconnect the wind turbine in the event of a problem with the utility power and to automatically reconnect the turbine after the problem is remedied.

The LCD digital display on the front of the Powersync II provides information on the status of your Bergey EXCEL 10 wind turbine. The contrast can be adjusted UP or DOWN using hidden buttons on the right side of the display.

In normal operation the Powersync II will show the status as "Running" and will display the instantaneous Output Power in Watts. Other operating modes that may be indicated are as follows:

A. INVERTER SPECIFICATIONS

Input – From Turbine

Input Voltage Maximum (3 Phase Input)	400 VAC
Input Start Voltage Minimum	30 VAC
Input Operating Voltage Range	200 to 400 VAC
Input Frequency Maximum	400 Hz
Input Current Maximum	40 Amps
AC Backfeed Current to Input Source	N/A

Output – To Utility

Model	PSII12	PSII126208
Continuous Output Power Maximum	12000 KW	10400 KW
Continuous Output Power Tolerance	±10%	
Output Voltage Nominal (Single Phase) Line-Line	240 VAC	208 VAC
Operating Voltage Range Line-Line	212-264	184-228
Output Voltage Nominal (Single Phase) Line-Neutral	120 VAC	
Operating Voltage Range Line-Neutral	106-132 VAC	
Continuous Output Current Maximum	50 Amps	
Continuous Output Current Tolerance	± 10%	
Voltage Measurement Tolerance	± 10 VAC	
Operating Frequency Nominal	60 Hz	
Operating Frequency Range	59.3 to 60.5 Hz	
Operating Frequency Measurement Tolerance	± 0.5 Hz	
Output Power Factor	0.95 ± 0.05	
Temperature Range Normal Operation	-4°F to 113ºF (-20ºC to 45ºC)	
Output Over-Current Protection Maximum	80 Amps	
Synchronization In-Rush Current Maximum	6.3 Amps	
Utility Interconnection Trip Time	100 msec	
Time Measurement Tolerance	± 85 msec	

B. Other Specifications

Dimensions	32.2"H x 24.3"W x 9" D 817 x 607 x 230 mm
Weight	153 lbs / 64 Kg
Enclosure	NEMA Type 1

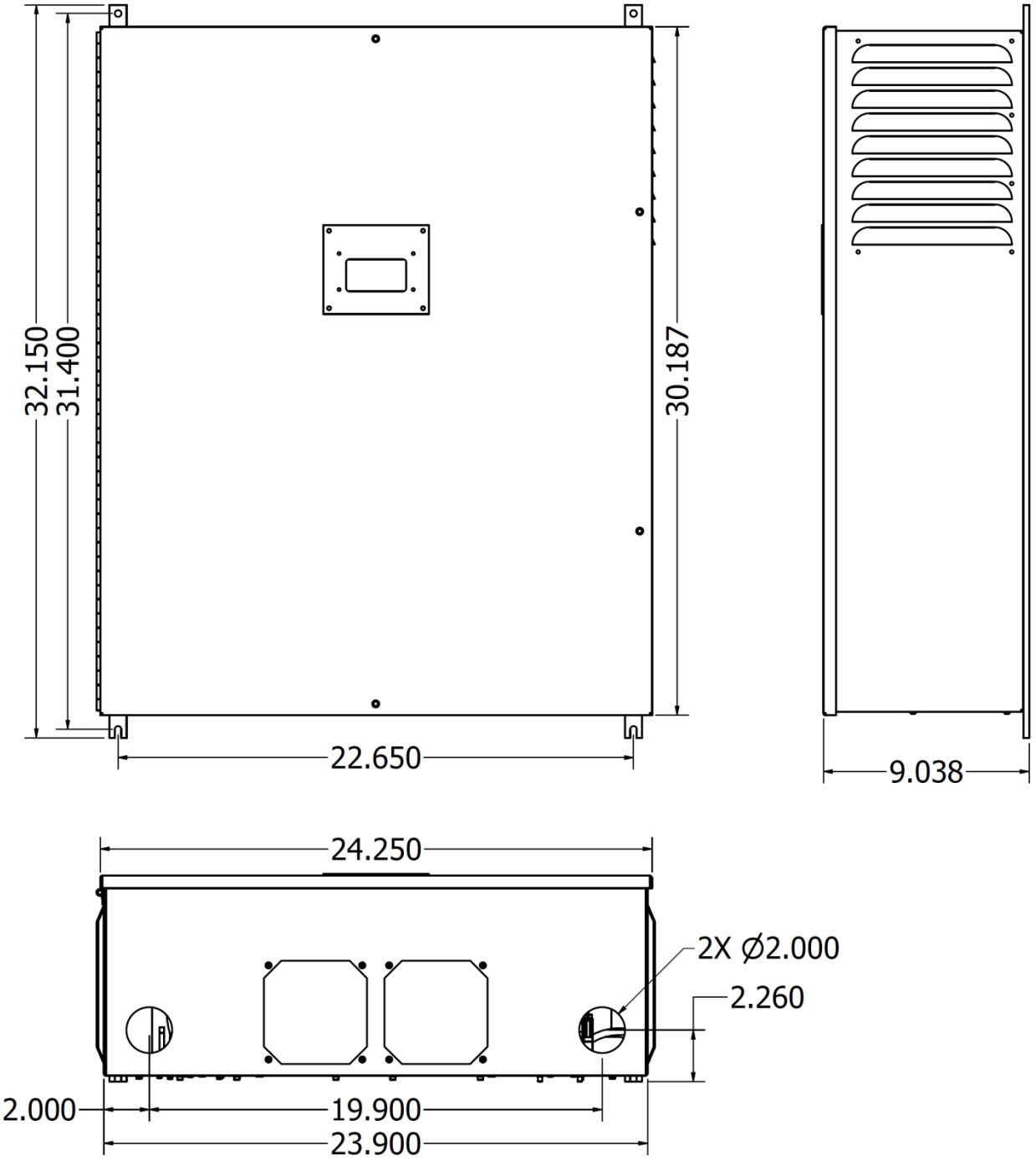
NEMA 1 indicates that the enclosure is constructed for indoor use only. It provides protection to personnel against incidental contact with the enclosed equipment.

C. Important Inverter Safety Instructions

SAVE THESE INSTRUCTIONS This manual contains important instructions for Models PSII12 and PSII126208 that shall be followed during installation and maintenance of the inverter.
The output field wiring terminal can be used for connection of a maximum of: One 1/0 AWG wire per terminal (1 wire for each line)
The input field wiring terminal can be used for connection of a maximum of: One 2 AWG wire per terminal (1 wire per phase per terminal provided).
The field-wiring terminals shall be connected using the following wire types: Copper Conductors Only (Input connection) Use No. 8 - 2 AWG, 90 °C copper wire only Copper, Aluminum or Copper-Clad Aluminum Conductors Only (Output connection) Use No. 6 – 1/0 AWG, 90 °C Copper Conductors Use No. 4 – 1/0 AWG, 90 °C Copper Clad Aluminum, or Aluminum Conductors.
The following symbols are used as markings on this product with the following meanings: Equipment grounding conductor – 
This inverter is intended for operation in an indoor NEMA 1 compatible environment having a maximum ambient temperature of 45° C (113° F).
This unit or system is provided with fixed trip limits and shall not be aggregated above 30 kW on a single Point of Common Connection
CAUTION To reduce the risk of fire, connect only to a circuit provided with 80 amperes maximum branch-circuit over-current protection in accordance with the National Electrical Code, ANSI/NFPA 70.
 Hot surfaces – To reduce the risk of burns – Do not touch The enclosure and the rear heatsink can exceed 70° C (150° F).
Note that the input and output circuits are isolated from the enclosure. In accordance with Clause 15.2.1.1 of CAN/CSA-C22.2 No. 107.1, system grounding, when required by the *Canadian Electrical Code, Part I,* is the responsibility of the installer.

D. Installation

1. Dimensions



2. Locating

- The inverter must be installed in a weather protected environment.
- The inverter emits audible noise when operating. Do not locate the inverter in living spaces or on walls directly connected to living spaces.
- For maximum energy production, avoid installing in direct sunlight or in locations that are likely to exceed 45ºC (113ºF) local ambient temperature.

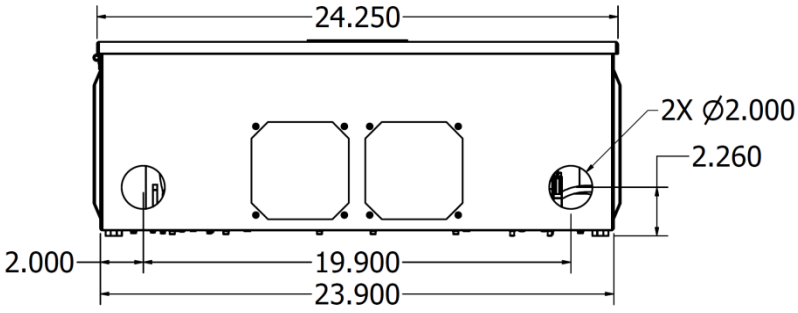
- The inverter will automatically shut down if the temperature is below -20ºC (-4ºF). Protect from extreme cold exposure if this is undesirable.
- Enclosure ventilation is to be provided such that the following guidelines are satisfied.
    - Provide a minimum of 12 inches clearance to the bottom air inlet filters.
    - Provide a minimum of 6 inches clearance to the outlet side vents.
    - Use in a well-ventilated area within the maximum ambient temperature rating.
- If the inverter is installed in a small structure or out building, the structure must be provided with top and bottom venting of at least 100 square inches at each opening.

3. Mounting

- The enclosure, having a NEMA 1 rating, is designed for indoor installation.
- The enclosure is provided with four mounting feet with 0.281" dia. mounting holes.
- For mounting to a 0.10" thick metal surface, use M6, ¼-20 or ¼-28 bolts grade 3 or higher with nuts and flat washers.
- For mounting to concrete, use M6 or ¼" bolts using concrete anchors with an 800 pound or greater tension rating.
- The required bolt length is such that the internal threads need to be 100% engaged.
- The enclosure is to be oriented with the conduit openings facing toward the floor.

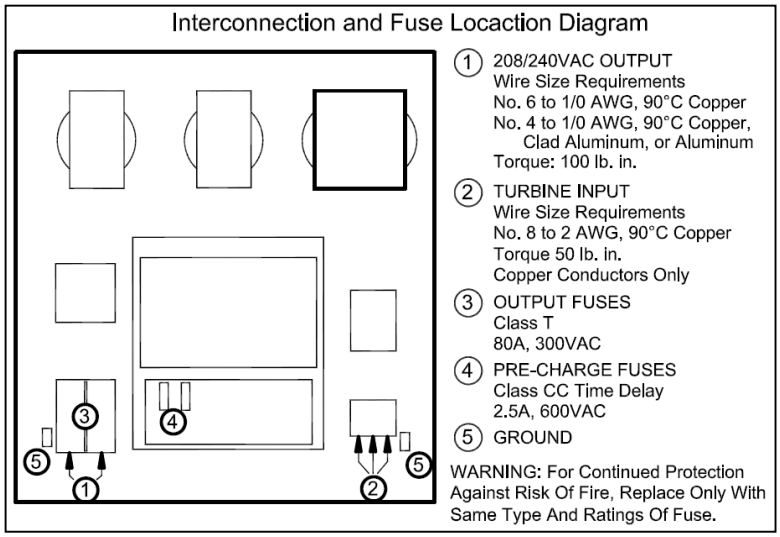
4. Electrical Connections

- Connections are made to the unit via the holes in the bottom of the enclosure.
- **Holes are sized for 1.5'' rated conduit**. Wiring methods in accordance with the National Electrical Code, ANSI/NFPA 70 are to be used.
- It is recommended that at least 12" of flexible conduit be used below the inverter to make alignment easier.
- Cutting additional holes in the enclosure is not recommended and voids the warranty on the enclosure against corrosion and water damage. Any damage to the electronics caused by the modification will be **<u>your</u>** responsibility.



5. AC Output Connection

- The AC output is single phase and not bonded to ground.
- Connect the two single phase 240VAC or 208VAC wires from the distribution panel to the dual fuse block located on the lower left side of the enclosure.
- Tightening torque, allowable wire size, and type, for the Field-Wiring Terminals:
- 6 AWG to a maximum of 1/0 AWG for Copper Conductors Only
- 4 AWG to a maximum of 1/0 AWG for Aluminum Or Copper-Clad Aluminum Conductors Only
- Wire rated 90°C minimum
- 100 lbf-in tightening torque maximum



6. AC Input Connection (Turbine)

- Connect the three phase turbine wires to the terminal block located on the lower right side of the enclosure.
- The inverter's wind turbine input must be connected to a 3-phase "delta" or "wye" connection with the neutral not connected to earth ground (left floating).
- The inverter must be provided with 3, UL listed fuses rated, 400 VAC minimum, 50 Amp maximum for proper protection from the wind turbine input to the unit as well as an appropriate UL listed fuse holder to accommodate the fuses.
- Tightening torque, allowable wire size, and type, for the Field-Wiring Terminals:
- 50 lbf-in tightening torque
- 8 AWG - to a maximum of 2 AWG for Copper Conductors Only
- Wire rated 90°C minimum.

7. Earth Ground Connection

- Earth ground is to be connected to the two terminals provided inside the enclosure indicated by the earth ground equipment marking.

- Allowable wire size range is 8 AWG – 4 AWG.
- 50 lbf-in tightening torque
- The inverter's earth ground connections available on both the input and output terminals must be bonded directly to the service entrance's earth ground which in turn is bonded to neutral. With a second bond, the inverter's earth ground

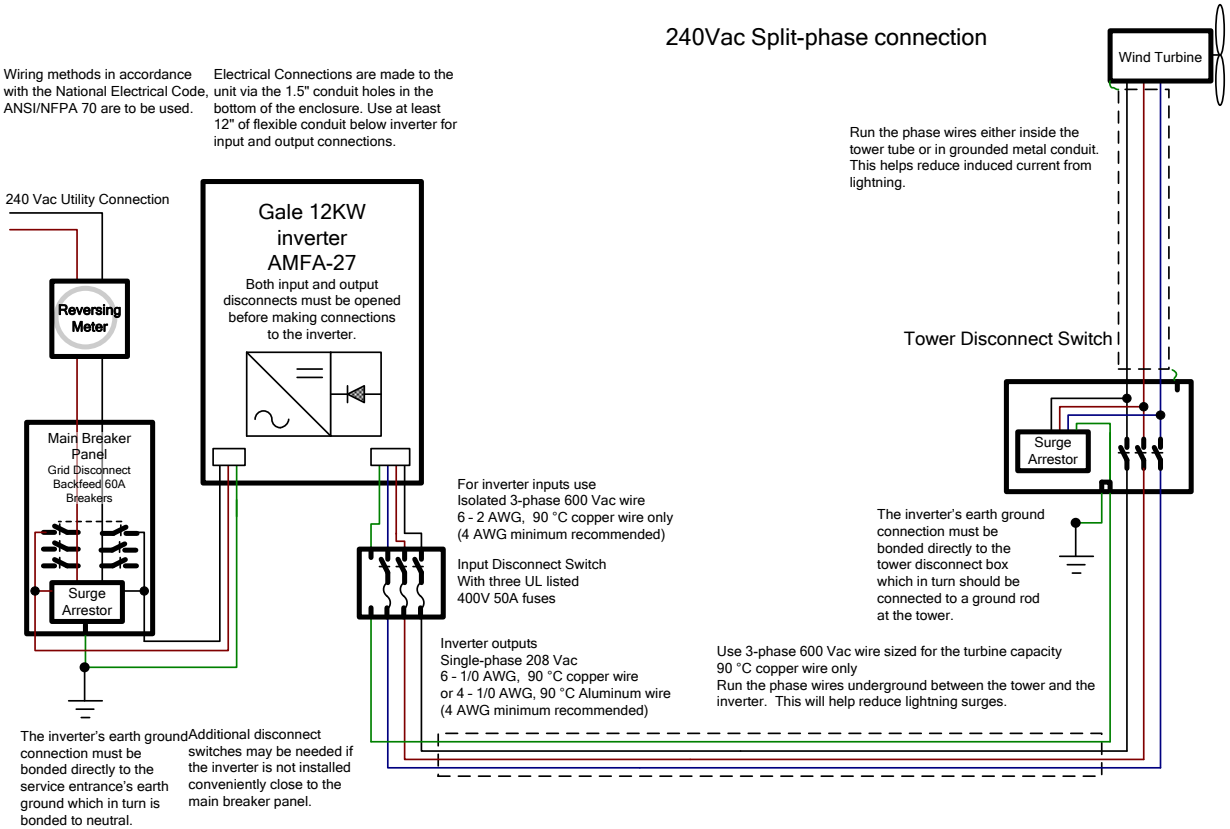
connection must be bonded directly to the tower disconnect ground lug which in turn is bonded to the tower's ground rod.

- The input and output circuits are isolated from the enclosure. System grounding when required by the *Canadian Electrical Code, Part I,* is the responsibility of the installer.

8. Fuse replacement

- **Warning:** For continued protection against risk of fire, replace only with same type and ratings of fuse.
- Two output fuses are located in the dual fuse block on the lower left side of the enclosure.
- Class T 80A, 300VAC
- Two pre-charge fuses are located on the Input/Output PCB board.
- Class CC Time Delay, 2.5A, 600VAC
- Three input fuses are located in a separate fuse box provided by the installer. Fuse type may vary, but must be UL listed fuses rated, 400 VAC minimum, 50 Amp maximum

9. Connection example



With the wind turbine tower sticking high into the air, lightning damage is a concern to most inverter customers; especially those customers in areas with frequent cloud to ground lighting. BWC's warranty does not cover lightning damage to the inverter. A direct lightning strike can easily be in excess of 100kV at 100kA. Proper grounding of the turbine to the tower and running the input wires down the tower in grounded metal conduit will take care of most of this energy. The standard inverter is capable of

withstanding input line to ground surges of about 6kV at 3kA. Contact your distributor or BWC for application specific lightning surge suppression solutions.

E. Inverter Operation

This equipment is a UL 1741 certified Utility Interactive Inverter and complies with the requirements of IEEE1547 which is the standard for interconnecting distributed resources with electric power systems. It will not operate in an off-grid or backup power configuration.

The normal operation of the inverter is as follows: When single phase utility power is applied to the output of the inverter, the display will power up and a message stating that the unit is initializing is shown. If there are no faults, i.e. grid voltage and frequency are in tolerance, a countdown timer set for 5 minutes (300 seconds) starts before the inverter is ready to transfer power to the utility grid. The inverter will automatically transfer power to the utility when AC voltages in the range of 30VAC to 400VAC are present at the Turbine input.

As the heatsink heats up after exporting significant power for a period of time the internal cooling fans will activate. The inverter is be able to operate at full power continuously if provided with adequate ventilation and the local ambient temperature stays below 45ºC (113ºF). If the ventilation is compromised or the heatsink temperature exceeds 60°C, the inverter will automatically reduce its output power.

F. Touch Screen Display

The touch screen display located on the front panel of the enclosure provides manual over-ride and status of the inverter's operation. The touch screen display also provides a Stop and a Reset button. The Stop button is used when it is desired to disconnect the inverter from the power grid and the wind turbine. After Stop is pressed the inverter will remain in a powered-up stand-by mode until Reset is pressed or Grid voltage is removed. When Reset is pressed the inverter will resume normal operation.

The status of the inverter's operation is shown on the lines one and two of the display. The following table lists the status messages that may appear.

Status Message	Description
Waiting Initializing	The inverter has been reset or that the 5 minute countdown delay is in progress
Waiting For Wind	The voltage from the turbine is lower than the factory set auto-start voltage threshold
AC Running	The active rectifier is regulating the internal DC Boost voltage
Running	The inverter is transferring power to the utility grid
Fault	A fault has occurred. See fault messages
Manual Stop Press Reset	The manual stop button has been pressed
Fault Limit Press Reset	Three faults have occurred in an hours time
Disconnected	Indicates that a communication problem exists between the

	display and the inverter. Check for bad cable connection.
OV Power Limit	The inverter has detected that the output voltage is approaching the over voltage limit and is reducing its output to compensate for the less than ideal current carrying ability of grid connection.

Using the Up and DOWN arrows you can scroll through the additional Powersync II information available, as shown below.

Parameter	Description
Grid Voltage	Magnitude of the connected single phase grid voltage
Grid Frequency	Frequency of the connected single phase grid voltage
Bus Voltage	Magnitude of the DC link bus voltage
DC Current	Averaged value of the DC current
Turbine Volts	Averaged value of the rectified DC voltage from the Input
Output Power	Output power displayed in Watts
Accumulated Energy	Output Energy (kW hours) accumulated over time of operation
VREF	Used for factory/installer setup
IREF	Used for factory/installer setup
Last Fault	Displays the last fault that occurred since the inverter was powered up along with a fault code that may be useful when troubleshooting.
Unit Code Rev	Indicates the firmware revision of the control DSP
Disp Code Rev	Indicates the firmware revision of the LCD display DSP

A hidden feature of the display is the contrast adjustment. The right side of the display has invisible up and down arrows that can be used to increase and decrease the contrast of the display.

Grid Voltage
This the voltage measured line to line on the output of the inverter. The voltage must be between 212 to 264Vac (184 to 228Vac for 208V units) for the inverter to operate. The line to neutral voltage is important as well, although it is not reported on the LCD screen. It must be between 106 and 142Vac for both 240V and 208V units.

Grid Frequency
This is the frequency of the grid and determined by the utility. The frequency must be between 59.4 and 60.4 Hz for the inverter to operate.

Bus Voltage
This is the voltage of the boosted DC link bus that is used to generate the output sine wave. This voltage should stay between 200 and 570 Vdc but will not trip off until it reaches 680Vdc.

DC Current
This is the input current measured after the 3-phase AC input has been rectified to DC.
Idc = IREF / 9
This current should not exceed 58A.

Turbine Volts
This is the DC voltage of the input measured after the 3-phase AC input is rectified. The inverter will begin exporting power when this voltage exceeds 85Vdc. This voltage should never exceed 690Vdc.
Vdc = Vac * 1.41

Output Power
This is how much real power in Watts the inverter is currently producing or consuming if it is waiting for wind. Standby power while waiting for wind is about -10W. This measurement is not completely accurate and may not agree with an external meter.

Accumulated Power
This is how much real power the inverter has produced or consumed since it was last calibrated at BWC. This measurement is not completely accurate and may not agree with an external meter.

VREF
VREF is the input rectified voltage as a raw value. VREF = Vdc * 2.52.
Vref is used as an index look-up into a virtual table used for a customizable 32 point power curve table.

IREF
IREF is the current request in counts for a given DC input voltage tracked by VREF. Using this configuration the inverter can be adjusted to provide any power curve required. IREF = Idc * 9

Last Fault
Fault messages are displayed when a fault occurs and when the last fault parameter is selected. The following table is a list of possible faults that may be displayed.

A. Inverter Fault Codes

Fault Message	Fault Code	Description
INTERNAL ERROR	10	IGBT or control logic fault. An occurrence of this fault requires that the unit be completely powered down to reset it. Frequent code 10 faults indicate that the unit should be returned to BWC for service.

DC OVER VOLT 1	1000	The DC Bus voltage has exceeded its maximum threshold. This occurs if the input power exceeds the output power. This may occur in exceptionally high winds especially if the OV Power limit is active or temperature throttling is occurring.
DC OVER VOLT 2	1500	The DC Input voltage has exceeded its maximum threshold. This may occur in exceptionally high wind conditions.
DC UNDER VOLT	1250	The internal DC Boost voltage has dropped below its minimum threshold. This usually indicates a configuration problem and is normally never seen.
AC OVER VOLT	2030	The AC line voltage has exceeded its maximum threshold. This occurs if OV limiting was not able to influence the high grid voltage. If this happens routinely consider increasing the output wire gage or making arrangements with the utility to upgrade their distribution transformer.
AC UNDER VOLT	2280	The AC line voltage has dropped below its minimum threshold. It is normal to see this when the inverter has been disconnected from the grid. It may also occur momentarily when large equipment is turned on nearby.
TURBINE PHASE	2500	Indicates that there is a problem with one or more of the turbine input phases. Bad connection, shorted or missing phase. When the inverter detects excessive ripple on the DC input, it shuts down to protect the turbine from destructive vibration.
OVER CURRENT	3000	Phase A line current sensed by the converter module has exceeded its maximum current threshold. This may indicate that current is returning on the earth ground wire.
OVER CURRENT	3020	Phase C line current sensed by the converter module has exceeded its maximum current threshold. This may indicate that current is returning on the earth ground wire.
OVER CURRENT	3050	The DC Boost phase of the converter module has exceeded its maximum current threshold. Indicates a loss of boost control.
OVER TEMP	4000	The internal high temperature threshold has been exceeded. Check that unit has adequate ventilation, that the intake and exhaust vents are not obstructed, and that the cooling fans are operating.
UNDER TEMP	4250	The internal low temperature threshold has been exceeded. Avoid exposing the unit to temperatures below -20ºC (-4ºF).

GROUND FAULT	7000	An input phase appears to be shorted to chassis ground. It may require a high voltage measurement device such as a Megger to confirm the fault.
AC OVER FREQ	8000	The frequency of the utility grid voltage went out of range. The upper range threshold was crossed. If supported (Unit Rev 1005 or greater) this code is also used to indicate that the ROCOF threshold was reached. ROCOF might occur when large equipment is switched on or off.
AC UNDER FREQ	8100	The frequency of the utility grid voltage went out of range. The lower range threshold was crossed.

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When the Powersync II is starting up after initialization, or after the RESET button has been pushed, or after a power outage, it will go through a 300 second (5 minute) countdown that is required by UL 1741. This UL standard also dictates high and low limits for utility voltage and frequency, outside of which the inverter is required to shut down until they return to the acceptable range. This is called a FAULT condition.

There are a number of possible FAULT conditions during which the Powersync II will be protecting itself or the power grid. When a FAULT occurs the Powersync II will shut down (no power production) and a Fault Code will be displayed on the digital display. A list of the Fault Codes can be found in the detailed instructions for the Powersync II inverter provided in the Appendix. FAULTS will reset themselves automatically; assuming the underlying cause of the fault has been cleared, unless the inverter experiences three (3) FAULTS of any type in a one hour period. In this case a manual RESET is required on the digital display.

CAUTION If a manual reset is required we highly recommend that you check the FAULT CODE list for indications that there is an equipment or wiring problem that needs addressing.

One unique feature of the Powersync II inverter is its Soft Grid power limiting capability that can reduce the number of nuisance FAULTS on weak power lines during periods of high turbine power output. On a weak power line the EXCEL 10 wind turbine can, on a windy day, raise the local utility voltage above the UL 1741 threshold, causing a FAULT. The Soft Grid feature tries to prevent these FAULTS by reducing power output from the wind turbine. When the Powersync II is in this mode the digital display will show "Soft Grid".

The STOP pad on the digital display will shut down the Powersync II inverter. Press the RESET pad to restart (which will start the 300 sec. countdown).

If the circuit breaker in your home or business load center (circuit breaker panel) trips, it should be reset by first switching it to the OFF position and then to the ON position. If the breaker trips again immediately, or if it continues to trip after brief periods of normal operation, switch the breaker OFF and contact your Bergey dealer for assistance.

The following recommendations will help ensure the safe operation of the Powersync II inverter:

1. Keep all sources of moisture away from the Powersync II enclosure.

2. Do not work near the Powersync II with gasoline, paint thinner, or any material which produces flammable vapor. Do not store flammable materials near the Powersynce II enclosure.

3. Do not open the Powersync II enclosure unless the circuit breaker and Accessible Disconnect Switch (ADC) at the base of the tower have been switched OFF. **Note that even with the circuit breaker and ADC switched OFF, a shock hazard will still be present inside the Powersync II enclosure for approximately 15 minutes (as the capacitor voltage drains down).**

4. Do not block airflow around the Powersync II enclosure in any way. A six-inch clearance must be maintained around the sides, top, and bottom of the enclosure for adequate air circulation.

VI. TURBINE INSTALLATION

Please use the following instructions in assembling and commissioning your system. If you need any additional information, please contact us.

A. BWC EXCEL WIND TURBINE and TOWER

Please refer to the BWC EXCEL Installation Manual, and any addendum for the specific tower design, for instructions on installing the wind turbine and tower.

B. FUSED DISCONNECT SWITCH

The electrical output of the wind turbine is a three-phase alternating current (AC). We strongly recommend the installation of a fused three-phase AC disconnect switch between the wind turbine and the Powersync II, as shown in the drawing on Page XXX. This switch is commonly referred to as an Accessible Disconnect Switch (ADC) and most utilities will require one to be installed. A 60A weather-tight switch box with 45A

fuses for the 240 VAC, 60Hz or 220VAC, 50Hz system is recommended. The fuses will help protect the alternator in the event of a wiring, controller, or load short circuit. The fused disconnect switch is normally installed at the base of the tower.

CAUTION Do not install a permanent "short circuiting switch" that will provide dynamic braking of the alternator. These switches can be easily misused, leading to serious damage to the alternator. Such damage is not covered by the BWC warranty.

C. WIRE RUN AND WIRE SIZES

Please refer to the BWC EXCEL Installation Manual for recommended wire and conduit sizes for the tower-to-Powersync II wire run. Refer to the row labeled "BWC Excel-S" for appropriate wire sizes.

D. POWERSYNC II INVERTER

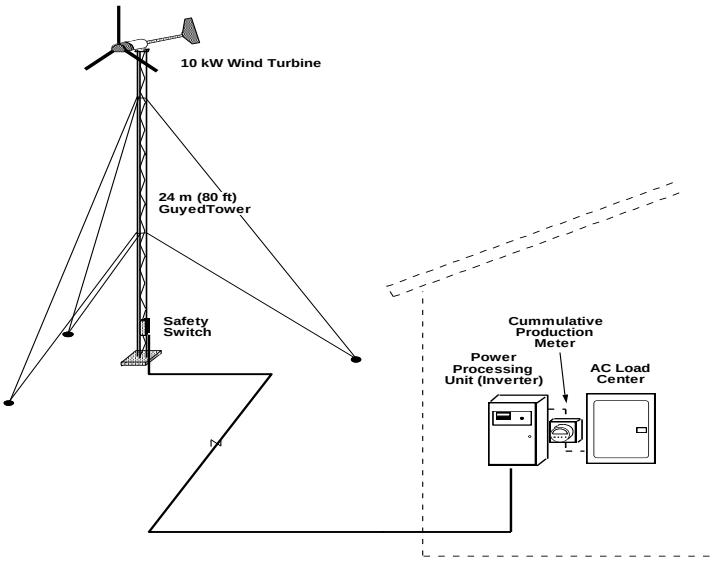
The Powersync II inverter should be installed indoors, near the main breaker enclosure if possible. The Powersync II is designed to operate in a clean environment and should never be installed outdoors as it is not weatherproof and will be damaged by rain. A minimum of six inches of clearance is required on the top, bottom and sides of the Powersync II to ensure adequate air flow through the enclosure.

The Powersync II should be connected to a dedicated 70A breaker installed in the main breaker box. System grounding is accomplished by attaching a wire, # 8 AWG minimum, from the grounding lug inside the Powersync II enclosure to the panel ground inside the main breaker box. Additionally, the tower "bond" ground wire should be connected to the grounding lug inside the Powersync II enclosure. A typical system wiring schematic for the Bergey EXCEL 10 is shown below. The three AC connections from the wind turbine can be connected to the Powersync II terminals in any order; there is no required phase orientation.

DANGER Do not attempt to make the Powersync II connections with energized leads. Always have the wind turbine fully disconnected and the circuit breaker switched to "off" before making the Powersync II connections.

All wiring should conform to the National Electric Code or other governing local electrical code. The use of electrical conduit for wiring between components is highly recommended. All terminations should be coated with an anti-oxidation compound to prevent corrosion.

CAUTION All loads should be equipped with fuses or circuit breakers to avoid hazards from accidental short circuits.



VII. INSPECTIONS AND MAINTENANCE

The Bergey EXCEL 10 turbine and tower should be inspected 30 days after installation, and then again 180 days after installation.

Following these two inspections the installation should be inspected every two years and after any particularly severe weather. Inspections should be done on days when the wind is below 16 mph (7 m/s).

Check List for Inspections

1. Inspect each of the anchor points. Ensure that all hardware is secure and the guy wires are properly tensioned. Check to ensure that no strands are broken and the turnbuckle safety cables are in place.

2. Furl the wind turbine and check that the damper restricts the tail's unfurling to a period of at least three seconds when the winch cable is rapidly unwound.

3. Disconnect the inverter, furl the turbine and short the alternator using the procedure given in the installation manuals. Climb the tower. Always use proper safety climbing gear and safe climbing practices.

4. Inspect the blades for:
   A. Cracks outboard of the hub pad, in the blade pultrusion itself. Cracks in the molded hub pad are normal after a few weeks of operation and will not affect the strength or reliability of the blade.
   B. Condition of the leading edge protection tape. Torn or peeling tape will need replacing.
   C. Leading or trailing edge damage.
   D. Condition of the paint.

5. Remove the spinner and hang it from the machine. Check the torque on the blade nuts; the recommended value is 150 ft-lbs. Check the front bearing for seal integrity and grease loss. Reattach the spinner and check that it is secure.

6. Open the hatch on the nacelle. Use a small rope to lash the hatch open.

7. At the 180 day inspection only: Inspect the flanged connection between the mainframe and alternator. Check the torque on each of the bolts; the recommended value is 80 ft-lbs.

8. Check the rear alternator bearing for seal integrity and grease loss.

9. Inspect the mainframe for cracks.

10. Remove the slip-ring cover plate. Make the following inspections:
    A. Check brushes for ease of movement in the brush holder.
    B. Check slip rings for signs of arcing damage.
    C. Check that no grease from the yaw bearings has leaked on to the slip-rings.

11. Inspect damper. Some leakage around the front seal is okay.

12. Inspect the furling cable (particularly at the ball end/fork attachment to the tail boom) and furling cable conduit.

13. Check for cracks or loose hardware on the tail boom and fin.

14. Check the tail pivot pin and particularly its fasteners.

15. Close the nacelle and check that all of its fasteners are secure.

16. While descending the tower, inspect the following:
    A. Check that the tower wiring is properly secure.
    B. Check all fasteners.
    C. Look for any cracks in the tower structure.
    D. Check the condition of the guy wire attachment.
    E. Check the furling cable.

17. Check the furling winch and make sure that the furling cable is not twisted up. If the cable is twisted up, check the swivel.

18. Check the connection on all ground rods and hardware.

19. Remove the alternator shorting connection. Check the disconnect switch.

20. Switch the disconnect switch to "OFF" and unfurl the wind turbine. Listen to the sound of the machine as it speeds up. No mechanical sounds, such as a "clunking" or "banging," should be heard. Also watch for any new or significant vibration. The turbine operation should be smooth.

21. Inspect the wire run, particularly all electrical connections.

22. Use a Meggar to check the three-phase wiring from the turbine to the controller (the procedure is the same as used for commissioning).

23. Use a VOM to check that the three legs of the AC output of the wind turbine are balanced.

24. Check condition of all wiring connections into and out of the Powersync II.

25. Check the fan filters on the Powersync II.

At the second annual inspection, and at each alternate inspection thereafter, the right nacelle half should be opened and the slip-ring cover removed. This will allow the condition of the brushes and slip-rings, and internal fasteners to be checked.

DANGER Only qualified personnel with proper safety equipment should climb the tower. Never climb the tower when the rotor is turning.

VIII. Trouble-Shooting Problems

The following guide can help to pin-point the cause of operational problems with the Bergey EXCEL 10 wind turbine and the Powersync II inverter For problems or symptoms not found in the following listing please contact the Service Department at Bergey Windpower Co. at Tel. No. 1-405-364-4212, Telefax No. 1-405-364-2078, or E-mail: service@bergey.com

Problem	Cause(s)	Diagnosis	Remedy
Broken furling cable	1. Over-tightening of furling cable 2. Jammed cable furling cable conduit 3. Leaving turbine furled for long periods 4. Swivel not installed or not working	When replacing cable check for free play inside furling cable conduit. Check swivel.	Replace cable and conduit as indicated.
Oil stain at rear of nacelle	Tail damper failure	Check for damper effectiveness by furling the turbine and then rapidly unwinding the furling cable. It should take at least three (3) seconds for the tail to return to the straight position.	If damper fails the test, the turbine should be furled during high winds until the damper is replaced.
Turbine makes an unusual blade sound, such as whistling or buzzing	1. Damaged blade leading edge tape	1. Have leading edge tape inspected	1. Replace tape as necessary
	2. Blade (pultrusion) structural damage	2. Have blades inspected. Cracks outboard of the molded hub can lead to blade failure.	2. If blade damage is suspected, the turbine should be furled until it is inspected. Contact your dealer.
Rotor is unbalanced, causing the turbine to move slightly back and forth as it spins	1. Uneven ice build-up on blades	1. Ice on turbine and tower. Turbine ran smoothly before ice storm. Slow rotor speed.	1. Do nothing – ice will dislodge in a few days. No need to furl the turbine.
	2. Blade damage	2. No ice. Turbine ran smoothly before	2. If blade damage is suspected, the turbine should be furled until it is inspected. Contact your dealer.

Problem	Cause(s)	Diagnosis	Remedy
Turbine makes a banging or rattling sound once per revolution, particularly at low speeds	1. Loose spinner	1. More likely on pre-2004 turbines (when design was changed)	1. Have spinner inspected
	2. Alternator rear bearing ring fasteners loose or missing	2. Requires inspection	2. Have alternator inspected
	3. Alternator bearings	3. Excessive grease leakage. Squeaking sounds at low speed.	3. Have alternator inspected
Turbine makes a "fog horn" sound at certain, typically low, wind speeds	Electro-mechanical interaction between alternator and inverter that causes transient vibrations in the turbine	Sound comes and goes, but occurs at the same wind speed(s)	This is normal, but contact your dealer or the Bergey Service Department if the noise is excessive
Turbine makes a continuous growling or rumbling sound, which reduces at higher wind speeds		Switch fused disconnect on tower to OFF. If growling disappears an electrical problem is indicated. If growling continues a mechanical problem is indicated	
	1. Wiring fault	1. Check fuses. Check wiring for continuity, phase-to-phase fault, or short to ground.	1. Repair or replace as needed
	2. Inverter fault	2. After completing the wiring check, disconnect the inverter and reconnect wiring to the turbine. If the noise disappears an inverter problem is indicated.	2. Contact your dealer
	3. Alternator bearings	3. Check for excessive grease loss	3. Have the alternator inspected

Problem	Cause(s)	Diagnosis	Remedy
Rotor turns slowly and does not speed up in higher winds	1. Ice build-up on blades	1. Check for ice 2. Open tower disconnect. If turbine spins freely an electrical system problem is indicated 3. The most likely problem is a shorted alternator. Diagnosis requires tower climbing	1. Do nothing – ice will dislodge in a few days. No need to furl the turbine.
	2. Short circuit in wiring or inverter		2. Contact your dealer
	3. Short circuit in tower wiring, slip-rings, or alternator		3. Contact your dealer
Rotor does not turn at all	Mechanical failure inside alternator	Rotor does not turn even when winds exceed 15 mph (6.7 m/s)	Contact your dealer
Powersync II display not functioning	1. No power to inverter 2. Display or other inverter component not functioning properly		1. Turn off utility power to inverter, using the dedicated breaker in your breaker panel, for a minimum of 20 seconds. Then turn power back on using the breaker. Wait 300 seconds (5 minutes). If inverter does not resume operation, with full display functionality, contact your dealer

Appendix

10 Year Limited Warranty

BWC Excel Wind Turbine

Bergey Windpower Company

Wind turbines, their associated electronics and towers supplied by Bergey Windpower Company (BWC) are warranted against defects in design, material and workmanship under normal use for which intended. BWC Excel wind turbines and blades carry a ten (10) year warranty after date of installation. Electronic components and towers supplied by BWC carry a five (5) year warranty after date of installation. During the warranty period BWC will repair or replace, at its discretion, defective components or assemblies. BWC will also pay one-way shipping charges. For customers not in the USA, shipping and insurance charges will be pre-paid to the port of entry into the customer's country. This limited warranty is transferable and covers only products shipped after January1, 2009.

Warranty coverage is extended only to customers who have submitted a properly completed BWC Warranty Registration Form and acceptable proof of correct system installation as requested in the BWC Registration Form. Customer must also perform and document recommended inspections and any maintenance tasks that may be identified during inspections.

This limited warranty does not cover:

1. **Towers and equipment, materials or supplies not manufactured or supplied by BWC;**
2. **BWC equipment that has been modified without prior factory approval;**
3. **Repairs performed by personnel not authorized by BWC;**
4. **Damage resulting from use of equipment not supplied by BWC;**
5. **Damage or loss of function sustained during periods when wind speed exceeds 60 m/s (135 mph);**
6. **Acts of God;**
7. **Incidental or consequential damages.**

This limited warranty is in lieu of all other BWC guarantees or warrantees expressed or implied. No employee, agent, dealer, or other person is authorized to offer warranties on behalf of BWC. BWC reserves the right to make design changes, improvements and additions to its products without obligation to install such in products previously manufactured.

RETURN THIS CARD TO BWC ALONG WITH PHOTOS DOCUMENTING INSTALLATION
NOTE: DIGITAL PHOTOGRAPHS PREFERRED IF AVAILABLE

June 8, 2009
Return to: Bergey Windpower Company
2200 Industrial Blvd.
Norman, Oklahoma 73069
(405) 364-4212

BWC WIND TURBINE SYSTEM REGISTRATION CARD

OWNER NAME _____

Address _____ _____

City, Slate, Postal Code _____

Country _____

Phone (_____) _____

DEALER NAME _____

Address_____

City, Slate, Postal Code _____

Country _____

Phone (_____) _____

LOCAL UTILITY COMPANY INFORMATION (if grid-connected system)

Name of Utility _____

Net Metering? ☐ Yes ☐ No

HYBRID SYSTEM (If applicable)

Is turbine part of hybrid wind-PV-diesel system? ☐ Yes ☐ No

PV array? ☐ Yes ☐ No PV Power rating _____ kW

Diesel Gen-set? ☐ Yes ☐ No Generator rating _____ kW

WIND SYSTEM MODEL _____

Serial No. (e.g. 2009866; near top of mainframe tube)

Mainframe: _____

Alternator: _____

Controller: ☐ PowerSync II ☐ VCS-10 ☐ Powercenter

Controller Serial No._____

Blade Serial Numbers (e.g. 10080025; stamped on blade root pad)

_____ _____ _____

Tower Type _____ Height _____

Anchor Type _____

Wiring Run Length (Tower-to-Controller): _____ ft

Wire Size _____ gauge

Wire Type ☐ Copper ☐ Aluminum

BATTERY BANK INFORMATION (if applicable)

Battery Manufacturer & Model _____

Battery Bank Voltage ☐24V ☐48V ☐120V ☐240V

Battery Bank Amp Hours _____

Number of Battery Strings _____

Inverter Manufacturer and Model_____

OWNER'S or DEALER'S SIGNATURE _____

DATE SYSTEM INSTALLED _____

WARRANTY REPAIR IS PERFORMED ONLY AFTER FACTORY AUTHORIZATION. PLEASE RETURN THIS CARD AND PHOTOGRAPHS OF INSTALLATION PROMPTLY IN ORDER TO ASSURE COVERAGE.

Required Photographs

1. Complete tower - turbine system view
2. Anchor photos including all anchor hardware
3. Photos showing all grounding connections
4. Turnbuckle photos showing safety cables
5. Installed rebar cages for anchors, pads, piers and any other concrete items
6. Controller location and environment
7. Controller interior showing wiring connections
8. Interior of tower-base disconnect switch showing fuses and wiring connections

Powersync II - 240 VAC (AMFA-27)
and
Powersync II - 208 VAC (AMFA-29)

Operator's Manual
&
Installation Instructions

Rev. 2.6

Date: 22 November, 2010