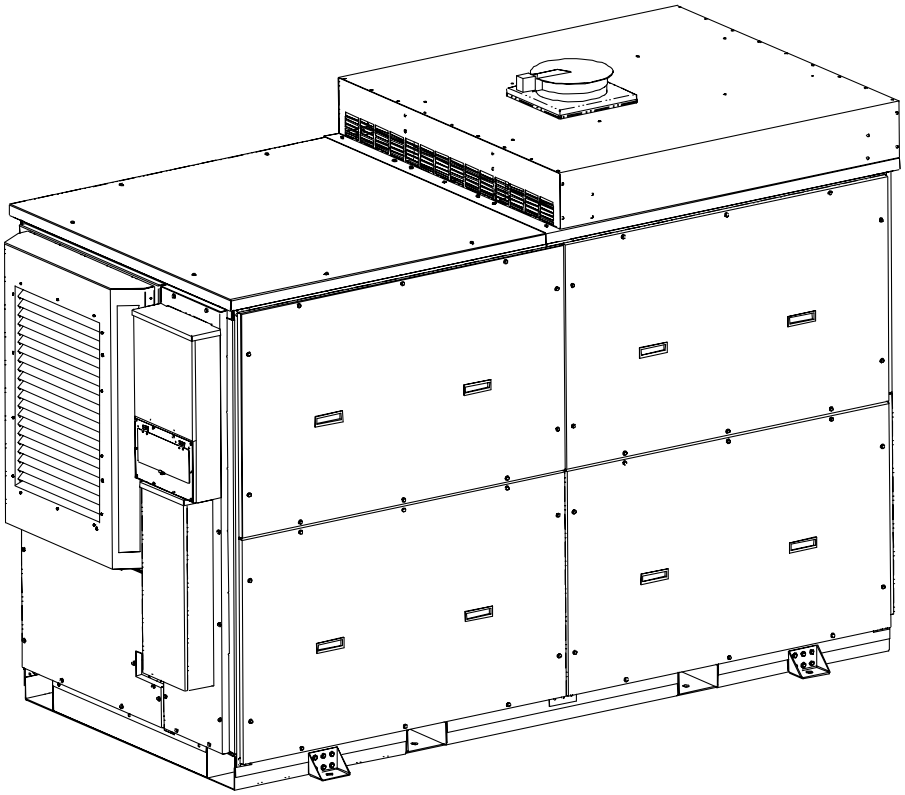
Capstone MicroTurbine
Model C200 User's Manual

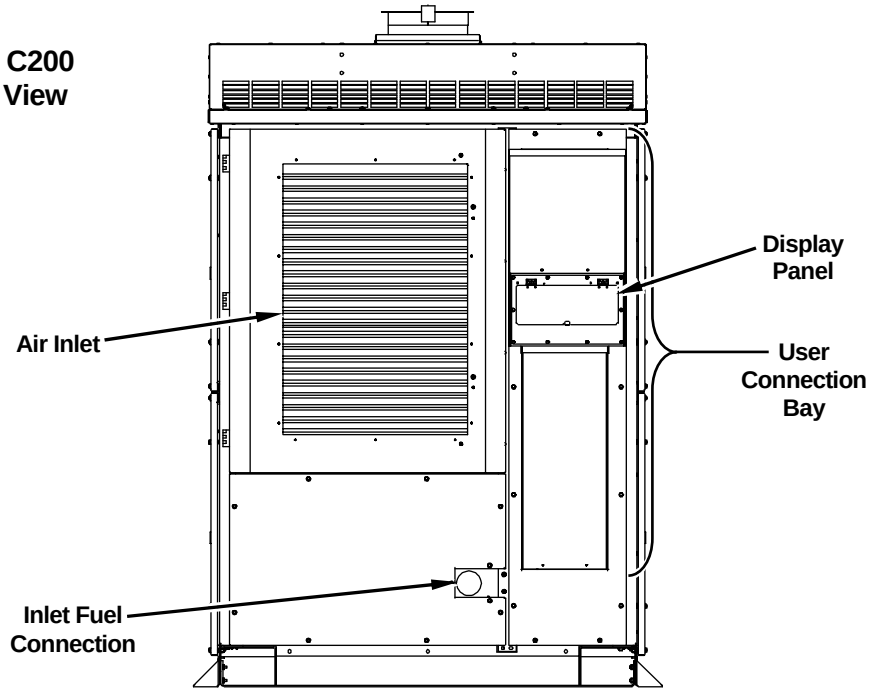


Capstone Turbine Corporation
21211 Nordhoff Street, Chatsworth, California 91311 USA

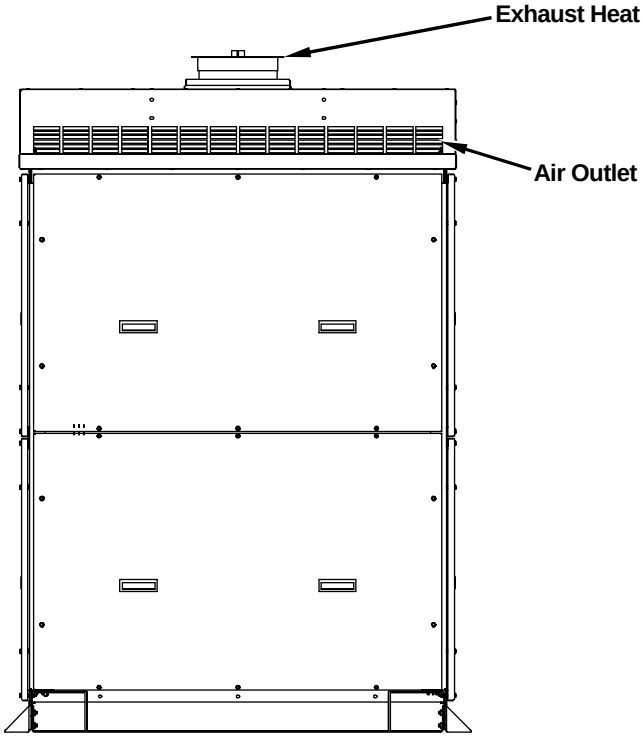
Welcome to the world of Capstone Power Generation!

We are pleased that you have chosen the Capstone MicroTurbine product for your application.

Model C200
Front View



Model C200
Rear View



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About This Document

This document provides user instructions to operate and maintain the Capstone Turbine Corporation Model C200 MicroTurbine.

This document is intended for user personnel who may not have specific training on the MicroTurbine (sometimes abbreviated as MT in this manual). Capstone Authorized Service Providers (ASPs) have received rigorous training and have been certified to perform commissioning, troubleshooting, and repair of the MicroTurbine. This document reflects C200 MicroTurbine with software version 1.XX, which meets the requirements of IEEE 1547.1 and the revisions to UL1741 compliance updates effective May 2007.

User personnel who have not received certification of satisfactory completion of the Authorized Service Provider training should not attempt any procedures other than those specifically described in this document.

Safety Information

This section presents safety information for the user of Capstone Turbine Corporation MicroTurbines. The user must read and understand this manual before operation of the equipment. Failure to obey all safety precautions and general instructions may cause personal injury and/or damage to the equipment.

It is the user's responsibility to read and obey all safety procedures and to become familiar with these procedures and how to safely operate this equipment.

Introduction

The Capstone MicroTurbine is an advanced power generation system with user and material safety foremost in mind. Fail-safe operation includes mechanical systems, electrical systems, and engine control software.

Symbols

There are three very important symbols used in this document: Warnings, Cautions, and Notes. WARNINGs and CAUTIONs alert you to situations and procedures that can be dangerous to people and/or cause equipment damage. NOTEs provide additional information relating to a specific operation or task.

WARNING	A Warning means that personal injury or death is possible.

CAUTION	A Caution means that damage to the equipment is possible.

NOTE	A Note is used to clarify instructions or highlight information that might be overlooked.

General Precautions

The following general precautions must be observed and followed at all times. Failure to do so may result in personal injury and/or equipment damage.

NOTE	Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.

- **Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.**
- Read and understand the User's Manual before operating the equipment.
- Read and obey all warnings and cautions.
- Make sure all fuel connections are tight, free from leaks, and protected from damage.
- Make sure all electrical connections are tight, clean, dry, and protected from weather and damage.
- The MicroTurbine may be equipped with a heat recovery system. Use caution around relief valves where hot water and steam may be present.
- A pressurized enclosure (e.g., hazardous location package) should not be opened: 1) Unless the area is known to be free of flammable materials; 2) All devices have been de-energized from the utility. Power should not be restored until the enclosure has been purged for three minutes.
- Use hearing protection when you work on or near an operating MicroTurbine for extended time periods.
- The MicroTurbine is heavy. Be careful when you move or lift the MicroTurbine.
- Keep the equipment clean.
- Keep all flammable materials away from the MicroTurbine and its components.
- Do not operate or work on the equipment if mentally or physically impaired, or after consumption of alcohol or drugs.
- Make sure all fasteners are installed and properly tightened.
- Keep an ABC rated fire extinguisher near the MicroTurbine.
- Obey all applicable local, state, and national codes and regulations.

Electrical Precautions

WARNING	The MicroTurbine system contains and produces high voltage. High voltage can injure or kill. Obey all safety procedures when you work around electrical equipment.

WARNING	Make sure the system is off and the dedicated disconnect switch is in the open position and is locked. This will help prevent injury and damage to the equipment.

NOTE	Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.

The output voltage and residual capacitor voltage of this equipment is dangerous. Use caution when you work on electrical equipment. The MicroTurbine system can include multiple sources of power. Make sure to turn off the system and lock out all sources of power prior to doing any work on the equipment.

- Command the MicroTurbine system to OFF.
- Open and lock the dedicated disconnect switch to isolate the MicroTurbine from the electric utility grid or loads.
- If the MicroTurbine is equipped with battery packs (i.e., if the MicroTurbine includes the Stand Alone Option), open the battery isolation switches and unplug the battery cables.
- Wait five (5) minutes for any capacitive stored voltage to dissipate.
- Always disconnect all power sources.
- Use a voltmeter to make sure that all circuits are de-energized.
- All output connections must be made in accordance with applicable codes.

Fuel Precautions

WARNING	MicroTurbine fuel is flammable and explosive. An explosion can cause death or injury to personnel and/or damage to equipment. No open flame or smoking is allowed near the MicroTurbine.

WARNING	Gaseous fuels can be corrosive. Concentrations of Hydrogen Sulfide (H_2S) can be found in Sour Natural Gas and Sour High Btu Gas. Injury to personnel and/or damage to equipment can occur. Minimize exposure to gaseous fuels and provide satisfactory fresh airflow when you are around equipment.

The Capstone MicroTurbine operates on approved gaseous fuels. Keep flames, sparks, pilot lights, equipment that produces electrical arcs, switches or tools, and all other sources of ignition away from areas where fuel and fumes are present. If there is a fire, use a multi-purpose dry chemical or CO_2 fire extinguisher, and contact the appropriate fire officials.

Fuel lines must be secure and free of leaks. Fuel lines must also be separated or shielded from electrical wiring. If you smell fuel fumes, immediately stop operation of the equipment, close the fuel isolation valve, and locate and repair the source of the leak or call a qualified professional.

Exhaust Precautions

WARNING	The MicroTurbine exhaust contains nitrogen dioxide and carbon monoxide, which are poisonous at high concentrations. Make sure there is satisfactory fresh airflow when you work around the equipment.

WARNING	The exhaust airflow and pipes are hot enough to cause personal injury or fire. The exhaust airflow can reach temperatures as high as 371 °C (700 °F). Keep people, equipment, and other items away from the exhaust airflow and pipes. Always vent exhaust away from personnel.

WARNING	Hot surfaces and hot exhaust can be dangerous. Personal injury and/or damage to equipment are possible. Be careful when you work on equipment.

The MicroTurbine exhaust is clean and oxygen rich (approximately 18% O_2), with very low levels of air pollutants. Like all fossil fuel combustion technologies, the MicroTurbine produces oxides of nitrogen (NOx) and carbon monoxide (CO) emissions from the fuel combustion process. Although the MicroTurbine has ultra low NOx and CO emission levels, make sure precautions are taken to prevent personnel from being exposed to these pollutants while the system is operating.

When installed indoors, the MicroTurbine exhaust must be vented to the outside. Make sure there is a satisfactory fresh air supply. An exhaust system must be added to direct the exhaust away from the system to reduce the risk of exposure to dangerous emissions.

For exhaust connection data, temperatures, pipe requirements, and other related information, contact your Capstone Authorized Service Provider.

When installed outdoors, the MicroTurbine should be located where there is a satisfactory fresh airflow so the exhaust emissions will be dissipated.

Acoustic Emissions Precautions

The Capstone MicroTurbine is designed to produce safe acoustic emissions. However, when working at a radius of 10 meters (or 33 feet) from an enclosed Capstone MicroTurbine, sound level exposure will average approximately 65 dBA.

Capstone recommends that hearing protection be worn when working on or in the immediate vicinity of operating MicroTurbines for extended time periods.

Other acoustic emissions regulations may apply to your specific installation location. Always check to be certain that your installation complies with all codes required by the local jurisdiction.

Certifications, Permits, and Codes

Your Capstone MicroTurbine is designed and manufactured in accordance with a variety of national and international standards.

The Capstone MicroTurbine operates on approved gaseous fuels; thus installation frequently requires one or more permits from local regulatory agencies.

It is not practical to list in the User's Manual the requirements of each authority having jurisdiction and how the Capstone MicroTurbine meets those requirements. For certification data, such as weights, dimensions, required clearances, noise levels, and the Capstone MicroTurbine Compliance List, please contact your Capstone Authorized Service Provider.

Document Overview

This document provides the data necessary for the user to operate and maintain the Capstone MicroTurbine. Basic troubleshooting is included in this manual, but only Capstone Authorized Service Providers are permitted to perform detailed troubleshooting and repair of the equipment.

For detailed technical data, or for service to the MicroTurbine, contact your Capstone Authorized Service Provider.

MicroTurbine Introduction

The Capstone MicroTurbine is an adaptable, low-emission, and low maintenance power generation system. A turbine-driven high-speed generator is coupled with digital power electronics to produce high quality electrical power.

The Capstone MicroTurbine is a versatile power generation system suitable for a wide range of applications. Capstone's proprietary design allows users to optimize energy costs while operating in parallel with an electric utility grid. The MicroTurbine can provide prime power generation where the electric utility grid is not readily available or where service is unreliable.

The Alternating Current (AC) electrical power output from the MicroTurbine can be paralleled with an electric utility grid or with another generation source. The MicroTurbine can act as a Stand Alone generator for standby, backup, or remote off-grid power. Multiple systems can be combined and controlled as a single larger power source, called a MultiPac.

The MicroTurbine can efficiently use a wide range of approved hydrocarbon-based gaseous fuels.

The MicroTurbine produces dry, oxygen-rich exhaust with ultra-low emissions. Utilizing both the generated electric power and the exhaust heat can provide even greater energy cost savings.

Key Mechanical Components

The key mechanical components that make up the Capstone MicroTurbine are shown in Figure 1.

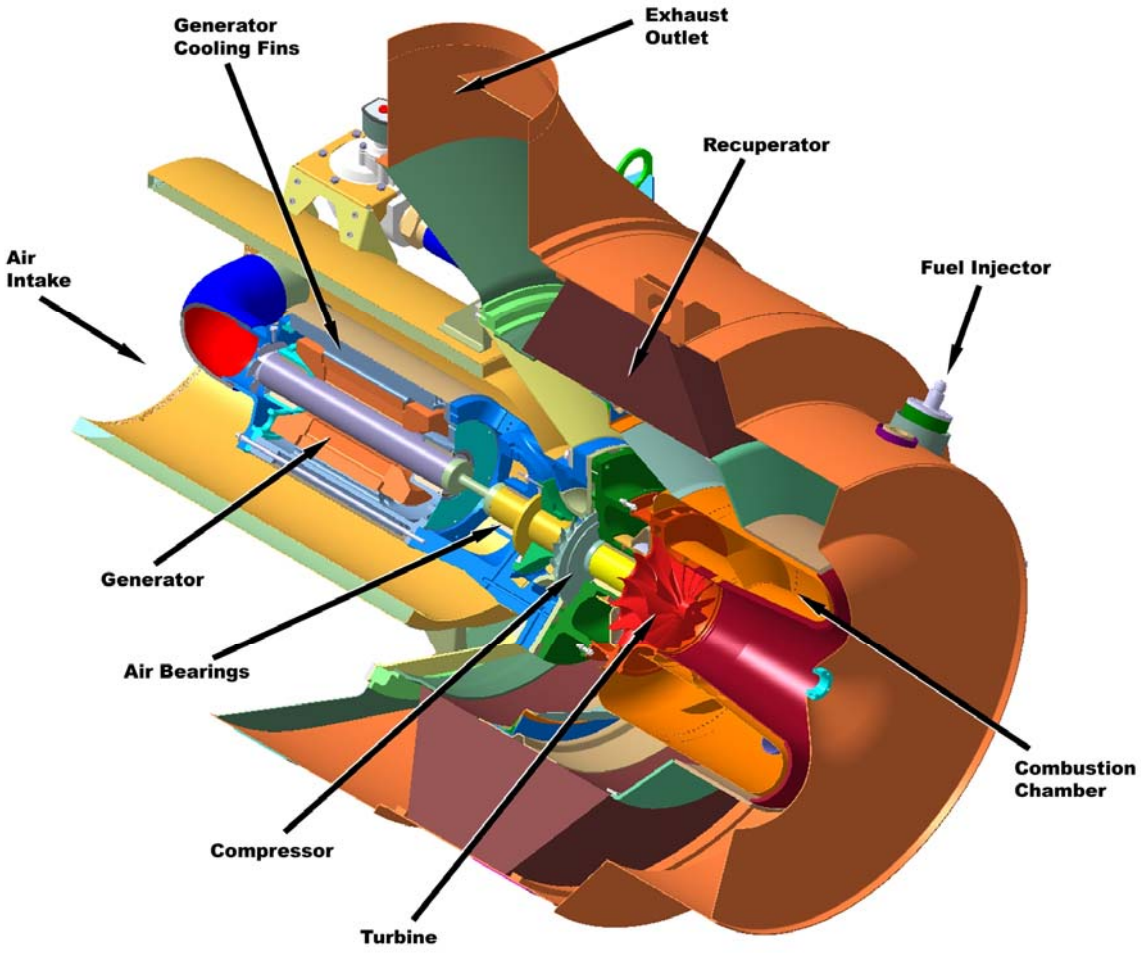


Figure 1. Typical Capstone C200 MicroTurbine Engine

Main Features

The various features of the Capstone MicroTurbine are listed below:

- A state-of-the-art digital power controller with built-in protective relay functions provides two output choices:
  - Built-in synchronous AC
  - Stand Alone AC output (optional)
- Patented air bearings eliminate the need for oil or other liquid lubricants.
- Air-cooled design of the entire system (turbine and controller) eliminates the need for liquid coolants.
- The engine has only one moving part: no gears, belts, or turbine-driven accessories.
- Advanced combustion control eliminates the need for ceramics or for other costly materials or for catalytic combustion, and provides ultra-low emissions.

- The integral annular recuperator (heat exchanger) doubles thermal efficiency.
- Digital control technology facilitates advanced control or Ethernet monitoring, and diagnostic capabilities, both on-board and remotely.

MicroTurbine Engine

The MicroTurbine engine is a combustion turbine that includes a compressor, combustor, turbine, generator, and a recuperator. The rotating components are mounted on a single shaft supported by patented air bearings and spin at a nominal speed of 60,000 RPM. The permanent magnet generator is cooled by the airflow into the MicroTurbine. The output of the generator is variable voltage, variable frequency AC. The generator is used as a motor during start-up and cooldown cycles.

Controller

The digital power electronics control the MicroTurbine system operation and all subsystem operations. The digital power electronics change the variable frequency AC power from the generator to DC voltage, and then to constant frequency AC current.

During start up, the digital power electronics operate as a variable frequency drive, and motor the generator until the MicroTurbine has reached ignition and power is available from the MicroTurbine. The digital power electronics again operate as a drive during cooldown to remove heat stored in the recuperator and within the MicroTurbine engine in order to protect the system components.

Air Bearings

The MicroTurbine utilizes gas foil bearings (air bearings) for high reliability, low maintenance, and safe operation. This allows fewer parts and the absence of any liquid lubrication to support the rotating group. When the MicroTurbine is in operation, a gas film separates the shaft from the bearings and protects them from wear.

Fuel System

The MicroTurbine can efficiently use a wide range of approved hydrocarbon-based gaseous fuels, depending on the model. The MicroTurbine includes an integral fuel delivery and control system. The standard system is designed for pressurized hydrocarbon-based gaseous fuels. Other models are available for low-pressure gaseous fuels, gaseous fuels with lower heat content, gaseous fuels with corrosive components, and biogas (landfill and digester gas) fuels. Contact your Capstone Authorized Service Provider for data on approved fuels and performance specifications.

Emissions

The Capstone MicroTurbine is designed to produce very clean emissions. The exhaust is clean and oxygen rich (approximately 18% O_2) with very low levels of air pollutants. Like all fuel combustion technology, the MicroTurbine produces emissions (like nitrogen dioxide and carbon monoxide) from the fuel combustion process. The MicroTurbine has ultra low nitrogen dioxide (NO_2) and carbon monoxide (CO) emission levels.

Enclosure

The MicroTurbine standard enclosure is designed for indoor and outdoor use, and conforms to NEMA 3R requirements.

Capstone components for Original Equipment Manufacturer (OEM) use can be provided with or without a mounting frame.

Stand Alone Option

Stand Alone (or "Dual Mode") models are available for the MicroTurbine. These models include two large battery packs used for unassisted start and for transient electrical load management. The Stand Alone option includes a power converter and battery management system. The battery packs are lead-acid type and completely sealed.

When equipped with the Stand Alone option, the system can power connected loads at user-selected voltage and frequency setpoints. It can power remote facilities such as construction sites, oil fields, offshore platforms, and other locations where the electric utility grid is not available.

Distributed Generation

The MicroTurbine produces synchronous current when connected to an electric utility grid. It allows electric utilities to expand power generation capacity in small increments, to optimize current infrastructure, and reduce or delay the need to develop, fund, and build new transmission and distribution lines.

Heat Recovery Module

The C200 Heat Recovery Module (HRM) accessory operates with the C200 MicroTurbine to provide hot water heat recovery. The HRM is an exhaust economizer with integral temperature setpoint controller and exhaust diverter. The controller provides digital readout of water temperature leaving the heat exchanger, and allows the user to set the desired outlet temperature. An electrically operated exhaust gas diverter valve is actuated by the controller to maintain outlet temperature to the selected setpoint. Power for the controller and actuator can be supplied by the auxiliary electrical output of the C200.

Operational Features

Operational features of the MicroTurbine are presented in the following paragraphs.

Peak Shaving

The MicroTurbine can augment utility supply during peak load periods, thus increasing power reliability and reducing or eliminating peak demand charges.

Combined Peak Shaving and Standby

The MicroTurbine can be used for both Grid Connect power and Stand Alone power for protected loads. With the Dual Mode System Controller (DMSC) accessory, the MT can be programmed to switch automatically upon loss/restoration of electric utility grid power. The MicroTurbine, with its low emissions, low maintenance requirements, and high reliability is well suited for combination peak-shaving and standby power applications.

MultiPac Power

C200 MicroTurbines can be installed in groups of up to 20 units using a standard Capstone MultiPac communications cable. This MultiPac capability enables connected MicroTurbines to operate as a single power generation source. A MultiPac configuration features a single control point and synchronous voltage and frequency output for all units. Individual MicroTurbines share power, current, and load on both a dynamic and steady state basis. An optional Capstone Advanced Power Server (APS) can be used to manage the power distribution for up to 30 MicroTurbines.

Resource Recovery

Capstone MicroTurbine models are available that use methane-based oilfield flare casing gas or low-energy landfill/digester gas as fuel sources. C200 models are available that can accept Sour Gas with up to 5000 ppmV Hydrogen Sulfide (H_2S) content. This application helps reduce pollution and provides economical power for on-site use as a by-product.

Thermal Heat Recovery

The oxygen-rich exhaust from the MicroTurbine can also be used for direct heat or as an air pre-heater for downstream burners. The optional C200 HRM allows commercial businesses to offset or replace local thermal loads such as domestic hot water, space heating, pool heating, and industrial hot water. In addition, the oxygen-rich exhaust together with ultra-low emissions makes the direct exhaust applicable for some food processing and greenhouse uses, such as heating, cooling (by absorption), dehumidifying, baking, or drying.

OEM Applications

The MicroTurbine core technology can be integrated into a wide variety of products and systems. Uninterruptible power supplies, all-in-one combined heat and power systems, and welding machines are just a few examples of original equipment manufacturer applications.

Output Measurements

The measurements presented in this document are in metric units (with U.S. standard units in parentheses). Refer to the sections below for more data.

ISO Conditions

Combustion turbine powered devices (including the Capstone MicroTurbine) are typically rated at 15 °C (59 °F) at sea level, or 1 atmosphere (1 atm) which is 760 mm Hg (14.696 psia) and identified as International Standardization Organization (ISO) conditions. For a complete definition of ISO testing conditions, refer to ISO 3977-2.

Pressure

Pressure figures assume gauge pressure, or 1 standard atmosphere (1 atm) 760 mm Hg (14.696 psia) less than absolute pressure, unless otherwise indicated.

Volume

Fuel gas and exhaust gas volumetric measurements are given in normalized cubic meters (m^3), defined at 0 °C (32 °F), and standard cubic feet (scf), defined at 15.6 °C (60 °F). Both volumes are defined at 1 atm (760 mm Hg, 14.696 psia).

Heating Values

Heat contents and heat rates will be found in either Lower Heating Value (LHV) (dry) or Higher Heating Value (HHV), depending upon the application. Capstone calculates heating values at 1 atmosphere (atm) and 15.6 °C (60 °F), according to ASTM D3588.

MicroTurbine Performance

The MicroTurbine electrical output capability is reduced when operating in higher ambient temperatures or elevations, and by intake or exhaust restrictions. Contact your Capstone Authorized Service Provider for data on performance specifications.

Grid Connect Output

The MicroTurbine electrical output in Grid Connect mode is 3-phase, 400 to 480 VAC and 45 to 65 Hz (both voltage and frequency are determined by the electric utility grid). Allowable connection types include:

- 4-wire Wye
- 3-wire Wye with neutral grounding resistor

Stand Alone Output

When equipped with the Stand Alone option, the electrical output is user adjustable from 150 to 480 Volts AC and from 10 to 60 Hz.

The output power need not be balanced. Loads can be connected 3 phases or single phase and phase-to-phase or phase-to-neutral, so long as the current limits of each phase are respected. A Ramp Start feature can assist in starting single/individual loads with large in-rush currents.

Power Quality

The MicroTurbine output conforms to IEEE 519-1992, IEEE Recommended Practices, and Requirements for Harmonic Control in Electrical Power Systems.

Heat Output

The recuperated MicroTurbine can produce up to 1,420,000 kJ (1,350,000 Btu) per hour of clean, usable exhaust heat in the range of 232 to 310 °C (450 to 590 °F).

The MicroTurbine exhaust stream is 305 mm (12 in) in diameter, flowing up to 28 m^3 (2600 scf) per minute.

Contact your Capstone Authorized Service Provider for data on heat output performance for specific system variations and/or ambient conditions.

Operating the MicroTurbine

Typical operation of the MicroTurbine is presented in the following paragraphs.

Basic MicroTurbine (MT) Operation

This section details basic system operation and explains how to use the MicroTurbine.

Routine Operation

Most MT applications require no regular interaction with an operator during normal operation. Built-in dispatch features include peak shaving with local or remote control, external switch control, programmable scheduling, automatic restart, and automatic loading.

Communications

There are two ways for the user to communicate with the MicroTurbine, either (1) via manual operation of the Display Panel, or (2) via digital communications through the User Interface Port (UIP) or Maintenance Interface Port (MIP). Details of Display Panel operation are described in a later section.

A PC may be connected to the User Interface Port directly (with an RS-232 null modem cable or using a serial – to – Ethernet converter) or via a phone line and optional modem. Communication is then possible by use of the optional Capstone Remote Monitoring Software (CRMS) on the PC, or other program that uses Capstone's open communication protocol. The Capstone Service Network (CSN) is another optional remote communication system using an internet connection through a secure Virtual Private Network (VPN), which can also be used to monitor the MicroTurbine in real time. With a ModBus Translator connected to the UIP, a customer can also use a RS-485 ModBus network to communicate with the MicroTurbine.

The set-up, control, and basic performance of the MicroTurbine can be monitored and adjusted through the UIP and MIP.

Primary user communications include:

- Start and stop functions
- Adjustment of power output
- Storage and display of operation history
- The configuration of operational parameters
- Battery management functions

Routine Operation Data

The Display Panel (or a computer connected directly or via modem) can be used to monitor many operational parameters during system operation. Only some of the routine operation and performance data items available for monitoring are listed below:

- Power Output (in kilowatts, or kW)
- Turbine Speed (in revolutions per minute, or RPM)
- Turbine Exit Temperature (in °C or °F)
- Phase Voltages (in Volts) and Currents (in Amperes)

Control Device Authority and Priority

A PC connected to the User or Maintenance Interface Ports can function as a control device for the MT. A PC can view system data at any time, but only one device can control the MT operation (that is, providing start/stop command or changes to power demand).

The Display Panel has default control authority to issue operational commands to the MT. The user can start and stop the MT without logging on to the system (that is, no password is required). All other system adjustments require the user to log on to the system with the user password.

The User Interface Port will take control when a password is entered either from the Capstone Remote Monitoring Software or other software using the Capstone open communication protocol.

All system commands via the User Interface Port, such as start, stop, and adjustment of Power Demands, require entry of a user password. When the User Interface Port has control, the Display Panel does not have control and can only be used to view information. The system automatically cancels a log on after five minutes of inactivity.

Start-up

A Start command can be issued from the Display Panel or remotely through a CRMS software/PC interface. When the command has been issued, the generator operates as a motor to bring the MT up to ignition speed, at which point fuel is introduced into the combustion chamber and ignited. When the Turbine Exit Temperature (TET) sensors detect an increase in temperature, the system is declared lit, and the MT accelerates. Once the MT enters the load state, it accelerates to full load. The start-up process from a cold start to full load requires approximately six minutes. The startup process can take longer for a Stand Alone MT, which can take as long as 20 minutes to recharge the battery packs to the level needed for full load operation.

Shutdown

When the MT is issued a Stop command, power output is reduced, followed by a period that the MT is motored at nominal speed to remove heat stored in the recuperator and MT engine in order to protect the system components.

The overall cooldown period is up to ten minutes, but is affected by MicroTurbine model and temperature at shutdown. A restart may be attempted at any time, and a start will

occur after completion of the initial cooldown period. Auto Restart is not available for MicroTurbines with pressurized enclosures, such as those used in hazardous locations.

If the Stand Alone batteries require a recharge (after a stop command is issued), the MicroTurbine will continue to operate with fuel in order to recharge the batteries. The MT will enter the cool down period after the batteries have reached a 90 to 95% state of charge. The batteries can require as long as 20 minutes to recharge after a stop command has been issued before entering cooldown. This will be followed by a cooldown period of up to 10 minutes.

Emergency Stop (E-Stop)

The User Connection Board contains input pins to which the user can connect an Emergency Stop (E-Stop) device. The E-Stop function enables the safe and immediate shut down of the MicroTurbine in the event of an emergency. Activation of the E-Stop immediately shuts off fuel and electrical output. This will cause the compressor bypass valve to open, vent the compressed air out of the MT, and the turbine will coast to a stop.

After an emergency stop, the power to the MT must be turned off for 30 seconds before a restart can be attempted. Emergency stops should **NEVER** be used for routine shutdowns. Emergency stops increase stress on the system components and will result in reduced service life of the MicroTurbine.

CAUTION	Repeated use of the optional Emergency Stop function will result in damage to the MicroTurbine. Use only in emergency situations.

Also, after an emergency stop, you may want to close the external fuel isolation valve to shut off any additional fuel flow into the MT. The external fuel isolation valve must be returned to the open position before a restart of the MT is attempted.

Restart

The MicroTurbine system can normally be restarted after a shutdown, while the batteries recharge, or during the cool down period before the speed of the MT reaches zero. This allows for faster power output and helps to eliminate wear on the bearings.

Using the Display Panel

Use of the Display Panel (Figure 2) is described in the following paragraphs.

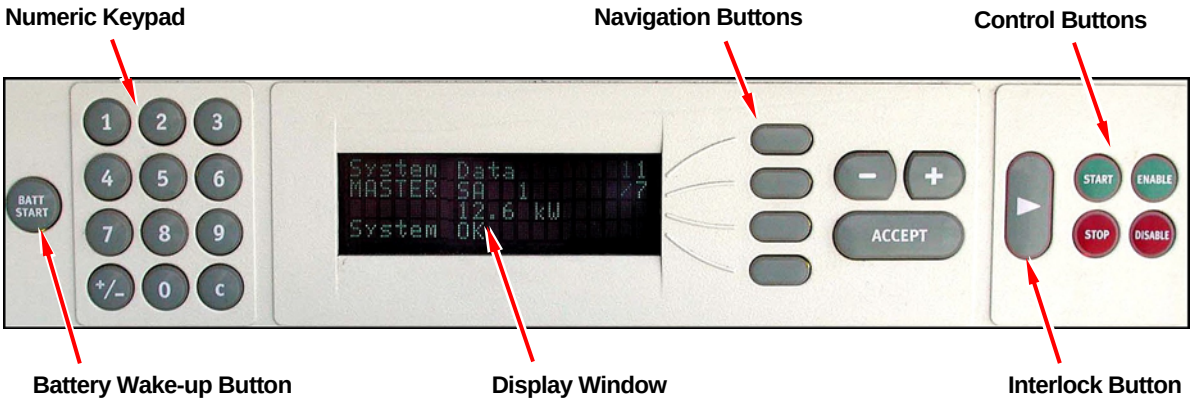


Figure 2. Display Panel and Functions

The Display Panel is located on the front of the package above the engine air inlet, and is used to control MT operation and access data stored within the system. The Display Panel includes a keypad, a display window, navigation buttons, and system control buttons. The paragraphs below describe Display Panel operation.

For applications with the pressurized enclosure, the Display Panel screen information is visible through a see-thru plastic window. However, access to the panel navigation buttons and numeric keypad should **only** be attempted during maintenance operations, and **only** if the area has been tested to be free of flammable gases.

Display Panel Areas

The **BATT START** button, at the far left of the Display Panel, is used to wake a Stand Alone system from sleep mode (see Waking a Stand Alone MicroTurbine on page 43).

The **Numeric Keypad**, located to the left of the Display Window, is for data input. The system accepts data input only on specific screens, and the input line must be selected, indicated by the flashing line. Data input from the Numeric Keypad requires logging-on with a password (see Logging On with a Password on page 23).

The **Display Window** is in the center of the Display Panel. The Display Window can display four lines of twenty characters, each of which indicate menu hierarchy position, data display, and data input.

The **Navigation Buttons** are located to the right of the Display Window, and consist of four buttons arranged vertically, each with a line to its left indicating a line of data in the Display Window. These four buttons, plus the buttons just to their right labeled (**-**), (**+**), and ACCEPT, are the navigation buttons; they are used for selecting various display screens or data items.

Menu Navigation

Movement around the top-level menu screens can be accomplished by use of the Navigation Buttons. The top line of the display always shows the name of the current top-level menu. Refer to Figure 3 for panel and display layout.

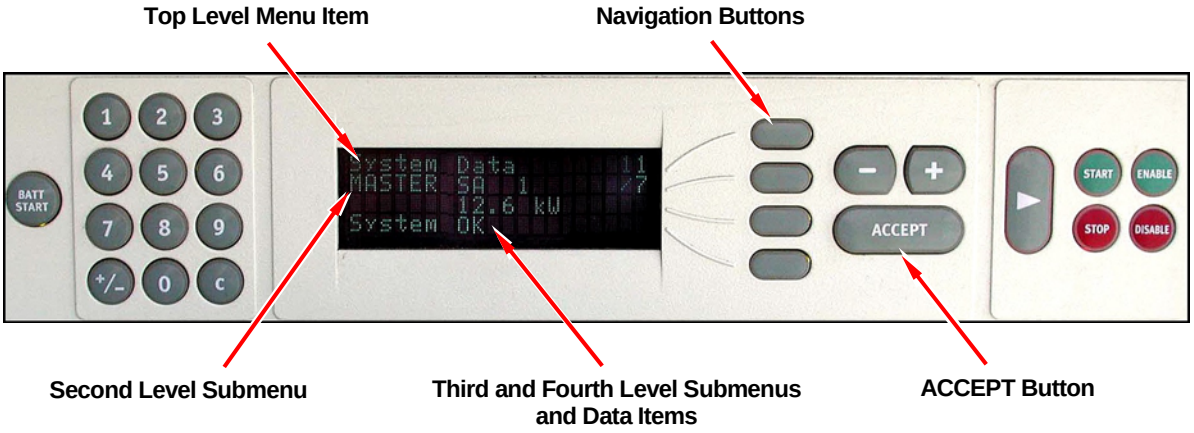


Figure 3. Display Panel and Navigation Functions

To move around the top-level menus, press the topmost of the four line Navigation Buttons. The menu position indicator numbers at the right end of the top line will flash. When the numbers are flashing, press the (**-**) or (**+**) buttons to move around the menus.

Each of the top-level menu screens has a number of submenus. The second line in the Display Window shows the current submenu. Movement around the submenus is similar to the top-level menus except you must press the second line Navigation Button to select line two of the display. When the numbers are flashing, press the (**-**) or (**+**) buttons to move around the submenus.

When you reach the desired menu, press the ACCEPT button to choose the menu, or wait 20 seconds for the system to automatically accept the menu selected.

The third and fourth levels display the selected performance data or allow input, like passwords or adjustment of power settings. The descriptions of each screen or submenu are grouped according to the top-level menu.

Display Panel Data Entry

Data input requires selection of the appropriate level with the Navigation Buttons, causing the display line to flash. Enter data using the Numeric Keypad, or scroll through available data entry options with the (**-**) or (**+**) buttons and press the ACCEPT button when finished. To make changes to any system set-up or operational mode requires the entry of a user password. Numeric entries can be cancelled by use of the (**-**) button.

Logging On with a Password

To enter commands from some of the Display Panel menus, the user must log on with a valid password (the description of the various menus on the following pages includes whether logging on with a password is required).

NOTE	The default user password (at the Display Panel) is set to **87712370**. In the event of a lost user password, your Capstone Authorized Service Provider can reset the user password to this default.

To log on with a password, follow these steps:

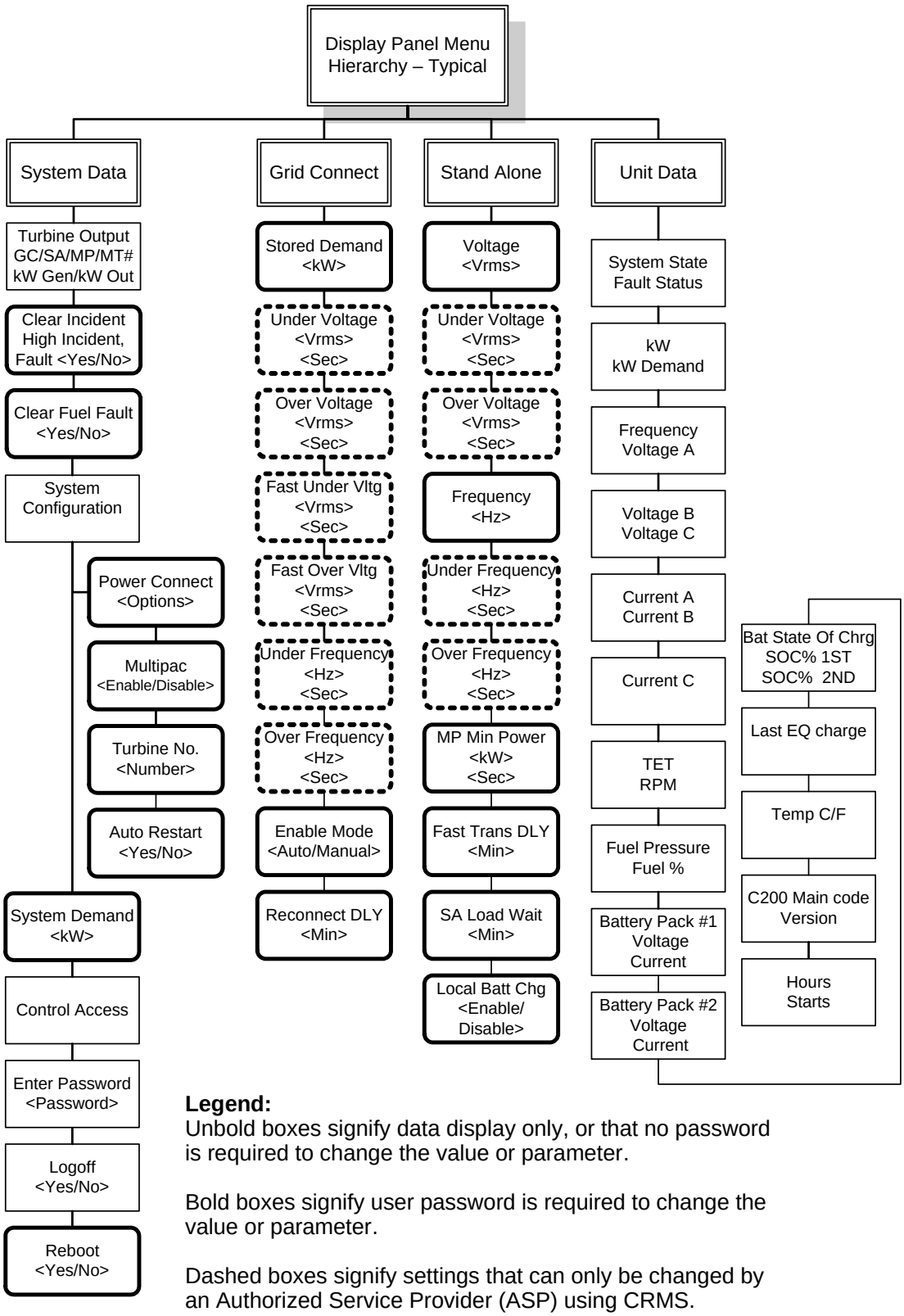
1. At the top-level System Data Menu, push the second level Navigation Button and the (**-**) or (**+**) buttons until you come to the Enter Password submenu.
2. Select the third level Navigation Button (the display indicates "************"). Enter the current password (see the above notes).
   - Note that the display of ************ becomes **--------** as you enter the password.
3. Press the ACCEPT Button. The display will indicate "PROTECTED LEVEL SET".
4. You are now logged into the system.

Not all data items can be modified at the user password level.

NOTE	It is not possible to change the user password at the display panel on the Model C200 MicroTurbine. It can only be done with an RS-232 command using the User Interface Port. Contact your Capstone Authorized Service Provider to change the user password.

Display Panel Menus - Overview

The Display Panel menu hierarchy shown in Figure 4 represents the typical structure of the system software menus and submenus for the Model C200 MicroTurbine with software version 1.XX. These menus and submenus are also detailed in text following the menu hierarchy chart.



Legend:
Unbold boxes signify data display only, or that no password is required to change the value or parameter.

Bold boxes signify user password is required to change the value or parameter.

Dashed boxes signify settings that can only be changed by an Authorized Service Provider (ASP) using CRMS.

Figure 4. Display Panel Menu Reflecting Function Hierarchy

System Data Menu

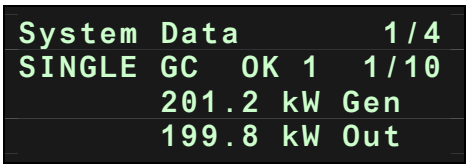
NOTE	The user is able to view the data on various screens of the System Data Menu without logging on. Some of the settings require logging on with a user password.

On power-up, the Display Panel defaults to the top-level System Data menu. The System Data menu displays the total output for a system of 1 to 20 MicroTurbines (up to 30 MicroTurbines with the optional Advanced Power Server) along with other system states.

System Data submenus are detailed below with a sample of the actual display for each submenu. The same applies for the other top level menus, as applicable.

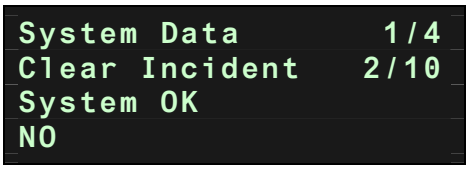
NOTE	In the following submenus, the first line always displays System Data menu.

Turbine Output Submenu



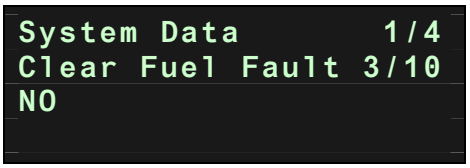
The second line shows configuration information including whether it is currently configured for GC (Grid Connect) or SA (Stand Alone), whether it is a Single unit, a MultiPac (MP) unit, or the Master of a MultiPac system, and the MicroTurbine number. This submenu also gives individual generator output as <kW Gen> on the third line and the individual inverter output of the system in kilowatts (kW Out) on the fourth line. If the MT is the master MT in a MultiPac, then the total aggregate MP system output is indicated.

Clear Incident Submenu



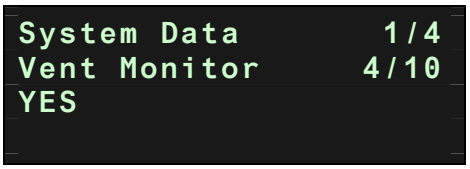
The Clear Incident submenu attempts to clear the highest-level fault and to return the system to standby. The <High Incident, Fault> line displays the system highest fault type and the associated identification number of the fault currently reported by the system. If the fault can be cleared, the fault # line will be updated with the next highest active fault, or System OK if all faults were cleared. If the same fault remains, the fault cannot be cleared. Note that the user must be logged in with the current password to clear the faults.

Clear Fuel Fault Submenu



The Clear Fuel Fault clears a fault originated by the fuel vent system which causes a MT shutdown. The user must electrically energize the MT, then activate the 'Clear Fuel Fault' which clears the fault. Then the user must do a Reboot. The cause of this fault may be a leak in the system, so troubleshooting and leak detection must be done immediately. Note that the user must be logged in with the current password to clear the faults.

Vent Monitor Submenu



C200 MicroTurbines include a fuel vent monitor that will activate an automatic shutdown if the seal on the fuel metering valve fails with gaseous fuel in the system. The default setting for the fuel vent monitor option is YES, and this setting should never need to be changed. However, the vent monitor option can be set to NO by a Capstone Authorized Service Provider for MicroTurbine repair or testing.

System Configuration Submenu

The System Configuration submenu contains system settings and allows the user to adjust the third level data, as detailed below:

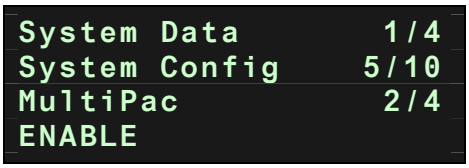
Power Connect Submenu

The Power Connect submenu allows the user to change the operating mode of the MicroTurbine. Note that the user must be logged in with the current password to change the operating mode.

- Invalid State (Initial Factory Setting)
- Stand Alone
- Grid Connect
- Dual Mode

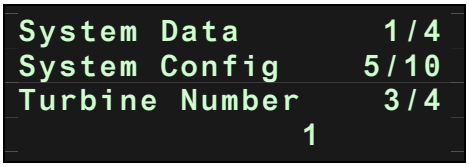
NOTE	The initial Factory Setting of "INVALID" is intended to ensure the true Power Connect option is set to match your specific application.

MultiPac Submenu



The MultiPac submenu allows the user to remove or add a MicroTurbine to a MultiPac. This allows maintenance of a MicroTurbine unit in a MultiPac without having to shut down all MicroTurbines in the system. Note that the user must be logged in with the current password to change this setting.

Turbine Number Submenu

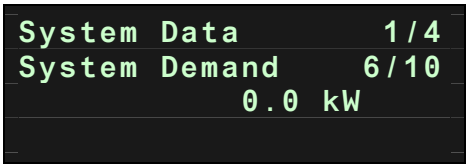


The main controller MicroTurbine in a MultiPac system is designated as the "Master", and must be assigned as number "1". Other MicroTurbines may be assigned in any order in a MultiPac system, however, each MT must have a unique turbine number. Note that the user must be logged in with the current password to change the turbine number.

Auto Restart Submenu

The Auto Restart submenu enables or disables the system's ability to automatically attempt to restart after an incident driven shutdown. The MicroTurbine, however, will not attempt a restart if the fault that caused the shutdown is a serious (high level) fault, even if Auto Restart is enabled by this submenu. The user must be logged in with the current password to change this setting.

System Demand Submenu

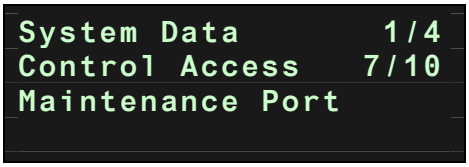


The System Demand submenu allows the user to set the system power demand in kW while in grid connect mode. This setting is active until the MicroTurbine is shut down. Each time the MicroTurbine starts up, any previous System Demand setting is no longer available and the kW value is set to zero. On startup, or any time System Demand is set to 0.0 kW, the MicroTurbine uses the Stored Demand setting (refer to page 29). Note that the user must be logged in with the current password to change system demand.

In a MultiPac, the System Demand setting of the MicroTurbine configured as the MultiPac master is used as the System Demand setting for the entire MultiPac. When it overrides the Stored Demand setting, the System Demand setting of the MultiPac master is used as the power output demand for the MultiPac. In this case, each MicroTurbine in the MultiPac is commanded to supply an equal fraction of the total power output as specified by the System Demand setting of the master MicroTurbine. For example, if the System Demand setting of the master MicroTurbine in a MultiPac of six MicroTurbines is 600 kW, the power demand for each MicroTurbine would be 100 kW, or 1/6th of the System Demand setting.

In a MultiPac, the System Demand setting for the MultiPac is changeable and viewable from the master MicroTurbine only. A MicroTurbine operating as a MultiPac-enabled slave will only display its fractional portion of the total power demand at the System Demand submenu. Also, any change made using the System Demand submenu of a MultiPac-enabled slave MicroTurbine during MultiPac operation will have no effect.

Control Access Submenu



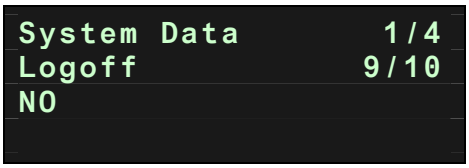
The Control Access submenu displays which communication device currently has control authority for changing settings of the MicroTurbine.

- Display Panel
- User Port
- Maintenance Port

Enter Password Submenu

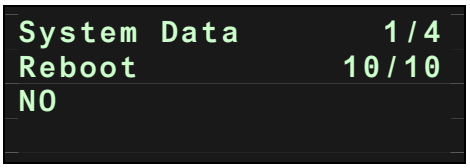
The Enter Password submenu allows the user to logon and access the MicroTurbine controls. The factory default User-level password is 87712370. Refer to the previous section on passwords for more details on entering and changing passwords.

Logoff Submenu



The Logoff submenu allows the user to log off and prevents further access to the MicroTurbine controls. Note that the system will automatically logoff if there is no user interaction with the Display Panel for more than four minutes.

Reboot Submenu



The Reboot submenu allows the user to reboot the system.

If Yes is selected, the system will reboot immediately. Note that the user must be logged in with the current password to reboot the system.

Grid Connect Menu

The top-level Grid Connect menu establishes operation parameters for the Grid Connect mode. This menu is applicable only when the MicroTurbine operates in Grid Connect mode. The Grid Connect Protective Relay settings are displayed here, and can only be changed using CRMS.

Refer to the C200 Technical Reference (410066) as required.

The Grid Connect submenus are detailed below:

NOTE	In the following submenus, the first line always displays the Grid Connect top level menu.

Stored Demand Submenu

The Stored Demand submenu allows entry of the power output demand level in kilowatts. A password is required to adjust this parameter from the Display Panel. Power output is adjustable from 0.0 to 2,000,000.0 kW to include the output capacity of a MultiPac configuration, as well as allow for future increases in the power generating capability of Capstone turbines.

This setting is permanently stored in memory, even after a shut down, and is available for use by the MicroTurbine after it starts up. The System Demand setting (refer to page 27), if greater than zero, will override the Stored Demand setting until the MicroTurbine is shut down.

In a MultiPac, the Stored Demand setting of the MicroTurbine configured as the MultiPac master is used as the Stored Demand setting for the entire MultiPac. If not overridden by the System Demand setting, the Stored Demand setting of the MultiPac master is used as the power output demand for the MultiPac. In this case, each MicroTurbine in the MultiPac is commanded to supply an equal fraction of the total power output as specified by the Stored Demand setting of the master MicroTurbine. For example, if the Stored Demand

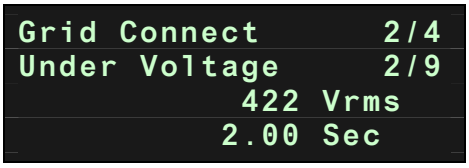
setting of the master MicroTurbine in a MultiPac of six MicroTurbines is 600 kW, the power demand for each MicroTurbine would be 100 kW, or 1/6th of the Stored Demand setting.

In a MultiPac, the Stored Demand setting for the MultiPac is changeable and viewable from the master MicroTurbine only. Each MicroTurbine has its own, permanently saved, Stored Demand setting, even when it is configured as a MultiPac-enabled slave. However, a MicroTurbine operating as a MultiPac-enabled slave will only display its fractional portion of the total power demand at the Stored Demand submenu. Also, an individual MicroTurbine's Stored Demand setting cannot be changed at its Stored Demand submenu if it is configured as a MultiPac-enabled slave.

NOTE	The primary Grid Connect Protective Relay function is to ensure that the MicroTurbine does not energize utility wires de-energized by the utility.

WARNING	All of the following Protective Relay settings can only be changed by a Capstone Authorized Service Provider (ASP) using CRMS. Do not attempt to change any Grid Connect Protective Relay functions yourself. Injury to personnel and/or damage to equipment can occur.

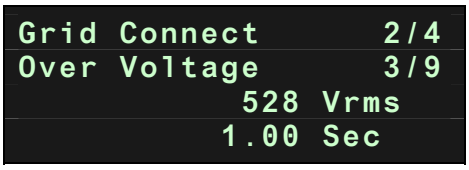
Under Voltage Submenu



The Under Voltage submenu shows the line-to-line voltage trip point and associated delay time. If the RMS voltage between any phases falls below this setting, the delay timer is started. If the voltage has not recovered at the end of this time, the system will shut down. This is adjustable from 352 up to the Over Voltage setpoint in 1 volt increments. Initial Factory Setting is 422 VAC line-to-line.

Under Voltage Delay establishes the time allowed for any phase voltage to fall below the Under Voltage limit. The delay is adjustable from 0.01 up to 10 seconds in 0.01 second increments. Initial Factory Setting is 2.0 seconds. This setting can only be changed by a Capstone ASP using CRMS.

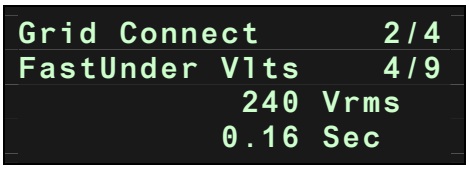
Over Voltage Submenu



The Over Voltage submenu shows the line-to-line voltage trip point and associated delay time. If the RMS voltage between any phases rises above this setting the delay timer is started. If the voltage has not subsided by the end of this time, the system will shut down. This is adjustable from 528 down to the Under Voltage setpoint in 1 volt increments. Initial Factory Setting is 528 Volts.

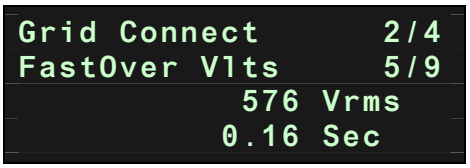
Over Voltage Delay establishes the time allowed for any phase voltage to rise above the Over Voltage limit. The delay is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 1.0 second. This setting can only be changed by a Capstone ASP using CRMS.

Fast Under Voltage Submenu



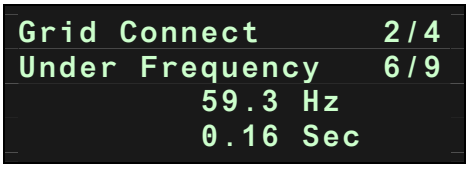
The Fast Under Voltage submenu shows the transient line-to-line voltage trip point and associated delay time. The system will cease power export to the grid within 1 msec if any phase RMS voltage drops below the Fast Under Voltage setting for the set time delay. If the grid voltage re-stabilizes within 1 second of the initial under voltage, then the system will resume power output; otherwise, the system will shut down. The Fast Under Voltage value at which this sequence will be triggered is adjustable from 0 VAC up to the Under Voltage setpoint. The delay time is adjustable from 0.03 to 1.00 second in 0.01 second increments. Initial Factory Settings are 240 V line-to-line and 0.16 second delay. This setting can only be changed by a Capstone ASP using CRMS.

Fast Over Voltage Submenu



The Fast Over Voltage submenu shows the transient line-to-line voltage trip point and associated delay time. The system will cease power export to the grid within 1 msec if any phase RMS voltage exceeds the Fast Over Voltage setting for the set time delay. If the grid voltage re-stabilizes within 1 second of the initial over voltage, then the system will resume power export; otherwise, the system will shut down. The Fast Over Voltage at which this sequence will be triggered is adjustable here from the Over Voltage up to 634 volts. The delay time is adjustable from 0.03 to 1.00 second in 0.01 second increments. Initial Factory Settings are 576 V line-to-line and 0.16 second delay. This setting can only be changed by a Capstone ASP using CRMS.

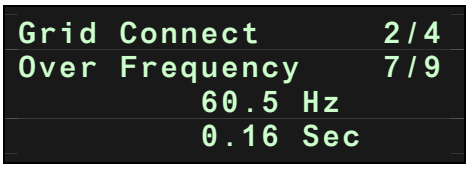
Under Frequency Submenu



The Under Frequency submenu shows the system under frequency trip point and associated delay time. If the grid frequency falls below this under frequency trip point for the set delay time, the system will shut down. The frequency is adjustable from 45 Hz up to the Over Frequency setting, in 0.1 Hz increments. Initial Factory Setting is 59.3 Hz.

The Under Frequency Delay is the number of seconds allowed for the Under Frequency condition before the system shuts down. This is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 0.16 second. This setting can only be changed by a Capstone ASP using CRMS.

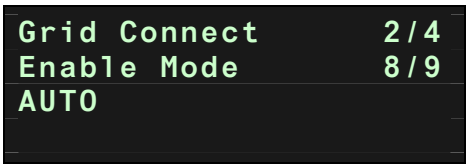
Over Frequency Submenu



The Over Frequency submenu shows the system over frequency trip point and associated delay time. If the grid frequency exceeds this over frequency trip point for the set delay time, the system will shut down. The frequency is adjustable from the Under Frequency setting to 65, in 0.1 Hz increments. Initial Factory Setting is 60.5 Hz.

The Over Frequency Delay is the number of seconds allowed for the Over Frequency condition before the system shuts down. This is adjustable from 0 to 10 in 0.01 second increments. Initial Factory Setting is 0.16 second. This setting can only be changed by a Capstone ASP using CRMS.

Enable Mode Submenu



The Enable Mode submenu applies only to Dual Mode configured systems. The display shows whether the system will transition back to Grid Connect Mode manually (manual) or automatically (auto) with this setting.

Reconnect Delay Submenu

The Reconnect Delay submenu applies only to Dual Mode configured systems. After a transition to Stand Alone, the turbine checks that the utility grid voltage is within the protective relay settings for this time limit before reconnecting to the grid. It is the minimum amount of time the system will operate in the Hot Standby state. In Hot Standby, the engine is on and ready to generate power in Stand Alone mode if the utility grid loses power during the delay period. The initial factory setting for Reconnect Delay is 5 minutes. The timer can be set from 5 to 30 minutes.

Stand Alone Menu

The top-level Stand Alone menu establishes voltage and frequency output and is applicable only when the MicroTurbine operates in Stand Alone mode. It also establishes the operational limits for voltage and frequency, and the rates at which voltage and frequency are increased to nominal on start up (RampStart). These limits are usually set when the MicroTurbine is commissioned and are not changed once set.

The Stand Alone submenus are detailed below:

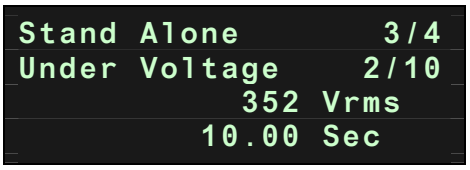
NOTE	In the following submenus, the first line always displays the Stand Alone top level menu.

Voltage Submenu

The Voltage submenu is used to set the nominal RMS output voltage (line-to-line) in Stand Alone Mode. Voltage is adjustable from 150 to 480 in one-volt increments. Initial Factory Setting is 480 VAC line-to-line. Note that the user must be logged in with the current password to change this voltage setting.

WARNING	All of the following Protective Relay settings can only be changed by a Capstone Authorized Service Provider (ASP) using CRMS. Do not attempt to change any Grid Connect Protective Relay functions yourself. Injury to personnel and/or damage to equipment can occur.

Under Voltage Submenu



The Under Voltage submenu shows the line-to-line voltage trip point and associated delay time. If the RMS voltage between any phases falls below this setting, the delay timer is started. If the voltage has not recovered at the end of this delay time, the system will shut down. Voltage is adjustable from 0 up to nominal. Initial Factory Setting is 352 volts.

The Under Voltage Delay establishes the time period allowed for any phase voltage to fall below the Under Voltage limit. The delay is adjustable from 0.01 up to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds. This setting can only be changed by a Capstone ASP using CRMS.

Over Voltage Submenu

The Over Voltage submenu shows the line-to-line voltage trip point and associated delay time.

If the RMS voltage between any phases rises above this setting the delay timer is started. If the voltage has not subsided by the end of this time span, the system will shut down. Voltage is adjustable from 528 down to nominal in 1 volt increments. Initial Factory Setting is 528 Volts.

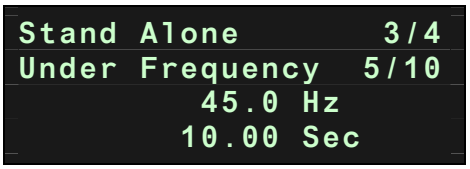
Over Voltage Delay establishes the time span allowed for any phase voltage to rise above the Over Voltage limit. The delay is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds. This setting can only be changed by a Capstone ASP using CRMS.

Frequency Submenu

The Frequency submenu establishes the nominal output frequency. This is adjustable from 45 to 65 in 1-Hz increments. Initial Factory Setting is 60 Hz.

Note that the user must be logged in with the current password to set this frequency.

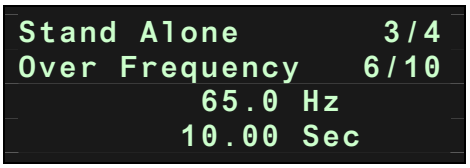
Under Frequency Submenu



The Under Frequency submenu shows the system under frequency trip point and associated delay time. If the output frequency falls below this under frequency trip point for the set delay time, the system will shut down. The frequency is adjustable from 45 to the nominal output frequency in 0.1 Hz increments. Initial Factory Setting is 45 Hz.

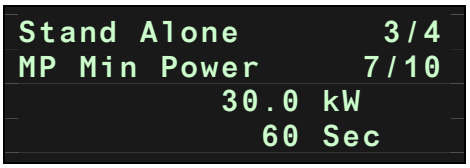
Under Frequency Delay is the time span allowed for output frequency to fall below Under Frequency (Hz) before the system will shut down. This is adjustable from 0.01 to 10 seconds in 0.01 second increments. Initial Factory Setting is 10 seconds. This setting can only be changed by a Capstone ASP using CRMS.

Over Frequency Submenu



The Over Frequency submenu shows the system over frequency trip point and associated delay time. If the output frequency rises above this over frequency trip point for the set delay time, the system will shut down. The frequency is adjustable from 65 Hz down to the nominal output frequency, in 0.1 Hz increments. Initial Factory Setting is 65 Hz. If the output frequency exceeds the Over Frequency setting for the time delay setting, the system will shut down. The time delay is adjustable from 0.01 to 10 seconds in 0.01 second intervals. Initial Factory Setting is 10 seconds. This setting can only be changed by a Capstone ASP using CRMS.

MultiPac Minimum Power Submenu

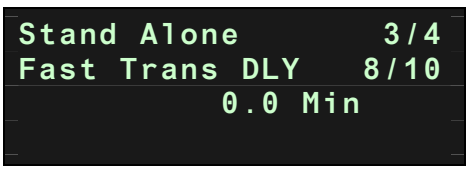


The MultiPac Minimum Power submenu sets the minimum power level that a Stand Alone MultiPac must be able to provide before it switches to load operation. The kW setting is the minimum value of total power available from the MultiPac MicroTurbines before the Master MicroTurbine commands the MicroTurbine(s) to go into Load State and begins outputting power. This setting ensures that the system has enough power generating capability before power is allowed to be exported to the load and should be set to the maximum expected load. Initial Factory Setting is 0 kW.

The timeout period setting establishes the maximum time the MultiPac has to achieve the minimum power setting before the system shuts down automatically. This timeout setting is adjustable from 60 to 3600 seconds in 1 second intervals. Initial Factory Setting is 60 seconds.

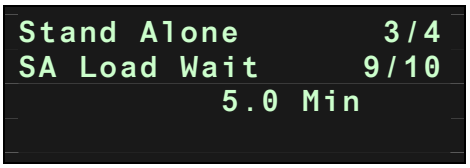
Refer to C200 Technical Reference (410066) as required. Note that the user must be logged in with the current password to change these settings.

Fast Transfer Delay Submenu



The Fast Transfer Delay submenu applies only to Dual Mode configured systems. This submenu displays the delay timer for the mode transition, in both directions, during fast transfer. The Initial Factory Setting is 0 minutes. The timer can be set from 0 to 30 minutes. The system will operate in Hot Standby while this timer runs before the transfer is completed.

Stand Alone Load Wait Submenu



The Stand Alone Load Wait submenu applies only to Dual Mode configured systems. This submenu displays the timer that maintains the system in Stand Alone Load State before the transition back to Grid Connect, after the grid has returned to normal. The timer begins when the utility voltage and frequency are detected to be within the required operating range, and maintains the turbine in the Stand Alone load state until the time has expired. The Initial Factory Setting is 5 minutes. The timer can be set from 5 to 30 minutes.

Local Battery Charge Submenu

The Local Battery Charge submenu controls whether the system begins a battery equalization charge. This can be done when the system is in Grid Connect mode, or in standby or Hot Standby state. Selecting ENABLE will begin the equalization charge, which can last up to 4 hours. Note that the user must be logged in with the current password to change this setting.

Unit Data Menu

The submenus in the Unit Data menu display real-time data for the MicroTurbine. Descriptive labels and data are contained in the second, third, and fourth lines of the submenu. As in all Display Panel submenus, the first line indicates the top-level menu, in this case the Unit Data menu. Real-time data can also be accessed using CRMS.

The Display Panel submenus related to Unit Data menu are listed below:

Line 2	Line 3	Line 4	Description
System State	Fault Status		System state and fault status.
kW	Demand		Actual kW output and commanded power level.
Frequency	Voltage A		Output frequency and phase A voltage.
Voltage B	Voltage C		Phase B and phase C voltages.
Current A	Current B		Phase A and phase B currents.
Current C			Phase C current.
TET	RPM		Turbine Exit Temperature and engine speed (RPM).
Fuel Pressure	Fuel %		Fuel pressure and fuel percentage.
Battery Pack #1*	Voltage	Current	Voltage and current of the first battery pack.
Battery Pack #2*	Voltage	Current	Voltage and current of the second battery pack.
Batt State of Chrg	SOC% 1ST*	SOC% 2ND*	State of Charge percentage for each battery pack.
Last EQ Charge			The last equalization charge time for the battery packs.
Temp C/F			Temperature in °C or °F.
C200 Main Code	Version		C200 main CPU software version.
Hours	Starts		Running time in hours and number of starts.

* Refer to Figure 6 for battery pack locations.

Below is an example display showing the kW Output and kW Demand (Dmd) submenu.

Using the User Interface Port

The User Interface Port is a DB9 RS-232 serial communications port located on the User Connection Board in the Communications Bay on the front of the MicroTurbine, and is available for remote MT operation.

WARNING	The User should NOT open the Power Connection Bay within the User Connection Bay (UCB). Potentially lethal voltages exist inside the Power Connection Bay.

Figure 5 shows the User Interface Port location.

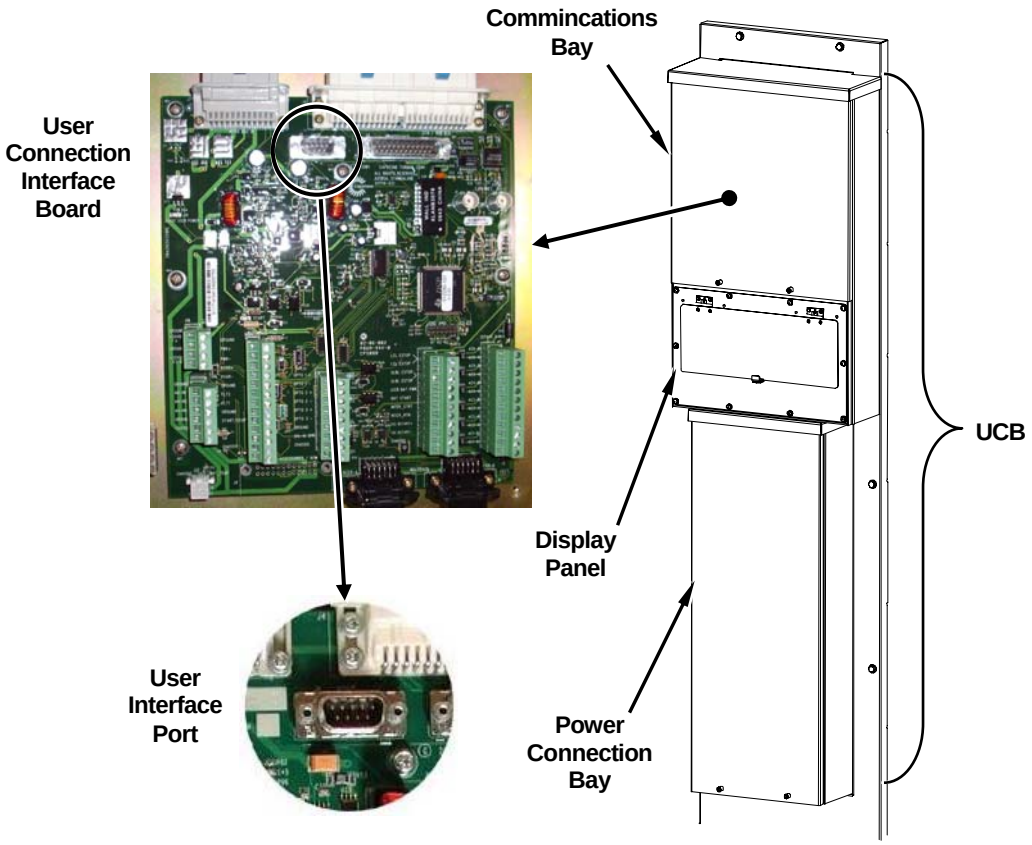


Figure 5. MicroTurbine User Interface Port Location

You can communicate with the MicroTurbine via the User Interface Port by using a Windows 98/2000/NT or later computer with an RS-232 null modem cable or Serial to Ethernet Converter and CRMS. Optionally, a modem may be connected to the User Interface Port for remote operation via a phone line at a baud rate of up to 56k bps.

NOTE	The communication software is not compatible with Windows Vista at this time.

NOTE	The default User Interface Port user password is set to **USR123P**; the user can change it by using the Capstone Remote Monitoring Software on a computer connected either directly to the User Interface Port or remotely via a modem. In the event of a lost user password, your Capstone Authorized Service Provider can reset the user password to this default.

Capstone Remote Monitoring Software

Capstone Remote Monitoring Software (CRMS) is the optional Capstone proprietary software that can operate and control the MicroTurbine from the RS-232 User Interface Port. This allows communication interface devices (a laptop plugged in with a null-modem cable or Serial to Ethernet Converter or a remote computer via a modem) to communicate via the RS-232 port.

CRMS is an easy to use, menu driven Windows-based software for a remote computer to monitor and control the Capstone MicroTurbine. The software can control from 1 to 100 MicroTurbine systems, by direct connection or remotely via a modem. Copies of and licenses for this software are available for purchase from Capstone.

MicroTurbine Operating Modes

This section explains the different operating modes of the Capstone MicroTurbine and how to issue the applicable commands for each mode.

Grid Connect Operation

The MicroTurbine in Grid Connect operation allows electric utilities to expand generating capacity in small increments. This optimizes current infrastructure and reduces the need to upgrade specific site capacity and lowers overall costs.

Grid Connect Dispatch

Operation of the Capstone MicroTurbine in parallel with an electric utility grid consists only of commanding the system on or off, and commanding an output power level. In most configurations these commands are mostly or entirely automated in various ways termed dispatch modes.

NOTE	If Grid Power is removed for any reason, the auto restart dispatch mode can automatically command the system ON when Grid Power is restored.

Configuring Grid Connect

To configure the MT for Grid Connect operation it is necessary to enable the Grid Connect Interlock and then command the system to Grid Connect mode either through the Display Panel or RS-232 commands using the User Interface Port.

Grid Connect Interlock

The Grid Connect Interlock consists of a pair of 5-volt dry circuit contact terminals located on the User Connection Board. A low resistance closed circuit between these terminals permits Grid Connect operation, opening the circuit disallows Grid Connect operation. The terminals are found in the Communications Bay at the front of the MicroTurbine enclosure. **Your Capstone Authorized Service Provider should make this electrical connection.**

Grid Connect Mode Enable

To enable the Grid Connect mode, the MicroTurbine must be correctly connected to a suitable live electric utility grid and the Grid Connect Interlock must be closed. **Your Capstone Authorized Service Provider should make this electrical connection.**

To enable the Grid Connect mode from the Display Panel, requires logging on with a password; then navigate to the System Data menu, then to the System Configuration submenu, and then to the Power Connect submenu. Select Grid Connect mode and then press the **ACCEPT** button. If the Grid Connect Interlock is open, the system will accept the command but post a GC Interlock fault, prohibiting a start.

Starting a Grid Connect System

The MicroTurbine system in Grid Connect mode must be commanded to start. Even if the system is configured for automatic operation, the initial **START** command is required to enable the automatic mode. If the Auto Restart feature is enabled, the **ON** command is stored by the system even through a loss of Grid Power.

To start the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **START** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Start or On to start the system.)

Stopping a Grid Connect System

The MicroTurbine system can be stopped at any time. In Grid Connect operation, an **OFF** command will override any dispatch mode settings, and is stored by the system.

The shutdown process includes a cool down period, which can last up to 10 minutes, depending on the operating temperature at shutdown. During the cool down cycle, the power output is reduced and fuel supply is off but the MicroTurbine continues to rotate to dissipate excess heat.

A restart can be attempted at any time during a cool down period.

To stop the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **STOP** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Stop or Off to stop the system.)

Grid Connect Power Demand

In Grid Connect operation, the MicroTurbine system must be commanded to a specific output power level. Each dispatch mode includes a power level setting. Some dispatch modes include automatic output power level changes.

Stand Alone Operation

Stand Alone operation provides power to remote facilities such as construction sites, oilrigs, or other locations where the electric utility grid is not available.

If the Capstone MicroTurbine is equipped with the Stand Alone option, operation consists of commanding the system on or off, and then enabling or disabling the power output. These commands can be automated.

Configuring Stand Alone

To configure the MicroTurbine for Stand Alone operation it is necessary to enable the Stand Alone Interlock and then command the system to Stand Alone mode either through the Display Panel or RS-232 commands via the User Interface Port.

Stand Alone Interlock

The Stand Alone Interlock consists of a pair of 5-volt dry circuit contact terminals. A low resistance closed circuit between these terminals permits Stand Alone operation. An opened circuit prevents Stand Alone operation. The terminals are found in the Communications Bay at the front of the MicroTurbine enclosure. **Your Capstone Authorized Service Provider should make this electrical connection.**

Stand Alone Mode Enable

To enable Stand Alone mode, the MicroTurbine must be powered on (set the Stand Alone Battery Isolation Switches to **ON**) and the Stand Alone Interlock closed. To enable Stand Alone mode from the Display Panel requires logging on with a password; then navigate to the System Data Menu, System Configuration submenu, and the Power Connect submenu. Select Stand Alone mode, then press the **ACCEPT** button. If the Stand Alone Interlock is open, the system will accept the command but post an SA Interlock fault. If no battery is detected, an internal No Battery fault will be reported.

Stand Alone Batteries

The Stand Alone MicroTurbine includes two large battery packs that store energy for MT startup when disconnected from the electric utility grid. They also provide an electrical buffer for sudden increases or decreases in load during Stand Alone operation. Management of the batteries and their state of charge is automatic within the MT. An awareness of these battery management functions will promote an understanding of why the system may appear to behave autonomously. For example, the MicroTurbine will always attempt to fully recharge the battery after a user commanded shut down and before the MicroTurbine enters the cool down state.

Stand Alone Battery Isolation Switch

Each battery in the Stand Alone MicroTurbine has a battery isolation switch to disable the MT for service or transport. The battery switches are found behind the access panel at the bottom front of the enclosure (Figure 6). Set the switch to **ON** for system operation. Be sure to switch the breaker to **OFF** when not operating the system to maximize battery life.

Figure 6. Battery Isolation Switch View, Lower Front of MT with Panel Removed

System Sleep in Stand Alone Mode

Reducing battery draw to near zero during prolonged periods of non-use can extend the MicroTurbine battery charge significantly. This is called Sleep Mode. Sleep Mode is automatic, but the time of inactivity can be adjusted using CRMS. If the battery isolation switches are set to **ON**, and the Display Panel is dark, the system is most likely in Sleep Mode. In Sleep Mode, the battery packs need to be recharged periodically. Refer to the section on Battery Maintenance for more data on recharging the Battery.

Waking a Stand Alone MicroTurbine

If the Stand Alone system is in Sleep Mode, pressing the **BATT START** button at the far left of the Display Panel (for 2 seconds or less) will wake it up. If communicating with the MicroTurbine remotely using a modem connected to the User Interface Port, the modem ring indicator will wake up a sleeping Stand Alone system.

CAUTION	Permanent closure of the battery start contacts (in the following paragraph) will completely discharge the UCB battery. Therefore, the battery start contacts may only be closed for a period of 0.1 to 2.0 seconds.

Alternately, momentarily closing the battery start contacts in the communication bay will wake up the system. This must be a momentary closure of 0.1 to 2.0 seconds only, as permanent closure of these contacts will completely discharge the battery. **Your Capstone Authorized Service Provider should make this electrical connection.**

Starting a Stand Alone System

The MicroTurbine system in Stand Alone operation must be commanded to start. Even if the system is configured for automatic operation, an initial start command is required to enable the automatic mode. If the Auto Restart feature is enabled, the **ON** command is stored by the system even through a loss of system power.

To start the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **START** button. (If your MT has been configured with a remote start/stop switch, simply set the switch to Start or On to start the system.)

Enabling Stand Alone Power Output

To enable power output, first start the MicroTurbine, and wait for the engine to warm up and for the base battery state of charge to reach at least 60%. A Not Ready to Load message is displayed. Press and hold the **INTERLOCK** button, and then press the **ENABLE** button.

NOTE	The Enable command can be issued at any time. The system will transition to power output when battery voltage and state of charge are ready.

When Auto Enable Power is set to ON, the MicroTurbine will automatically issue the Enable command when the system is ready to support the connected loads. Auto Enable Power is set using CRMS.

Stand Alone System Power Level

In Stand Alone mode, the MicroTurbine system will produce (up to its capacity) whatever current is necessary to maintain the commanded voltage and frequency. The output power is determined by the connected load(s).

Disabling Stand Alone Power Output

To disable power output, press and hold the **INTERLOCK** button, and then press the **DISABLE** button. All power output will immediately cease, but the system will continue operating with fuel.

Stopping a Stand Alone System

The MicroTurbine system can be stopped at any time.

To stop the system from the Display Panel, press and hold the **INTERLOCK** button, and then press the **STOP** button. (If your MicroTurbine has been configured with a remote start/stop switch, simply set the switch to Stop or Off to stop the system.)

A system **OFF** command first disables power output. The system then charges the battery, which can take up to 20 minutes. Finally, the turbine shutdown process includes a cool down period, which can last up to 10 minutes.

Dual Mode Operation

If the MicroTurbine is equipped with the Stand Alone option and the optional Dual Mode System Controller (DMSC) accessory is installed, a setting in the MicroTurbine system software enables the system to reconfigure itself to either Grid Connect or Stand Alone operation mode. This is called Dual Mode.

In the case of grid loss/recovery, MT operation in Dual Mode is identical to the operation in Grid Connect mode or Stand Alone mode, depending on the state of the utility grid. Operation of the Dual Mode feature consists of switching the MT (and protected loads) from Grid Connect operation to Stand Alone operation, or back.

Capstone DMSC

The Capstone DMSC is an optional accessory that enables the MicroTurbine to automatically transition from Grid Connect operation to Stand Alone operation when a utility power outage occurs. During a utility power outage, the MicroTurbine normally operates in Stand Alone mode to provide power to Protected Loads. The DMSC accessory provides the logic for an electrically operated circuit protection device to isolate the Protected Loads during Stand Alone operation. When utility power is restored, the DMSC automatically returns the MT and the Protected Loads to Grid Connect operation. The DMSC accessory also allows the MT to be used as an automatically dispatched standby generator for Protected Loads.

The DMSC can:

- Sense the loss of electric utility grid voltage, and then send a trip signal to a circuit protection device to disconnect the MT and its connected (protected) loads from the electric utility grid.
- Start the system to supply Stand Alone power.
- Sense the return of electric utility grid voltage, and then shut down the MT.
- Issue a close command to the circuit protection device to reconnect the MT and its protected loads to the electric utility grid.
- Start the system to supply electric utility grid parallel power.

The MicroTurbine can be configured to automatically start and load itself in either mode.

Configuring Dual Mode

The MicroTurbine system settings must be established for both Grid Connect parameters and Stand Alone parameters, since the system will be operating in both modes at different times. Contact your Capstone Authorized Service Provider for data on establishment of these parameters.

Setting the System for Dual Mode Operation

To set the system to Dual Mode, use either the Display Panel or the User Interface Port. If using the Display Panel, you must log on with a password. Navigate to the top-level System Data menu, then the System Configuration submenu, and then the Power Connect submenu, and then select **DUAL MODE** and press the **ACCEPT** button.

Switching Times for Dual Mode

C200 MicroTurbines with software version 1.XX and higher include the capability for Fast Transfer between Grid Connect and Stand Alone modes. During a transition from Grid Connect and Stand Alone, the protected load will experience less than 10 seconds of power loss. When transferring back from Stand Alone to utility grid power, the protected loads will experience even less duration of power loss, and the MicroTurbine(s) will remain in Hot Standby until the utility grid has remained stable for at least 5 minutes. (this delay time is adjustable from 5 to 30 minutes). The MicroTurbines(s) will then automatically transition back to Grid Connect operation.

MultiPac Operation

C200 systems may be configured into an array of up to 20 MicroTurbines (or 30 when used with the optional Capstone APS. Such an array will operate as a single power generation source. This MultiPac capability features a single control point (the master unit) and the combined synchronous output of the units in the MultiPac. Individual MTs share power, current, and load on both a dynamic and steady state basis.

MultiPac operation allows controlling the individual MTs through the master unit. Observation and control of each MT in a MultiPac can be accomplished by the connection of a communications interface device through the master unit or APS. Any MicroTurbine or the APS can be designated as the master unit. This unit then becomes the physical and logical control connection point for the entire MultiPac system.

Contact your Capstone Authorized Service Provider for additional information on establishment of a MultiPac system.

MultiPac Grid Connect Operation

In Grid Connect operation, each MicroTurbine independently synchronizes to the grid. MultiPac functionality provides a single interface point for Start, Stop, and Power Demand control. It is not necessary to connect a modem or signals from an external power meter to each individual MT in a MultiPac, only to the master unit.

MultiPac Stand Alone Operation

In Stand Alone operation, MultiPac functionality provides the capability to synchronize the voltage source outputs of the individual MTs such that they share power and current on both a dynamic and steady state basis. The master MicroTurbine unit broadcasts synchronization data to the other units over a dedicated Capstone-proprietary digital communications bus.

MultiPac Redundancy

In MultiPac operation, if an individual MicroTurbine fails (shuts down due to a fault), the remaining units will continue to operate. If the master unit fails and communication is not possible, the entire MultiPac system will shut down. If the master unit fails, another unit in the MultiPac system can be manually programmed to be the new master unit, however the MultiPac system must not be operating while this re-configuration is performed.

MultiPac Enable/Disable

Individual MicroTurbines must be disabled from a MultiPac system for service and maintenance. When service or maintenance is completed, the individual MTs must be added back into the MultiPac system (i.e., re-enabled). For data on the steps to Enable/Disable a MT unit in a MultiPac system, refer to the Display Panel Menus section on the top-level System Data Menu and the System Configuration submenu or contact your Capstone Authorized Service Provider.

Changing the Master Unit in a MultiPac

In a MultiPac system, one MicroTurbine is the master unit. To assign a different MT to be the master unit, perform the following steps. The steps are presented in functional groups of steps for clarity.

NOTE	The following steps are performed on the MicroTurbine that was the original master unit in the MultiPac. Alternatively, comparable steps can be performed using CRMS on a computer connected to the MicroTurbine User Interface Port.

- *Disable the old Master from the MultiPac*
  1. Log on with the User Password (see Logging On with a Password on page 23).
  2. Go to the **System Data** top-level menu.
  3. Navigate to the **System Configuration** second-level menu.
  4. Navigate to the **MultiPac <Enable/Disable>** third-level menu.
  5. Use the (**+**) or (**-**) buttons to select Disable; then press the ACCEPT button.

NOTE	The following steps are performed on the Display Panel of the MicroTurbine that will be the new master unit in the MultiPac.

- *Set the MicroTurbine that will be the new master unit to number 1*
  6. On the new master unit, log on with the User Password (see Logging On with a Password in the 'Logging on With a Password' section, or page 23).
  7. Go to the **System Data** top-level menu.
  8. Navigate to the **System Configuration** second-level menu.
  9. Navigate to the **Turbine Number <Number>** third-level menu.
  10. Press the "1" Numeric Keypad button to set the Turbine Number to 1; then press the ACCEPT button.
- *Enable MultiPac from the new master unit*
  11. Go to the **System Data** top-level menu.
  12. Navigate to the **System Configuration** second-level menu.
  13. Navigate to the **MultiPac <Enable/Disable>** third-level menu.
  14. Use the (**+**) or (**-**) buttons to select Enable, then press the ACCEPT button.

- *Reboot the new master unit*

15. Go to the **System Data** top-level menu.
16. Navigate to the **Reboot <No/Yes>** second-level menu. Use the (+) or (-) buttons to select Yes, then press the ACCEPT button.
17. If there had been a telephone line connected to the modem in the original master unit, move the telephone line connection to the modem in the new master unit.
18. If there are any other cables (e.g., from a power meter or a global E-Stop device) connected to the original master unit, also move these connections from the original to the new master unit.

WARNING	Some connections (e.g., gas booster power lines) require that the entire system be de-energized in order to be moved safely. To prevent injury to personnel or damage to equipment, completely remove power from the original and new master units, and from the connected equipment, before moving any cables.

At this point, the MicroTurbine that had been the original master unit is not part of the MultiPac. To include it in the MultiPac, continue with these steps on its Display Panel.

19. Go to the **System Data** top-level menu.
20. Navigate to the **System Configuration** second-level menu.
21. Navigate to the **Turbine Number <Number>** third-level menu.
22. Use the Numeric Keypad to set the Turbine Number to a unique value; then press the ACCEPT button.
23. Navigate to the **MultiPac <Enable/Disable>** third-level menu. Use the (**+**) or (**-**) buttons to select Enable, then press the ACCEPT button.

MicroTurbine Preventive Maintenance

This section details the preventive maintenance procedures that must be performed on the Capstone MicroTurbine.

WARNING	The MicroTurbine system generates and uses voltage levels that can injure or kill. Obey all safety precautions when you work with or around electrical equipment.

NOTE	Failure to provide proper maintenance will void the MicroTurbine warranty. Users do not perform the following MicroTurbine maintenance procedures, but it is important for users to be aware of them.

Only Capstone Authorized Service Providers can access the inside of the MicroTurbine enclosure (except for accessing the User Connection Board in the UCB/JUCB).

Only Capstone Authorized Service Providers can perform maintenance on the Micro-Turbine components.

Scheduled Maintenance

Preventive maintenance of the C200 MicroTurbine includes performing scheduled maintenance of its components at regular intervals. The list of maintenance schedules for C200 components is contained in the MicroTurbine Standard Maintenance Schedule Work Instructions (440000). This document is available from your Authorized Service Provider for reference. Only Authorized Service Providers are permitted to access MicroTurbine components and perform these maintenance tasks.

Preventive Maintenance

Preventive maintenance activities for the MicroTurbine Inlet Filter, External Fuel Filter, and for the Battery Packs are described in the following paragraphs.

MicroTurbine Inlet Air Filter

CAUTION	The MicroTurbine requires clean, dust free air for operation. Do not operate the MicroTurbine without the inlet air filter in place or damage to the equipment can occur.

The engine air inlet filter should be inspected periodically to ensure unrestricted flow of clean combustion and cooling air to the generator and turbine engine. The recommended interval for this inspection is every 4,000 hours of operation or annually, based on clean environment operation.

Outdoor operation, especially in areas subject to wind and airborne dirt or dust, will require a significant reduction in this interval. If the MicroTurbine is operated under unusual conditions, the filters should be checked more frequently to determine a site-specific service interval. Filters may require more frequent attention based upon environment, installation, and/or air quality.

If specifically permitted by the Capstone Authorized Service Provider, the end user can replace the inlet air filter element. The Capstone Authorized Service Provider will provide instruction and oversight.

External Fuel Filter

WARNING	MicroTurbine fuel is flammable and explosive. An explosion can cause death or injury to personnel and/or damage to equipment. No open flame or smoking is allowed near the MicroTurbine.

The optional external fuel filter element should be replaced periodically to ensure unrestricted flow of clean fuel to the MicroTurbine. This is necessary for MicroTurbine optimal performance. The recommended interval for this replacement is every 8,000 hours of operation. The service interval is based on typical clean fuel supplies found in the United States. Filters may require more frequent attention based upon environment, installation, and/or fuel quality.

If specifically permitted by the Capstone Authorized Service Provider, the end user can replace the external fuel filter element. The Capstone Authorized Service Provider will provide instruction and oversight.

Battery Maintenance During Storage

The battery packs are lead acid type and completely sealed. Each battery pack should be fully charged prior to storage and charged again prior to being put back into service. If the MicroTurbine is equipped with batteries, a Battery Isolation Switch is included on each battery (see Figure 6).

MicroTurbines equipped with the Stand Alone option require maintenance for the battery packs. Each battery pack is maintained through software during regular use, however battery packs stored for extended periods will become discharged and require service. Recharge intervals for battery packs in storage with the battery breaker **OPEN** are dependent upon the ambient storage temperatures.

The battery isolation switches should be set to OFF if the MicroTurbine is to be serviced or transported, or if the MicroTurbine will not be operated for a period of greater than two weeks. See Figure 6 for a view of the battery isolation switches.

The maximum recharge interval is specified in the following table:

CAUTION	The recharge intervals shown in the following table also apply to the Model C200 UCB batteries stored unplugged from the UCB Board.

Storage Temperature °C (°F)	Recharge Interval – Days
<20 °C (68 °F)	180
20 °C (68 °F) to 30 °C (86 °F)	90
30 °C (86 °F) to 40 °C (104 °F)	45
40 °C (104 °F) to 50 °C (122 °F)	20
50 °C (122 °F) to 60 °C (140 °F)	5

NOTE	The maximum recommended storage temperature for a battery pack is 40 °C (104 °F). Long-term storage above this temperature may impact battery pack life.
NOTE	Capstone does not recommend storage over six months without charging or one year with charging, as it may contribute to a shortened battery life in the field.

Sleep Mode

During the Sleep mode, the battery packs should be at a higher state of charge since it is called upon to start the MicroTurbine and produce transient power immediately after start-up. This reduces the recharge intervals for Sleep state. Recharge intervals for battery packs in Sleep mode are dependent upon the ambient temperatures as specified in the following table:

NOTE	The recharge intervals in the following table do not apply to the UCB battery.

Ambient Temperature °C (°F)	Recharge Interval – Days
<20 °C (68 °F)	35
20 °C (68 °F) to 30 °C (86 °F)	22
30 °C (86 °F) to 40 °C (104 °F)	15
40 °C (104 °F) to 50 °C (122 °F)	10
50 °C (122 °F) to 60 °C (140 °F)	7

NOTE	A Grid Connect Idle Recharge or the Capstone External Battery Charger option may be used to perform the recharge as required. The battery voltage must be greater than 180 VDC to perform a Grid Connect Idle Recharge.

When the recommended recharge interval is reached, the battery pack voltage should be recorded, and the battery packs must be recharged.

If the MicroTurbine is in operation, a Manual Recharge or a Shutdown Recharge will be sufficient to recharge the battery packs. Refer to the section on Stand Alone operation and the Display Local Battery Charge submenu for more data.

If the MicroTurbine cannot be operated, the optional Capstone External Battery Charger can be used to recharge the battery packs. Contact your Capstone Authorized Service Provider for details on the Capstone External Battery Charger.

Battery Charge Management

The MicroTurbine system is designed to keep the batteries approximately 80% charged during operation. This allows for sourcing and sinking of power transients in Stand Alone Mode. After an **OFF** command the system will recharge the batteries to 90% before shutting down. This recharge can take up to 20 minutes.

During normal use, battery cells become charged unequally. Periodically, the MicroTurbine will perform an equalization charge cycle to keep the batteries in top condition. Allowable times (in 4-hour minimum windows) must be programmed for when this can occur. Use the CRMS to set these allowable time windows, or contact your Capstone Authorized Service Provider for proper setup.

Manual Battery Pack Equalization Charge

If the system is not operating or is in storage, a manual equalization charge may be commanded if the system is connected to the electric utility grid (see Grid Connect Operation). Initiate a Battery Pack Equalization charge as follows:

Using Display Panel

System Data Menu > Enter Password. The factory default User level password is 87712370.

Navigate to Stand Alone > Local Batt Chg > Enable. Press Accept.

Using CRMS or APS – CRMS

Select Settings > Battery Management. Set Equalization Charge to Enable.

NOTE	A battery pack equalization charge can take up to 4 hours.

Warranty

Each MicroTurbine ships with a standard warranty. Extended warranties are available. Contact your Authorized Service Provider for details on Capstone warranty terms and conditions.

Troubleshooting

WARNING	The MicroTurbine system produces and contains high voltage. High voltage can injure or kill. Obey all safety procedures when you work around electrical equipment. **Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.**

This section details basic troubleshooting procedures and steps that the user can perform on the Capstone MicroTurbine without accessing the inside of the enclosure. Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure.

Incidents

The MicroTurbine continuously monitors a wide variety of parameters both internal and external to the system. An **incident** occurs whenever a measured parameter falls outside prescribed limits. Incidents include (but are not limited to) low fuel pressure, utility interruptions, and utility over voltages.

Incident System Severity Levels

When the system detects an incident, it may take one of several actions, depending on the system severity level (SSL). Actions range from simply noting the occurrence and continuing to operate, to immediate shutdown of the system. The action taken depends upon the severity of the incident. The system will attempt a restart only if the severity of the incident will allow it.

Depending on the parameter and the magnitude of the incident, the event is classified as either a warning or a fault.

A **warning incident** is a condition that is outside normal operating parameters, but which does not require a system shut down.

A **fault incident** is a condition under which the system shuts down to prevent possible damage to the MicroTurbine or unsafe operating conditions.

Incident Display Format

When an incident occurs, the Display Panel displays a fault description (e.g., **GC INTERLOCK**) and the fault code (e.g., **7002**). This incident message appears on line three of the System State Fault Status submenu of the Unit Data menu (refer to page 38) as shown in the following example.

The fault code is a number up to five digits in length that, along with the fault code description, helps the Capstone Authorized Service Provider determine the cause of the incident.

Incident Records

When an incident occurs the system records a snapshot of conditions at that time, called an Incident Record. Several incidents can occur in quick sequence, and the MicroTurbine will continue to operate or shut down depending on the severity of the incident(s).

The Incident Record can only be accessed by an Authorized Service Provider, using CRMS. The Incident Record contains the incident name, incident code number, date and time of the incident, and conditions of the turbine at the time of the incident. Some examples of the data contained in the incident record are as follows:

- Cumulative number of starts
- Output power
- Engine speed
- Turbine exit temperature
- Fuel device command
- Ambient temperature
- Voltage and current on each phase
- Frequency
- DC bus and power supply voltage
- Several internal system temperatures

Isolation Messages

The Incident Record also contains an Isolation Message that describes the type of incident and if it is a Warning or a Fault. The Isolation Messages are listed below and described in the following paragraphs.

- Internal Warning or Fault
- Fuel Warning or Fault
- Grid Warning or Fault
- Lo-Temp Warning or Fault
- Hi-Temp Warning or Fault
- Hi-Alt Warning
- E-Stop Fault
- User Connection Fault

Internal

An Internal incident is one that is within a major subsystem of the MicroTurbine and is not recoverable by the user. In the case of an Internal Fault, the user should reboot the system. If unsuccessful in restoring normal operation, a Capstone Authorized Service Provider will be required to initiate repair of the MicroTurbine.

Fuel

The user should initially check the fuel supply to the MicroTurbine. Verify that the shut off valve is open. Ensure the line has the correct fuel pressure. Check the optional external filter to ensure that it is not blocked. If the problem persists, call your Capstone Authorized Service Provider.

Grid

This incident is likely to be due to an electric utility grid disturbance. Check all breakers and fuses to ensure they are not tripped before troubleshooting. Reboot the system and attempt a start. If the problem persists, call your Capstone Authorized Service Provider.

Lo-Temp/Hi-Temp/Hi-Alt

Generally, these incidents are due to ambient conditions that are outside the design envelope of the MicroTurbine. Possible solutions would be to adjust the room temperature, ensure that adequate ventilation is provided, and verify that the air input and exhaust are not obstructed. Continued operation under these conditions may affect operation and cause damage to the MicroTurbine.

E-Stop

If the event display reads **MANUAL E-STOP**, fix the original problem that initiated the E-Stop, as this fault must be cleared before it is safe to resume operation. Next, check the optional emergency stop button and verify that it has been activated. If it has, reset the button, cycle power off to the MicroTurbine for 30 seconds, and turn the power back on. The Manual E-Stop fault should clear, and the system should resume operation. If it does not, call your Capstone Authorized Service Provider.

User Conn (User Connection)

User Connection incidents can be due to incorrect Grid Connect / Stand Alone settings, mode transition faults when in Dual Mode operation, or to indicate a possible problem with external equipment connected to the MicroTurbine.

Basic Troubleshooting Procedures

Basic Troubleshooting procedures are presented in the following paragraphs.

WARNING	Users do not perform some of the following MicroTurbine troubleshooting procedures, but it is important for users to be aware of them. Only Capstone Authorized Service Providers are permitted access to the inside of the enclosure. Users are permitted to open the User Connection Bay to access the User Interface Port.

No Lights on Display Panel

If no lights are present on the Display Panel, troubleshoot as follows:

WARNING	Only Capstone Authorized Service Providers can perform the following troubleshooting steps.

1. If Stand Alone equipped, open the front door. Make sure the Battery Isolation switches are set to **ON**. Then press the **BATT START** button on the Display Panel.
2. If Grid Connect, verify electric utility grid voltage is present on the phase terminals in the Power Bay.

No Attempt to Start after ON Command

If no attempt is made to Start, after an **ON** Command, troubleshoot as follows:

1. Verify that the current communication device (Display Panel or User Interface Port) is the control device. See Control Device Authority and Priority on page 19.
2. Verify that **ON** command is consistent with the currently active dispatch mode. Refer to the section on Display Panel Menus for more data.

Start Attempt Fails

If a Start Attempt fails, troubleshoot as follows:

1. If the system attempts but fails to start, an incident code will be registered as described in the previous sections.
2. The troubleshooting procedure is the same as for Unexpected Shut Down or Warning in the next section.

Low Power Output

If Low Power Output is perceived, troubleshoot as follows:

1. Check your inlet fuel supply. Verify that the fuel isolation valve is open, and that the inlet fuel line has the correct fuel pressure.
2. Check your external fuel filter. Verify that the external fuel filter (if installed) is not blocked.
3. Check your inlet airflow, ventilation, and exhaust airflow. Verify that the inlet airflow and the exhaust airflow are not obstructed.
4. Check your ambient operating conditions and verify the expected power output due to temperature, altitude and other derating factors. Verify that ambient conditions are not outside the MicroTurbine design envelope.

Unexpected Shut Down or Warning

When a warning incident occurs, no action is required by the user. When a fault incident occurs, the troubleshooting steps are as follows:

1. Attempt to restart. If unsuccessful, then verify the fuel, air, and electrical supply to the MicroTurbine.
2. Attempt to restart. If unsuccessful, then enter the user password and reboot the system through the Display Panel.
3. Attempt to restart. If unsuccessful, then cycle the power by shutting off power to the system, waiting 30 seconds, and turning the power back on.
4. Attempt to restart. If unsuccessful, then note the event number listed on the Display Window, and then call your Capstone Authorized Service Provider for assistance.

When required, your Capstone Authorized Service Provider will determine whether the event noted requires a service call or if the user can perform fault correction on site. Generally, the Service Provider will initiate a service call for Internal Fault codes. In most other cases, the Service Provider will recommend a possible course of action to return the MicroTurbine to operational status.

- **Notes –**

Product Support

Capstone Turbine Corporation is dedicated to the concept of quality to the owners and users of every MicroTurbine. Your MicroTurbine should operate without trouble. If you require maintenance support or other technical assistance, **please contact your Capstone Authorized Service Provider**.

Capstone Technical Support can assist you by providing contact data for your Capstone Authorized Service Provider.

Fill in this record with information about your Capstone Authorized Service Provider to allow easier access.

Capstone Authorized Service Provider Contact Information	
ASP Contact Name	
Address	
Telephone	
Facsimile	
E-mail	

The following information will help your Authorized Service Provider assist you.

System Information	
MicroTurbine Model No.	
System Serial No.	
Fuel Type	
Modem Phone No.	
Options Installed, and any configuration data	

CUSTOMER SATISFACTION

We would love to hear feedback about your experience with our products.
Please send e-mail to: **comments@capstoneturbine.com**

- Maintenance Log –

Event	Date	Hours	Starts
Commissioning			

Reference Documents

Refer to the following table for a list of Capstone reference documents, as required.

Document Part No	Description
410066	C200 Technical Reference
440000	Standard Maintenance Schedule Work Instructions

Capstone Contact Information

If you have additional questions, please contact:

Capstone Applications

Toll Free Telephone: (866) 4-CAPSTONE or (866) 422-7786

Fax: (818) 734-5385

E-mail: applications@capstoneturbine.com

Capstone Technical Support

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Capstone Technical Support (Japan)

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