Capstone Turbine Corporation • 21211 Nordhoff Street • Chatsworth • CA 91311 • USA
Telephone: (818) 734-5300 • Facsimile: (818) 734-5320 • Website: www.microturbine.com

Technical Reference

Capstone Model C60/C65 Electrical

This document defines the electrical performance ratings of the Capstone Turbine Corporation® Capstone C60/C65 MicroTurbine™ in both single and MultiPac configurations.

This information is intended for use in the evaluations of applications for the Capstone C60/C65 MicroTurbine.

Electrical Performance Ratings Disclaimer	Many of the electrical performance ratings are software dependent. Capstone reserves the right to change its electrical performance ratings at any time without notice. The electrical performance of any unit may change whenever the software is changed or upgraded. Additionally, the electrical performance of any unit may deviate from the listed ratings due to the installation environment. The characteristics of the utility or connected load may also cause out-of-tolerance performance of any unit.

Capstone Turbine Corporation

21211 Nordhoff Street • Chatsworth • CA 91311 • USA

Telephone: (818) 734-5300

Facsimile: (818) 734-5320

Website: www.microturbine.com

Capstone Technical Support

Telephone: (818) 407-3600

Facsimile: (818) 734-1080

Toll Free Telephone: (877) 282-8966

E-mail: service@capstoneturbine.com

Table of Contents

Introduction

The Capstone C60 MicroTurbine provides electrical power generation. The Capstone C60 MicroTurbine may be configured for either Grid Connect or Stand Alone operation.

The Grid Connect configuration causes the MicroTurbine to source current into an energized electrical grid, and the Stand Alone configuration allows the MicroTurbine to function as a grid-isolated voltage source.

Capstone C60 MicroTurbines may be used in applications requiring greater than 60 kW of load. They may be connected together, in groups (identified as a MultiPac), to provide the required amount of power. A MultiPac grouping of MicroTurbines will function as if it were a single unit.

Purpose

The purpose of this document is to define the electrical performance ratings of the Capstone C60 MicroTurbine in both single unit and MultiPac configurations. This information is intended for use in the evaluations of applications for the Capstone C60 MicroTurbine.

Scope

This document defines only the electrical ratings and characteristics of the Capstone C60 MicroTurbine single unit and MultiPac. Other documentation is available for defining the ratings and characteristics of the other various MicroTurbine components.

MicroTurbine Compliance Listing

The Capstone C60 MicroTurbine has been designed, evaluated, tested, and certified to meet various directives and standards. Areas of compliance are noted in the Capstone MicroTurbine Compliance Listing.

Definitions

The following table presents General Terms and Definitions as used within this document.

General Terms and Definitions

General Terms	Definitions
A	Amp (or Ampere): The unit of measurement of electric current.
AC	Alternating Current: The type of power where the polarity of the current is reversed 60 times per second in the U.S. and 50 times per second in Europe.
ANSI C62.45	American National Standards Institute – Low Voltage AC Power Circuits: Surge Test Guide
ARMS	Amps Root Mean Square
BSOC	Battery State-of-Charge
CF	Crest Factor (CF) = I_{PEAK}/I_{RMS}
°C	Degree Celsius. A temperature scale. 0 Celsius (or 0 Centigrade) is the freezing point of water (32 °F)
°F	Degree Fahrenheit. The thermometric scale on which, under standard atmospheric pressure, the boiling point of water is at 212 degrees above the zero of the scale and the freezing point is 32 degrees above that zero

General Terms and Definitions (Continued)

General Terms	Definitions
Capstone	Capstone Turbine Corporation
DC	Direct Current
H	Henry (or henries)
HP	High Pressure
Hz	Hertz; The frequency of electrical alternations (cycles) per second. One Hz is equal to one cycle per second.
IEEE 519	Institute of Electrical and Electronic Engineers: Recommended Practices/Requirements for Harmonic Control – Electrical Power Systems
IEC 61000-3-3	International Electrotechnical Commission: Electromagnetic Compatibility – Part 3, Limits – Section 3: Limitation of voltage fluctuations and flicker in low voltage supply systems for equipment with rated current and less than or equal to16 amps.
ISO	International Standards Organization
IRMS	Current (or Amps) Root Mean Square
I/O	Input/Output
k	Thousand (kilo or $1x10^3$)
kohms	Thousand ohms
kV	Thousand volts
kVA	Thousand volt amperes
kVAR	Thousand volt amperes reactive
kW	Thousand watts
kW-Hr	Thousand watt-hours
KYZ	Option offered by Wattmeter OEM's that provides pulse train output for power rate-of-flow
L	Stands for Inductor (as in L1 = Inductor 1).
LP	Low Pressure
M	Mega; designation for one million (or $1x10^6$)
m	Milli; designation for one thousandth (or $1x10^{-3}$)
mA	Milliamp; one thousandth amp
N	Whenever an expression is listed, N = the number of individual MicroTurbines within a MultiPac (where where$1 \leq N \leq 100$).
N/A	Not Applicable
PF	Power Factor
RMS	Root Mean Square

General Terms and Definitions (Continued)

General Terms	Definitions
RS-232 Port	Defines three types of interfaces, electrical, functional, and mechanical. Ideal for the data-transmission range of 0-20 kbps/50 feet. It employs unbalanced signaling and is used with 25-pin D-shaped connectors (DB25) to interconnect various components. Serial data exits through an RS-232 port via the Transmit Data (TD) lead and arrives at the destination device's RS-232 port through the Receive Data (RD) lead.
RS-485 Port	Resembles other ports except that associated drivers are tri-state, not dual-state. It may be used in multipoint applications where one central computer controls many different devices. Up to 64 devices may be interconnected with RS-485.
TB	Terminal Board (as in TB1 = Terminal Board 1)
THD	Total Harmonic Distortion
V	Volt (or volts)
VAC	Volts Alternating Current
VDC	Volts Direct Current
VRMS	Volts Root Mean Square
UL	Underwriters Laboratories
W	Watt (or watts)

Electrical Ratings

The single unit and the MultiPac electrical ratings are dependent upon the operating mode selected, that is, Grid Connect or Stand Alone. The maximum number of MicroTurbines that may be connected together in a MultiPac is 100 (with optional equipment).

Electrical Ratings: Grid Connect

Table 1 presents the Electrical Ratings for the Grid Connect configuration. Whenever an expression is listed, N equals the number of individual MicroTurbines within a MultiPac (where1≤ N ≤ 100). See Figure 1.

Table 1. Electrical Ratings: Grid Connect

Description	Single Unit	MultiPac
Grid Voltage Operating Range	C60: 360 to 528 VAC, (3-phase only) C65: 380 to 528 VAC, (3-phase only)	Same as Single Unit
Output Voltage Connection	3 wire, L1, L2, and L3	Same as Single Unit
Maximum Grid Impedance	≤ 10% inductive (814 μH) and ≤ 5% resistive (0.153 ohms), Z_{base}= 3.07 ohms line-to-neutral	≤ 10% inductive (814/N μH) and ≤ 5% resistive (0.153/N ohms), Z_{base}= 3.07/N ohms line-to-neutral
Grid Voltage Harmonic Distortion	The grid must comply with IEEE 519. Note 1.	Same as Single Unit
Grid Voltage Balance	Within ± 2% at full load	Same as Single Unit
Grid Voltage Phase Displacement	120 (± 1) degrees	Same as Single Unit
Grid Voltage Phase Rotation	Either clockwise or counter-clockwise. Auto synchronization. For Dual Mode applications, the grid voltage phase rotation must be L1, L2, and L3, counter-clockwise.	Same as Single Unit
Grid Inrush Current @ Disconnect Switch Closure, (per individual unit within a MultiPac)	24 Amps RMS	Same as Single Unit
Grid Frequency Acquisition Range	45 - 65 Hz. Auto synchronization. The MicroTurbine senses the grid waveform and synchronizes to its phases and frequency before an output connection is made.	Same as Single Unit
Output Power	C60: 0 (Note 2) to 60 kW HP fuel. C65: 0 (Note 2) to 65 kW HP fuel.	0 to kW = Σ (kW_{MT}* N_{MT}) (Note 3)
Output kVA (@ 480 Volts)	83.0 kVA	N*83.0 kVA
Output Power Factor to Grid	± 0.985 displacement PF, for loads > 25% of rated load	Same as Single Unit
Output Power Slew Rate	± 2 kW/second, minimum	± N*2 kW/second, minimum
Output Current	100 Amps RMS, maximum steady state	N*100 Amps RMS, maximum steady state
Output Current Harmonic Content	Complies with IEEE 519, < 5% THD. See Figure 1.	Same as Single Unit
Output Current DC Content	<0.6 Amps DC (per UL 1741)	< N*0.6 Amps DC (UL 1741)

Table 1. Electrical Ratings: Grid Connect (Continued)

Description	Single Unit	MultiPac
Grid Fault Current Contribution by MicroTurbine	145 Amps RMS, maximum symmetrical and asymmetrical	N*145 Amps RMS, maximum symmetrical and asymmetrical
Power Required @ Start Command (per MicroTurbine)	6.8 kW peak, 0.014 kW-Hr, 42 Seconds	Same as Single Unit
Cool Down Power (per MicroTurbine)	2.0 kW peak, 0.3 kW-Hr, 90 seconds	Same as Single Unit
Standby Power	0.8 kW	N*0.8 kW
Grounding. Consult the Electrical Installation Technical Reference for details.	Grid must be Neutral grounded.	Same as Single Unit
Surge Voltage	ANSI 62.45, ± 4 kV standard ± 6 kV available. A surge suppresser option must be added to achieve this requirement. Contact Capstone.	Same as Single Unit
Short Circuit Rating	Per UL 508C, the MicroTurbine is not short circuit rated (Note 4)	Same as Single Unit

Note 1: Total harmonic voltage must be less than 5% (13.85 Volts RMS line-to-neutral). Also, the high frequency ripple voltage must be less than 5.5 Volts RMS line-to-neutral at frequencies greater than 3 kHz.

Note 2: The minimum typical power to the grid is 1.8 kW (@ T_{amb} = 122°F) or 3.4 kW (@T_{amb} = 59°F) when the Power Demand is 0 kW. For MultiPac, the typical minimum power to the grid is N* 1.8 kW (@ T_{amb} = 122°F) or 3.4 kW @ T_{amb} = 59°F).

Note 3: The total available power is the summation of the powers available from the individual MicroTurbines.
kW_{MT} = kW rating @ ambient conditions, of high pressure Capstone 60/C65 MicroTurbines
N_{MT} = number of high pressure Capstone C60/C65 MicroTurbines

Note 4: UL 1741 test-rated short circuit is 145 A_{RMS}.

Figure 1 presents the typical Total Harmonic Current as a function of load for one Capstone C60/C65 MicroTurbine of a MultiPac in the Grid Connect mode.

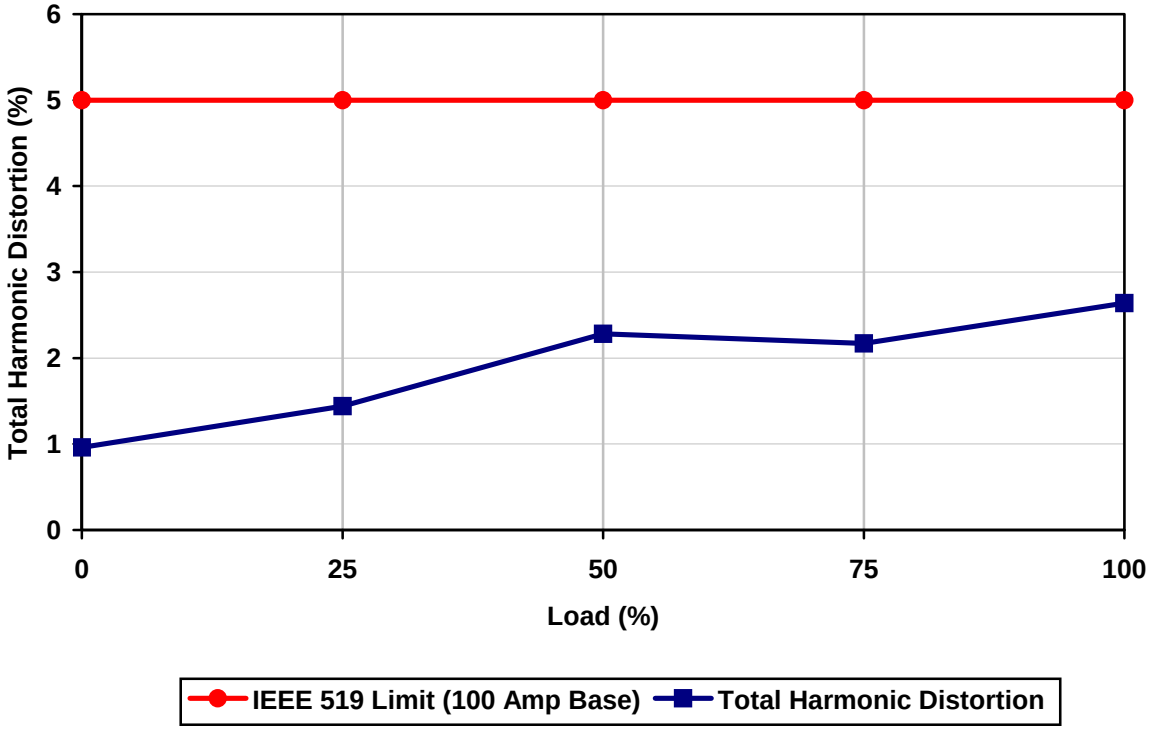

Figure 1. Typical Total Harmonic Current

Electrical Ratings: Stand Alone

Table 2 presents the Electrical Ratings for the Stand Alone configuration. Whenever an expression is listed, N equals the number of individual MicroTurbines within a MultiPac (where $1 \leq N \leq 100$). See Figure 2.

Table 2. Electrical Ratings: Stand Alone

Description	Single Unit	MultiPac
Output Voltage Adjustment Range	150 to 480 VAC line-to-line (1 VAC adjustment resolution)	Same as Single Unit
Output Voltage Accuracy	± 2% of reading, (± 1% typical) line-to-neutral	Same as Single Unit
Output Voltage Stability, Time	± 1.5% per 40,000 hours	Same as Single Unit
Output Voltage Stability, Temperature	± 0.2% over −20 to +60 °C (internal temperature)	Same as Single Unit
Output Voltage Configuration	3-Phase, 4 wire, L1, L2, L3, and N	Same as Single Unit
Output Power	0 to 60 kW HP fuel	0 to kW = $0.95*\Sigma (kW_{60HP}* N_{60HP})$ (Note 2)
Output kVA (@ 480 Volts)	83.0 kVA	N*83.0 kVA
Load Power Factor	0 lagging to 0.8 leading (Note 1)	Same as Single Unit
Output Voltage Harmonic Distortion, with Linear Load	≤ 5% THD, which complies with IEEE 519. See Figure 2.	Same as Single Unit
Output Voltage Harmonic Distortion, with CF load. Crest Factor (CF) = I_{PEAK}/I_{RMS}	< 8% THD, $I_{PEAK} \leq 180$ Amps $1.4 \leq CF \leq 3.0$	< 8% THD, $I_{PEAK} \leq .95*N*180$ Amps $1.4 \leq CF \leq 3.0$
Output DC Voltage Content	± 2.5 Volts DC line-to-neutral	Same as Single Unit
Output Voltage Step Load Regulation, load application or removal	< ± 20% of nominal voltage for any resistive step load ≤ 100% rated load	Same as Single Unit
Output Voltage Step Load Recovery Time	< 100 milliseconds to within ± 5% of nominal voltage for ≤ 100% rated load step	Same as Single Unit

Note 1: Operation at less than 0.8 leading power factor is possible if the total capacitive load is less than 50 kVAR.

Note 2: Different models of MicroTurbines may be mixed within a MultiPac. The total available power is the summation of the powers available from the individual MicroTurbines.
kW_{MT} = kW rating @ ambient conditions, of high pressure Capstone C60/C65 MicroTurbines
N_{MT} = number of high pressure Capstone C60/C65 MicroTurbines

Table 2. Electrical Ratings: Stand Alone (Continued)

Description	Single Unit	MultiPac
Output Voltage Phase Displacement	120 (± 1) degree @ balanced loads	Same as Single Unit
Output Voltage Phase Displacement Jitter	± 1 degree @ balanced loads	Same as Single Unit
Output Voltage Phase Rotation	L1, L2, L3 counter-clockwise	Same as Single Unit
Output Frequency Adjustment Range	10 - 60 Hz (0.1Hz adjustment resolution), ± 0.05% accuracy. For integer frequency settings, the accuracy is +/- 0.005%.	Same as Single Unit
Output Frequency Regulation	0% change for any steady state load or transient load ≤ 100%	Same as Single Unit
Output Frequency Stability, Time	± 0.0005% per year	Same as Single Unit
Output Frequency Stability, Temperature	± 0.005%, -20 to +60 °C (internal temperature)	Same as Single Unit
Output Load Current	100 Amps RMS, maximum steady state. The maximum output current tracks the engine power derating with ambient temperature.	Amps RMS = 0.9*100*N, 1≤ N ≤ 100 typical, maximum steady state. The maximum output current tracks the engine power derating with ambient temperature.
Output Load Crest Factor	1.8 maximum @ 100 Amps RMS with CF=180/I_{RMS} for loads < 100 Amps RMS	1.8 maximum @ Amps RMS = 0.9*100*N CF=0.9*N*180/I_{RMS} for loads < 0.9*100*N Amps RMS
Output Instantaneous Load Current	180 Amps peak, maximum	0.9*N*180 Amps peak, maximum
Overload Capacity (% of full rated power output per individual unit in a MultiPac)	150%, 10 seconds; 125%, 30 seconds; 110% 60 seconds (BSOC >70%). Under conditions of 480 Volts AC and 1.0 PF, available power is subject to temperature-related over-current limits.	Same as Single Unit
Output Fault Current	145 Amps RMS, maximum symmetrical and asymmetrical	N*145 Amps RMS, maximum symmetrical and asymmetrical

Table 2. Electrical Ratings: Stand Alone (Continued)

Description	Single Unit	MultiPac
Output Load Cycle Period	See Battery Performance Technical Reference (410044).	Same as Single Unit
Single Phase Loading (per individual MicroTurbine within the MultiPac)	25 kW line-to-neutral maximum steady state:	Same as Single Unit
Load Unbalance among the 3 phases (per individual unit within the MultiPac)	25 kW maximum. A typical arrangement of unbalanced loads is 30 kW, 5 kW, and 5 kW per phase, per unit, respectively.	Same as Single Unit
Surge Voltage	ANSI 62.45, ± 4 kV standard, ± 6 kV available. A surge suppressor must be added to achieve this requirement. Contact Capstone.	Same as Single Unit
Grounding. Consult the Electrical Installation Technical Reference for details.	Neutral must be solidly connected to earth ground in a single location.	Same as Single Unit
Motor Start, Across-the-line	Motor inrush current < 127 Amps RMS. This current limit must not be exceeded at any time during acceleration to full speed.	Motor inrush current < 0.9*N*127 Amps RMS. This current limit must not be exceeded at any time during acceleration to full speed.
Motor Start, Ramp Voltage and Frequency	127 Amps RMS: maximum starting current at any frequency and voltage. This current limit must not be exceeded at any time during acceleration to full speed.	0.9*N*127 Amps RMS, maximum starting current at any frequency and voltage. This current limit must not be exceeded at any time during acceleration to full speed.

Figure 2 presents the typical output voltage (Line-to-Line) Total Harmonic Distortion (THD) as a function of Linear Resistive Load for the Capstone C60/C65 MicroTurbine.

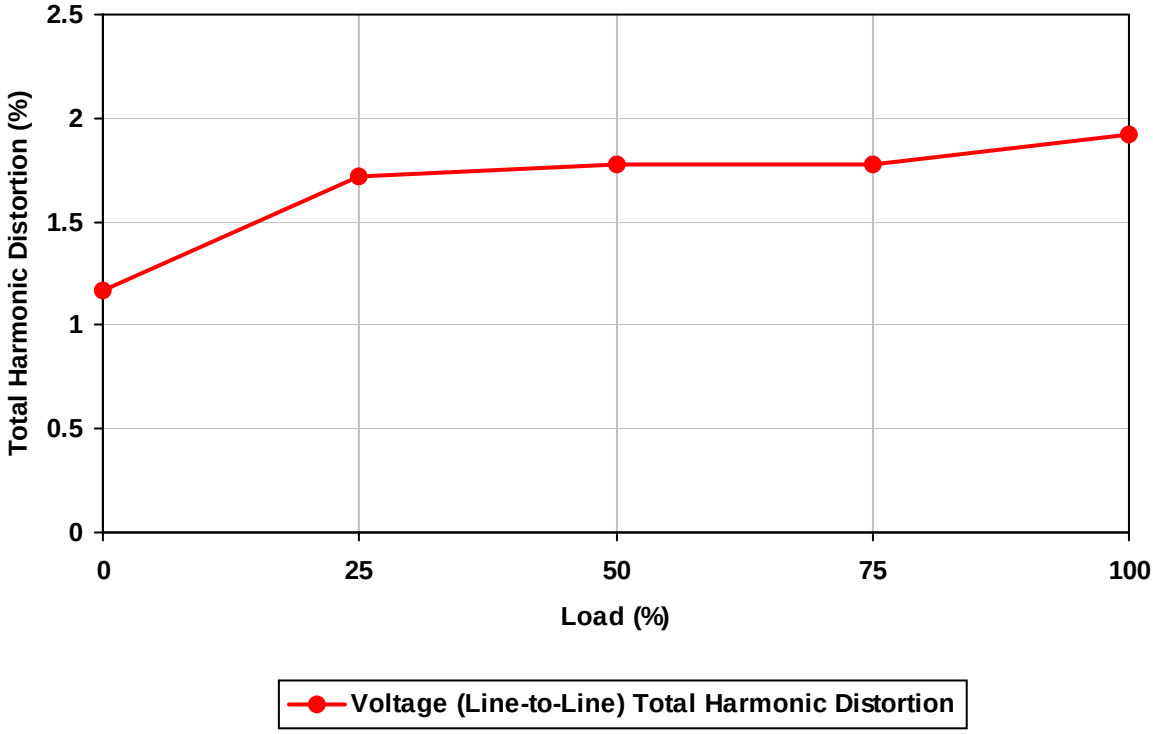

Figure 2. Typical Output Voltage Total Harmonic Distortion

Instrumentation Accuracy

The displays of the output voltages, currents, frequencies, and power have typical accuracies and coefficients as presented in Table 3.

Table 3. Typical/Maximum Instrumentation Accuracy and Coefficients

Instrumentation Item	Accuracy and Coefficients (Typical/Maximum)
Current	±1.5% of Full Scale (typical) / ±3.0% (maximum)
Current Temperature Coefficient	± 0.2% of Full Scale over –20 to +60 °C range
Voltage	± 1.0% of Full Scale (typical) /±2.0% (maximum)
Voltage Temperature Coefficient	± 0.2% of Full Scale over –20 to +60 °C range
Output Power	± 2.5% of Full Scale (typical) /± 5.0%(maximum)
Output Power Temperature Coefficient	± 0.4% of Full Scale over –20 to +60 °C range
Output Frequency	± 0.05% of Reading (or Indication)
Output Frequency Temperature Coefficient	± 0.005% of Reading over –20 to +60 °C range
Real Time Clock	±1 minute per month

Primary Settings and Adjustments

Primary settings and adjustments may be made from the Display Panel (optional) or via the RS-232 User Interface or Maintenance Ports on the User Connection Bay (UCB).

The settings and adjustments are grouped by the two operating modes: Grid Connect and Stand Alone.

Primary Settings/Adjustments: Grid Connect

Table 4 presents the Primary Settings and Adjustments for the Grid Connect configuration.

Table 4. Primary Settings/Adjustments: Grid Connect

Parameter	Setting and/or Adjustment
Power Demand	Sets the output power: 0 kW (Note 1) to N * (kW_{60HP}* N_{60HP}) with 0.1 kW resolution. Default = 0
Auto Restart	Automatically restarts after event-driven shut down, (Yes/No). Default = No (Maximum number of auto restarts is 5, after which restarting will be locked out.)
Auto Restart Delay	Delays the beginning of the restart sequence following an automatic restart command by 0.0 minutes to 60.0 minutes with 0.1-minute resolution. (The maximum number of sequential restarts is 5 before restarting is locked out.) Default = 0

Note 1: The minimum typical power to the grid is 1.8 kW (@ T_{amb} = 122°F) or 3.4 kW (@T_{amb} = 59°F) when the Power Demand is 0 kW. For MultiPac operation, the typical minimum power to the grid is N* 1.8 kW (@ T_{amb} = 122°F) or 3.4 kW (@T_{amb} = 59°F).

Primary Settings/Adjustments: Stand Alone

Table 5 presents the Primary Settings and Adjustments for the Stand Alone configuration.

Table 5. Primary Settings/Adjustments: Stand Alone

Parameter	Setting and/or Adjustment
Voltage	Sets output voltage: 150 to 480 volts (line-to-line) with 1-volt resolution. Default = 480
Frequency	Sets output frequency: 15 to 60 Hz with 0.1-Hz resolution. Default = 60
Auto Load	Enables/disables the presence of output voltage when Load state is achieved. (Enable/Disable)
Auto Restart	Automatically restarts after event-driven shutdown: (Yes/No). Default = No (The maximum number of auto restarts is 5, after which restarting will be locked out.)
Auto Restart Delay	Delays the beginning of the restart sequence following an automatic restart command by 0.0 minutes to 60.0 minutes with 0.1-minute resolution. (The maximum number of sequential restarts is 5, before restarting is locked out.). Default = 0

Table 5. Primary Settings/Adjustments: Stand Alone (Continued)

Parameter	Setting and/or Adjustment
Voltage Start	Sets initial value of output starting voltage ramp: 0 volts to nominal voltage set point with 1-volt resolution. Default = 0
Voltage Ramp	Sets rate-of-change of output starting voltage ramp: 3 to 6000 volts/second with 1 volt/second resolution. Default = 3000
Frequency Start	Sets initial value of output starting frequency ramp: 0 Hz to nominal frequency set point with 0.1-Hz resolution. Default = 0
Frequency Ramp	Sets rate-of-change of output starting frequency ramp: 1 to 2000 Hz/second with 1-Hz/second resolution. Default = 2000
Auto Sleep	Sets automatic sleep time. Default = 1 minute

Protective Settings and Adjustments

Protective settings and adjustments are used to shut down the output of the MicroTurbine should any abnormal conditions appear on the output.

Refer to the Protective Relay Technical Reference for the applicable Protective Settings and Adjustments for both Grid Connect and Stand Alone modes of operation.

Communications Bay

The Communications Bay provides the interconnection means for serial communications, digital inputs, analog inputs, contact closure inputs and outputs, and 12 volt DC power for a modem and auxiliary load operation. The data is presented in Table 6 through Table15.

- Table 6: Connectors J1 and J2 – MultiPac Communication Ports
- Table 7: Connectors J3 and J5 – Serial Communication Ports
- Table 8: Connector J6 – Inter-Controller (A) RS-485 Port
- Table 9: Connector J8 – Inter-Controller (B) RS-485 Port
- Table 10: Connector J10 – Miscellaneous I/O Connections
- Table 11: Connector J11 – Opto-Isolated Inputs from Wattmeter
- Table 12: Connector J12 – Contact Closure Inputs
- Table 13: Connector J14 – Analog Inputs
- Table 14: Connector J15 – Solid-State Relay Outputs
- Table 15: Connector J16 – Modem and User Power Outputs

Figure 3 presents a typical Model C60/C65 board layout in the communications bay.

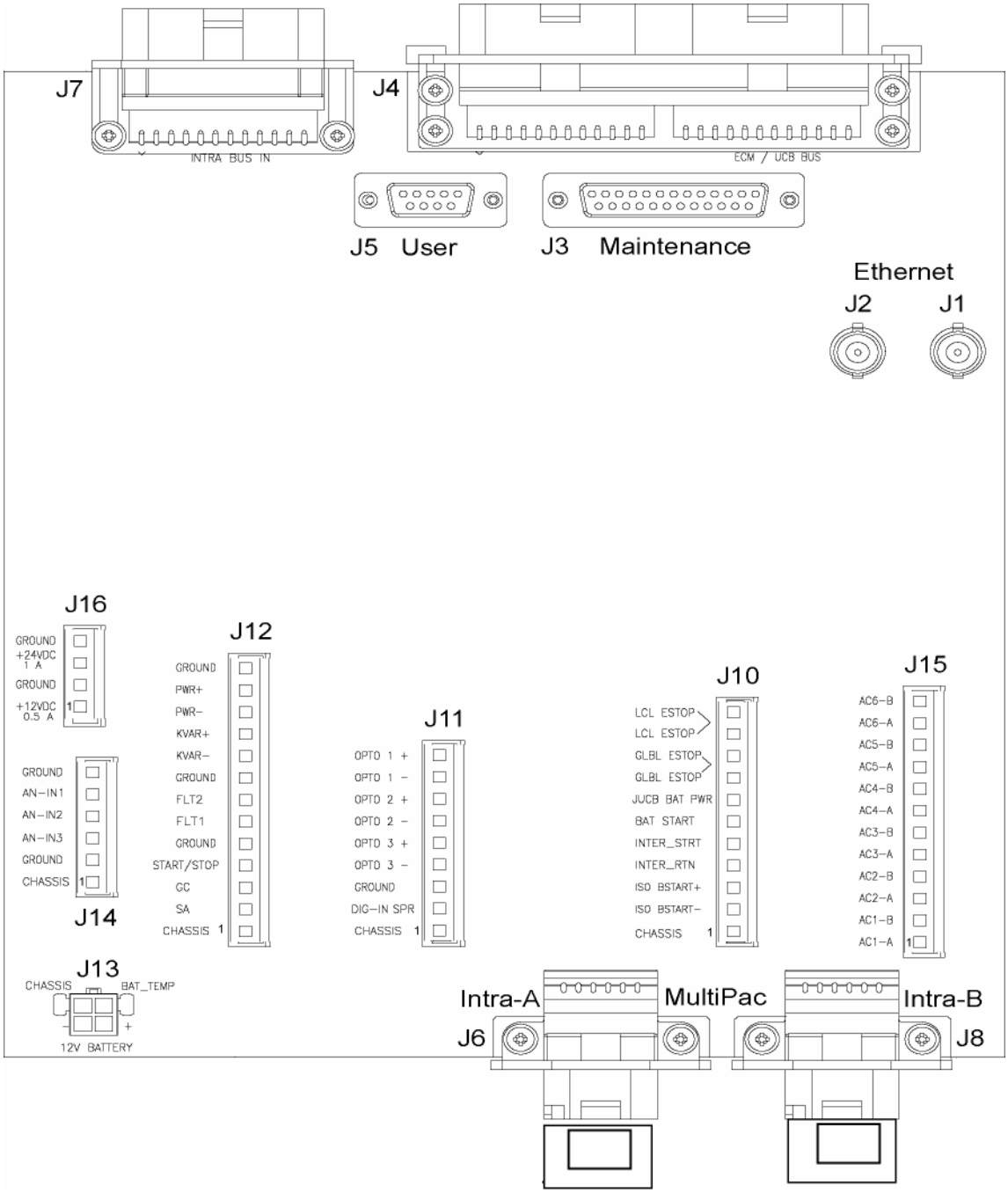

Figure 3. Model C60/C65 Board Layout

Table 6. Connectors J1 and J2 – MultiPac Communication Ports

Pin	Signal	Parameter
J1	MultiPac Communication	Ethernet Protocol (I/O) (Note 1) (Note 2)
J2	MultiPac Communication	Ethernet Protocol (I/O) (Note 1) (Note 2)

Note 1: Whenever J1 or J2 are at the extremities of the Ethernet network, 50-ohm BNC terminators must be installed at these ports. The maximum number of nodes is 30, and the maximum total RG-58A/U coaxial cable length is 185 meters. Each MicroTurbine has 1.93 meters of internal cable length that must be included in the total length considerations. Repeaters may be added whenever the maximum cable length or the maximum numbers of nodes are exceeded. Notice that these ports are reserved for the interconnection of MicroTurbines only.

Note 2: Connections made to these ports MUST be isolated from ground.

Table 7. Connectors J3 and J5 – Serial Communication Ports

Pin	Signal	Parameter
J3	Maintenance Interface Port	DB25 (male polarity) and RS-232 protocol. Maximum null modem cable length is 50 feet (Note 1)
J5	User Interface Port	DB9 (male polarity) and RS-232 protocol. Maximum null modem cable length is 50 feet (Note 1)

Note 1: Connections made to these ports MUST be isolated from ground and/or communication ports of other MicroTurbines.

Table 8. Connector J6 – Inter-Controller (A) RS-485 Port

Pin	Signal	Parameter
J6 (A)	Serial Communication	RS-485, Bus A Protocol (Note 1)
J6 (B)	(Not Applicable)	Chassis Ground
J6 (C)	Inter-Controller Start	+24 Volts DC @ 15 milliamps per MicroTurbine (Note 2)
J6 (D)	(Not Applicable)	Chassis Ground
J6 (E)	Global E-Stop	Normal Operation: N*42 milliamps. E-Stop: (+) 24 Volts DC (Note 3)
J6 (F)	(Not Applicable)	Chassis Ground
J6 (G)	(Not Applicable)	Spare
J6 (H)	E-Stop Return	Normal Operation: N*42 milliamps. E-Stop: 0 Volts DC
J6 (J)	(Not Applicable)	Reserved
J6 (K)	Inter-Controller Start Return	30 milliamps per MicroTurbine @ 0 Volts DC
J6 (L)	(Not Applicable)	Reserved
J6 (M)	Serial Communication	RS-485, Bus B Protocol

Note 1: Whenever J6 is at the extremities of the RS-485 multi-drop network; Capstone-provided terminators must be installed. The maximum number of nodes is 32, and the maximum RS-485 cable length is 1000 meters. Each MicroTurbine has 1.93 meters of internal cable length, which must be included in the total length considerations. Repeaters may be added whenever the maximum cable lengths or the maximum number of nodes are exceeded.

Note 2: No more than 20 MicroTurbines may be connected on one multi-drop branch. Parallel branch wiring must be used when N>20.

Note 3: The Global E-Stop connection sinks 42 milliamps per MicroTurbine in a MultiPac E-Stop circuit. The voltage drop to the most remote MicroTurbine in the interconnecting cables must be kept to 6 volts DC maximum N≤51 on any global E-Stop multi-drop using W900 interconnecting cables. Use branch circuits for N>51. As an alternative, Connector J10, terminals 10 and 11 may be used with external wiring to connect the global E-Stop circuit in lieu of the W900 cables. The maximum voltage drop in this external cable must be < 6.0 Volts DC for the most remote MicroTurbine.

Table 9. Connector J8 – Inter-Controller (B) RS-485 Port

Pin	Signal	Parameter
J8 (A)	Serial Communication	RS-485, Bus A Protocol (Note 1)
J8 (B)	(Not Applicable)	Chassis Ground
J8 (C)	Inter-Controller Start	+24 Volts DC @ 15 milliamps per MicroTurbine (Note 2)
J8 (D)	(Not Applicable)	Chassis Ground
J8 (E)	Global E-Stop	Normal operation: N*42 milliamps. E-Stop: (+) 24 Volts DC (Note 3)
J8 (F)	(Not Applicable)	Chassis Ground
J8 (G)	(Not Applicable)	Spare
J8 (H)	Global E-Stop Return	Normal operation: N*42 milliamps. E-Stop: 0 Volts DC
J8 (J)	(Not Applicable)	Reserved
J8 (K)	Inter-Controller Start Return	30 milliamps per MicroTurbine @ 0 Volts DC
J8 (L)	(Not Applicable)	Reserved
J8 (M)	Serial Communication	RS-485, Bus B Protocol

Note 1: Whenever J8 is at the extremities of the RS-485 multi-drop network; Capstone-provided terminators must be installed. The maximum number of nodes is 32, and the maximum RS-485 cable length is 1000 meters. Each MicroTurbine has 1.93 meters of internal cable length, which must be included in the total length considerations. Repeaters may be added whenever the maximum cable lengths or the maximum numbers of nodes are exceeded.

Note 2: No more than 20 MicroTurbines may be connected on one multi-drop branch. Parallel branch wiring must be used when N>20.

Note 3: The Global E-Stop connection sinks 42 milliamps per MicroTurbine in a MultiPac E-Stop circuit. The voltage drop to the most remote MicroTurbine in the interconnecting cables must be kept to 6 volts DC maximum N≤51 on any global E-Stop multi-drop using W900 interconnecting cables. Use branch circuits for N>51. As an alternative, Connector J10, terminals 10 and 11 may be used with external wiring to connect the global E-Stop circuit in lieu of the W900 cables. The maximum voltage drop in this external cable must be < 6.0 Volts DC for the most remote MicroTurbine.

Table 10. Connector J10 – Miscellaneous I/O Connections

Pin	Signal	Parameter
J10 (1)	Chassis Ground	To be used for cable shield connections
J10 (2)	Wake up signal if asleep (Input) Return	Isolated return for signal of J10 (3)
J10 (3)	Wake up signal if asleep (Input)	Momentary (0.1 to 2 seconds) input +4 to +15 Volts with respect to J10 (2). Opto-isolated (±150 Volts DC maximum to earth)
J10 (4)	Inter Start (Input/Output) Return	Return for signal of J10 (5) (Note 1)
J10 (5)	Inter Start (Input/Output)	(Output) = MultiPac start signal, +24 Volts DC, 30 milliamps/0.7 Amps maximum, momentary (0.1 to 2 seconds), 27 C60/C65 units maximum connections. (Input) = 755 ohms load (Note 1)
J10 (6)	Internal Battery Wake Signal (Input)	+5 Volts to Ground, Z_{in} = 130 k ohms RESERVED – Do not connect external circuits. Use J10 (2) and J10 (3) for battery wake-up (Note 1)
J10 (7)	JUCB Battery Power (Output)	+12 Volts JUCB Battery Power, 0.6 Amps re-settable fused (Note 2)
J10 (8)	Global E-Stop (Input)	Return for J10 (9) (Note 1)
J10 (9)	Global E-Stop (Input)	MultiPac dry circuit contact closure. Closed for normal operation, open for E-Stop. (+) 24 Volts DC @ N*42 milliamps (Note 1)
J10 (10)	Local E-Stop (Input)	Return for J10 (11) (Note 1)
J10 (11)	Local E-Stop (Input)	Dry circuit contact closure. Closed for normal operation, open for E-Stop. (+) 24 Volts DC @ 42 milliamps (Note 1)

Note 1: Connections made to these terminals MUST be Dry Circuit rated and isolated from ground/chassis. They may not be connected in parallel with other MicroTurbine input terminals.

Note 2: Connections made to this terminal MUST be isolated from ground/chassis. It may not be connected in parallel with other MicroTurbine input and/or power supply terminals.

Table 11. Connector J11 – Opto-Isolated Inputs from Wattmeter

Pin	Signal	Parameter
J11 (1)	Chassis Ground	To be used for shield connections
J11 (2)	DIGINSP	0-5 Volt Analog Signal
J11 (3)	AGND	Analog Ground for J11 (2). Impedance =10 ohms
J11 (4)	OPTO 3 (-)	Isolated return for J11 (5). Isolated. (150 Volts DC maximum to earth)
J11 (5)	OPTO 3 (+)	KVAR Pulse Train from Wattmeter (+5 to +15 Volts, Z_{in}= 1 kohm, Isolated) (150 Volts DC maximum to earth)
J11 (6)	OPTO 2 (-)	Isolated return for J11 (7). Isolated. (150 Volts DC maximum to earth)
J11 (7)	OPTO 2 (+)	Negative Power Pulse Train from Wattmeter (+5 to +15 Volts, Z_{in}= 1 kohm, Isolated. (150 Volts DC maximum to earth)
J11 (8)	OPTO 3 (-)	Isolated return for J11 (9). Isolated. (150 Volts DC maximum to earth)
J11 (9)	OPTO 3 (+)	Positive Power Pulse Train from Wattmeter (+5 to +15 Volts, Z_{in}= 1 kohm, Isolated. (150 Volts DC maximum to earth)

Table 12. Connector J12 – Contact Closure Inputs

Pin	Signal	Parameter
J12 (1)	Chassis Ground	To be used for shield connections
J12 (2)	SA (Stand Alone mode)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (3)	GC (Grid Connect mode)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms
J12 (4)	Start/Stop	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (5)	AGND	Return circuit for connector J12 contact closures (Note 1)
J12 (6)	FLT1 (User Fault Input)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (7)	FLT2 (User Fault Input)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (8)	AGND	Return circuit for connector J12 contact closures (Note 1)
J12 (9)	KVAR (-) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (10)	KVAR (+) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (11)	PWR (-) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (12)	PWR (+) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms (Note 1)
J12 (13)	AGND	Return circuit for connector J12 contact closures (Note 1)

Note 1: Connections made to these terminals MUST be Dry Circuit rated and isolated from ground/chassis. They may not be connected in parallel with other MicroTurbine input terminals.

Table 13. Connector J14 – Analog Inputs

Pin	Signal	Parameter
J14 (1)	Chassis Ground	To be used for shield connections
J14 (2)	AGND	Return for analog signals. Impedance =10 ohms (Note 1)
J14 (3)	ANIN3	0 to (+) 5 Volts DC, high impedance (Note 1)
J14 (4)	ANIN2	0 to (+) 5 Volts DC, high impedance (Note 1)
J14 (5)	ANIN1	0 to (+) 5 Volts DC, high impedance (Note 1)
J14 (6)	AGND	Return for Analog Signals. Impedance = 10 ohms (Note 1)

Note 1: Connections made to these terminals MUST be Dry Circuit rated and isolated from ground/chassis. They may not be connected in parallel with other MicroTurbine input terminals.

Table 14. Connector J15 – Solid-State Relay Outputs

Refer to Note 1 below for solid-state relay contact general information.

Pin	Signal	Parameter
J15 (1)	AC1-A	AC1 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (2)	AC1-B	AC1 load, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (3)	AC2-A	AC2 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (4)	AC2-B	AC2 load, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (5)	AC3-A	AC3 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (6)	AC3-B	AC3 load, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (7)	AC4-A	AC4 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (8)	AC4-B	AC4 load, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (9)	AC5-A	AC5 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (10)	AC5-B	AC5 load, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (11)	AC6-A	AC6 line, 25 VAC maximum voltage, 100 milliamps maximum current
J15 (12)	AC6-B	AC6 load, 25 VAC maximum voltage, 100 milliamps maximum current

Note 1: These contacts must only be connected in Class 2 circuit for limited voltage and limited current power source at maximum voltage of 25 VAC. If switching at higher voltages and currents is required, please contact Capstone Applications for recommendations.

Table 15. Connector J16 – Modem and User Power Outputs

Pin	Signal	Parameter
J16 (1)	Modem Power	12 Volts DC, 0.5 Amps maximum (re-settable fuse protected) (Note 1)
J16 (2)	PWRGND	Modem Power Return (Note 1)
J16 (3)	User Power	24 Volts DC, 1 Amp maximum (re-settable fuse protected) (Note 1)
J16 (4)	PWRGND	User Power Return (Note 1)

Note 1: Connections made to these terminals MUST be isolated from ground/chassis. They may not be connected in parallel with other MicroTurbine input and/or power supply terminals.