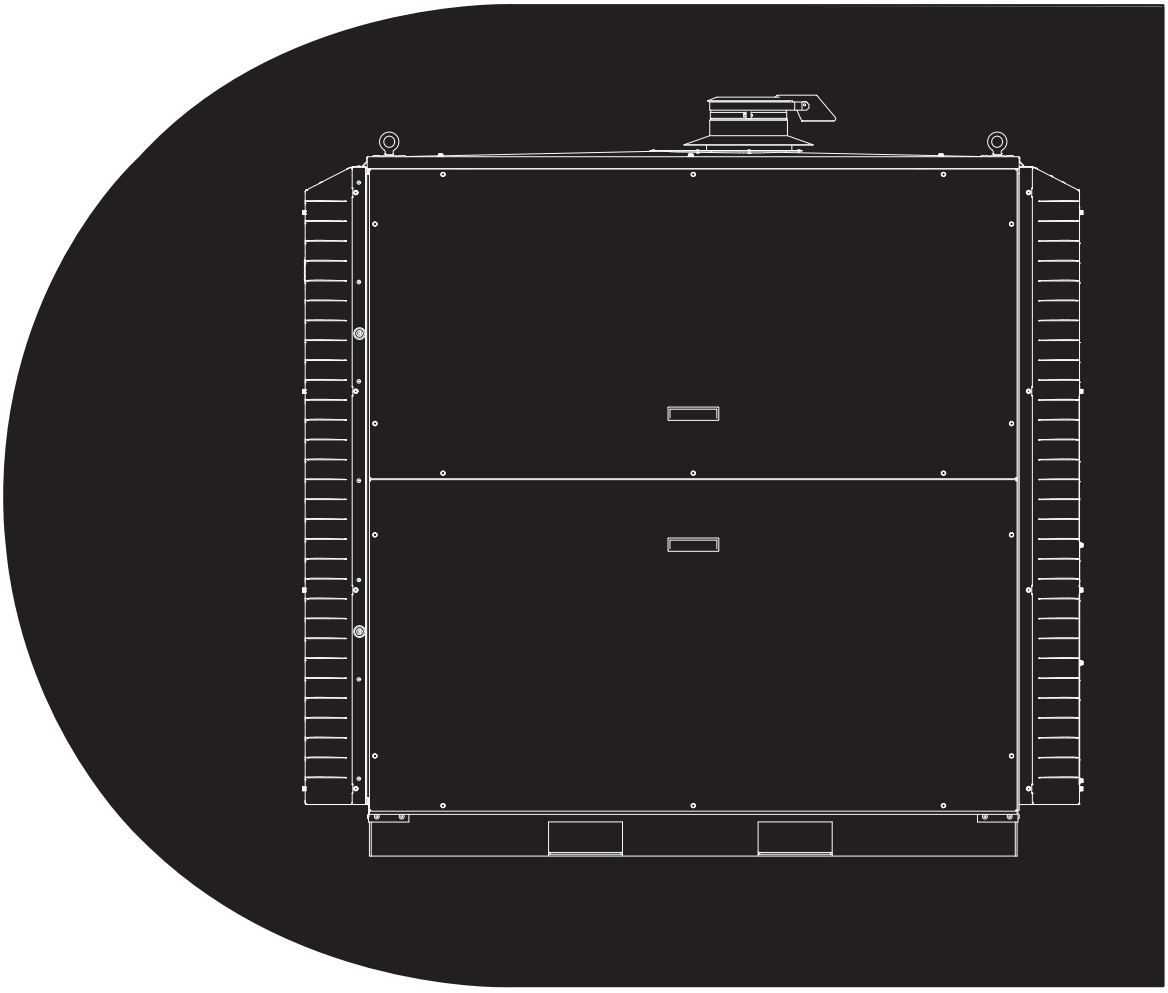
Power Generation

OPERATION MANUAL

Model GTAA, GTAB
Microturbine Generator Set



Printed in U.S.A.

950-0100 09-02

WARNING:

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

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Safety Precautions

Only trained and experienced personnel authorized by Cummins Power Generation are permitted to open the Microturbine generator set cabinets for start-up, maintenance, service or replacement of parts.

SAVE THESE INSTRUCTIONS and thoroughly read them before operating the Microturbine. Safe operation and top performance can only be attained when equipment is operated and maintained properly.

The following symbols in this manual alert you to potential hazards to operator, service personnel and equipment.

⚠ DANGER ***alerts you to an immediate hazard which will result in severe personal injury or death.***

⚠WARNING ***alerts you to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***alerts you to a hazard or unsafe practice which can result in personal injury or equipment damage.***

GENERAL PRECAUTIONS

Electricity, fuel, exhaust, moving parts and batteries present hazards which can result in severe personal injury or death.

- Keep multi-class ABC fire extinguishers handy. Class A fires involve ordinary combustible materials such as wood or cloth; Class B fires, combustible and flammable liquid and gaseous fuels; Class C fires, live electrical equipment. (ref NFPA No. 10)
- Make sure all fasteners are secure and torqued properly.
- Keep the Microturbine and surrounding area clean, free of obstructions and well ventilated.
- To prevent fire or obstructing cooling air, do not stow flammable materials, equipment or tools inside the Microturbine.
- Do not work on the Microturbine when mentally or physically fatigued or after consuming alcohol or drugs.
- Wear hearing protection.
- Avoid contact with hot exhaust plenums and shields.
- Carefully follow all applicable local, state and federal codes for installation and operation.

MICROTURBINE VOLTAGE IS DEADLY!

- The Microturbine encloses multiple sources of power and residual capacitor voltages. Always verify with a voltmeter that all circuits are de-energized before connecting, disconnecting, or servicing the Microturbine.
- Use caution when working on live electrical equipment. Remove jewelry, make sure clothing and shoes are dry and stand on a dry wooden platform.
- Make sure all electrical connections are tight, clean, dry, and protected from weather and physical stresses.
- Microturbine output connections must be made by a trained and experienced electrician in accordance with applicable codes.

TURBINE EXHAUST IS DEADLY!

- Turbine exhaust includes carbon monoxide (CO), an odorless, colorless, deadly gas. Learn the symptoms of carbon monoxide poisoning. Get out into fresh air immediately if you experience dizziness, throbbing temples, headache, nausea, vomiting, weakness, sleepiness or the like. Get medical attention if the symptoms persist.
- When the Microturbine is installed indoors, vent the turbine exhaust to the outside in accordance with applicable codes.
- Exhaust piping must be gas tight. It must not terminate in enclosed or sheltered areas or near building doors, windows or vents.
- Provide ample fresh air for combustion and ventilation.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Do not smoke or turn electrical switches ON or OFF where fuel fumes are present or in areas sharing ventilation with fuel tanks or equipment. Keep flame, sparks, pilot lights, arc-producing equipment and all other sources of ignition well away.
- The fuel supply system must be designed, constructed, installed and inspected in accordance with applicable codes. Fuel lines must be secure, free of leaks and separated or shielded from electrical wiring.
- A manual fuel shutoff valve must be provided within sight of the Microturbine.
- If you smell gas, immediately shut down the Microturbine, close the fuel shutoff valve, and locate and repair the leak.
- Take care to prevent leaks and the accumulation of gas. Leaks can lead to explosive accumulations of gas. Natural gas rises when released and can accumulate under hoods and inside housings and buildings. LPG sinks when released and can accumulate inside housings and basements and other below-grade spaces.

SERVICE PRECAUTIONS

The Microturbine encloses multiple sources of power and residual capacitor voltages. Before connecting, disconnecting, or servicing the Microturbine, ***always***:

- Command the Microturbine to OFF.
- Open and lock the dedicated disconnect switch to isolate the Microturbine from the utility grid or loads.
- If the Microturbine is equipped with batteries, open the battery isolation switch and unplug the battery cable.
- Wait five (5) minutes for residual capacitor voltage to decay.
- Verify with a voltmeter that no voltage is present on any electrical terminals.

Introduction

ABOUT THIS MANUAL

This manual presents information necessary for operation and maintenance of the generator set (Microturbine) models listed on the front cover. Information pertaining to proper installation, commissioning and establishing of operational parameters is found in the *Installation and Start-Up Manual*.

Basic troubleshooting is included in this manual but detailed troubleshooting and repair of the Microturbine is intended to be performed only by a Cummins Power Generation Authorized Service Provider.

GENERAL

The Microturbine is a clean, compact source of electrical power and heat. It is a turbine-driven high-speed generator coupled with digital power electronics to produce high quality electrical power.

Alternating current electrical power may be paralleled with a utility grid or other generation source, or 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 generating source, called a Multi-Pac.

ELECTRICAL OUTPUT

The electrical power rating of the Microturbine (*Appendix B: Specifications*) is at International Standards Organization (ISO) conditions of 15° C (59° F) at sea level. This output capability is reduced by higher ambient temperatures or elevations, or by intake or exhaust restrictions, and some options.

Grid Connect Output

In grid connect mode voltage and frequency (3-phase) are determined by the grid and can vary within the specified range (*Appendix B: Specifications*). Allowable connection types include:

- 4-wire wye with ground (Preferred)
- 3-wire wye with ground

Stand Alone Output

When the Microturbine is equipped with the Stand Alone option the electrical output (3-phase) is user adjustable within a specified range (*Appendix B: Specifications*). See *Appendix B: Specifications* also for the maximum power and current per phase, which need not be balanced between phases, and the 10 second overload that can be accommodated. The Ramp Start feature can assist in starting loads with large in-rush currents.

Power Quality

Power output conforms to Institute of Electrical and Electronics Engineers (IEEE) 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, IEEE, New York.

HEAT OUTPUT

In addition to producing electricity, the Microturbine produces usable exhaust heat for hot water, steam and other industrial processes (*Appendix B: Specifications*). When designing exhaust ducting use the maximum design exhaust temperature and exhaust flow values.

System Design Features

FEATURES

- State-of-the-art digital power conditioning provides for, (1) built-in synchronous AC with built-in protective relay functions, (2) stand alone AC output (optional).
- Patented air bearings eliminate the need for oil or other lubricants.
- Air cooled design of the entire system (engine and controller) eliminates the need for liquid coolants.
- Only one moving part in the engine: no gears, no belts, no engine-driven accessories.
- Advanced combustion control eliminates the need for ceramics or for other costly materials or for catalytic combustion.
- An integral annular recuperator (or heat exchanger) doubles thermal efficiency.
- Digital control technology facilitates advanced control, monitoring, and diagnostic capabilities, both onboard and remote (RS-232 link).

GAS MICROTURBINE

The Microturbine power plant is a combustion turbine which includes a compressor, a recuperator, a combustor, a turbine, and a generator. The rotating components are mounted on a single shaft supported by air bearings and spin at up to 96,000 RPM. The permanent magnet generator is cooled by the airflow into the Microturbine. The output of the generator is variable voltage, variable frequency AC power. The generator is used as a motor both during start-up and cool-down cycles.

CONTROLLERS

Model GTAA: The Digital Power Controller (DPC) controls Microturbine system operation and all subsystem operations. The DPC performs power conversion functions while converting variable frequency power from the generator to DC voltage and then to constant frequency AC current.

During start-up the PDC operates as variable frequency drive and motors the generator until power is available from the Microturbine. The PDC again operate as a drive during cool-down to dissipate heat stored in the recuperator and engine structure in order to protect the various engine components.

Model GTAB: The power controllers (Engine Control Module, Load Control Module, and Battery Control Module [Stand Alone only]) control the Microturbine system operation and all subsystem operations. The Engine Control Module (ECM) performs power conversion functions, while converting variable frequency power from the generator to DC voltage.

The Load Control Module (LCM) then converts the DC voltage to constant frequency AC current.

During start-up the power controllers operate as a variable frequency drive and motor the generator until power is available from the Microturbine. The power controllers again operate as a drive during cool-down to dissipate heat stored in the recuperator and engine structure in order to protect the various engine components.

FUEL SYSTEMS

The Microturbine includes an integral fuel delivery and control system. The standard system is designed for pressurized gaseous hydrocarbon based fuels.

BATTERY SYSTEM

When equipped for Stand Alone, the Microturbine includes a large battery used for unassisted start and for transient electrical load management. The system includes a power converter and battery management system which keeps the battery optimally charged. The battery is a lead-acid type, completely sealed and maintenance free.

System Operating Modes

GRID CONNECT MODE

The Microturbine, when in Grid Connect mode, is connected in parallel to the electricity grid and delivers electricity to grid connected loads. Electricity generated by the Microturbine is supplied to these loads only when the utility is present. During grid supply interruptions, the Microturbine senses the loss and immediately disconnects from the grid. When the utility returns, the system can restart automatically and resume supplying electricity to the connected loads. In Grid Connect mode, the Microturbine is a current source only, the existing grid is used for both voltage and frequency reference.

STAND ALONE MODE

When the Microturbine is equipped with the Stand Alone option connected loads may be powered directly and the Microturbine is a voltage *and* current source. A battery system provides energy for starting and transient demand management.

MULTIPAC MODE

Up to 20 Microturbines can be operated as a single system, and up to 100 units (five groups of 20) can be operated using the optional Power Server. The master or controlling system is always number 1. All the systems are then controlled and viewed from either the display panel, the user interface or the maintenance interface.

RECONFIGURING THE MICROTURBINE

The Microturbine is normally programmed for a specific operation profile (configured) just once, during the commissioning of the system. Further configuration changes are rare but may be needed if the electrical or regulatory environment changes, or if the application of the Microturbine system changes.

Some Microturbine applications may require reconfiguring the system to switch between Grid Connect and Stand Alone modes of operation. Those configuration instructions are found later in this manual.

Configuration changes are accomplished via the display panel or over the communication port using the Remote Monitoring Software (sold separately) or other software utilizing Cummins Power Generation's open communication protocols.

For specific configuration and setup programming instructions refer to the *Installation and Start-Up Manual*.

Basic System Operation

There are three ways for the user to communicate with the Microturbine:

- Display panel
- User interface port (UIP)
- Maintenance interface port (MIP)

Also some basic communications can be accomplished by making or breaking contact between pairs of terminals on the printed circuit board located in the communications bay found on the rear of the system. The user may communicate directly through the display panel mounted on the Microturbine or through a PC (personal computer) connected to the user interface port (UIP). The PC may be connected to the UIP either directly (RS-232 Dsub9 null modem cable) or via phone line and optional modem. Communication is then possible using the Remote Monitoring Software program on the PC, or other program using the open communications protocol.

START-UP

The Microturbine start-up process includes motoring, ignition, warm up, and acceleration to full load. The start-up process from a cold start to full load requires approximately two minutes or less. Start-up can be commanded from the display panel or via remote means through the use of the user interface port or the maintenance interface port using the Remote Monitoring System.

SHUTDOWN

After the command is entered for a system shutdown, power output is automatically terminated, followed by a period during which the Microturbine is motored at nominal speed to cool the various components. The overall cool-down period is approximately two minutes, but is affected by operating temperature at the time of shutdown. Approximately one to two minutes into the cool-down period, a restart may be initiated. If the battery requires recharging (after a stop command is issued), the Microturbine will continue to operate with fuel to recharge the battery up to 90 to 95% prior to stopping completely. The battery normally requires as much as 20 minutes to recharge following an Off Command.

If an optional emergency stop (E-Stop) switch is installed, it may be initiated locally by the operator. The following typical actions occur during an E-Stop:

1. Power export ceases
2. The output contactor is opened
3. The gas fuel solenoid valve is closed
4. The compressor bypass valve opens
5. Internal power is shut down
6. The rotor coasts to a stop

Emergency stops should only be used for emergency conditions and should **NEVER** be used for routine shut-downs. Emergency stops increase stress on the system components and **will** result in reduced service life of the Microturbine.

ROUTINE OPERATION

Most Microturbine applications require no regular interaction with an operator during normal operation. Built-in dispatch features include peak shaving with local or remote control, external switching control, programmable scheduling, automatic restarting and automatic reloading. Load following may be accomplished in grid connect applications through the use of an external power meter (not included).

ROUTINE OPERATING DATA

Routine operating data is not archived in the power controllers (DPC or ECM and LCM). The display panel, the user communications port, and the maintenance communications port may be used to recover current values of the following routine operating data:

- Power output (kW)
- Turbine speed (RPM)
- Turbine exit temperature (TET) (° C)
- Phase voltages, currents, and power

Communications Interfaces

Set-up, control, and monitoring of the Microturbine is managed through the display panel, the user interface port (UIP), and the maintenance interface port (MIP). Some operating communications are accomplished via discrete terminals.

Primary user communications include:

- Establishing operating parameters and settings
- Starting and stopping the Microturbine
- Adjusting power output
- Recovering operating data

Maintenance and commissioning communication functions include:

- Establishing operating modes
- Establishing operating parameter set points/ limits
- Establishing dispatch modes and parameters
- Recovering event data
- Troubleshooting

DISPLAY PANEL

The front-mounted display panel includes a keypad, a display window, navigation buttons, and system controls (Figure 3).

USER INTERFACE PORT

A Dsub9 RS-232 serial communications port is located in the user connection bay and is available for remote operation (Figures 1 and 2). A Microsoft Windows 95 / 98 / 2000 / NT based computer, RS-232 cable, and Remote Monitoring System software are used to communicate through this port. Optionally, a modem and an analog phone line may be connected to the port for remote operation.

MAINTENANCE INTERFACE PORT

A Dsub25 RS-232 serial communications port is located in the user connection bay and is functionally identical to the user interface port (Figures 1 and 2). System diagnostics and software upgrades are performed via this port.

CONTROL DEVICE AUTHORITY AND PRIORITIES

The display panel or a computer connected to either communication port is referred to as a communications device. Any device can view system data at any time, but only one device can control Microturbine operation.

The display panel has default control authority in issuing operational commands to the Microturbine. The user may start and stop, without logging on to the system (i.e., no password is required). All other system settings require logging on to the system with the user password.

The UIP will take control when a password is entered from the Remote Monitoring Software. All system commands via the UIP including start, stop, and change Power Demand, require entry of a user password. When the UIP has control, the display panel does not have control and can only view information.

When an Authorized Service Provider logs in to the MIP, the maintenance computer will have control authority. Neither the display panel nor the UIP will be able to change system settings until the maintenance computer link is logged off.

The UIP, the MIP, or the display panel are each said to be logged on after a password has been entered and accepted. The system automatically cancels a log on after 5 minutes of inactivity.

FIELD WIRING TERMINALS

Electrical terminals are provided for the following connections:

- Optional emergency stop switch
- User power (24 VDC, 0.7 A)
- Modem power (12 VDC, 0.5 A)
- Remote power meter
- Remote start/stop switch
- Battery wakeup

FAULT INPUTS

Two fault detect input terminals are provided. See menu descriptions for details.

OUTPUT RELAYS

Six solid-state output relay terminals are provided. These may be programmed to be activated by any of the 11 machine states listed below. The logic for each relay may be programmed either *active open* or *active closed*. See menu descriptions for details.

- Standby
- Run
- Contactor Closed
- Fault
- Stand Alone
- SA Load
- Disable
- Fuel On
- Fuel Purge (liquid fuel only)
- Load State
- External Load

User and Maintenance Interfaces

INTERFACE PORTS

The User and Maintenance Interface Ports (Figures 1 and 2) are RS-232 connectors which allow you to interface with the Microturbine by computer. They are located in the User Connection Bay (UCB) at the rear of the Microturbine enclosure.

REMOTE MONITORING SOFTWARE

The Remote Monitoring Software is proprietary Windows-based software that runs the user interface port (UIP) and the maintenance interface port (MIP). The software can control from 1 to 40 Microturbines. It is easy to use and menu driven. Copies of and licenses for this software are available for purchase from Cummins Power Generation.

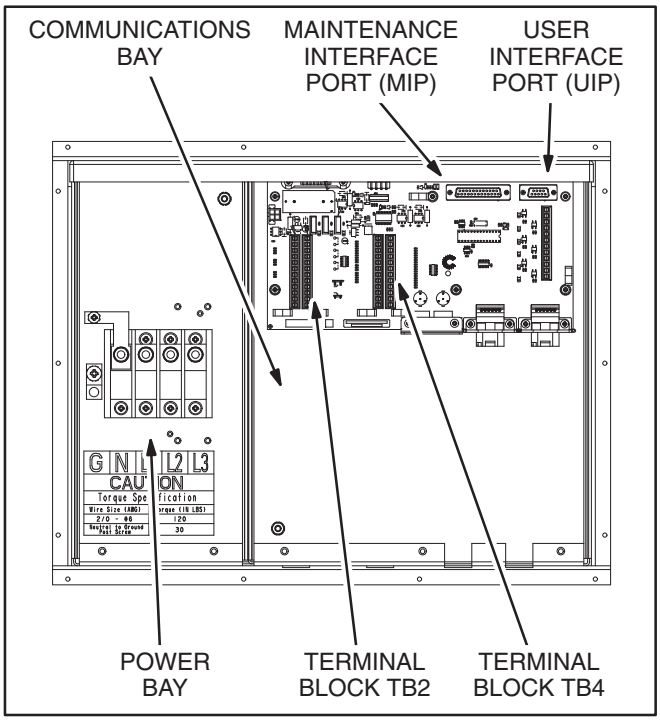


FIGURE 1. GTAA USER CONNECTION BAY (UCB)

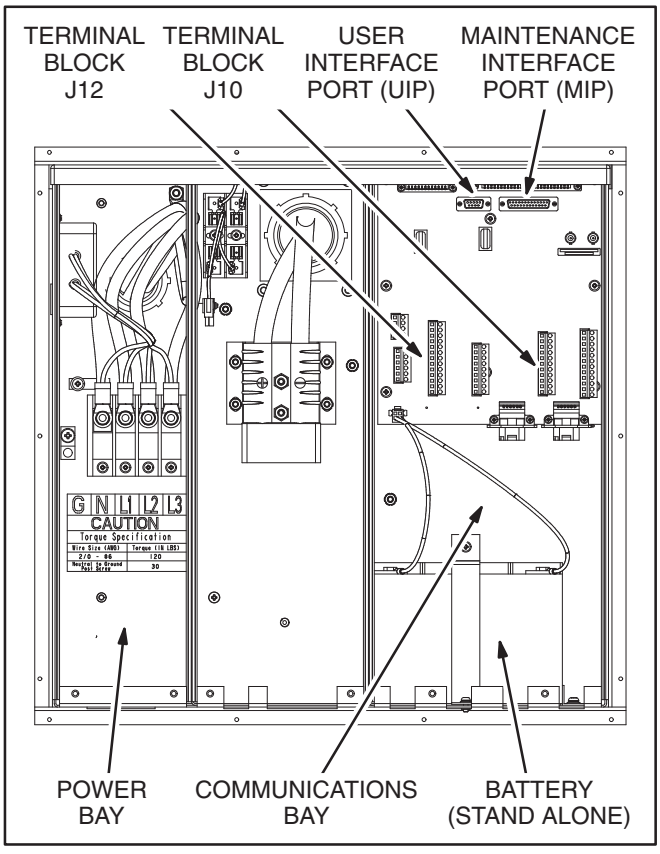


FIGURE 2. GTAB USER CONNECTION BAY (UCB)

Display Panel Operation

THE DISPLAY PANEL

When so equipped, the Microturbine may be configured and commanded from the Microturbine **Display Panel** (Figure 3) located on the front door. The display panel is used to control Microturbine operation and access data stored within the system.

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

The ***Navigation Keys***, immediately to the right of the display window, are four buttons arranged vertically, each with a line inscribed to its left indicating a line of data in the display window. These four buttons along with the buttons just to their right labeled (**–**), (**+**), and ACCEPT, are the navigation keys, used for selecting various display screens.

The ***Command Keys*** are to the right of the Navigation Keys. The command keys start and stop the Microturbine and enable and disable power output in Stand Alone mode. Command Keys are functional only when the ***Interlock Key*** is depressed.

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 line flashing. Most data input requires log on with a password.

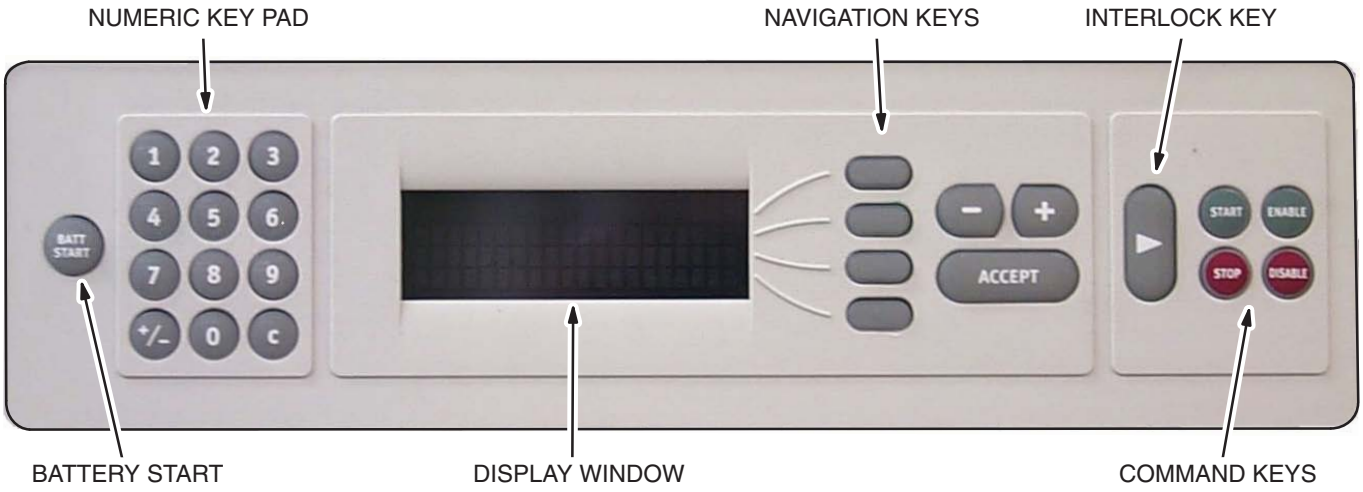


FIGURE 3. DISPLAY PANEL

MENU NAVIGATION

To understand navigation of the menu levels and options, refer to the Display Panel Menu Hierarchy chart in Appendix A and the detailed menu descriptions that follow. Each box in the menu hierarchy chart represents one display screen.

There are top level menus which may be traversed using the Navigation Keys. The top line of the display always shows the name of the current top level menu. At the far right of the top line is the top level menu position indicator. For example: one of eleven (1/11); two of eleven (2/11), and so forth.

To traverse the top level menus, press the topmost of the four line Navigation Keys. The menu position indicator numbers at the right end of the top line will flash. When the numbers are flashing, press the (**+**) or (**–**) keys to traverse the menus. The (**+**) key traverses the menu forward to higher numbers, while (**–**) key traverses the menu back to lower numbers.

The second line shows the current **submenu**. Traverse submenus in a similar manner as top-level menus except press the second line Navigation Key to select line two of the display, When the numbers are flashing, press the (**+**) or (**–**) keys to traverse the menus. The (**+**) key traverses the menu forward to higher numbers, while (**–**) key traverses the menu back to lower numbers. Proceed vertically through the menu item boxes.

When you reach the desired menu, either 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 lines either display the selected operating data or allow input, as when entering passwords or changing power settings.

DISPLAY PANEL DATA ENTRY

Data input requires selection of the appropriate line with its line select key, causing the display line to flash. Enter data using the Numeric Keypad, or scroll through available data entry options with the (**+**) KEY or the (**–**) or press the ACCEPT key when finished. Most data entry screens require entry of the user password. The Microturbine may also be configured and commanded from the display panel. To make changes to any system settings or operational modes requires the entry of a user password.

CHANGING PASSWORDS

The Microturbine display panel has an eight digit numeric user password (**87712370**) preset at the factory. Logging on plus entering and changing passwords may be accomplished as follows:

1. At System Data Menu, 1/11, push the (**–**) button to go directly to Enter Password, (7/7).
2. Select line 3 (********). Enter the current password. You must be logged in to change password.
3. Press the ACCEPT key
4. Scroll to System Settings, (4/11), and then down to User Password (14/16); or Maintenance Password (15/16).
5. Select line 3 (********Change), enter new password.
6. You will notice that the **** become---- as you enter the password.
7. Press the ACCEPT key. A confirmation message will be posted stating password needs to be verified.
8. Verify Password on line 4 (********Verify), enter new password again to verify.
9. You will notice that the **** become---- as you enter the password.
10. Press the ACCEPT key. A confirmation message will be displayed stating that the password has been verified. If the new password is not verified in this manner, the old password remains in effect.

Notice on the Display Menu Hierarchy chart that (most of) the boxes with the bolded borders represent all the parameters that may be either viewed or changed with the user protected level password.

In the event the user password is lost, the Authorized Service Provider may reset the user password.

Grid Connect Operation

DISPATCH MODES

Operation of the Microturbine in parallel with a 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*.

CONFIGURING GRID CONNECT

To configure the Microturbine 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 over the remote communications interface: the user interface port (UIP) or maintenance interface port (MIP).

GRID CONNECT INTERLOCK

The Grid Connect Interlock consists of a pair of 5 volt dry circuit contact terminals (Figure 4) in the Communications Bay (Figures 1 and 2, Page 7) at the rear of the Microturbine enclosure. A low resistance closed circuit between these terminals permits Grid Connect operation, opening the circuit disallows Grid Connect operation.

GRID CONNECT MODE ENABLE

To enable the Grid Connect mode, the Microturbine must be correctly connected to a suitable live electric power grid and the Grid Connect Interlock must be closed. To enable the Grid Connect mode from the display panel the user navigates to the System Data menu, System Configuration submenu, and the Power Connect submenu. Select *Grid Connect* mode and then press the ACCEPT key. If the Grid Connect Interlock is open, or the Stand Alone Interlock is closed, the system will accept the command but post a *User Connection Error* fault, prohibiting a start. (This is only a problem in Dual mode operation. In Grid Connect operation the Stand Alone Interlock can be closed without giving a fault.)

COMMANDING THE SYSTEM ON

The Microturbine system in Grid Parallel Operation must be explicitly commanded ON. Even if the system is configured for automatic operation, the initial ON 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 command the system ON from the display panel keyboard (Figure 3, Page 8), press and hold the INTERLOCK key, and then press the START key.

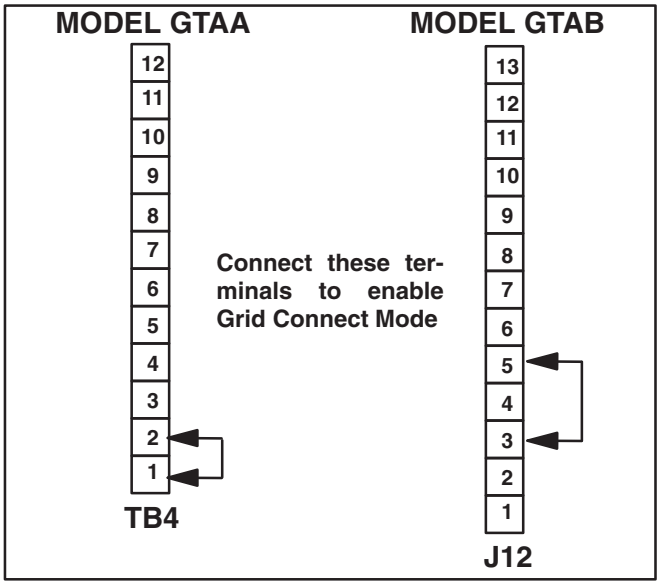


FIGURE 4. GRID CONNECT MODE

COMMANDING THE SYSTEM OFF

The Microturbine system may be commanded OFF at any time. In grid parallel operation, an explicit OFF command will override any dispatch mode settings, and is not stored by the system.

Note: If Grid Power is removed for any reason, dispatch modes may *automatically* command the system ON when Grid Power is restored.

The shutdown process includes a cool-down period which can last up to two minutes, depending on operating temperature at shutdown.

TIP: It is possible to disable control of the Microturbine from the display panel via remote control. When the remote control connection is removed, control reverts to the display panel.

During the cool-down cycle, the power output and fuel supply are off but the Microturbine continues to rotate to dissipate excess heat.

Once the turbine exit temperature (TET) reaches 427° C (800° F), a restart may be initiated.

RESTARTING

The Microturbine system can normally be restarted following a shutdown, during the cool-down period. Commanding the System Power Level 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.

EMERGENCY STOP (E-STOP)

If an optional emergency stop (E-Stop) has been installed, the E-Stop switch may be activated in an emergency. Activating E-Stop immediately shuts off the fuel and electrical output. This will cause the compressor bypass valve to open, venting the compressed air out of the Microturbine and the turbine will coast to a stop.

⚠ CAUTION ***Repeated use of the optional Emergency Stop switch will result in damage to the Microturbine. Use only in emergency situations.***

Following an emergency stop, the power to the Microturbine must be cycled (turned off for 30 seconds, and then back on again prior to restart).

Stand Alone Operation

STAND ALONE OPERATION

If the Microturbine is equipped with the Stand Alone Option, operation in Stand Alone mode consists of commanding the system on or off, and then enabling or disabling power output. These commands may be automated.

The Stand Alone Microturbine includes a large battery which stores energy for starting the Microturbine when disconnected from the grid, and which provides an electrical buffer for sudden increases or decreases in load during Stand Alone operation.

Management of the battery and its state of charge is automatic within the Microturbine. An awareness of these battery management functions will promote an understanding of why the system may appear to behave autonomously. For instance, the Microturbine will always attempt to fully recharge the battery after a user commanded shut down and before entering the cool-down state.

ENERGIZING THE MICROTURBINE

The battery includes an isolation switch for disabling the Microturbine for service or transport. The battery isolation switch is found behind the front door of the Microturbine (Figure 5). Set the switch to ON.

CONFIGURING THE MICROTURBINE FOR 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.

This is done either through the display panel or RS-232 commands over the remote communications interface: the user interface port (UIP) or maintenance interface port (MIP).

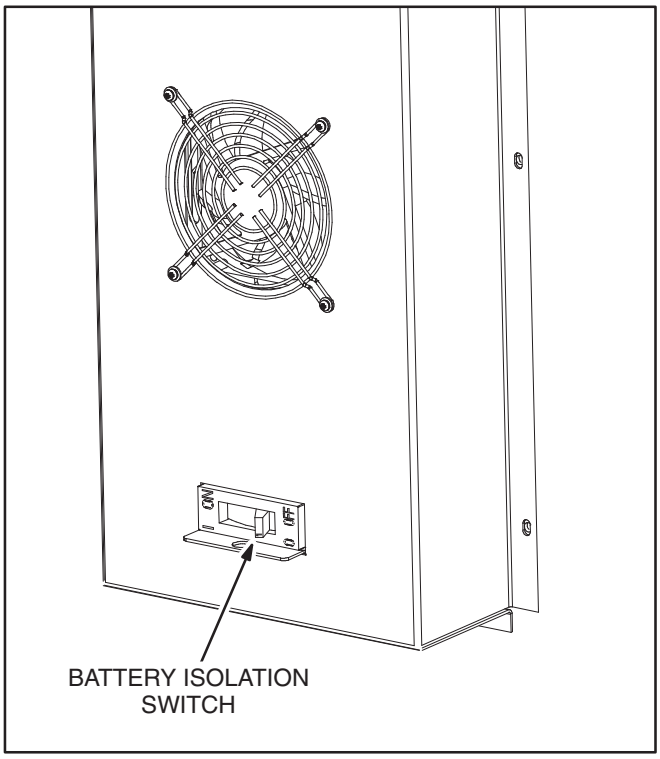


FIGURE 5. BATTERY ISOLATION SWITCH

STAND ALONE INTERLOCK

The Stand Alone Interlock consists of a pair of 5 volt dry circuit contact terminals (Figure 6) in the Communications Bay (Figures 1 and 2, Page 7) at the rear of the Microturbine enclosure. A low resistance closed circuit between these terminals permits Stand Alone operation, opening the circuit disallows Stand Alone operation.

STAND ALONE MODE ENABLE

To enable the Stand Alone mode, the Microturbine must be powered on (set the Battery Switch to ON) and the Stand Alone Interlock closed. To enable the Stand Alone mode from the display panel requires entering the user password, then navigate to the System Data Menu, System Configuration submenu, and the Power Connect submenu. Select *Stand* Alone mode and then press the ACCEPT key (Figure 3, Page 8). If the Stand Alone Interlock is open or the Grid Connect Interlock is closed, the system will accept the command but post a *User Connection Error* fault, prohibiting a start (this is only an issue in Dual mode).

SYSTEM SLEEP

Microturbine battery charge is extended significantly by reducing battery draw to near zero during prolonged periods of non-use. This is called system sleep. If the battery isolation switch is set to ON, and the display panel is dark, the system is probably asleep.

AWAKENING THE MICROTURBINE

If the system is asleep, it can be awakened by pressing the BATT START button at the far left of the Display Panel. Alternately the system can be awakened by momentarily closing the battery start contacts:

Model GTAA – Terminals 7 and 8 on terminal block TB2 (Figure 1, Page 7)

Model GTAB – Terminals 6 and 7 on terminal block J10 (Figure 2, Page 7).

THIS MUST BE A MOMENTARY CLOSURE. Permanent closure of the contacts can completely discharge the battery.

COMMANDING THE SYSTEM ON

The Microturbine system in Stand Alone operation must be explicitly commanded ON. Even if the system is configured for automatic operation, the initial ON command is required to enable the automatic mode. If the AutoRestart or AutoEnable features are enabled, the ON command is stored by the system even through a loss of system power.

To command the system ON from the display panel keyboard, press and hold the INTERLOCK key, and then press the START key (Figure 3, Page 8).

ENABLING POWER OUTPUT

To enable power output, first start the Microturbine, and wait for the engine to warm up and for the base state-of-charge (SOC) to reach at least 60%. Wait until *Ready to Load* message is displayed. Press and hold the INTERLOCK key, and then press the ENABLE key.

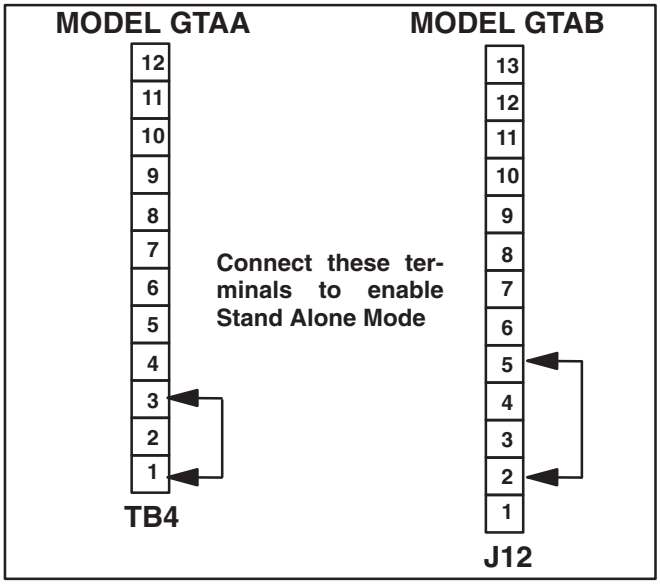


FIGURE 6. STAND ALONE CONNECTIONS

SYSTEM POWER LEVEL

In Stand Alone mode, the Microturbine system produces (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 POWER OUTPUT

To disable power output, press and hold the INTERLOCK key, and then press the DISABLE key. All power export will immediately cease.

COMMANDING THE SYSTEM OFF

The Microturbine system may be commanded OFF at any time. To command the system OFF from the display panel keyboard, press and hold the INTERLOCK key, and then press the STOP key.

TIP: It is possible to disable control of the Microturbine from the display panel via remote control. When the remote control connection is removed, control reverts to the display panel.

A system OFF command first disables power output. The system then charges the battery (including a conditioning cycle if needed), which can take up to 30 minutes. Finally, the turbine shutdown process includes a cool-down period which can last up to two minutes, depending on operating temperature at shutdown.

RESTARTING

The Microturbine system can normally be restarted following a shutdown, during the battery conditioning or the cool-down periods.

EMERGENCY STOP (E-STOP)

If an optional emergency stop (E-Stop) has been installed, the E-Stop switch may be activated in an emergency. Activating E-Stop immediately shuts off the fuel and electrical output. This will cause the compressor bypass valve to open, venting the compressed air out of the generator and the turbine will coast to a stop.

⚠ CAUTION ***Repeated use of the optional Emergency Stop switch will result in damage to the Microturbine. Use only in emergency situations.***

Following an emergency stop, the battery isolation switch must be cycled (turned off for 30 seconds,and then on again).

Dual Mode Operation

DUAL MODE

If the Microturbine is equipped with the Stand Alone option, a setting in the Microturbine system software enables the system to reconfigure itself to either Grid Connect or Stand Alone operating mode. This is called Dual mode.

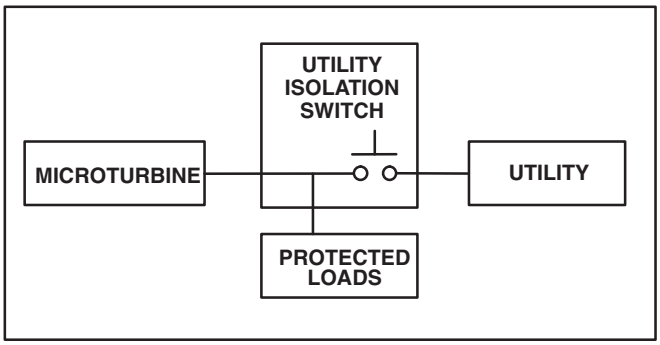


FIGURE 7. DUAL MODE SCHEMATIC

Operation of the Microturbine in Dual mode is identical to operation in either the Grid Connect mode or the Stand Alone mode, whichever is currently active. Refer to those sections of this manual for operating instructions.

Operation of the Dual mode feature consists of switching the Microturbine (and *Protected* loads) from Grid Connect operation to Stand Alone operation, or back. The steps to convert from one mode to the other are:

1. Shut down the Microturbine (if running)
2. Change the state of the connection to the grid
3. Open the old mode interlock connection
4. Close the new mode interlock connection
5. Restart the Microturbine (if needed)

Note that the interlock terminals, permissive in either Grid Connect or Stand Alone mode, are ACTIVE COMMANDS in Dual Mode. Closing the Interlock circuit for either Grid Connect mode or Stand Alone mode is an *enable* command for that mode and the system may start if measured parameters are within limits, operational settings call for power output, and AutoRestart is enabled.

TIP: Switching may be done manually or may be automated by using the optional Automatic Dual Mode Controller.

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. See the *Installation and Start-Up Manual* to establish these settings.

Command the system to Dual Mode either through the Display Panel or RS-232 commands over the remote communications interface: the user interface port (UIP) or maintenance interface port (MIP). If using the display panel, the user password must be entered. Then navigate to the System Data menu, System Configuration submenu, and the Power Connect submenu, select DUAL MODE and then press the ACCEPT key.

INTERLOCKS

Each mode (Stand Alone and Grid Connect) has a pair of 5 volt dry circuit contact terminals (Figure 8) in the Communications Bay (Figures 1 and 2, Page 7). When the system is configured for Dual Mode, a low resistance closed circuit between one of these pairs (when the other pair is open) commands the Microturbine to reconfigure to that mode. Note that when the system configuration setting is Dual mode, operation is prohibited when both interlock circuits open or both interlock circuits are closed. These conditions result in a *User Connection* Error fault.

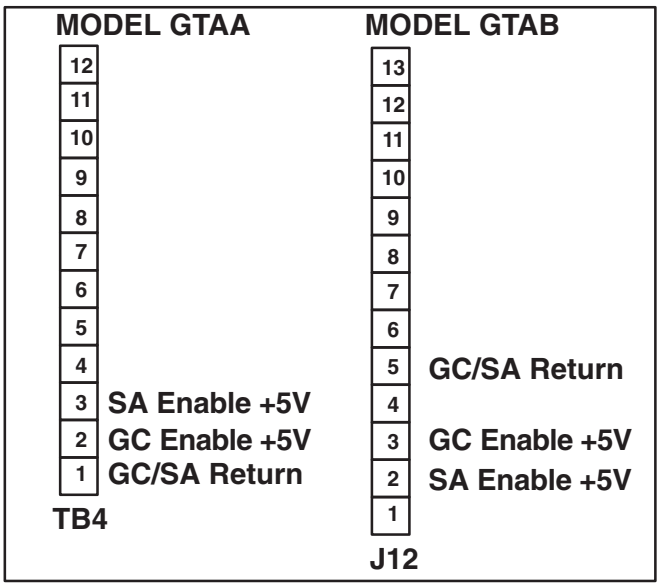


FIGURE 8. DUAL MODE CONNECTIONS

SWITCHING FROM GRID CONNECT TO STAND ALONE

1. Command the system OFF. The system will immediately cease exporting power, shut off the fuel, and enter the cool-down state. Upon completion of cool down, the system will enter the Standby state.
2. Disconnect the Microturbine and protected loads from the grid.
3. Open the Grid Connect Interlock circuit.
4. Connect the Microturbine to the protected loads, if necessary.
5. Verify that the system is powered (the battery switch is ON).
6. Close the Stand Alone Interlock circuit.
7. Press the BATT START key on the display panel.
8. Press and hold the INTERLOCK key on the display panel, and then press the START key. The system will transition through the start states and after the run, when the engine has warmed up and the battery has been charged to a base state-of-charge (SOC) of at least 60% the system will be ready to load.
9. Press and hold the INTERLOCK key on the display panel, and then press the ENABLE key.

Note that steps 7, 8, and 9 may occur automatically depending on the Microturbine dispatch mode. See the *Installation and Start-Up Manual*.

SWITCHING FROM STAND ALONE TO GRID CONNECT

1. Command the system OFF. The system will immediately cease exporting power, and may enter the Battery Charge state. Upon completion of the battery charging (up to 30 minutes), the system will enter the cool-down state (up to two minutes) and then enter the Standby state.
2. Open the Stand Alone Interlock circuit.
3. Connect the Microturbine (and protected loads, if necessary) to the grid.
4. Close the Grid Connect Interlock circuit.
5. Press and hold the INTERLOCK key on the Display Panel, and then press the START key. The system will transition through the start and warm-up states, and then begin exporting power per the Grid Connect configuration settings.

Note: Step 5 may occur automatically depending on the Microturbine dispatch mode. See the *Installation and Start-Up Manual*.

AUTOMATIC DUAL MODE CONTROLLER

The above transition steps can be accomplished entirely automatically through the use of the Automatic Dual Mode Controller. This optional accessory, sold separately, can:

- Sense the loss of grid voltage
- Disconnect the Microturbine and its connected (protected) loads from the grid
- Send the reconfiguration signal to the Microturbine
- (If Stand Alone dispatch modes are so configured, the system starts and supplies Stand Alone power.)
- Sense the return of grid voltage
- Shut down the Microturbine
- Reconnect the Microturbine and protected loads to the grid (within 10 seconds of the restoration of grid voltage)
- Send the reconfiguration signal to the Microturbine
- (If Grid Connect dispatch modes are so configured, the system starts and supplies grid parallel power.)

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

Battery Management (Stand Alone Only)

The Microturbine, when equipped with the Stand Alone Option, includes a large battery used for unassisted black start of the turbine engine and for transient electrical load management.

BATTERY STORAGE, HANDLING AND TRANSPORT

⚠WARNING ***The battery is heavy. Do no attempt to move, remove, or install the battery without appropriate lifting equipment.***

⚠WARNING ***The battery contains a lethal amount of electricity. Always keep the battery isolation switch set to OFF and the battery cable unplugged when working with or around the battery.***

The battery is a lead-acid type, completely sealed, and maintenance free. It has been tested and determined to be in compliance with section 173.159(d) of the *United States Department of* Transportation (USDOT) regulation. The battery is excepted from all other shipping requirements of 49 Code of Federal Regulations (CFR), subchapter 173.159, and as of September 30 1995, all shipments are classified as unregulated *nonspillable* wet electric storage batteries. All batteries and shipping containers are marked NONSPILLABLE or NONSPILLABLE BATTERY.

When the battery is stored or unused the ambient temperature should be controlled to prolong battery capacity. For best results, the battery should be fully charged prior to storage, stored at room temperature or below, and charged again prior to being put back into service.

BATTERY CHARGE MANAGEMENT

The Microturbine system is designed to keep the battery approximately 80% charged during operation (to allow for sourcing and sinking of power transients in a Stand Alone circuit), and to then recharge the battery over 90% before shutting down.

Normally, the system will take approximately 20 minutes to recharge the battery following an OFF command.

SLEEP

The system includes a *sleep* feature to prolong battery charge life. After shutdown, the system will enter the Standby state. If the system is not commanded ON during a user adjustable time period (up to 23.9 hours), the system will automatically enter a minimum battery drain state called *sleep*. If the system is in Grid Connect mode, the delay period before sleep is a non-adjustable 15 minutes. (In Grid connect mode only the battery system is in sleep mode.)

A sleeping Microturbine must be awakened before any operation (even automatic or remote) is possible. Sleep duration is indefinite, and will preserve battery charge for starting the Microturbine for 6 to 9 months. Battery charge life without sleep is approximately 3 days.

EQUALIZATION CHARGING

During normal use, battery cells become charged unequally. Periodically, the Microturbine will perform an **equalization** charge cycle to keep the battery in top condition. This equalization charge may take up to 4 hours. The equalization charge cycle may be allowed or disallowed by the user during certain hours of certain days of the week to prevent interference with dispatch schedules.

TIP: Applications where the peak daily temperature routinely exceeds 40° C (104° F), we suggest establishing equalization permission start and end times to encompass the coolest 6 hours of the day.

MANUAL CHARGING

The Microturbine can recharge the battery when in Grid Connect mode. Enabling Manual Charge will perform a 4-hour equalization charge. (In the Stand Alone Load State enabling manual charge will also start a 4-hour equalization charge.)

Maintenance

The Microturbine is a high technology product which requires only limited maintenance. It uses a proprietary air bearing system. Use of air bearings eliminates the need for lubricating oil and an oil-based lubrication system. Also eliminated are the environmental hazards such as emissions associated with lubricating oil.

Using air bearings significantly reduces the amount of time required for maintenance operations. Normal preventive maintenance activities on the Microturbine require only minutes. The user may perform maintenance on the external fuel filter and the Microturbine inlet air filter. Cummins Power Generation recommends that only Authorized Service Providers maintain all other Microturbine components.

⚠WARNING ***The Microturbine contains lethal energy. Do not open the Microturbine except as directed in this manual. Only Cummins Power Generation Authorized Service Providers should open the Microturbine enclosure.***

SCHEDULED MAINTENANCE

The Maintenance Schedule (Table 1) reflects operation of the Microturbine under normal environmental conditions.

If the Microturbine is being operated under extreme or unusual environmental conditions with high levels of air borne particles, the filters should be inspected and replaced more frequently.

Cummins Power Generation recommends that only authorized service technicians change the electronics air filter, internal fuel filter, thermocouple, ignitor, and fuel injectors. Failure to provide proper maintenance may void the Microturbine warranty.

TABLE 1. MAINTENANCE SCHEDULE

Item	Action	Service Interval (Hours)
Air Filter, Turbine	Replace	8,000
Air Filter, Electronics	Clean	8,000
Fuel Filter, Internal	Inspect	8,000
Fuel Filter, External	Replace	8,000
Turbine Exhaust Thermocouple	Replace	16,000
Ignitor	Replace	16,000
Fuel Injectors (6)	Replace	16,000
Rotary Flow Compressor (RFC)	Replace	See Table 2
Note: 8,000-hour and 16,000-hour service kits are available from Cummins Power Generation		

ROTARY FLOW COMPRESSOR (MODEL GTAA ONLY)

Rotary flow compressor (RFC) life and required replacement interval are affected by inlet gas pressure (Table 2). Operation at an inlet pressure of less than 34 kPa (5 psig) is possible but not warranted as it will further decrease the service interval.

Cummins Power Generation recommends regulating inlet gas pressure to 15 psig for low pressure systems.

TABLE 2. RFC REPLACEMENT INTERVALS

Inlet Gas Pressure	Replacement Interval (Hours)
34 kPa (5 psig)	3,000
52 kPa (7.5 psig)	5,000
69 kPa (10 psig)	8,000
103 kPa (15 psig)	16,000

PREVENTIVE MAINTENANCE - BATTERY

If the Microturbine is equipped with a battery (**Stand Alone Option**) a Battery Isolation Switch is included (Figure 5, Page 12). The isolation switch should be set to OFF and the battery cable DISCONNECTED if the Microturbine is to be serviced or transported, or if it will not be operated for a period exceeding 90 days.

PREVENTIVE MAINTENANCE - FUEL FILTER

The user should replace the external fuel filter element periodically (Table 1) to ensure unrestricted flow of clean fuel to the Microturbine, necessary for its optimal performance.

It is common to find significant amounts of contamination in newly installed fuel lines. A new installation should inspect the external fuel filter frequently until the contamination trapped in the filter falls to a consistent rate. Some new installations have plugged the external filter in one day.

⚠WARNING ***Natural gas is flammable and explosive. No spark or open flame near natural gas. No smoking near natural gas. Use approved American Gas Association (AGA) procedures when servicing natural gas lines or filters.***

If the optional Cummins Power Generation supplied external fuel filter is used, perform the following eleven steps in the specified order when servicing the external fuel filter:

1. Command the Microturbine OFF and wait for the cool-down cycle to complete
2. Close gas supply valve, shutting off gas flow to filter
3. Purge the gas line
4. Drain gas filter into clear container
5. Inspect contents of clear container for abnormal contaminants
6. Remove gas filter element
7. Inspect element for serviceability and replace if required
8. Reinstall element
9. Ensure all drain and purge valves are closed
10. Turn on gas flow to filter
11. Check for leaks

If a non-Cummins Power Generation supplied external fuel filter is used, perform service steps as directed by the filter manufacturer.

PREVENTIVE MAINTENANCE - AIR FILTER

The user should inspect and replace the engine air inlet filter periodically (Table 1) to ensure unrestricted flow of clean combustion and cooling air to the generator and turbine engine.

Areas subject to wind and airborne dirt or dust, may require inspection and/or replacement of the air inlet filter as often as once every 500 operating hours or less, or when there is a noticeable drop in the output power.

⚠CAUTION ***The turbine engine requires clean, dust free air for operation. Do not operate the Microturbine without the engine air filter in place. Do not remove or service the air inlet filter any time the Microturbine is running.***

To service the Microturbine air filter, proceed as follows:

1. Command the Microturbine OFF and wait for the cool-down cycle to complete
2. Unlock and open the front door
3. Pull out and remove the air filter from the engine inlet
4. If the filter appears too dirty, replace it with a new filter
5. Close and lock the front door

Troubleshooting

⚠WARNING ***Adhere to the Caution, Warning, and Danger labels on the enclosure. Lethal energy may exist inside the system enclosure and the Power Bay. Access is intended for Cummins Power Generation Authorized Service Providers only.***

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.

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

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

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

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 (Table 3). Depending upon the severity of the incident, the system may or may not attempt to restart, and may or may not allow a restart.

TABLE 3. SYSTEM SEVERITY LEVELS

Code	Severity	System
SSL 0	Non-Fatal	No Fault
SSL 1	Non-Fatal	Anticipated Error
SSL 2	Non-Fatal	Warning
SSL 3	Non-Fatal	Engine Control Fault
SSL 4	Fatal/Non-Fatal	Inverter Loss
SSL 5	Fatal	Loss of Power Path
SSL 6	Fatal	Emergency Stop
SSL 7	Fatal	CPU Failure

INCIDENT NAMES AND CODES

When an incident occurs, the **incident name** and incident code are displayed on the display panel. The incident names are:

1. Internal Warning or Fault
2. Fuel Warning or Fault
3. Grid Warning or Fault
4. Lo-Temp Warning or Fault
5. Temp Warning or Fault
6. Hi-Alt Warning
7. E-Stop Fault

Following the incident name will be a number up to five digits in length, called the incident or fault code. These codes aid in the troubleshooting effort by a Cummins Power Generation Authorized Service Provider.

Internal Incident - 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 follow the troubleshooting procedures listed here. If unsuccessful in restoring normal operation, a Cummins Power Generation Authorized Service Provider will be required to initiate repair of the Microturbine.

Fuel Incident - The user should initially check the fuel supply to the Microturbine. Ensure the line has the correct fuel pressure. Check the filter to ensure that it is not blocked. Verify that the external shut off valve is open. If the problem persists, call the service provider.

Grid Incident - This event is likely to be due to a grid disturbance. Before following the troubleshooting steps, check the breakers and fuses to ensure they are not tripped. If the problem persists, call the electric service provider.

Lo-Temp/Hi-Temp/Hi-Alt Incidents - Generally, these incidents are due to ambient conditions which are outside the design envelope of the Microturbine. Continued operation under these conditions may affect operation and cause damage to the Microturbine.

E-Stop Incident - If the event display reads "MANUAL E-STOP 7000", check the optional emer-

gency stop button and verify whether or not 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 fault should clear, and the system should resume operation. If it does not, call the authorized service provider.

VIEWING INCIDENT RECORDS

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

The following parameters are recorded as part of the incident record:

- Incident name
- Incident code
- Cumulative number of starts
- Date and time
- Output power
- Engine speed
- Engine exhaust temp
- Fuel valve position
- Ambient temperature
- Voltage and current on each phase
- Frequency
- DC bus and power supply voltage
- Several internal system temperatures

To view an incident record on the display panel, navigate to the Incident Log menu.

The Incident Log menu on the display panel can display the twenty most recent incident records. They are numbered: 1/20 (read: “one of twenty”) being the most recent incident, 2/20 the next most recent, and so forth up to 20/20.

When a new incident occurs, it is recorded as 1/20, all of the incident records in the incident history move toward the end one by one as they occur, and the previous 20/20 (if it existed) drops off the list.

TROUBLESHOOTING PROCEDURES

No Lights on Display Panel

1. If Stand Alone equipped, press the “BATT START” key on the Display Panel.
2. If Stand Alone equipped, make sure the Battery Isolation switch, is set to ON (Page 12).
3. If Grid Connect, verify grid voltage is present on the phase terminals in the Power Bay (Page 7).

No Attempt to Start after ON Command

1. Verify that current device is the control device. See the Display Panel Menu Hierarchy (*Appendix A*).
2. Verify that ON command is consistent with the currently active dispatch mode. See the *Installation and Start-Up Manual*.

Start Attempt Fails

1. If the system attempts but fails to start, an incident code will be registered.
2. Troubleshooting procedure is same as for *Unexpected Shutdown or Warning* in the next section.

Unexpected Shutdown or Warning

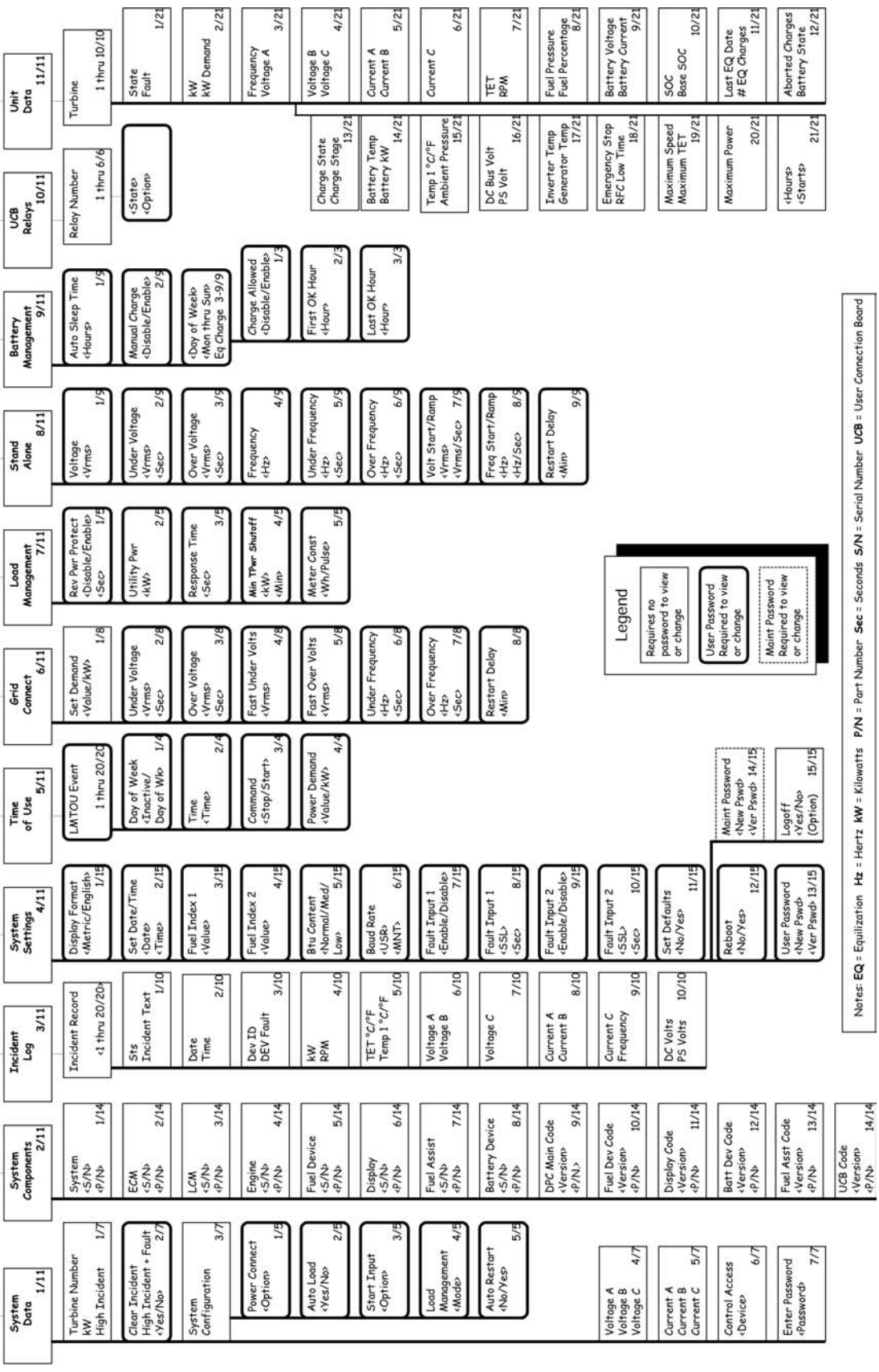
When a **warning** incident occurs, no action is required by the user. When a **fault** incident occurs, the troubleshooting steps are:

1. Attempt to restart. If unsuccessful, then:
2. Verify the fuel, air, and electrical supply to the Microturbine. Attempt to restart. If unsuccessful, then:
3. Enter the user password and reboot the system through the display panel.
4. Attempt to restart. If unsuccessful, cycle the power by shutting off power to the system, waiting 30 seconds, and turning the power back on.
5. Attempt to restart. If unsuccessful, note the event number listed on the display window, and call the Cummins Power Generation Authorized Service Provider for assistance.

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

Appendix A: Display Panel Menus

Display Panel Menu Hierarchy



OVERVIEW

Each box in the Display Panel Menu Hierarchy chart represents a screen which may be viewed on the Microturbine Display Panel.

Follow the instructions under the *Display Panel Operation* section of this manual to learn to navigate to the desired screen. Overall, the top line of the display always shows the name of the current top level menu; press the first line select key on the panel to the right of the display. The remainder second, third and fourth select buttons correspond to the second, third and fourth lines on the display.

You may use the + and - button to move forward and back through the menus and press the Accept button to make your menu selection (or wait 20 seconds for the system to automatically accept the option selected).

The third and fourth lines either display the selected operating data or allow input, as when entering passwords or changing power settings.

The collection and organization of screens is called the Display Panel Menu Hierarchy. There are 11 top-level menus each with a number of submenus. The following descriptions of each screen or submenu are grouped according to the top-level menu.

SYSTEM DATA—1/11

On power-up of the Microturbine, the menu defaults to the System Data menu. System Data displays cumulative output for a System of 1 to 20 Microturbines and certain variable measurements and various system states. Using the System Data Menu you can control up to 20 Microturbines to operate as one system, called a MultiPac. The Control Access submenu (6/7) displays which control device is active. In the next submenu, 7/7 the user can enter a password to log onto the control panel.

1/7
TURBINE#
This is a combined string showing configuration with the following 3 items:

- GC (Grid Connect) or SA (Stand Alone)
- Single, Master or MultiPac (MP)
- Turbine #

<kW>
Total Output of 1-20 Microturbines

HIGH INCIDENT
(Highest level faults &/or warnings). Displays the system severity fault code (Table 4) and displays the highest fault type and the highest identification number of the faults currently reported by the system. This is the information that should be forwarded to the authorized service provider if requested.

TABLE 4. SYSTEM SEVERITY LEVELS

Code	Severity	System
SSL 0	Non-Fatal	No Fault
SSL 1	Non-Fatal	Anticipated Error
SSL 2	Non-Fatal	Warning
SSL 3	Non-Fatal	Engine Control Fault
SSL 4	Fatal/Non-Fatal	Inverter Loss
SSL 5	Fatal	Loss of Power Path
SSL 6	Fatal	Emergency Stop
SSL 7	Fatal	CPU Failure

2/7
CLEAR INCIDENT
Clears the highest level fault, if possible, in an attempt to return the system to standby.

FAULT #
Displays the system severity level (SSL) fault code (Table 4) and displays the highest fault type and the highest identification number of the faults currently reported by the system. (Duplicate information as in High Incident in 1/7 above.)

<YES/NO> (Clear)
If the fault was able to be cleared, the fault # line will be updated with the new highest SSL fault or system OK if all faults were cleared. If the same fault remains, the fault cannot be cleared.

3/7
SYSTEM CONFIGURATION SUBMENU
Allows the user to input system settings.

1/5 POWER CONNECT <Option>
Set once at commissioning only.

0 = Invalid State, factory default, not yet set up

1 = Stand Alone

2 = Grid Connect

3 = Dual Mode (Battery or Stand by)

2/5 AUTO LOAD <Yes/No>
Here the user can enable or disable the Microturbine to automatically meet the load demand when running in Stand Alone mode.

Yes = Microturbine automatically makes power available to match output with the load demand.

No = The user must manually use the display panel Interlock + ENABLE button to allow power to be output when in Stand Alone mode before the turbine will produce power to meet the load demand.

3/5 START INPUT <Option>

0 = USER_INPUT: User start priority (Control Panel, UIP or MIP) when switch is disabled.

1 = REMOTE_INPUT: UCB start priority when switch is enabled. This is a remote start priority (**GTAA** terminals 3 and 4 on TB1; **GTAB** terminals 4 and 5 on J12).

2 = REMOTE_SA_USER_GC: User start priority in GC, UCB start priority in SA. The remote switch has priority in Stand Alone, a) when in GC, user has priority to start the system, or b) in SA mode, priority is switched to the Remote Switch (5/6). (GC = Grid Connect; SA = Stand Alone.)

3 = REMOTE_GC_USER_SA: The Opposite OF #2; User start priority in SA, UCB start priority in GC.

4/5 LOAD MANAGEMENT <Mode>
The mode options are:

- Disable
- Not used
- Load following (Settings in Load Management menu 7/11)
- Time of use (Settings are in Time of Use menu 5/11).

5/5 AUTO RESTART <No/Yes>
Enables or disables the system's ability to automatically attempt to restart after an incident driven shutdown. Default = No.

4/7
VOLTAGE A
Actual output rms voltage, phase A to Neutral [VA] in AC volts

VOLTAGE B
Actual output rms voltage, phase B to Neutral [VB] in AC volts

VOLTAGE C
Actual output rms voltage, phase C to Neutral [VC] in AC volts

5/7
CURRENT A
Actual output rms current, phase A in amps

CURRENT B
Actual output rms current, phase B in amps

CURRENT C
Actual output rms current, phase C in amps

Sum of all Microturbines on the master system of a MultiPac.

6/7
CONTROL ACCESS <Device>
Displays which communication device currently has control for changing settings of the Microturbine.

- Display panel
- User port
- Maintenance port

7/7
ENTER PASSWORD
<Password>
<Level>
Enter password <value>. This is required for access to the Microturbine settings. The factory default user password is **87712370** for protected-user level.

Logging On and Passwords – Logging on plus entering and changing passwords may be accomplished as follows:

1. At System Data Menu, 1/11, push the "-" button to go directly to Enter Password,(7/7).
2. Select line 3 (********). Enter the current password. You must be logged in to change password.
3. Press the ACCEPT key
4. Scroll to System Settings, (4/11), and then down to User Password (13/15); or Maintenance Password (14/15);
5. Select line 3 (********Change), enter new password.
6. You will notice that the **** become---- as you enter the password.
7. Press the ACCEPT key. A confirmation message will be posted stating password needs to be verified.
8. Verify Password on line 4 (********Verify), enter new password again to verify.
9. You will notice that the **** become---- as you enter the password.
10. Press the ACCEPT key. A confirmation message will be displayed stating that the password has been verified.

If the new password is not verified in this manner, the old password remains in effect.

Notice on the Display Menu Hierarchy chart that (most of) the boxes with the bolded borders represent all the parameters that may be either viewed or changed with the user protected level password.

SYSTEM COMPONENTS—2/11

System components are the hardware and software that are installed on your Microturbine. This menu lists serial numbers, part numbers, and test data for the Microturbine, control board, power board, display panel, fuel device and battery. Serial numbers are six digits, all numeric. Part numbers are six digits-dash-three digits.

1/14
SYSTEM
<S/N>
<P/N>
The serial and part number of the system.

2/14
ECM (Engine Control Module)
<S/N>
<P/N>
The serial and part number of the ECM.

3/14
LCM (Load Control Module)
<S/N>
<P/N>
The serial and part number of the LCM.

4/14
ENGINE
<S/N>
<P/N>
The serial and part number of the engine.

5/14
FUEL DEVICE
<S/N>
<P/N>
The serial and part number of the fuel device.

6/14
DISPLAY
<S/N>
<P/N>
The serial and part number of the display.

7/14
FUEL ASSIST (RFC in a liquid fuel system)
<S/N>
<P/N>
The serial and part number of the fuel assist device.

8/14
BATTERY DEVICE
<S/N>
<P/N>
The serial and part number of the battery device.

9/14
DPC MAIN CODE
<Version>
This is the software version of the DPC main code set, the overall version of software for the Microturbine, for example 2.04.
<S/N>
<P/N>
The serial and part number of the DPC software.

10/14
FUEL DEVICE CODE
<Version>
This is the software version of the fuel device (for troubleshooting).
<S/N>
<P/N>
The serial and part number of the fuel device code.

11/14
DISPLAY CODE
<Version>
This is the software version of the display code (for troubleshooting).
S/N
The serial number of the display code.

12/14
BATTERY DEVICE CODE
<Version>
This is the software version of the code for the battery device (for troubleshooting).
<P/N>
The part number of the battery device code.

13/14
FUEL ASSIST CODE
<Version>
This is the software version of the fuel assist device (RFC) code (for troubleshooting).
<P/N>
The part number of the fuel assist code.

14/14
UCB CODE
<Version>
This is the software version of the UCB (User Connection Bay) software device (for troubleshooting).
<P/N>
The part number of the UCB code.

INCIDENT LOG—3/11

The Incident Log records the last 20 faults and warnings. When the log is full, the oldest fault or warning drops off and the new one goes to the top as number 1.

Line 2 may be used to traverse through the 20 incidents. Submenus in line 3 & 4 contain data for the selected incident.

INCIDENT RECORD 1-20 SUBMENU

1/10 STS (COMBUSTOR STARTS)
Combustor starts at time of incident or warning.

<INCIDENT TEXT>
Incident text displayed is a description of the fault or warning.

2/10 DATE, TIME
Displays the system date in MM/DD/YYYY and the time in 24:00:00.

3/10 Device ID, Device Fault
Displays the device fault information (Reference: Fault Code 5000).

4/10 kW, RPM
The power output and speed at time of incident.

5/10 TET (Turbine Exit Temperature) °C/°F

6/10 VOLTAGE A, VOLTAGE B (at time of incident)

VOLTAGE A
Actual output AC voltage, phase A [VA]

VOLTAGE B
Actual output AC voltage, phase B [VB]

7/10 VOLTAGE C (at time of incident)

VOLTAGE C
Actual output AC voltage, phase C [VC]

8/10 CURRENT A, CURRENT B (at time of incident)

CURRENT A
Actual output current, phase A in amps

CURRENT B
Actual output current, phase B in amps

9/10 CURRENT C, FREQUENCY (at time of incident)

CURRENT C
Actual output current, phase C in amps

FREQUENCY
Actual output frequency in Hertz

10/10 DC, PSV
DC Bus Volts and Power Supply Voltage at time of selected incident.

SYSTEM SETTINGS—4/11

The System Settings menu provides for the user or authorized service provider to establish global Microturbine operating parameters. These settings apply regardless of application or operating mode. Usually these will be established at installation and not changed thereafter.

1/15
DISPLAY FORMAT
<Metric/English>
Provides for either Metric or English engineering units to be used for all pressures and temperatures displayed on the Display Panel. Default = Metric

2/15
SET DATE/TIME
Set time/date. Displays the system date in MM/DD/YYYY and the time in 24:00:00.

3/15
FUEL INDEX 1
<Value>
A parameter used to adjust the fuel system controls to handle fuels of very low or very high energy content. See the Fuel Selection and Utilization appendix of the Installation and Start Up manual for details or see the Fuel Parameter section in the Product Data Sheet. Default = 1.00

4/15
FUEL INDEX 2
<Value>
A second parameter used to adjust the fuel system controls to handle fuels of very low or very high energy content. See the Fuel Selection and Utilization appendix of the Installation and Start Up manual for details. Default = 1.00

5/15
BTU CONTENT
<Normal / Medium / Low>
Btu Content/Mode enables the system to use fuels outside the normal energy content range. See the Fuel Selection and Utilization appendix of the Installation and Start Up manual for details. Default = Normal.

6/15
BAUD RATE
User Baud Rate <USR>
<bps> Establishes the communication speed for the User Interface Port. Available settings are 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600. Default = 57600.

MAINTENANCE BAUD RATE<MNT>
<bps> Establishes the maximum communication speed for the Maintenance Interface Port. Settings and default same as User Interface Port.

7/15
FAULT INPUT 1
<Enable/Disable>
Detect a fault input into the system from an external fault source. Fault Input and Fault Input SSL allow users to enable, select the severity level, and adjust the debounce time for fault input detection from an external device.

8/15
FAULT INPUT 1
System Severity Level <SSL>
<Sec>
Configures the fault input enabled by 7/15 above; severity level of fault and debounce time.

9/15
FAULT INPUT 2
<Enable/Disable>
Detect a fault input into the system from an external fault source. Fault Input and Fault Input SSL allow users to enable, select the severity level, and adjust the debounce time for fault input detection from an external device.

10/15
FAULT INPUT 2
System Severity Level <SSL>
<Sec>
Configures the fault input enabled by 9/15 above; severity level of fault and debounce time.

11/15
SET DEFAULTS
<No/Yes>
Selecting YES, restores factory default settings. All modes are set to disable. All protective relay settings are restored to factory defaults.

12/15
REBOOT
<No/Yes>
Reboot resets the system and is possible only in a standby or fault state. Reboot does NOT revert user-entered settings to factory default (as in 13/15).

13/15
USER PASSWORD
<Change Pswd>
Provides for entry of a new user level password.
<Verify Pswd>
Provides for verification of the new user level password entered. If the new password is not verified, the old password remains in effect.

14/15
MAINTENANCE PASSWORD
<Change Pswd>
Provides for entry of a new maintenance level password.
<Verify Pswd>
Provides for verification of the new maintenance level password entered. If the new password is not verified, the old password remains in effect. (For ASP's).

15/15
LOGOFF
<No/Yes>
Logoff commands the system to base password mode, disabling all password protected parameter adjustments. (The system will automatically revert to base password mode following 5 minutes of inactivity - this is not implemented in currently released display. User should manually log off using this menu.)

TIME OF USE—5/11

The Time of Use menu is activated from the Load Management menu and provides for programming on/off and power demand settings for the Microturbine based on day of week and time of day. When Time of Use is activated, up to 20 time of use events may be programmed. An event consists of an on or off command, a power level demand setting, and the time that the event executes.

1/20 TIME OF USE EVENT SUBMENU

LMTOU Event (1-20) LOAD MANAGEMENT TIME OF USE. Select the time of use events to be configured on line 1 using the LMTOU submenus 1/4-4/4 on lines 3 & 4.

1/4 DAY OF WEEK <Active/Inactive>
Day, identifies the day of the week for the event execution. 1 = Sunday through 7 = Saturday. Default = 0. Entering 0 disables the event without changing its time or other parameters.

2/4 TIME
Time <value> Identifies the time of day for the incident execution. Enter in 24:00:00 format. Default = 00:00:00

3/4 COMMAND <Stop/Start> (Off or On)

4/4 POWER DEMAND
Power Demand <value> Identifies the power output demand level for the event. Adjustable from: **GTAA –** 0.0 to 30.0 kW, **GTAB –** 0.0 to 60.0 kW. Default = 0.

GRID CONNECT—6/11

This menu establishes operating parameters for the grid connect mode and are applicable only when the Microturbine is operating in Grid Connect mode. Operating limits, sometimes called “Protective Relay Settings” are established here.

1/8
SET DEMAND
<Kw>
Displays and allows entry of commanded power output level in kilowatts. A password is not required to adjust this parameter from the display panel. The range of valid settings extends from 0 - 2,000,000 kW in 0.1 kW increments. The maximum demand possible which a user may input with this software is 2GW to allow for future improvements and increased Microturbine capacity. For example, the maximum output of the Model GTAB is now 60kW. Multiply that by the number of Microturbines in the MultiPac. For 20 GTABs it would be 1,200 kW. Do not enter a decimal point. To enter 60 kW, enter: six zero zero. Default = 0.

2/8
UNDER VOLTAGE
<Vrms>
If the voltage on any phase falls below this setting the timer is started. If the voltage has not recovered at the end of the time period, the system will shut down. Adjustable from 360 up to the Over Voltage set point (3/8). Default = 428.
<Sec>
Establishes the time period allowed for any phase voltage to fall below the Under Voltage limit established in Vrms. Adjustable from 0.01 up to 10 seconds in 0.01 second increments. Default = 1.9.

3/8
OVER VOLTAGE
<Vrms>
If the voltage on any phase rises above this setting the timer is started. If the voltage has not subsided by the end of the time period, the system will shut down. Adjustable from 528 down to the Under Voltage set point (2/8) in 0.1 volt increments. Default = 524.
<Sec>
Establishes the time period allowed for any phase voltage to rise above the Over Voltage limit established in <Vrms>. Adjustable from 0.01 to 10 seconds in 0.01 second increments. Default = 1.9.

4/8
FAST UNDER VOLTS
<Vrms>
The system will cease power export to the grid within 1 msec if any phase voltage drops below Fast Under Voltage for a predetermined time (user adjustable). If the grid voltage re-stabilizes within 1.0 second of the initial under voltage, then the system will resume power export, otherwise the system will shut down. The Fast Under Voltage at which this sequence will be triggered is adjustable here from 0 VAC up to the Under Voltage (established Under Voltage Volts). Default = 264.
<Sec>
Establishes the time period allowed for any phase voltage to fall below the Fast Under Voltage limit established in <Vrms>. Adjustable from 0.001 to 1.000 second in 0.001 second increments. Default = 0.065.

5/8
FAST OVER VOLTS
<Vrms>
The system will cease power export to the grid within 1 msec if any phase voltage exceeds Fast Over Volts for a predetermined time (user adjustable). If the grid voltage re-stabilizes within 1.0 second of the initial under 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 (established in Over Voltage Volts, 3/8) up to 634 volts. Default = 600.
<Sec>
Establishes the number of seconds allowed for Fast Over Voltage condition before the system shuts down. Adjustable from 0.001 to 1.000 second in 0.001 second increments. Default = 0.015.

6/8
UNDER FREQUENCY
<Hz>
If the grid frequency falls below this value for the time period established in Under Frequency Delay, the system will shut down. Adjustable from 45 to Over Frequency (established in Over Frequency), in 0.1 Hz increments. Default = 59.3
<Sec>
Establishes the number of seconds allowed for Under Frequency condition before the system shuts down. Adjustable from 0.01 to 10 in 0.01 second increments. Default = 0.07.

7/8
OVER FREQUENCY
<Hz>
If the grid frequency exceeds this value for the time period established in Over Frequency Delay, the system will shut down. Adjustable from Under Frequency (established in Item 8) to 65, in 0.1 Hz increments. Default = 60.5.
<Sec>
Establishes the number of seconds allowed for Over Frequency condition before the system shuts down. Adjustable from 0 to 10 in 0.01 second increments. Default = 0.07.

8/8
RESTART DELAY
<Min>
Introduces a time period between an automatic restart command and the actual beginning of the restart sequence. Adjustable from 0.0 to 60.0 minutes, Default = 0.

LOAD MANAGEMENT—7/11

The Load Management menu allows the user to implement various dispatch schemes for the Microturbine when it is in Grid Connect mode.

1/5
REV PWR PROTECT (Reverse Power Protection)
<Disable/Enable>
Enables the ability of the system to automatically shut down if a connected power meter (not supplied) registers negative power flow. Default = Disable SEC.
<Sec>
Number of seconds allowed to output negative power flow before shutdown.

2/5
UTILITY POWER
<kW>
Enter the number of kilowatts which the system will attempt to keep a connected power meter (not supplied) reading. Adjustable from -0 to 2,000,000 kW in 0.1 kw increments. (Power meter must be connected between Microturbine and electric service entrance.)

3/5
RESPONSE TIME
<Sec>
Specifies the time period required for a power reading before the system responds with a new output command. Adjustable from 1 to 120 seconds in one second increments. Default = 1.

4/5
MIN TPWR SHUTOFF (Minimum Time Power Shutoff)
<kW>
<Min>
Minimum Time Power Shutoff Adjustable from 1 to 15 minutes in one minute increments. Default = 15 minutes. If your load is drawing less than a setable amount of kW for the Minimum Time Power Shutoff adjustment, then the Microturbine will shutdown, and inversely, the opposite is also true. The Microturbine will start up if your load is drawing more than the kW of the Minimum Time Power Shutoff such as for peak shaving.

5/5
METER CONST (Meter Constant)
<WH/PULSE> (Watt hours/Pulse)
The number of watt-hours represented by a single pulse signal from the external power meter. Adjustable from 0.000 to 50.000. Default = 0.000 watt-hours/pulse.

STAND ALONE—8/11

This menu establishes voltage and frequency output for the Stand Alone mode of operation. 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).

1/9
VOLTAGE
<Vrms>
Establishes nominal output voltage (line to line). Adjustable from 150 to 480 in one volt increments. Default = 480.

2/9
UNDER VOLTAGE
<Vrms>
If the voltage on any phase falls below this setting the timer <Sec> is started. If the voltage has not recovered at the end of the time period, the system will shut down. Adjustable from 0 up to nominal. Default = 360.
<Sec>
Establishes time period allowed for any phase voltage to fall below the Under Voltage limit established in Vrms. Adjustable from 0.01 up to 10 seconds in 0.01 second increments. Default = 10.

3/9
OVER VOLTAGE
<Vrms>
If the voltage on any phase rises above this setting the timer is tripped. If the voltage has not subsided by the end of the time period, the system will shut down. Adjustable from 528 down to nominal in 0.1 volt increments. Default = 528.
<Sec>
Establishes time period allowed for any phase voltage to rise above the Over Voltage limit established in <Vrms>. Adjustable from 0.01 to 10 seconds in 0.01 second increments. Default = 10.

4/9
FREQUENCY
<Hz>
Establishes nominal output frequency. Adjustable from 10 to 60 in 0.1 Hz increments. Default = 60.

5/9
UNDER FREQUENCY
<Hz>
If the output frequency falls below this value for the time period established in <Sec>, the system will shut down. Adjustable from 5 to Nominal (established in Item 4/9), in 0.1 Hz increments. Default = 45.
<Sec>
Establishes time period allowed for output frequency to fall below Under Frequency (Hz) before the system will shut down. Adjustable from 0.01 seconds to 10 seconds in 0.01 second increments. Default = 10.

6/9
OVER FREQUENCY
<Hz>
If the output frequency rises above this value for the time period established in Over Frequency Delay <Sec>, the system will shut down. Adjustable from 65 Hz down to nominal (Frequency), in 0.1 Hz increments. Default = 65
<Sec>
If the output frequency exceeds Over Frequency <Hz> for the time period established here, the system will shut down. Adjustable from 0.01 seconds to 10 seconds in 0.01 second intervals. Default = 10.

7/9
VOLT START/RAMP
<Vrms>
Establishes the starting voltage for RampStart. When the output contactor closes, the system will provide demanded current at this starting voltage and immediately begin increasing the voltage at the rate established in Ramp Rate Volts, up to the nominal voltage. Adjustable from 0 to the nominal voltage in one volt increments. Default = 0.
<Vrms/Sec>
Establishes the voltage increase rate for RampStart. When the output contactor closes, the system will provide demanded current at the voltage established in <Vrms> and immediately begin increasing the voltage at this rate. Adjustable from 3 to 6000 volts per second in one volt increments. Default = 3000.

8/9
FREQ START/RAMP
<Hz>
Establishes the starting frequency for RampStart. When the output contactor closes, the system will provide demanded current at this starting frequency and immediately begin increasing the frequency at the rate established, up to the nominal frequency established in 4/10. Adjustable from 0 to the nominal frequency (4/10) in 1 Hz increments. Default = 0.
<Hz/Sec>
When the output contactor closes, the system will provide demanded current at the starting frequency (Freq Ramp Start) and immediately begin increasing the output frequency at this rate. Adjustable from 1 to 2000 in 1 Hz increments. Default = 2000.

9/9
RESTART DELAY
<Min>
Restart Delay <minutes> introduces a time period between an automatic restart command and the actual beginning of the restart sequence. Adjustable from 0.0 to 60.0 minutes, Default = 0.

BATTERY MANAGEMENT—9/11

The Battery Management Menu provides for adjustment of the Stand Alone battery charging parameters.

1/9
AUTO SLEEP TIME
<Hrs>
Establishes the time that an inactive Microturbine will remain in the Standby state, before automatically entering the Sleep state. Adjustable from 0.1 to 23.9. Default = 1 hour.

2/9
MANUAL CHARGE
<Disable/Enable>
Controls whether the system is allowed to recharge the battery when the system is in Grid Connect mode, connected to a live grid, and in the StandBy state. Also works in SA Load State.

3/9
DAY: MON-SUN EQ CHARGE (Battery Equalization)
<Disable/Enable>
Day of Week <Enable/Disable, Mon., Tue., etc.> Allows or disallows a battery equalization charge cycle to occur. Selects the Day of the week to which the following three equalization charge allow parameters apply. Selecting “Inactive” (0 Hour) disallows the entire day. Default = All days active.

3/9 - 9/9 BATTERY EQUALIZATION SUBMENU

1/3 CHARGE ALLOWED
<(Disable/Enable>
Establishes whether automatic battery charging is allowed on the day displayed (3/9). Default = Yes.

2/3 FIRST OK HOUR
Start Hour <00:00>* (User sees 00.)*
Sets the hour of the day after which start of automatic battery charging is allowed. Default = 00:00.

3/3 LAST OK HOUR
End Hour <23:59>* (User sees 23.)*
Sets the hour of the day after which start of automatic battery charging is not allowed. Default = 23:59*. (Only the hours 10* to 23* are changeable.)

*Only the hours 00 to 23 are changeable, NOT the minutes.

NOTE: Once an equalization charge has started it will complete regardless of day and hour permission setting.

UCB RELAYS—10/11

This menu allows the user to establish the logic of the output relays. All are default = 0 (when the state is active, the relay contacts are open).

There are 6 relays and the user may define each relay with any of 11 functions listed below. A function can even be assigned to more than one relay.1/6-6/6

RELAY NUMBER

UCB SUBMENU

<STATE>
The system state will display one of the following system states:

- Standby
- Run
- Contactor Closed
- Fault
- Stand Alone
- SA Load
- Disable
- Fuel On
- Fuel Purge
- Load State
- External Load

The default state for all relays is active open. The first 6 (0-5) are the default functions. All are available as programmable functions:

0 = Standby (System in standby ready to start)

1 = Run (Engine running or power electronics enabled)

2 = Contactor Closed (Output contactor is closed)

3 = Fault (Highest fault severity level in system 3 [fatal /shutdown] or greater)

4 = Stand Alone (system utility connection is Stand Alone)

5 = SA Load (Logical AND between Load and Stand Alone)

6 = Disable (System is disabled or downloading software)

7 = Fuel On (Fuel controls are enabled (NOT idle)

8 = Fuel Purge (Active for 10 seconds after fuel controls are disabled - liquid fuel only)

9 = Load State (Active when the Microturbine is in the Load State)

10 = External Load (This output indicates when the external load may be engaged).

<OPTION> (Active Open / Close)

ACTIVE OPEN—Normally closed relay contact opens when function is true.

ACTIVE CLOSED—Normally open relay contact closed when function is true.

EXAMPLE: If relay 1 is programmed to show the stand-by condition and it is programmed active open, then the relay will be open (high impedance) when the system is in stand-by. In all other states the relay will be closed (low impedance). If relay 1 is programmed to show the stand-by condition and it is programmed active closed then the relay will be closed (low impedance) when the system is in stand-by. In all other states the relay will be open (high impedance).

- STANDBY

  When the system is in the Standby state, the Standby relay contacts will be either open or closed depending on this setting.

- RUN

  Determines whether the Run relay contacts are open or closed when the engine is running or power electronics are enabled.

- CONTACTOR CLOSED

  Allows the user to choose the state of the Load relay contacts (open or closed) when the output contactor is closed.

- FAULT

  When a fault is active, this setting determines whether the Fault relay contacts will be open or closed when the system active faults creates a severity level greater than a warning.

- STAND ALONE

  If the Microturbine is in the Stand Alone mode, the Stand Alone relay contact logic (either open or closed) is determined by this setting.

- STAND ALONE LOAD

  If the Microturbine is in the SA mode and in the Load State, this setting determines whether the SA Load relay contacts will be open or closed.

- DISABLE

  When the system is in the disable state, the contacts will be either open or closed depending in the setting.

- FUEL ON

  The Fuel On relay contacts will be open or closed depending on this setting.

- FUEL PURGE

  Contact will be either open or closed for 10 seconds after the main fuel shutoff is closed.

- LOAD STATE

  The output relay contacts will be open or closed depending on Load state setting.

- EXT LOAD

  The relay contacts will be open or closed depending on the Ext Load setting. The relay indicates when the external load may be engaged. For example, the relay can be used to run/stop the Fuel Gas Booster in low pressure systems.

UNIT DATA—11/11

Displays real-time data for each Microturbine in a MultiPac system. Select turbine on line 2; line 3 & 4 will display data for that turbine. Line 2 will only allow Turbine 1 for a single system or a slave system in a MultiPac.

TURBINE 1 - 10

UNIT DATA SUBMENU—1/21

TURBINE (State)
System state of operation. The system state will display one of the following system states:

- Power-up
- Stand-by
- Prepare to start
- Liftoff
- Accel
- Run
- Load
- Recharge
- Light off
- Cooldown
- Warmdown
- Restart
- Idle recharge
- Shutdown
- Fault
- Disable
- Software download

FAULT
The system event severity level displays the highest event severity level. There are 7 event severity levels. They are listed below with general descriptions of the events:

Level 0: No Fault

Level 1: Minor error, do not log

Level 2: Warning, log and continue to run

Level 3: Shut down error, re-start OK

Level 4/5: Power to DPC lost, re-start possible

Level 6: E-Stop, re-start if cleared

Level 7: Disabling condition, no re-start possible

2/21
Kw
The actual output in kW
kw DEMAND
Power Demand <kW> Microturbine displays power output in kilowatts and <Dmd> and shows demanded power.

3/21
FREQUENCY
Displays the Microturbine's output frequency.
VOLTAGE A
Actual output rms voltage, phase A [VA] in AC volts.

4/21
VOLTAGE B:
Actual output rms voltage, phase B [VB] in AC volts
VOLTAGE C:
Actual output rms voltage, phase C [VC] in AC volts

5/21
CURRENT A
Actual output rms current, phase A in amps
CURRENT B
Actual output rms current, phase B in amps

6/21
CURRENT C
Actual output rms current, phase C in amps

7/21
TET (Turbine Exit Temperature, °C/°F)
Temperature of turbine
RPM
Current operating speed

8/21
FUEL PRESSURE
The inlet fuel pressure. Display may be in kilo Pascals (kPa) or pounds per square inch (psi).
FUEL PERCENTAGE
Percent Fuel Device (actual). The reading ranges from 0% (no fuel) to 100% (maximum fuel).

9/21
BATTERY VOLTAGE, BATTERY CURRENT
Measurement of battery in Stand Alone system

10/21
SOC (State of Charge)
Displays temperature-adjusted battery state of charge
BASE SOC
Displays battery base state of charge; current calculated SOC in Stand Alone system.

11/21
LAST EQ DATE
Date of last battery equalization charge
OF EQ CHARGES
Total number of battery equalization charges

12/21
ABORTED CHARGES
Number of aborted equalization charges
BAT STA (Battery State) (0-7)
Current battery state

13/21
CHARGE STATE
Displays battery charge state (0 to 5)
CHARGE STAGE
Displays battery charge stage (0 to 2)

14/21
BAT: BATTERY TEMPERATURE
Temperature of battery pack
BATT: BATTERY <Kw>
kW output by the battery in SA mode

15/21
T1 (INLET TEMPERATURE)
The air temperature at the inlet of the compressor. Display may be in Fahrenheit or centigrade.
AMBIENT PRESSURE <po KpA>
The ambient air pressure. Display may be in kilo pascals (kPa) or pounds per square inch (psi).

16/21
DCV
Displays the DC Bus Voltage.
PSV
Displays the Power Supply Voltage (For ASP's).

17/21
INV (INVERTER TEMPERATURE)
The inverter (LCM) temperature.
GEN (GENERATOR TEMPERATURE)
The generator (ECM) temperature.

18/21
EST (EMERGENCY STOP)
The number of times the Microturbine has experienced an emergency stop condition.
RFC LOW T
Not used at the present time.

19/21
MX S
Maximum speed engine has operated at. (For ASP's).
MAX TET:
Maximum TET temperature system has operated at.

20/21
MX PWR
Maximum power output system has produced. (For ASP's).

21/21
<Hours>
The total bearing time of the system.
<Starts>
The total, cumulative number of engine starts, including motoring, for the system.

Appendix B: Specifications

	GTAA	GTAB
Electrical Power (3-Ph)	30 kW	60 kW
Voltage (Frequency)—Grid Connect	400-480 VAC (45-65 Hz)	400-480 VAC (45-65 Hz)
Voltage (Frequency)—Stand Alone	150-480 VAC (10-60 Hz)	150-480 VAC (10-60 Hz)
Power (Current) / Phase—Stand Alone	10 kW (46 amps)	20 kW (100 amps)
Maximum (10-Sec) Current / Phase—Stand Alone	54 amps	110 amps
Full-Load Fueling Rate	440,000 kJ (417,000 Btu)	918,000 kJ (870,000 Btu)
Useable Exhaust Heat (ISO Conditions)	305,000 kJ (290,000 Btu)	571,000 kJ (541,000 Btu)
Exhaust Temperature	261-315° C (500-600° F)	225-338° C (490-640° F)
Maximum Design Exhaust Temperature	315° C (600° F)	370° C (700° F)
Maximum Exhaust Back Pressure	32 kPa (8 in WC)	32 kPa (8 in WC)
Exhaust Gas Flow	17 NM^3/ MIN (575 SCFM)	28 NM^3/ MIN (900 SCFM)
Maximum Inlet Air Restriction (Pressure Drop)	0.125 kPa (0.5 in WC)	0.125 kPa (0.5 in WC)
Engine Air Flow	15.6 NM^3 / MIN (550 SCFM)	26.6 NM^3 / MIN (900 SCFM)
Electronics Cooling Air Flow (SA & GC)	11.3 NM^3 / MIN (400 SCFM)	9.6 NM^3 / MIN (330 SCFM)
Battery Module Cooling Air Flow (SA)	5.6 NM^3 / MIN (200 SCFM)	8.4 NM^3 / MIN (290 SCFM)
Fuel Gas Compressor Cooling Air	17 NM^3 / MIN (600 SCFM)	–
Maximum Cooling Air Temperature	50° C (122° F)	50° C (122° F)
Minimum Cooling Air Temperature	-20° C (-4° F)	-20° C (-4° F)

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