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Technical Reference
Capstone Model C65 Electrical

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1. Introduction

This document defines the electrical performance ratings of the Capstone MicroTurbine® Model C65 in both single and MultiPac configurations. This information is intended for use in the evaluations of applications for the Capstone C65 Microturbine. Refer to Model C65 Product Specification (460044) for microturbine certification compliance.

The Capstone C65 Microturbine provides electrical power generation and can 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 C65 Microturbines may be used in applications requiring greater than 65 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.

2. Referenced Documents

The following table contains a list of documents referenced in this Technical Reference.

Table 1. Referenced Documents

Document Number	Description
410002	Fuel Requirements Technical Reference
410009	Electrical Installation Technical Reference
410014	CRMS Technical Reference Maintenance Edition
410028	Stand Alone Technical Reference
410032	MultiPac Operation Technical Reference
410033	Protective Relay Technical Reference
410044	Battery Performance Technical Reference
410048	C65 Performance Technical Reference
410071	Dual Mode System Controller Technical Reference
460044	Model C65 Product Specification
ANSI C62.45	American National Standards Institute: Low Voltage AC Power Circuits: Surge Test Guide
IEEE 519	Institute of Electrical and Electronic Engineers: Recommended Practices/Requirements for Harmonic Control – Electrical Power Systems
UL 1741	Underwriters Laboratories: Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
VDE-AR-N 4105	Verband der Elektrotechnik: Technical Requirements for Connection to and Parallel Operation with Low-Voltage Distribution Networks

3. Electrical Ratings

Electrical ratings for Grid Connect configuration (Table 2) and Stand Alone configuration (Table 3) are provided in the following paragraphs. Single unit and MultiPac electrical ratings are included. Whenever MultiPac ratings are listed, N equals the number of individual microturbines within a MultiPac (where $1 \leq N \leq 30$). The maximum number of microturbines that may be connected together in a MultiPac is 20, but a MultiPac can be increased to 30 with the use of the Advanced Power Server (APS). Refer to the APS-145 Technical Reference (410079) for details.

C65 microturbines can also be configured for dual mode operation, which combines Grid Connect and Stand Alone modes. A dual-mode microturbine can operate in parallel with the utility grid when available and in Stand Alone during a utility outage. The capability to switch automatically between Grid Connect and Stand Alone modes is provided by the Dual Mode System Controller (DMSC). Refer to the Dual Mode System Controller Technical Reference (410071) for details.

Ratings are at ISO conditions, defined as 15 °C (59 °F), 60% relative humidity, and 101.325 kPa (14.696 psia, standard sea level pressure), with no inlet pressure losses, exhaust back pressure, or parasitic loads.

Protective relay settings are discussed in separate documents. Refer to the Protective Relay Technical Reference (410033) for applicable protective relay settings for Grid Connect Mode. Refer to the Stand Alone Technical Reference (410028) for the applicable protective relay settings for Stand Alone Mode.

3.1. Grid Connect

Table 2 presents the Electrical Ratings for the Grid Connect configuration.

Table 2. Nominal Electrical Ratings: Grid Connect(1)

Description	Single Unit	MultiPac
Output Power (2)(3)(4)	0 to 65 kW	0 to 65 kW*N
Output kVA CE (5) HUPS & All Other	 81 kVA 65 kVA	 N*81 kVA N*65 kVA
Voltage Range	400 / 480 VAC	
Voltage Operating Range	360 to 528 VAC, (3-phase only)	
Frequency Range	50 / 60 Hz	
Frequency Operating Range (6)	45–65 Hz. auto synchronization	
Power Factor CE (400 VAC) (5)(7) CE (480 VAC) (5)(7) HUPS & All Other	 0.9 Leading / 0.9 lagging 0.8 Leading / 0.8 lagging ± 0.985 displacement PF, for loads > 25% of rated load	
Output Current, Max Steady State CE (5) HUPS & All other	 120 A_{RMS} 100 A_{RMS}	 N*120 A_{RMS} N*100 A_{RMS}
Grid Fault Current Contribution by Microturbine	145 A_{RMS}, maximum symmetrical and asymmetrical	N*145 A_{RMS}, maximum symmetrical and asymmetrical
Short Circuit Rating	145 A_{RMS}	N*145 A_{RMS}
Output Voltage Connection	3-Phase, 4 wire, L1, L2, L3, and Neutral	
Grid Voltage Phase Sequence	Auto synchronization. For Dual Mode applications, the grid voltage phase sequence must be L1, L2, L3	
Grounding (8)	Grid must be neutral grounded	
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 (9)	The grid must comply with IEEE 519	
Grid Voltage Balance	Within ± 2% at full load	
Grid Voltage Phase Displacement	120 ± 1.5 degrees	
Surge Voltage	ANSI C62.45 ± 6 kV	
Output Current Harmonic Content	Complies with IEEE 519 < 5% THD	
Output Current DC Content	< 0.6 Amps DC (per UL 1741)	< N*0.6 Amps DC (UL 1741)
Power Required @ Start Command	6.8 kW peak, 0.014 kW-Hr, 42 Seconds	N*(6.8 kW peak, 0.014 kW-Hr, 42 seconds)
Cool Down Power Gaseous Fuels Liquid Fuel	 2.0 kW peak, 0.3 kWh for 90 seconds 5.0 kW peak, 11 kWh for 12 minutes	 N*(2.2 kW peak, 0.3 kWh for 90 seconds) N*(2.2 kW peak, 11 kWh for 12 minutes)

Table 2. Nominal Electrical Ratings: Grid Connect[1] (Continued)

Description	Single Unit	MultiPac
Standby Power	0.8 kW	N*0.8 kW
Grid Inrush Current @ Disconnect Switch Closure	24 A_{RMS}	N*24 A_{RMS}
Starting Current from Grid	16 A_{RMS}	N*16 A_{RMS}
Output Power Slew Rate [2][10] Type A and Type B Liquid Fuel All Other	 0.35 kW/sec (250 rpm/sec) 2.35 kW/sec (1700 rpm/sec) 1.15 kW/sec (900 rpm/sec)	 N*0.35 kW/sec (250 rpm/sec) N*2.35 kW/sec (1700 rpm/sec) N*1.15 kW/sec (900 rpm/sec)

Table 2 Notes:

(1) Ratings are at full load power and ISO conditions with zero back pressure. Values do not include parasitic losses from any accessories. The nominal values contained in this table do not reflect tolerance ranges. Deviation from the nominal value can occur due to differences between microturbines, measurement inaccuracies, and other factors.

(2) Minimum power output is 35 kW for Type A and Type B fuels. Refer to Fuel Requirements Technical Reference (410002) for further definition on fuels.

(3) 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 N*3.4 kW @ T_{amb} = 59°F).

(4) Refer C65 Performance Technical Reference (410048) for real power capability as a function of ambient temperature, elevation, and other site conditions.

(5) Software versions 5.40 and higher (gaseous fuels) and 2.20 and higher (liquid fuel) include Verband der Elektrotechnik (VDE) and Power Factor (PF) functionality. These software versions meet VDE-AR-N 4105 requirements for low voltage grid interconnection and allow for power factor control. Upgrades in the field to these software versions require key code to enable functionality.

(6) The microturbine senses the grid waveform and synchronizes to its phases and frequency before an output connection is made.

(7) Power factor adjustable range is from 0.8 leading to 0.8 lagging. Power fold back will occur once current limit of inverter is reached.

(8) Refer to the Electrical Installation Technical Reference (410009) for grounding details.

(9) 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.

(10) Slew rate includes both turbine acceleration and deceleration.

3.2. Stand Alone

Table 3 presents the Electrical Ratings for the Stand Alone configuration.

Table 3. Nominal Electrical Ratings: Stand Alone[1]

Description	Single Unit	MultiPac
Output Power	0 to 65 kW	0 to 0.95* 65 kW*N
Output kVA CE (400 VAC) [2] CE (480 VAC) [2] HUPS & All Other (400 VAC) HUPS & All Other (480 VAC)	83 kVA 99 kVA 69 kVA 83 kVA	kVA*N*0.95
Voltage Range	400 / 480 VAC	
Output Voltage Adjustment Range	150 to 480 VAC line-to-line (1 VAC adjustment resolution)	
Frequency Range	50 / 60 Hz	
Output Frequency Adjustment Range	10 to 60 Hz (0.1Hz adjustment resolution) ± 0.05% accuracy	
Load Power Factor [3]	0.8 lagging to 0.8 leading	
Output Current, Max Steady State CE [2] HUPS & All Other	120 A_{RMS} 100 A_{RMS}	A_{RMS} = 0.9*120*N A_{RMS} = 0.9*100*N
Output Fault Current	145 A_{RMS}, maximum symmetrical and asymmetrical	N*145 A_{RMS}, maximum symmetrical and asymmetrical
Output Load Crest Factor CE [2] HUPS & All Other	1.8 maximum @ 120 A_{RMS} with CF=180/I_{RMS} for loads < 120 A_{RMS} 1.8 maximum @ 100 A_{RMS} with CF=180/I_{RMS} for loads < 100 A_{RMS}	1.8 maximum @ A_{RMS} = 0.9*120*N CF=0.9*N*180/I_{RMS} for loads < 0.9*120*N A_{RMS} 1.8 maximum @ A_{RMS} = 0.9*100*N CF=0.9*N*180/I_{RMS} for loads < 0.9*100*N A_{RMS}
Output Instantaneous Load Current	180 A_{PEAK} maximum	0.9*N*180 A_{PEAK} maximum
Single Phase Loading (per individual microturbine within the MultiPac)	25 kW line-to-neutral maximum steady state	
Load Unbalance among the 3 phases (per individual unit within the MultiPac)	25 kW maximum	
Output Load Cycle Period	See Battery Performance Technical Reference (410044)	
Motor Start, Across-the-Line [4]	Motor inrush current < 127 A_{RMS}	Motor inrush current < 0.9*N*127 A_{RMS}
Motor Start, Ramp Voltage and Frequency [4]	127 Amps RMS maximum starting current at any frequency and voltage	0.9*N*127 Amps RMS maximum starting current at any frequency and voltage
Output Voltage Connection	3-Phase, 4 wire, L1, L2, L3, and Neutral	
Output Voltage Phase Sequence	L1, L2, L3	

Table 3. Nominal Electrical Ratings: Stand Alone(1) (Continued)

Description	Single Unit	MultiPac
Grounding (5)	Neutral must be solidly connected to earth ground in a single location	
Output Voltage Harmonic Distortion with Linear Load	≤ 5% THD, which complies with IEEE 519	
Output Voltage Harmonic Distortion with CF load. Crest Factor (CF) = I_{PEAK}/I_{RMS}	< 8% THD, I_{PEAK} ≤ 180 Amps 1.4 ≤ CF ≤ 3.0	< 8% THD, I_{PEAK} ≤ .9*N*180 Amps 1.4 ≤ CF ≤ 3.0
Output DC Voltage Content	± 2.5 Volts DC line-to-neutral	
Output Voltage Step Load Regulation, load application or removal	< ± 20% of nominal voltage for any resistive step load ≤ 100% rated output power capacity	
Output Voltage Step Load Recovery Time	< 100 milliseconds to within ± 5% of nominal voltage for ≤ 100% rated output power step	
Output Voltage Balance	Within ± 3% at full load	
Output Voltage Phase Displacement	120 ± 1.5 degree @ balanced loads	
Output Voltage Phase Displacement Jitter	± 1 degree @ balanced loads	
Surge Voltage	ANSI C62.45 ± 6 kV	
Output Frequency Regulation	0.05% change for any steady state load or transient load ≤ 100%	
Output Frequency Stability, Temperature	± 0.05%, -20 to +60 °C (internal temperature)	

Table 3 Notes:

(1) Ratings are at full load power and ISO conditions with zero back pressure. Values do not include parasitic losses from any accessories. The nominal values contained in this table do not reflect tolerance ranges. Deviation from the nominal value can occur due to differences between microturbines, measurement inaccuracies, and other factors.

(2) Software versions 5.40 and higher (gaseous fuels) and 2.20 and higher (liquid fuel) include Verband der Elektrotechnik (VDE) and Power Factor (PF) functionality. These software versions meet VDE-AR-N 4105 requirements for low voltage grid interconnection and allow for power factor control. Upgrades in the field require key code to enable functionality.

(3) Values shown are limited by maximum current capability of the power electronics. For system design, total power factor for all connected loads should not be less than 0.8 (inductive or capacitive).

(4) Current limit must not be exceeded at any time during acceleration to full speed.

(5) Refer to the Electrical Installation Technical Reference (410009) for grounding details.

4. Instrumentation Accuracy

The displays of the output voltages, currents, frequencies, and power have typical accuracies and coefficients as presented in Table 4.

Table 4. 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

5. Communications Bay

The Communications Bay provides a user interconnection means for serial communications, digital inputs, digital outputs, analog inputs, and 12/24 volt DC power for a modem and auxiliary load operation. The following topics will be covered in the sections to follow.

- MultiPac Communication
- Serial Communication
- Wake-Up and E-Stop Inputs
- Digital Inputs
- Analog Inputs
- Digital Outputs
- Modem and User Power

Figure 1 presents a typical Model C65 board layout in the Communications Bay.

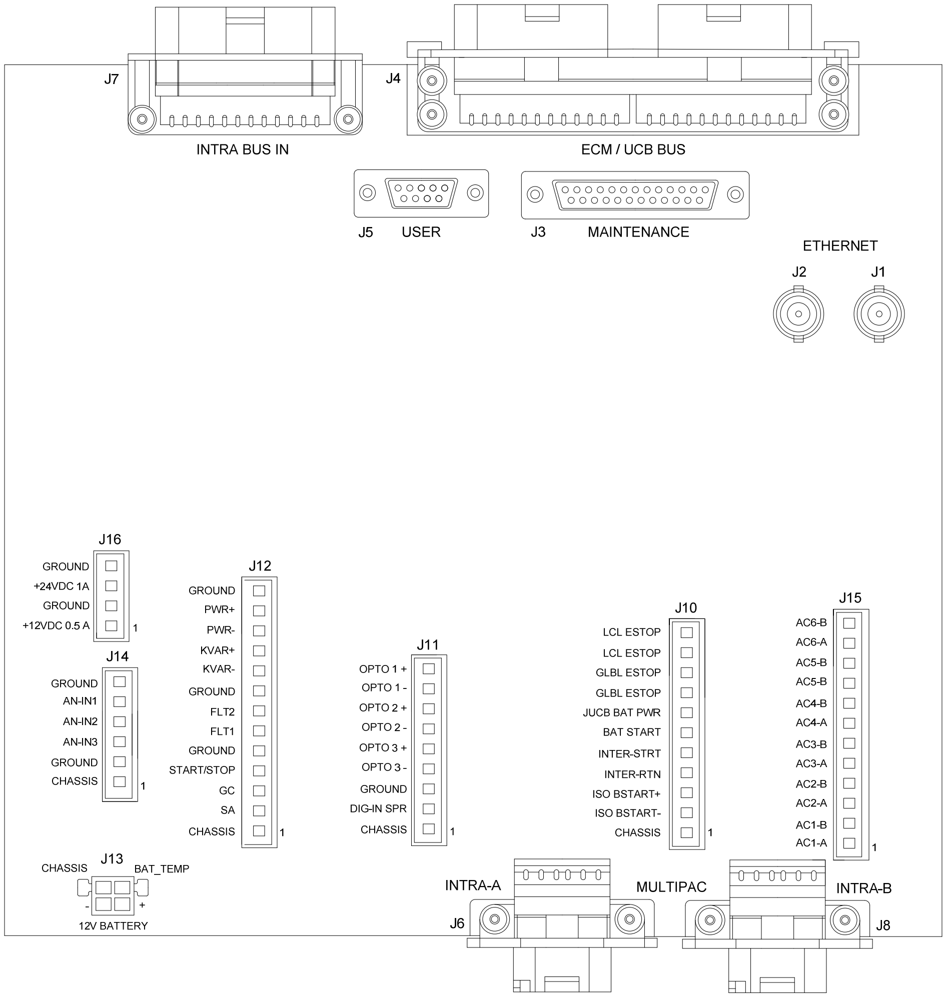


Figure 1. Model C65 User Control Board (UCB) Layout

5.1. MultiPac

The MultiPac feature allows for inter-communication between an array of microturbines in order for all microturbines to be dispatched and controlled as a single power source. The following communication signals are passed among the microturbines in a MultiPac:

- Ethernet – passes control commands to all microturbines in the MultiPac from the Master controller.
- RS485 – synchronizes voltage and frequency in Stand Alone mode for all microturbines in the MultiPac.
- Passes Global E-Stop and Wake-Up signal to all microturbines in the MultiPac.

Figure 2 shows two microturbines in a MultiPac configuration with a MultiPac cable and end terminators. Figure 3 shows how multiple microturbines are connected in a daisy chain pattern for a MultiPac configuration. Terminators must be installed on the first and last microturbines in the chain.

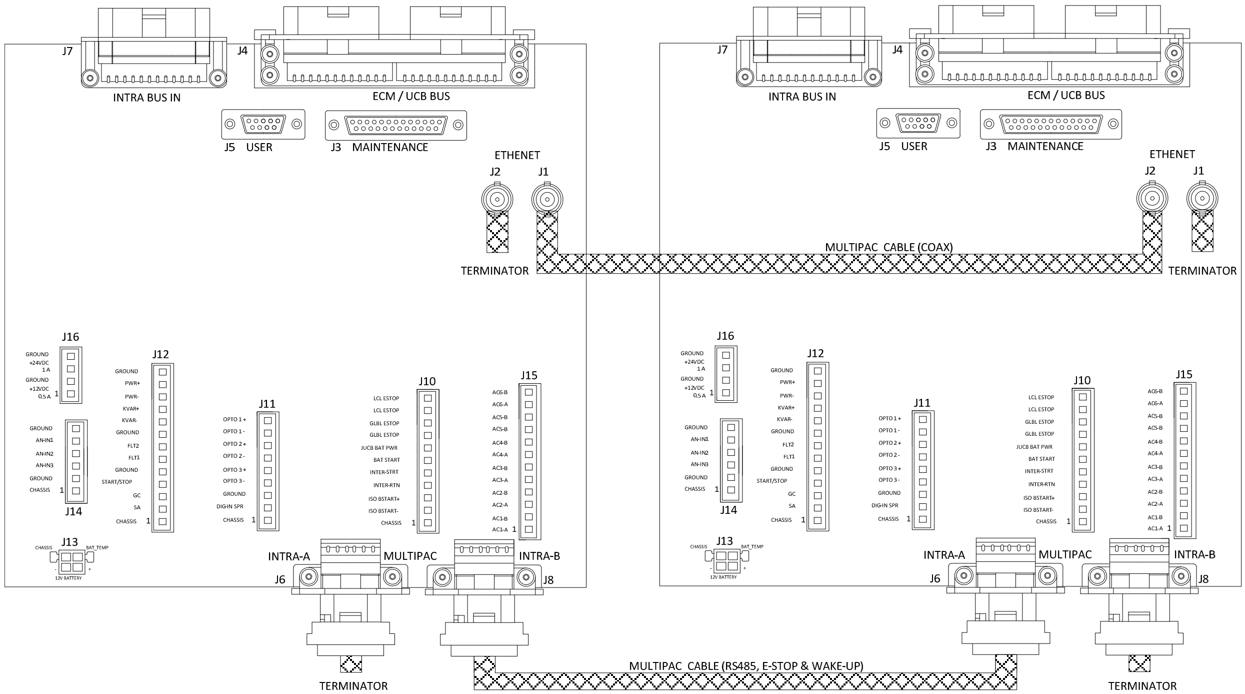


Figure 2. MultiPac Configuration

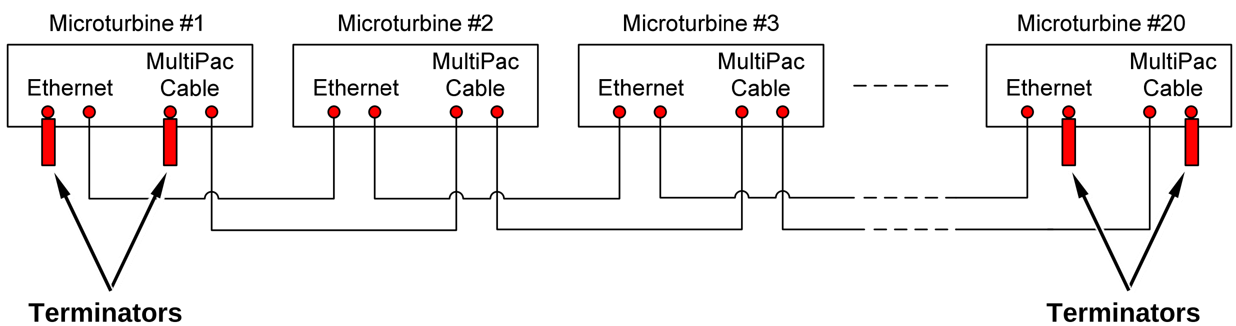


Figure 3. MultiPac Signal Interconnections

5.1.1. Signal Terminations

Signal terminators MUST be present on the initial and final connection for both Ethernet and RS-485 MultiPac cable connections (Figure 3). If termination is not present, electrical ringing may occur and the signal may be severely degraded or interrupted.

5.1.2. Ethernet I/O Connections (J1 and J2)

The connectors used for MultiPac communications are identified as J1 and J2 on the C65 UCB (see Figure 1). These connectors are 10BASE-2 connectors as specified in IEEE 802.3 Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. Refer to MultiPac Operation Technical Reference (410032) and to APS-145 Technical Reference (410079) for MultiPac operation description.

NOTE: Connectors J1 and J2 are reserved for the interconnection of microturbines only. Connections made to these ports MUST be isolated from ground.

5.1.3. Ethernet Cabling Requirements

The cable type required for Ethernet connection is RG-58A/U (coaxial, 50-Ohm impedance). The recommended cable type is Belden, Part Number 9907 or equivalent. Basic requirements for cabling include the following:

- The maximum segment length of a thin wire 10B2 cable is 185 meters (607 feet). For longer segments, a fiber optic repeater can be used.
- Up to 30 connections (Medium Attachment Units or MAUs) are allowed per Ethernet segment. For larger LAN's, repeater hubs are required. Each repeater connection requires a MAU that must be counted toward the total of 30 MAU connections per segment.
- 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.
- Whenever J1 or J2 are at the extremities of the Ethernet network, 50-ohm BNC terminators must be installed at these ports.

5.1.4. RS-485 Harness Interconnections (J6 and J8)

The RS-485 harness is used transfer the following hardware signals between microturbines:

- Inverter synchronization (Stand Alone only); one microturbine serves as an inverter master, passing voltage and frequency signals to all other microturbines in the MultiPac for synchronization.
- Global E-Stop - Wired to one turbine (typically the master), which shuts down all other microturbines in the MultiPac when opened.
- Battery Wake-Up – Wired to one turbine (typically the master), which wakes up all other microturbines in the MultiPac for Stand Alone operation.

NOTE: The RS-485 harness is not required if operating in Grid Connect mode and the Global E-stop is not configured.

Table 5 and Table 6 define all connection for connectors J6 and J8.

Table 5. Connector J6 – Inter-Controller (A) RS-485 Port

Pin	Signal	Parameter
J6 (A)	Serial Communication	RS-485, Bus A Protocol (1)
J6 (B)	(Not Applicable)	Chassis Ground
J6 (C)	Inter-Controller Start	+24 Volts DC @ 15 milliamps per microturbine (2)
J6 (D)	(Not Applicable)	Chassis Ground
J6 (E)	Global E-Stop	Normal Operation: N*42 milliamps. E-Stop: (+) 24 Volts DC (2)
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

Table 5 Notes:

(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.

(2) The Global E-Stop connection sinks 42 mA 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 $N \leq 30$ on any global E-Stop.

Table 6. Connector J8 – Inter-Controller (B) RS-485 Port

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

Table 6 Notes:

(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.

(2) 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 $N \leq 30$ on any global E-Stop.

5.2. Serial Communication Ports (J3 and J5)

A PC or PLC device may be connected to the UCB for monitoring, controlling, or trouble-shooting a microturbine system. The microturbine communicates via RS-232 protocols using a null modem cable with hardware handshaking. A DB9 connector (User Port) and a DB25 connector (Maintenance Port) are available. If devices are connected to both ports, the port accessed at a higher password level has priority for command of the system. If both are at the same password level, the Maintenance Port has priority.

5.2.1. DB25 Connector J3 (Maintenance Port)

Table 7 and Figure 4 define the connections for connector J3.

Table 7. DB25 Connector J3 (Maintenance Port)

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

Table 7 Notes:

(1) Connections made to these ports MUST be isolated from ground and/or communication ports of other microturbines.

A 25-pin RS-232 connector is used for Maintenance Port and is identified as J3 on the C65 UCB (see Figure 4). Pin designations are as follows:

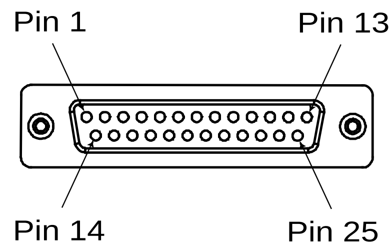
Pin No.	Signal	Description	RS-232 Connector (DB25)
2	TXD	Transmit Data	
3	RXD	Receive Data	
4	RTS	Request to Send	
5	CTS	Clear To Send	
6	DSR	Data Set Ready	
7	SG	Signal Ground	
8	DCD	Data Carrier Detect	
20	DTR	Data Terminal Ready	
22	RI	Ring Indicator	

Figure 4. RS-232 Connector (DB25)

5.2.2. DB9 Connector J5 (User Port)

Table 8 and Figure 5 define the connections for connector J5.

Table 8. DB9 Connector J5 (User Port)

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

Table 8 Notes:

(1) Connections made to these ports MUST be isolated from ground and/or communication ports of other microturbines.

A 9-pin RS-232 connector is used for the User Port and is identified as J5 on the C65 UCB (see Figure 5). Pin designations are as follows:

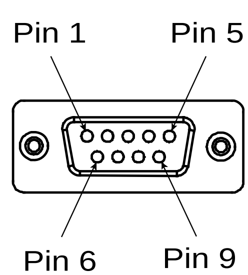
Pin No.	Signal	Description	RS-232 Connector (DB9)
1	DCD	Data Carrier Detect	
2	RXD	Receive Data	
3	TXD	Transmit Data	
4	DTR	Data Terminal Ready	
5	SG	Signal Ground	
6	DSR	Data Set Ready	
7	RTS	Request to Send	
8	CTS	Clear To Send	
9	RI	Ring Indicator	

Figure 5. RS-232 Connector (DB9)

5.2.3. Computer to Microturbine Communication

A communication cable is required for connection from a computer to the microturbine's User or Maintenance port. A null modem cable is required for this connection.

A null modem (or modem eliminator) cable is commonly used for connecting two computers together without a modem. It is a RS-232 cable that interchanges conductors 2 and 3. Wiring connections for null modem cables with DB9 connector (see Figure 6) and DB25 connector (see Figure 7) are as follows:

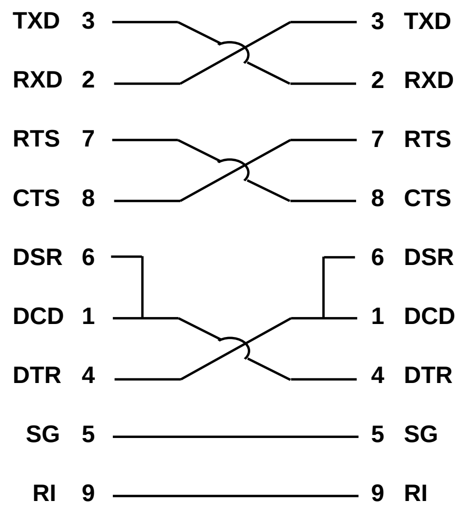


Figure 6. DB9 Null Modem Cable

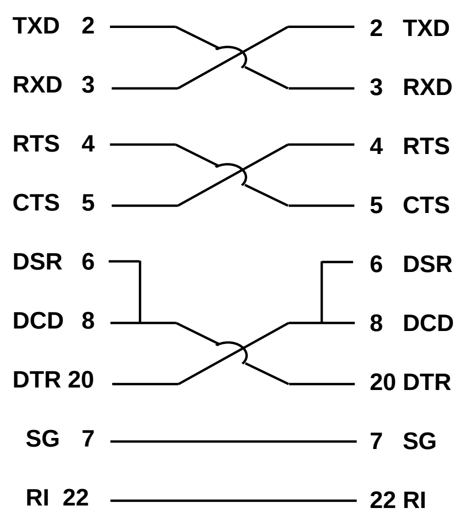


Figure 7. DB25 Null Modem Cable

5.2.4. Connections to Third-Party Modems

The following paragraphs present connection details between the microturbine and the third-party modems.

5.2.4.1 Communications Cable

The modem can be connected to the User Port or Maintenance Port of the microturbine. Typically, it is connected to the Maintenance Port. A straight-through serial cable is required in most cases for data connection between the modem and the microturbine.

5.2.4.2 Modem and Microturbine Settings

The microturbine port speed setting must be set to the same speed as the modem.

The default hardware configuration for the User and Maintenance Ports is 57,600 bits per second (maximum speed), 8-bit word length, no parity, one stop bit, and hardware handshake for flow control. It is recommended to use the highest speed available on the modem, not exceeding the maximum speed of the microturbine port.

Upon initialization, the microturbine sends an AT&F command to restore the factory settings of the modem. If this affects the desired settings on the modem, the modem can be powered on by a delay timer of at least two minutes after the microturbine wakes up. In this case, the modem should be configured independently though a HyperTerminal session or using the modem’s PC software.

Some telemetry modems have different modes for data packet transmission. For the microturbine to communicate properly, the transmitted data packets should never be split.

5.3. Wake-Up and E-Stop Inputs (J10)

Table 9 defines all connection for connector J10.

Table 9. Connector J10 – Wake-Up and E-Stop Connector

Pin	Signal	Parameter
J10 (11)	Local E-Stop (Input)	Dry circuit contact closure. Closed for normal operation, open for E-Stop. (+) 24 Volts DC @ 42 milliamps [(1)]
J10 (10)	Local E-Stop (Input)	Return for J10 (11) [(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 [(1)]
J10 (8)	Global E-Stop (Input)	Return for J10 (9) [(1)]
J10 (7)	JUCB Battery Power (Output)	+12 Volts JUCB Battery Power, 0.6 Amps re-settable fused [(2)]
J10 (6)	Internal Battery Wake Signal (Input)	**Reserved (DO NOT USE)**
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 C65 units maximum connections. (Input) = 755 ohms load [(1)]
J10 (4)	Inter Start (Input/Output) Return	Return for signal of J10 (5) [(1)]
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 (2)	Wake up signal if asleep (Input) Return	Isolated return for signal of J10 [(2)]
J10 (1)	Chassis Ground	To be used for cable shield connections

Table 9 Notes:

(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.

(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.

5.3.1. E-Stops

	CAUTION: Emergency stops increase stress on the system components. Repeated use of the Emergency Stop feature will result in damage to the microturbine. Use only in emergency situations.

Two Emergency Stop (E-Stop) inputs are available in the UCB Communications Bay (see Figure 8). The E-Stop inputs are identified as Local and Global E-Stops. These inputs are simple contact closures intended for dry contact circuits.

	NOTE: If no external E-Stop device is installed, the E-Stop terminals in the UCB must be jumpered.

5.3.1.1 Single MT E-Stop (Local)

Local E-Stop is used on a single microturbine system. When activated, it will only stop the microturbine that the E-Stop is wired to. See to Figure 8 for wiring details.

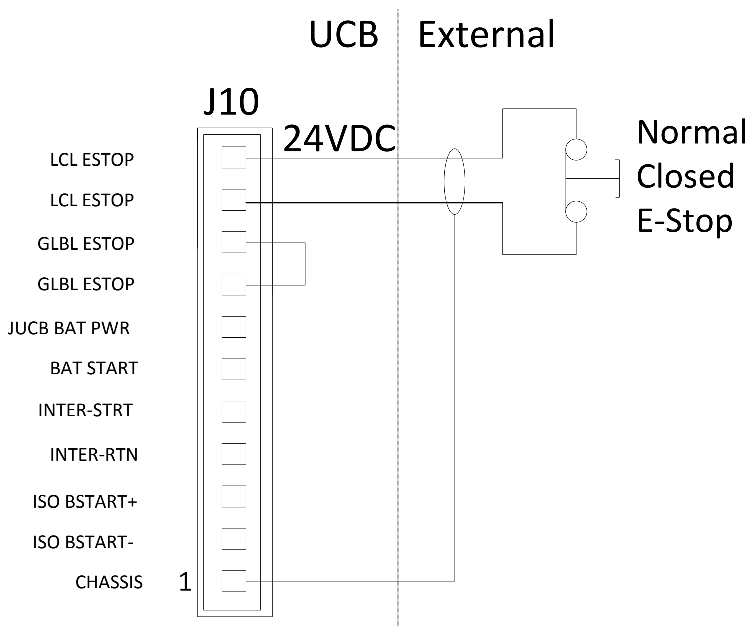


Figure 8. Single MT E-Stop (Local)

5.3.1.2 MultiPac E-Stop (Global E-Stop)

Global E-Stop is used on MultiPac Configurations (see Figure 9). The external E-Stop only needs to be connected to one microturbine in the MultiPac. When activated, it will stop all microturbine systems in the MultiPac.

The Global E-Stop jumper requirements are as follows:

- The local E-Stop (LCL ESTOP) pins on J10 of each microturbine in the MultiPac must be jumpered.
- The jumper must be removed from the global E-Stop (GLBL ESTOP) pins on J10 of each microturbine in the MultiPac.

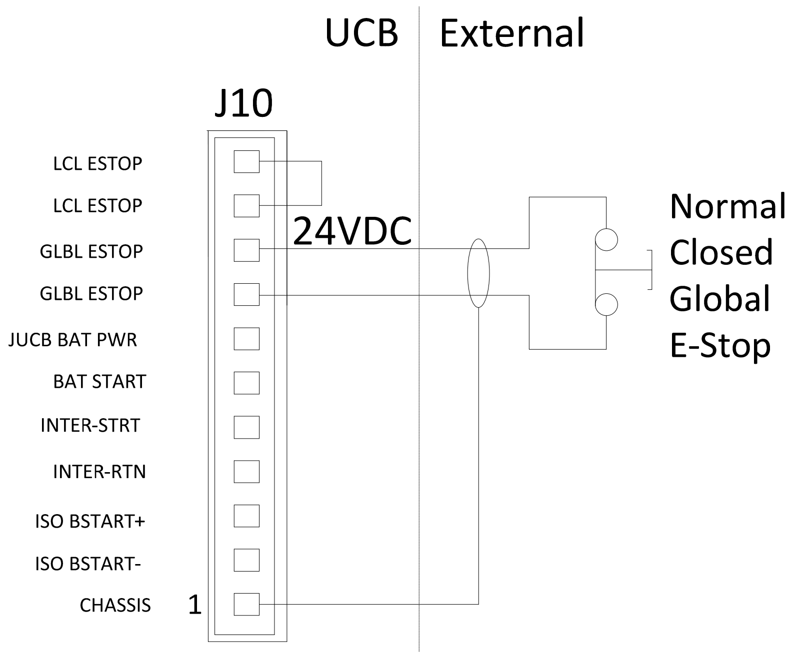


Figure 9. MultiPac E-Stop (Global E-Stop)

5.3.2. Battery Wake-Up Connections

A Stand Alone capable (battery-equipped) microturbine enters Sleep Mode to conserve battery power during prolonged periods of inactivity. A potential-free external contact that provides a momentary pulse can be used to wake up the microturbine from Sleep Mode, as well as any other microturbine connected through its MultiPac cable.

5.3.2.1 Single MT/MultiPac Wake-Up (Internal Battery)

An external UCB connection that uses internal 12 VDC power to wake up the microturbine is shown in Figure 10.

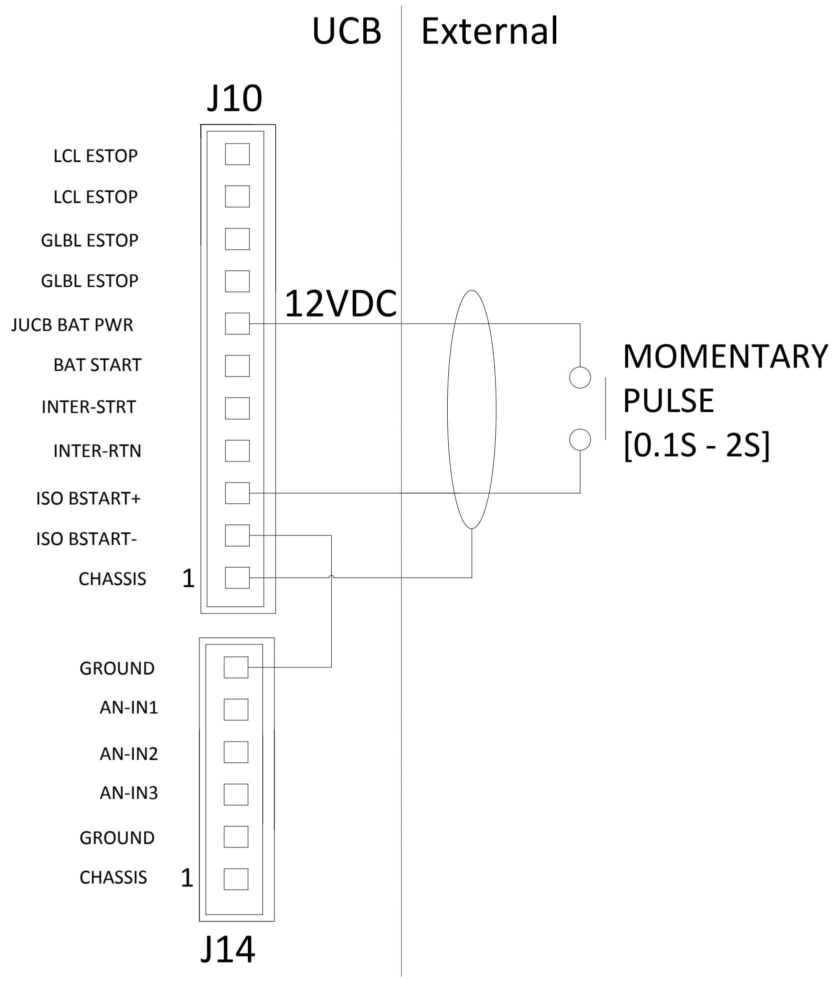


Figure 10. Single MT/MultiPac Wake-Up (Internal Battery)

5.3.2.2 Single MT/MultiPac Wake-Up – Opto-Isolated (Externally Powered)

An external UCB connection that uses external power (4-15 VDC) to wake up the microturbine is shown in Figure 11.

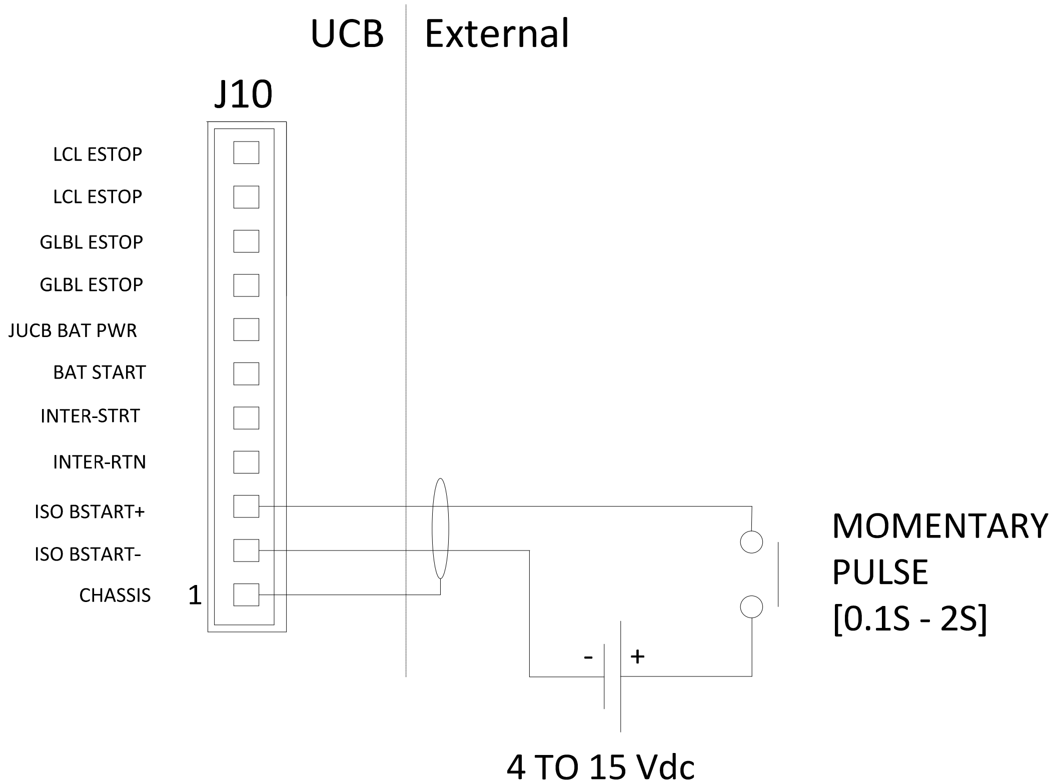


Figure 11. Single MT/MultiPac Wake-Up – Opto Isolated (Externally Powered)

5.3.2.3 Single MT/MultiPac Wake-Up (Externally Powered)

An external UCB connection that uses external power (24 VDC) to wake up the microturbine is shown in Figure 12.

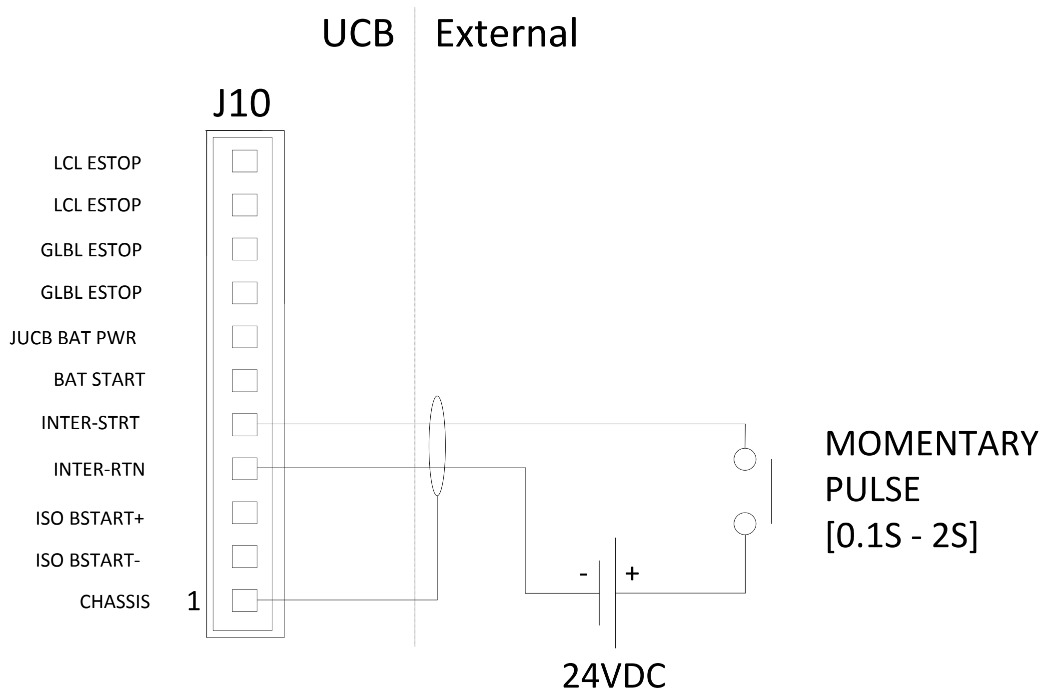


Figure 12. Single MT/MultiPac Wake-Up (Externally Powered)

5.4. Opto-Isolated Inputs - Reserved (J11)

The opto-isolated inputs shown in Table 10 are reserved and not available for use.

Table 10. Connector J11 – Opto-Isolated Inputs

Pin	Signal	Parameter
J11 (9)	OPTO 3 (+)	Reserved (DO NOT USE)
J11 (8)	OPTO 3 (-)	Reserved (DO NOT USE)
J11 (7)	OPTO 2 (+)	Reserved (DO NOT USE)
J11 (6)	OPTO 2 (-)	Reserved (DO NOT USE)
J11 (5)	OPTO 3 (+)	Reserved (DO NOT USE)
J11 (4)	OPTO 3 (-)	Reserved (DO NOT USE)
J11 (3)	AGND	Reserved (DO NOT USE)
J11 (2)	DIGINSP	Reserved (DO NOT USE)
J11 (1)	Chassis Ground	To be used for shield connections

5.5. Digital Inputs (J12)

Table 11 defines all connection for connector J12.

Table 11. Connector J12 – Digital Inputs

Pin	Signal	Parameter
J12 (13)	AGND	Return circuit for connector J12 contact closures [(1)]
J12 (12)	PWR (+) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (11)	PWR (-) (Wattmeter)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (10)	KVAR (+) (Wattmeter)	**Reserved (DO NOT USE)**
J12 (9)	KVAR (-) (Wattmeter)	**Reserved (DO NOT USE)**
J12 (8)	AGND	Return circuit for connector J12 contact closures [(1)]
J12 (7)	FLT2 (User Fault Input)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (6)	FLT1 (User Fault Input)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (5)	AGND	Return circuit for connector J12 contact closures [(1)]
J12 (4)	Start/Stop	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (3)	GC (Grid Connect mode)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (2)	SA (Stand Alone mode)	Dry circuit closure to AGND from (+) 5 Volt pull up, 4.7 k ohms [(1)]
J12 (1)	Chassis Ground	To be used for shield connections

Table 11 Notes:

(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.

5.5.1. Load Following Pulse Inputs

Two digital inputs are used for load following and reverse power protection. A power meter is required to provide potential free contacts that provide pulses for forward energy flow, and pulses for reverse energy flow.

Power flow in the forward direction (toward the loads) is measured as +PWR.

Power flow in the reverse direction is measured as –PWR. This input is only used if reverse power protection is required and enabled.

A 5 V wetting voltage is provided by the microturbine. See Figure 13 for wiring details and maximum wire length.

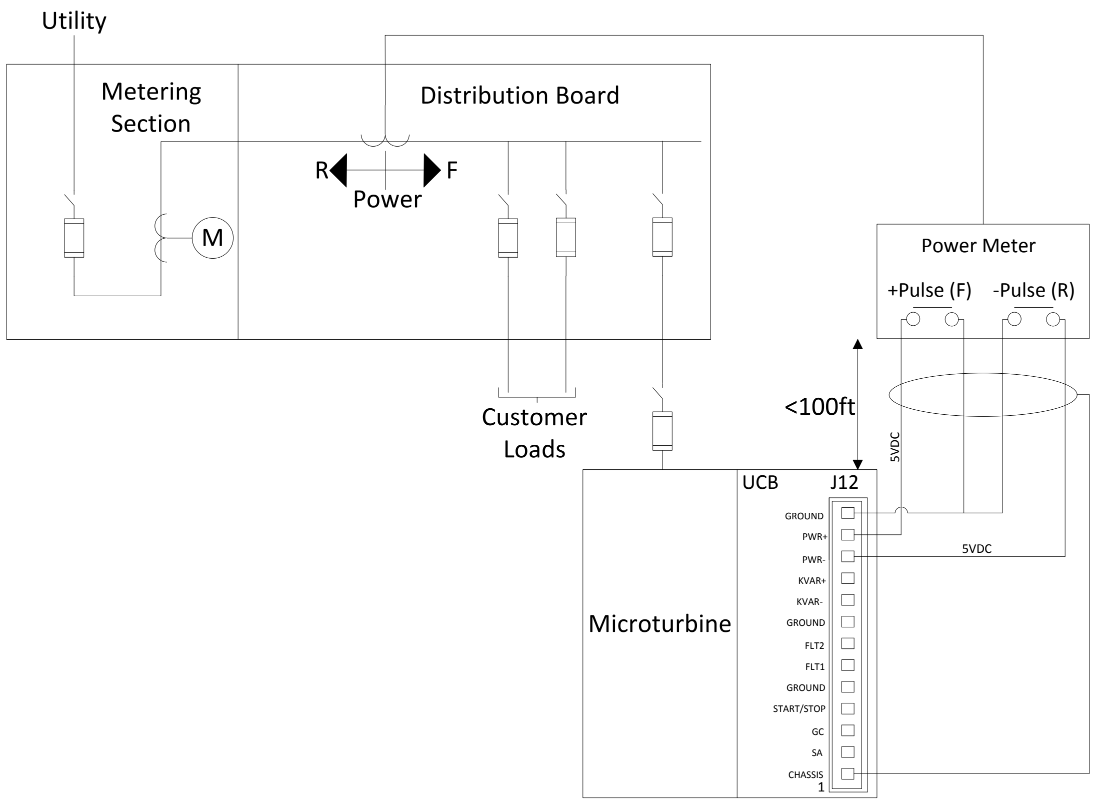


Figure 13. Load Following Pulse Inputs

5.5.2. Load Following Pulse Inputs (Interposing Relays)

Interposing relays are used to extend the distance > 100 feet. See Figure 14 for wiring details.

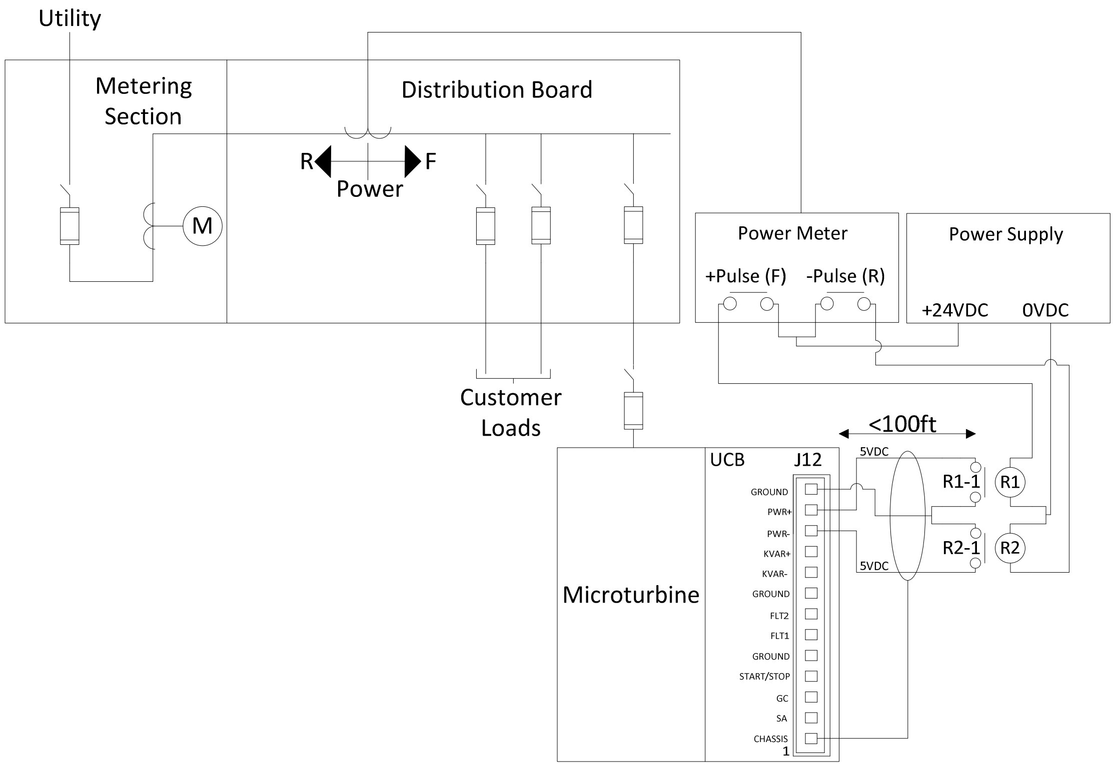


Figure 14. Load Following Pulse Inputs (Interposing Relays)

5.5.3. Fault Inputs

Fault inputs are simple contact closures intended for dry contact circuits.

The following settings (set in CRMS) are available for fault inputs:

- Enable/Disable (On/Off) – If On, control detects a fault input into the system from an external fault source.
- Fault Level - defines the system severity level of this fault source.
    - Level 2 – Warning issued. Microturbine will continue to operate.
    - Level 3 – Standard microturbine shutdown sequence (cooldown).
    - Level 4 – Fast microturbine shutdown sequence (warmdown).
- Time (sec) - adjusts the debounce time for fault input detection from an external device, i.e., how much time the fault is detected for before the fault is latched in the system.
- Active (Open / Close)
    - Active Open – If the fault input contact changes state and moves from a closed position to an open position the fault will occur.
    - Active Close – If the fault input contact changes state and moves from an open position to a closed position the fault will occur.

Figure 15 shows a wiring example for fault input 1 and 2. This example is set up as follows:

- Fault input 1 is used to shut down the microturbine in the event that the external push button (normally closed) is activated. This change of state is configured as Active Open in CRMS.
- Fault input 2 is used to shut down the microturbine in the event that the contact (normally open) is activated. This is change of state is configured as Active Close in CRMS.

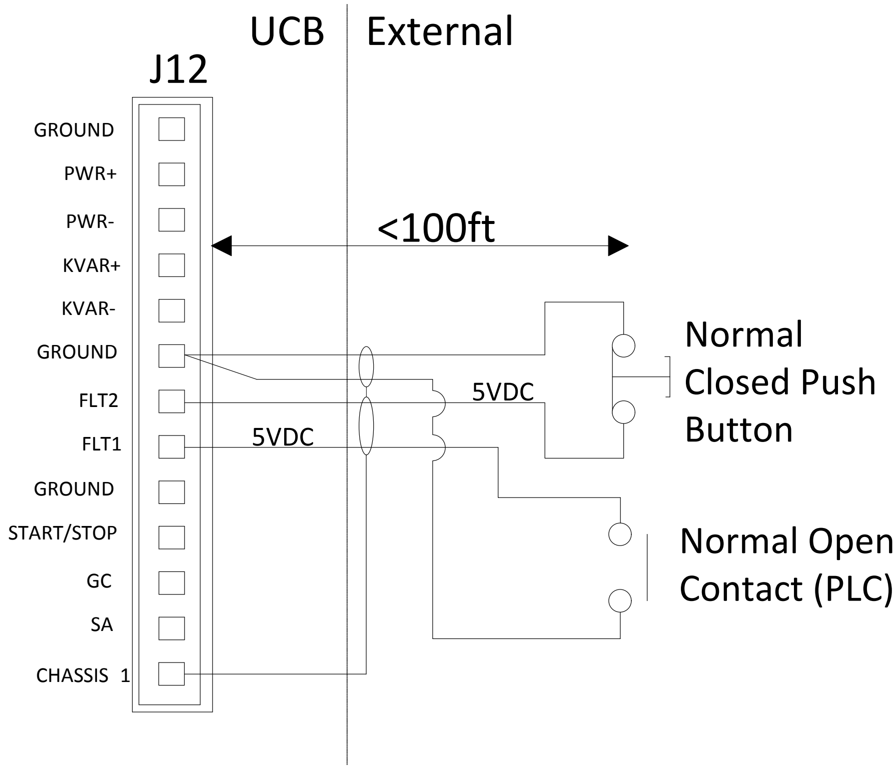


Figure 15. Fault Inputs

5.5.4. Fault Inputs Using Interposing Relays

Interposing relays are used for cable length greater than a 100ft and to fault multiple microturbines from a single fault device.

	CAUTION: Interposing relays are required if multiple microturbines are required to be faulted by an external fault input. Microturbine fault inputs cannot be wired together and need to be electrically isolated.

Figure 16 shows a wiring example using interposing relays. This example is set up as follows:

- Fault input 1 is used to shut down the microturbines in the event that the external fault device (normally closed) is activated. This is change of state at relay R1 contacts is configured as Active Close in CRMS.

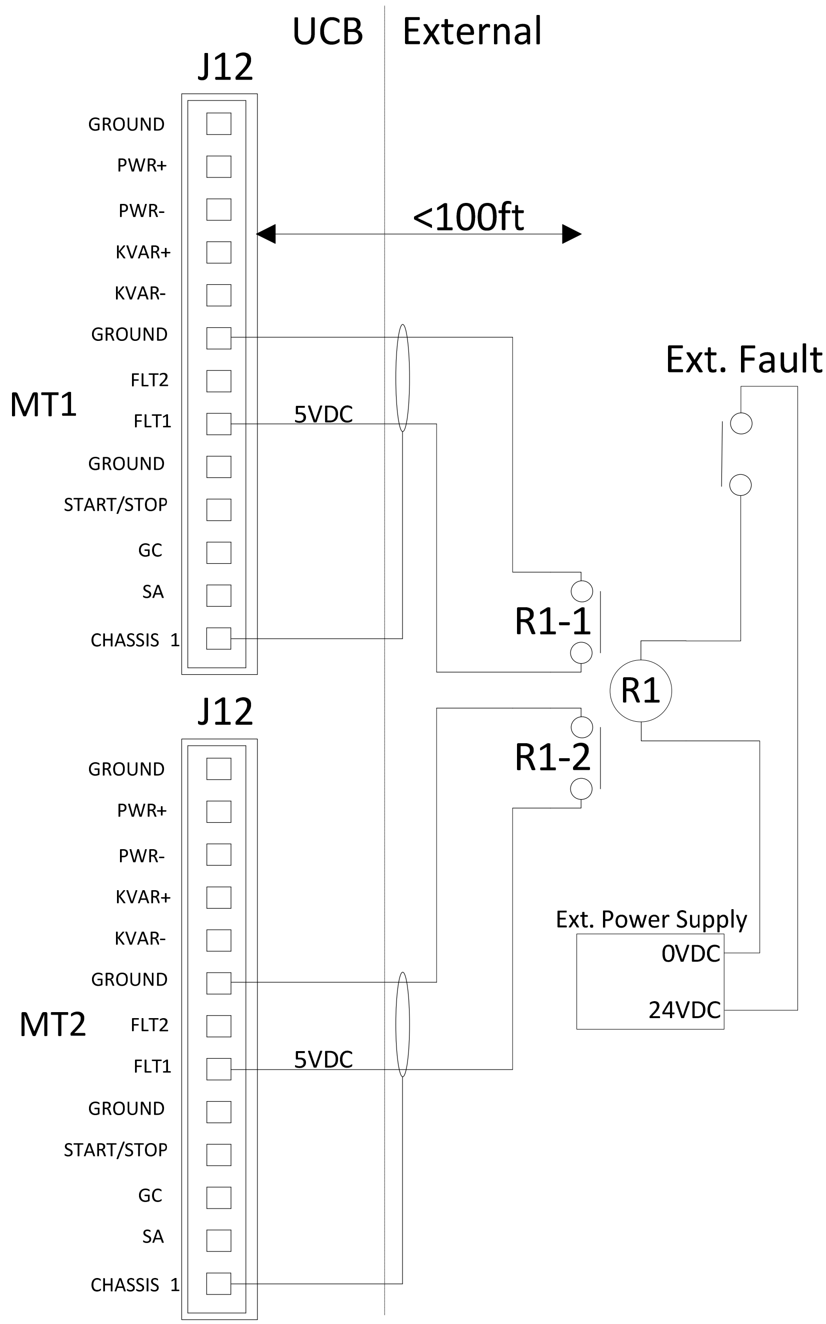


Figure 16. Fault Inputs Using Interposing Relays

5.5.5. Start/Stop Command in GC Mode

Figure 17 shows how a microturbine is wired for start and stop commands in Grid Connect mode. A contact closure provides a start command and a contact release provides a stop command. The GC interlock must be linked (jumpered) for Grid Connect operation.

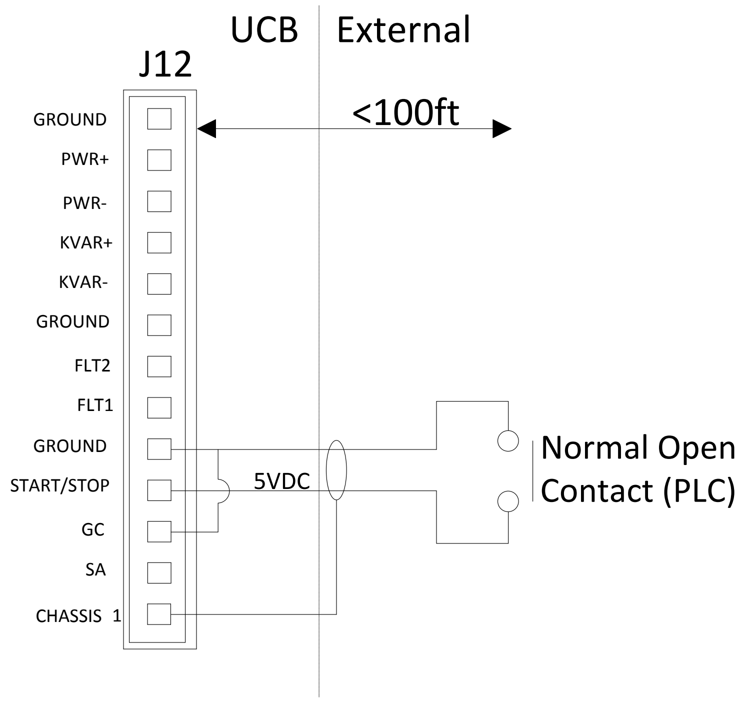


Figure 17. Start/Stop Command in GC Mode

5.5.6. Start/Stop Command in SA Mode

Figure 18 shows how a microturbine is wired for start and stop commands in Stand Alone mode. A contact closure provides a start command and a contact release provides a stop command. The SA interlock must be linked (jumpered) for Stand Alone operation.

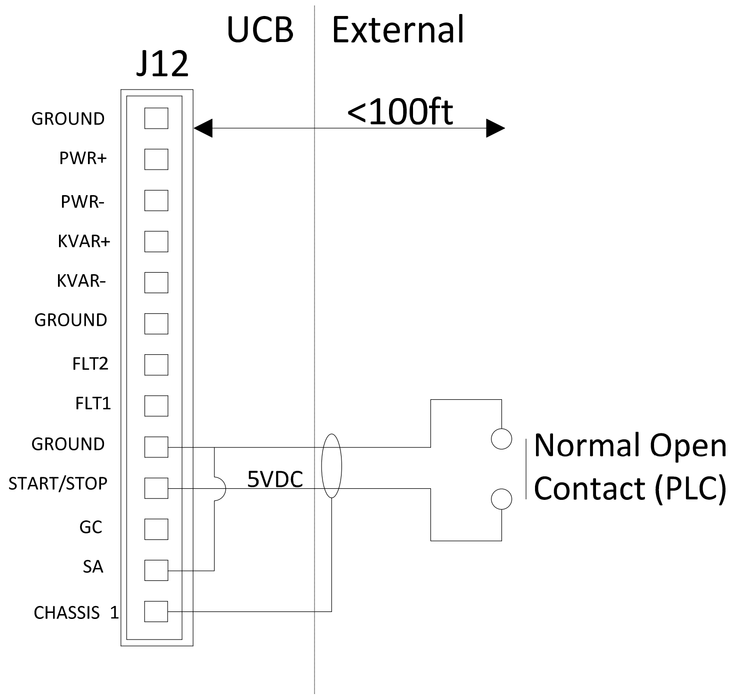


Figure 18. Start/Stop Command in SA Mode

5.5.7. Start/Stop, GC and SA Command with DMSC

Figure 19 shows an example of how a microturbine is wired for start and stop commands in Dual Mode. A contact closure provides a start command and, a contact release provides a stop command. The Stand Alone and Grid Connect interlocks positions are defined by the Dual Mode System Controller (DMSC). Refer to the DMSC Technical Reference (410071) for details.

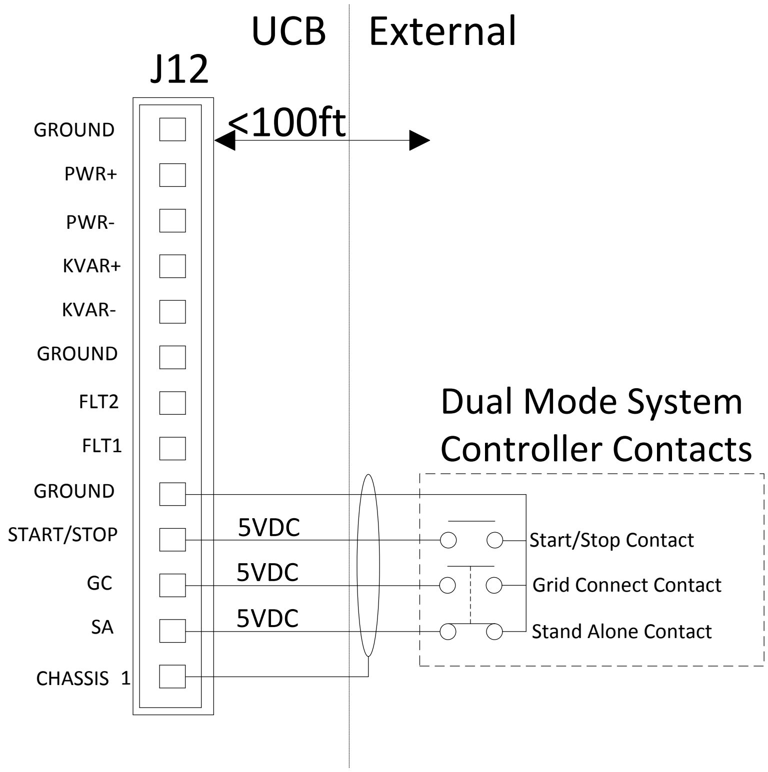


Figure 19. Start/Stop, GC and SA Command with DMSC

5.6. Analog Inputs (J14)

Table 12 defines all connections for connector J14 and Figure 20 shows a wiring example using the 0-5 VDC analog inputs. Figure 21 shows the difference in wiring between analog inputs configured for voltage signal and current signal. Refer to the following paragraphs for details.

Table 12. Connector J14 – Analog Inputs (1)

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

Table 12 Notes:

(1) Connections made to these terminals MUST be isolated from ground/chassis. They may not be connected in parallel with other microturbine input terminals.

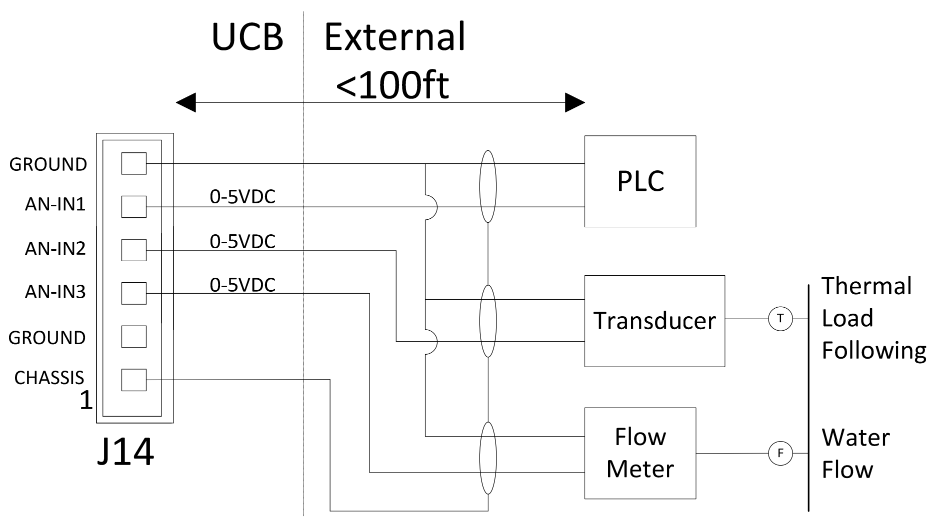


Figure 20. 0-5 VDC Analog Input

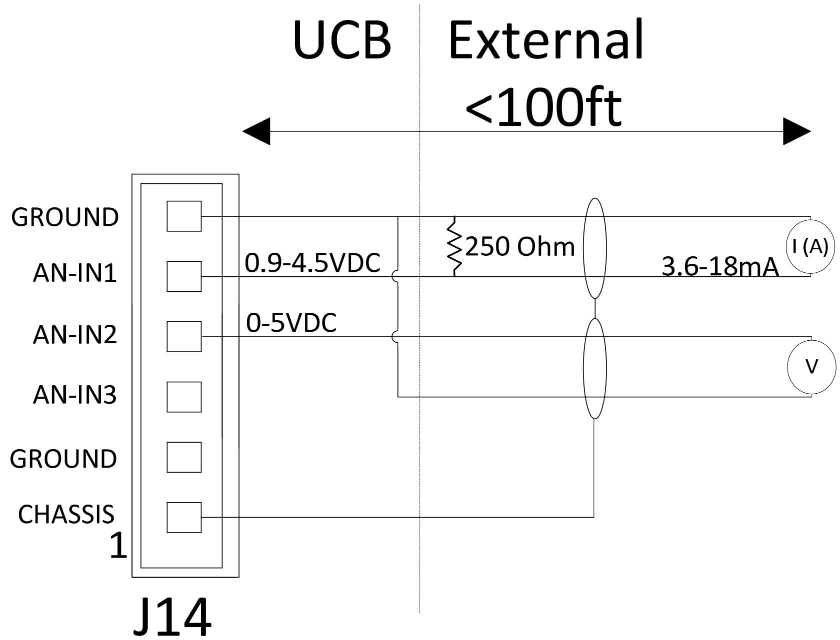


Figure 21. Analog Input for Voltage (0-5 V) and Current (4-20 mA)

5.6.1. Analog Inputs

Refer to the CRMS Technical Reference Maintenance Edition (410014) and enter the settings for the analog inputs as follows:

1. At the User Connection Bay Settings Panel, select the Input Signal Type:
   - **4-20 mA:** In order for the 4-20 mA input to work, a customer-supplied 250 ohm resistor must be installed. Internal software is scaled to work from 0.9 V to 4.5 V for full range operation (see Figure 21)
   - **0-5 V:** Function range is scaled between 0 V and 5 V.
2. Refer to Table 13 and select a function for the analog input.
3. Refer to Table 14 and enter the Low and High Limits for the function. Table 14 gives the minimum and maximum allowable values. For the Electrical Power Demand function, the High Limit displays 65000 W as the default. For a single microturbine application this value does not need to be changed. For a MultiPac, enter the maximum combined power demand of the microturbines in the MultiPac. For example, if the MultiPac consists of three C65 microturbines, the high limit will be 195000 W (3 X 65000).

Table 13. Connector J14 – Analog Input Functions

Function	Description
Not assigned	No software function assigned (Default).
Electrical Power Demand	Provides output power demand feedback
CHP Water Flow Rate	Provides water flow feedback if iCHP option is installed.
CHP Temperature Feedback	Provides temperature feedback if iCHP option is installed. Input can be used for thermal load following.
Propane Temperature Feedback	**Reserved (Do not use)**

Table 14. Analog Input Limits

Function	Low Limit			High Limit		
	Minimum	Signal Type		Maximum	Signal Type	
		0-5 V	4-20 mA		0-5 V	4-20 mA
Electrical Power Demand	0W	0 V	0.9 V (3.6 mA)	2090000W	5 V	4.5 V (18 mA)
CHP Water Flow Rate	0 gpm	0 V	0.9 V (3.6 mA)	80 gpm	5 V	4.5 V (18 mA)
CHP Temperature Feedback	32 °F	0 V	0.9 V (3.6 mA)	212 °F	5 V	4.5 V (18 mA)

5.6.2. Analog Input Scaling

The high and low limits entered in CRMS for an analog input function are used by the microturbine software as the starting and ending points of a linear scale. As shown in Table 14, the scale is different depending on whether the signal type is 0-5 V or 4-20 mA. How this scale is generated for each signal type is described below:

- Signal Type 0-5 V: The range of values is scaled between 0 and 5 Volts. Using CHP Water Flow Rate as an example, a voltage signal of 0 V represents 0 gpm and a voltage signal of 5 V represents 80 gpm. Therefore, a midrange voltage signal of 2.5 V would represent 40 gpm.
- Signal Type 4-20 mA: The software establishes a range between 0.9 V to 4.5 V for this signal type as shown in Figure 22. Fluctuations above and below this range can be misread by the system. The signal is treated as a fault if it is greater than 18.8 mA or less than 2.8 mA. Using CHP Water Flow Rate as an example, a current signal (using a 250 Ohm resistor) of 3.6 mA (0.9 V) represents 0 gpm and a current signal of 18 mA (4.5 V) represents 80 gpm. Therefore, a midrange signal of 10.8 mA (2.7 V) would represent 40 gpm.

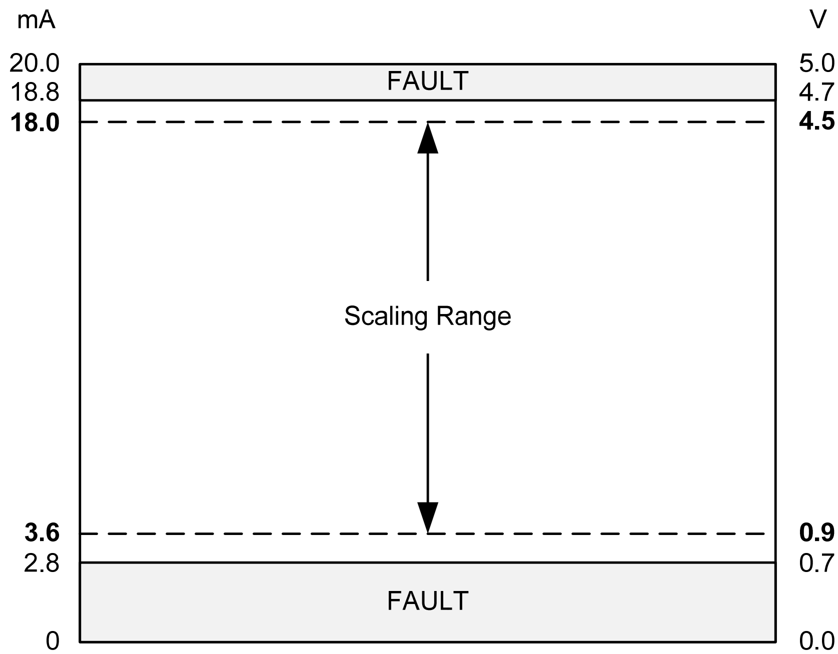


Figure 22. 4 to 20 mA Analog Input Limits

5.7. Digital Outputs (J15)

Table 15 defines all connections for connector J15.

Table 15. Connector J15 – Solid-State Relay Outputs (1)

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

Table 15 Notes:

(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.

CAUTION: Digital outputs must be configured BEFORE making any electrical connections. Failure to do this may cause damage to the microturbine and void the warranty.

For some applications, the current draw required on the external equipment may exceed the rated current on the UCB relays. In these cases, an interposing relay must be installed.

CAUTION: The coil rating of the interposing relay must not exceed the rated current and voltage on the UCB relays. Otherwise permanent damage to the UCB board may occur.

Electromechanical interposing relays are highly recommended over solid-state relays for electrical isolation.

The digital outputs (output relays) are simple contact closures intended for dry contact circuits. Wetting voltage must be provided by external power source.

The following functions (set in CRMS) are available for Digital Outputs:

- Control State Functions - digital outputs can be selected to switch at any control state as defined in Table 16.
- Active (Open / Close)
  - Active Open – If a control state is TRUE the digital output will change from a closed to open position.
  - Active Close – If a control state is TRUE the digital output will change from an open to closed position.

NOTE: When the microturbine is powered off the digital outputs revert back to their de-energized state of normally open.

Table 16 lists the control state functions that can be used with the output relays described in Table 15. Refer to the CRMS Technical Reference Maintenance Edition (410014) for details.

Table 16. Control State Functions

Function	Control State (Function is True)
Standby	System is in the Standby state.
Run	Engine is running or power electronics are enabled.
Contactor Closed	Output Contactor is closed.
Fault	Fault occurs that is severity level 3 or greater
Stand Alone	System is in the Stand Alone mode
Stand Alone Load	System is in the Stand Alone mode and in the Load State.
Disable	System is in the Disable state.
Fuel On	Electrical fuel shut-off is enabled.
Fuel Purge	10 seconds after the electrical fuel shutoff is closed (for units equipped for liquid fuel only).
Load State	System is in the Load State (GC or SA).

Table 16. Control State Functions (Continued)

Function	Control State (Function is True)
External Load	System is in Prepare to Start state and DC bus has been raised. This is generally used to start gas compressors that are powered from the DC bus.
Protective Relay	System has “PRT RLY Fault” (Protective Relay Fault).
Anti-islanding	System has “ANTI-ISL Fault” (Anti-Islanding Fault).
Not Assigned	No software function assigned (Default).
CHP Active (If installed)	This function is true when the system detects microturbine exhaust gas flow. Active in the following states: Light, Acceleration, Run, Load, Recharge (SA only), Cooldown, Warmdown, and Restart.
Dual Mode Control	This function is true for Dual Mode configured systems only. When selected it will act as an interlock to ensure the main breaker (M1) cannot be opened when performing Stand Alone operation.
HTC Start Relay	Reserved (Do not use)
EUCB	Reserved (Do not use)

5.7.1. Solid State Relays

Figure 23 shows how a microturbine is wired to the digital output to provide a start signal for an external gas compressor. The control state for relay #1 (AC1) would be set for External Load and the Active Close. The wiring diagram also shows how the interlock signal would be wired to the Dual Mode System Controller (DMSC). The control state for relay #2 (AC2) would be set for DUAL MODE CNTRL and Active Closed.

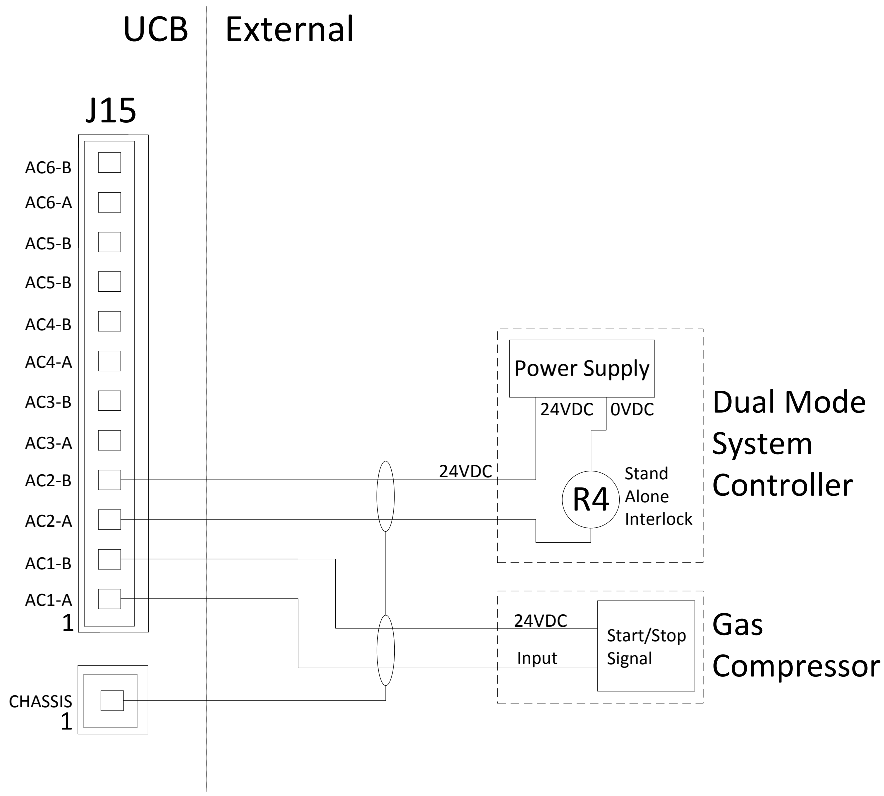


Figure 23. Solid State Relays

5.8. User Power (J16)

Table 17 defines all connections for connector J16. See Figure 24 for example connections using connector J16.

Table 17. Connector J16 – Modem and User Power Outputs [(1)]

Pin	Signal	Parameter
J16 (4)	PWRGND	User Power Return
J16 (3)	User Power	24 Volts DC, 1 Amp maximum (fuse protection must be provided when used)
J16 (2)	PWRGND	Modem Power Return
J16 (1)	Modem Power	12 Volts DC, 0.5 Amps maximum (fuse protection must be provided when used)

Table 17 Notes:

(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.

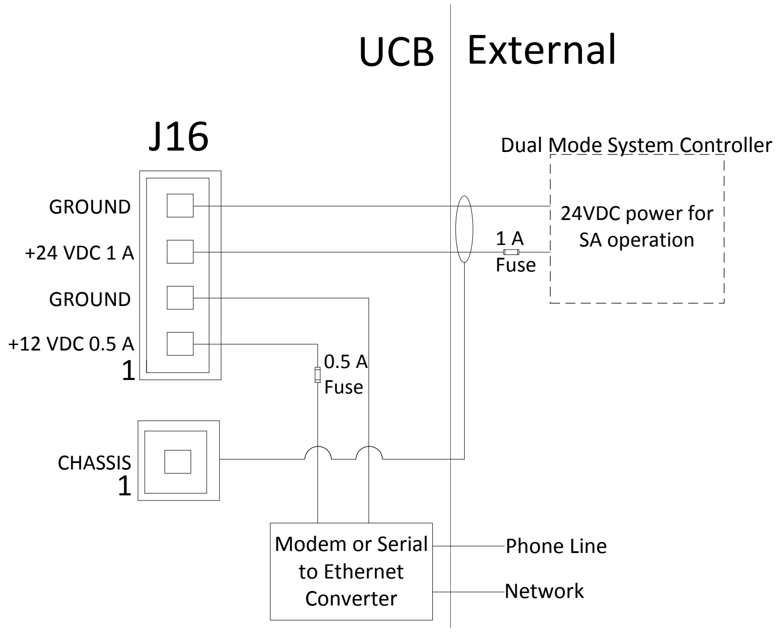


Figure 24. User Power (J16)