Windy Boy
Grid Tied Inverter

Operators Manual Addendum for the Sunny Boy 1800U/2500U/6000

Revision 1.4

Revision History			
1.0	October 20, 2003	Kent Sheldon	Initial Release
1.1	October 22, 2003	Kent Sheldon	15A DC Fuse Requirement
1.2	December 11, 2003	Kent Sheldon	DC Ripple Requirement
1.3	April 14, 2004	Kent Sheldon	GFDI Fuse Removal
1.4	March 22, 2005	Kent Sheldon	WB6000U

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Notice

The Windy Boy inverter must be used within the limits shown on the rating label. This document is an addendum to be used in conjunction with the Sunny Boy 1800, 2500 or 6000 (SB1800U, SB2500U or SB6000U) installation and operations manuals.

Caution

The Windy Boy inverter is designed to operate with wind turbines employing a 3-phase generator and rectifier that produce current and voltage within the allowable operating ranges of the inverter. All protective wind turbine input functions (over-current, over-voltage, over-power, fault tolerance and recovery, turbine mechanical protection, etc.) are the responsibility of the turbine manufacturer or system integrator/installer.

The Windy Boy inverter is a standard inverter designed to be installed only with qualified wind turbines. Input protection is the responsibility of the turbine manufacturer or system integrator/installer. Misapplication of the Windy Boy may cause irreparable damage to the inverter and turbine system, and will void all product warranties. Please contact your turbine manufacturer for detailed system information.

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Overview

The Windy Boy is the first SMA inverter designed for direct connection of a wind turbine generator to the utility grid. The Windy Boy is the same physical inverter as the Sunny Boy, operating in a special 'Turbine' software mode. This document details this operating mode and the requirements for connecting a wind turbine to the Windy Boy inverter.

Background

Historically, grid tied wind turbines have charged batteries through a charge controller and used another converter to process power from the battery to the utility grid. The dual conversion and inherent losses associated with moving power through a battery resulted in very inefficient delivery of wind power to the utility. Overall transfer/conversion losses were easily in the 40-50% range. This means that 50% of the energy available from the wind turbine was being delivered to the utility.

The Windy Boy inverter is a single conversion, DC to AC inverter, which is similar in operation to the Sunny Boy grid tied PV inverter. Mechanical power from the turbine is delivered to the inverter as DC voltage (speed) and current (torque). Most small turbines use an AC alternator and a diode rectifier bridge to convert variable frequency AC from the alternator to DC power. The inverter uses a programmed power versus voltage curve to command current from the turbine dependent upon the DC voltage generated by the turbine. Each alternator design has an optimum operating point or power curve of speed (voltage) versus torque (current). The Windy Boy incorporates a linear power curve that may be programmed by the user to match the characteristics of the specific wind turbine alternator.

Product Limitations and Warnings

The Windy Boy inverter is a standard inverter designed to be installed only with qualified wind turbines. Input protection is the responsibility of the turbine manufacturer or system integrator/installer. Misapplication of the Windy Boy may cause irreparable damage to the inverter and turbine system, and will void all product warranties. Please contact your turbine manufacturer for detailed system information.

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Inverter Selection and Specification

Currently, the wind turbine software mode is available with the WB1800U (1800 Watt peak), the WB2500U (2500 Watt peak) and the WB6000U (6000 Watt peak). Windy Boy inverters must be specially ordered from your wind turbine dealer. Contact your wind turbine dealer to determine which inverter is optimized for use with their turbines.

System Protection Requirements

WB1800U

Maximum Input Voltage	400Vdc
Maximum DC Fuse Requirement	15Adc, 600Vdc
Maximum DC Power	2000Wdc
Maximum DC Ripple	5% peak-to-peak
Maximum AC Current Protection	20Aac, 120Vac

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WB2500U

Maximum Input Voltage	600Vdc
Maximum DC Fuse Requirement	15Adc, 600Vdc
Maximum DC Power	2800Wdc
Maximum DC Ripple	5% peak-to-peak
Maximum AC Current Protection	15Aac, 240Vac

WB6000U

Maximum Input Voltage	600Vdc
Maximum DC Fuse Requirement	30Adc, 600Vdc
Maximum DC Power	6700Wdc
Maximum DC Ripple	5% peak-to-peak
Maximum AC Current Protection	40Aac (208/240/277Vac)

It is the responsibility of the turbine manufacturer and system installer to insure adequate system protection is provided for the Windy Boy inverter.

DC Over-voltage Protection

The largest danger to the inverter is from DC over-voltage. This is the common result of a wind turbine over-speed condition. The most radical over-voltage condition occurs when the inverter is processing power from the turbine and an event (most commonly a utility line fault) occurs causing the inverter to immediately stop processing power. When this happens, the power that was going to the utility is transferred back into the turbine as speed. The wind turbine will quickly increase speed, which causes the DC voltage to also increase rapidly. This can produce voltage in excess of 2000Vdc, if the turbine was fully loaded at the time of an event. Exceeding the maximum input voltage will void the inverter warranty.

Most turbine manufacturers have designed a protection circuit to protect power processing equipment from this condition.

Operating Specifications

WB1800U

WB1800U Specifications	
Maximum DC Input Voltage	400Vdc
DC Operating Range	155*-400Vdc (line voltage dependent, see SB1800U Technical Description)
VdcWindStart Programmable Range	155-375Vdc
VdcWindMax Programmable Range	155-375Vdc
Vpv-Start	155-375Vdc
Maximum DC Operating Current	12Adc
Maximum DC Short Circuit Current	18Adc
Nominal AC Output Voltage	120Vac
AC Operating Voltage Range	106-132Vac

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WB1800U Specifications	
Nominal AC Frequency	60Hz
AC Operating Frequency Range	59.3-60.5Hz
Maximum AC Output Current	17Aac
Maximum AC Output Power	1800Wac
Maximum AC Output Overcurrent Protection	20A
Power Factor	Fixed, Unity

WB2500U

WB2500U Specifications	
Maximum DC Input Voltage	600Vdc
DC Operating Range	220*-550Vdc (208Vac configuration) 250*-550Vdc (240Vac configuration) (line voltage dependent, see SB2500U Technical Description)
VdcWindStart Programmable Range	250-550Vdc (208Vac configuration) 220-550Vdc (240Vac configuration)
VdcWindMax Programmable Range	250-550Vdc (208Vac configuration) 220-550Vdc (240Vac configuration)
Vpv-Start	155-375Vdc
Maximum DC Operating Current	13Adc
Maximum DC Short Circuit Current	18Adc
Maximum AC Current	15Aac
Nominal AC Output Voltage	240Vac
AC Operating Voltage Range	183-229Vac (208V Nominal) 211-264Vac (240Vac nominal)
Nominal AC Frequency	60Hz
AC Operating Frequency Range	59.3-60.5Hz
Maximum AC Output Power	2500Wac (240Vac) 2100Wac (208Vac)
Maximum AC Output Overcurrent Protection	15A
Power Factor	Fixed, Unity

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WB6000U

WB6000U Specifications	
Maximum DC Input Voltage	600Vdc
DC Operating Range	250-550Vdc (line voltage dependent, see SB6000U Operators Manual)
VdcWindStart Programmable Range	250-550Vdc
VdcWindMax Programmable Range	250-550Vdc
Vpv-Start	250-550Vdc
Maximum DC Operating Current	25Adc
Maximum DC Short Circuit Current	25Adc
Maximum AC Current	25Aac
Nominal AC Output Voltage	208/240/277Vac (configurable)
AC Operating Voltage Range	183-229Vac (208V Nominal) 211-264Vac (240V Nominal) 244-305Vac (277V Nominal)
Nominal AC Frequency	60Hz
AC Operating Frequency Range	59.3-60.5Hz
Maximum AC Output Power	6000Wac (240 or 277Vac) 5100Wac (208Vac)
AC Output Overcurrent Protection	40A
Power Factor	Fixed, Unity

Power Curve Function

The Windy Boy controls power to the grid based upon the input DC voltage from the wind turbine. This is based upon a linear curve with a start voltage and a maximum operating voltage. These parameters may be adjusted and optimized for the specific turbine connected to the Windy Boy. When the DC input voltage reaches the start voltage setting, the inverter will begin a countdown to start delivering power to the grid. This length of time is dependent upon the start timer setting. If the DC input voltage remains above the start voltage setting for the prescribed length of time, the inverter will synchronize with the grid and begin delivering power. As the DC input voltage rises the power delivered to the grid will increase, as shown in the chart below:

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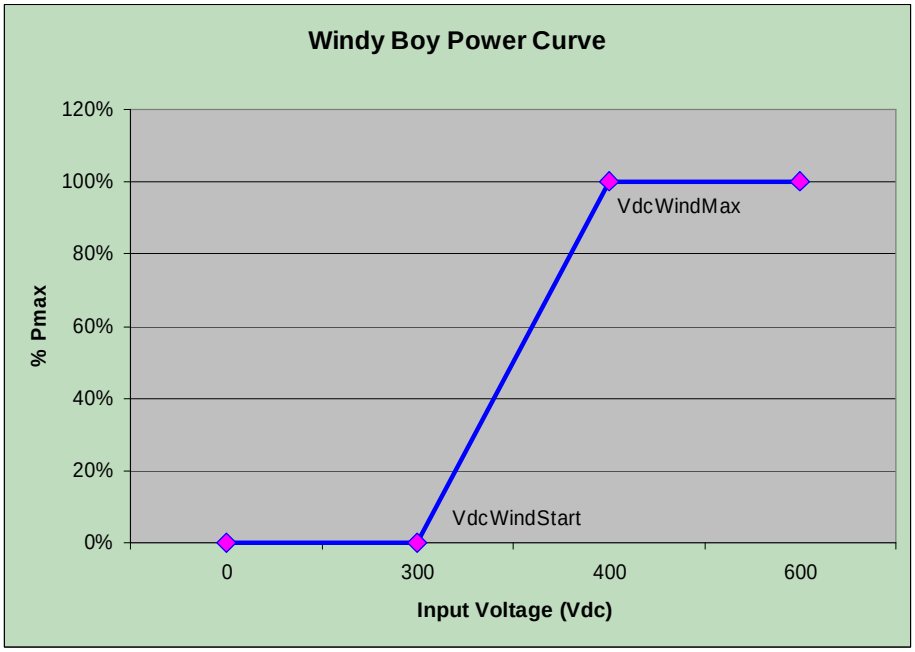

The operating parameter settings within the Windy Boy are pre-programmed by the wind turbine manufacturer or SMA America.

Operating Scenario

Consider the following scenario:

Parameter	Setting Value	Units
T-Start	10	Seconds
T-Stop	120	Seconds
Vdc Start	300	Vdc
Vdc Max	400	Vdc
Pmax	1000	Watts

When the DC input voltage from the wind turbine reaches 300 Volts, the inverter will wait 10 seconds. If the voltage remains above 300Vdc, the Windy Boy will synchronize with the utility and begin exporting power. When the DC voltage reaches 350Vdc, the Windy Boy will output 500 Watts AC to the utility. If the DC voltage reaches 400 Volts, the Windy Boy will output 1000 Watts AC. If the voltage continues to increase the Windy Boy will continue to output 1000 Watts AC, as specified by the <Pmax> parameter setting. If the wind slows down such that the DC voltage falls below 300 Volts, the inverter will continue to operate at zero power output for 120 seconds. If the DC voltage increases above 300 Volts, the stop timer will reset and the Windy Boy will process power according to the power curve. If the DC voltage remains below 300 Volts for 120 seconds, the Windy Boy will stop processing power and shut down.

Power Ramp Function

If the inverter is starting up from zero power and the DC input voltage is mid-range on the power curve, the inverter will ramp to the appropriate power point on the curve at a 500W/second rate. This insures that the turbine does not experience radical power steps

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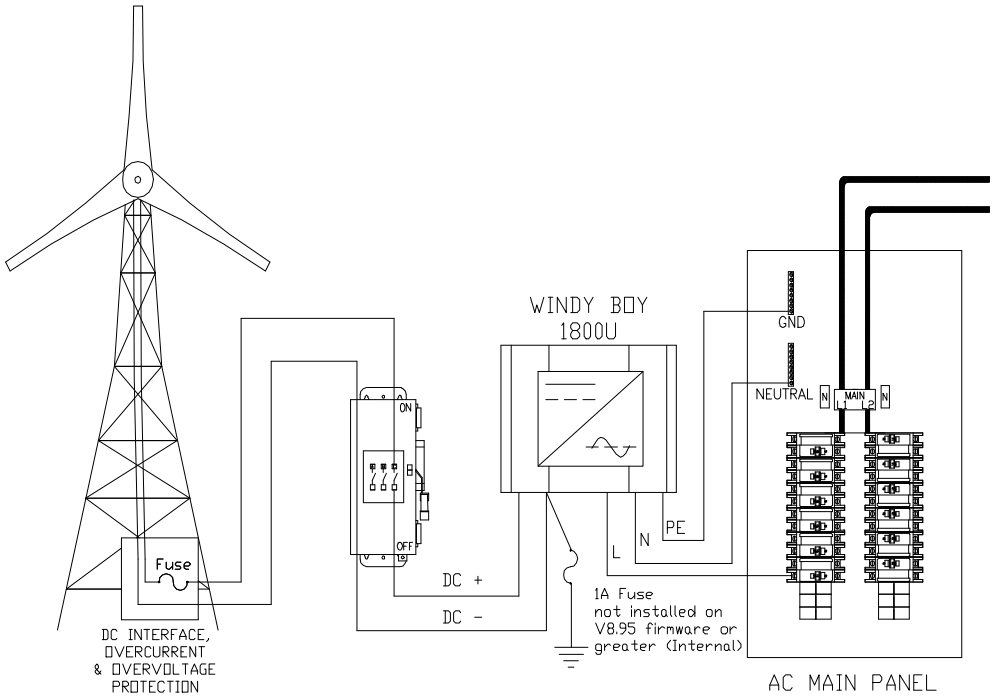
causing mechanical stress during gusting wind conditions. This ramp-rate is adjustable with the <P-Wind-Ramp> parameter.

Typical Installation Diagrams

The following drawings are not specific for any wind turbine or installation. They are provided as basic reference material, showing necessary major components and installation sequence. Please contact the specific wind turbine manufacturer for exact installation drawings specific for your wind turbine.



Windy Boy 1800U

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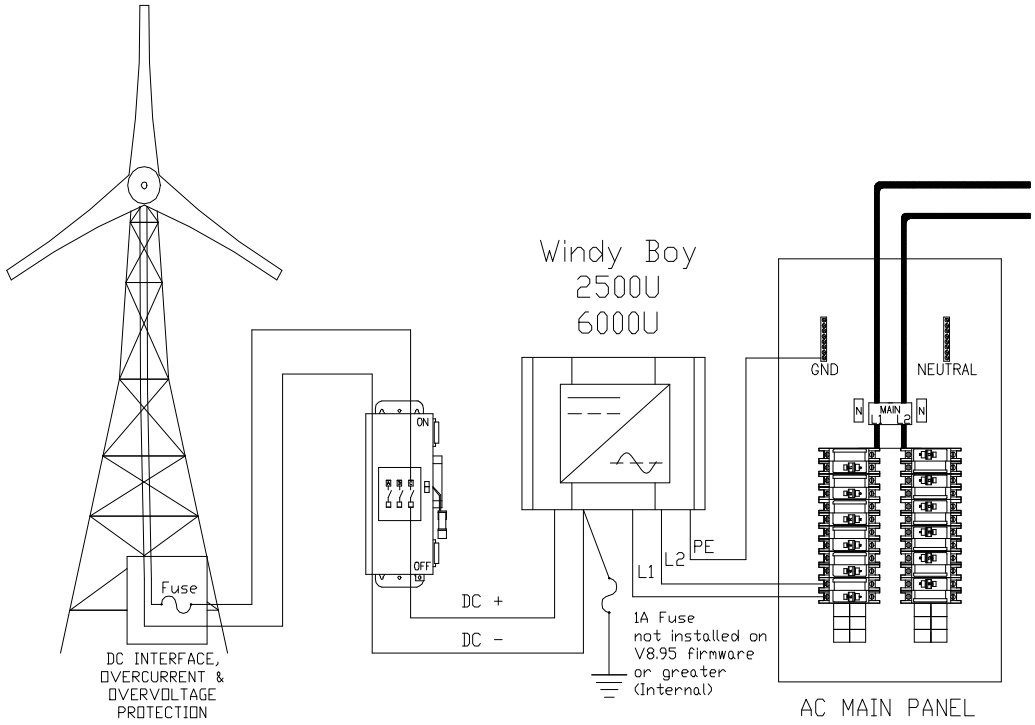

Windy Boy 2500U

Ground Fault Protection

Earlier version of the Windy Boy incorporated the GFDI fuse protection system found in all Sunny Boy PV inverters. This protection is only required by the NEC for PV systems. Windy Boy firmware 8.95 and greater disables the GFDI fault circuitry, and also requires removal of the 1A GFDI fuse for proper operation. Installation of this fuse may interfere with the over-voltage protection supplied by the wind turbine manufacturer.

DC Disconnect Switch

A means of disconnect between the wind turbine and the Windy Boy inverter is required by the NEC. It must be load break rated for the maximum DC voltage of the system (400Vdc for the WB1800U and 600Vdc for the WB2500U and WB6000U). The NEC requires the DC input be grounded. This is done on the negative DC input within the inverter through a 1 Amp fused GFDI detection circuit. Because of this, the negative input may not be switched at the DC disconnect, or anywhere else in the input circuit.

DC Input Fuse Requirement

A 15 Amp overcurrent device is required in the DC input circuit for both the WB1800U and the WB2500U. A 40A overcurrent device is required in the DC input circuit for the WB6000U. This could be either a circuit breaker or fuse rated for DC current and the appropriate maximum DC voltage of the system (400Vdc for the WB1800U and 600Vdc for the WB2500U and WB6000U).

Surge Protection

There are no surge protection devices within the Windy Boy inverter. SMA recommends placing appropriate surge protection devices as close to the AC and DC sources as possible. We recommend placing the AC surge protector within the AC main panel. The DC surge protector should be installed at the turbine, in the DC interface enclosure shown in the previous diagrams.

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Appendix

Contact Information

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