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Technical Reference

Dual Mode Controller Technical Information

Introduction

This document presents operational and installation information for the Capstone Dual Mode Controller, hereafter referred to as the DMC. The DMC interfaces with Capstone Model C30 and C60 MicroTurbines to transition MicroTurbine power to protected loads during an electric utility outage.

The DMC is available in four different voltage ranges: 440-480V, 200-220V, 380-420V, 220-260V, and each range is full current-rated between 125A and 1200A, depending on the number of configured MicroTurbines in the system. Each DMC is housed in a NEMA 4 enclosure. Table 1 lists available configurations.

Figure 1 presents a DMC configured for 480V, full current-rated at 600A.

Figure 1. Dual Mode Controller (DMC)

Configuration Options

Dual Mode Controllers are available in many options to meet site configuration requirements. Configuration options are listed in Table 1.

Table 1. DMC Configurations

Voltage Range	Part Number	Current Rating	Site Configuration
200 - 220	512802-00X	125A	1 Model C30
	512508-00X	225A	1-2 Model C30's, 1 Model C60
	512509-00X	400A	1-4 Model C30's, 1-2 Model C60's
	512510-00X	600A	1-6 Model C30's, 1-3 Model C60's
	512511-00X	800A	1-8 Model C30's, 1-4 Model C60's
	512512-00X	1200A	1-13 Model C30's, 1-6 Model C60's
220 – 260	512923-00X	125A	1-2 Model C30's, 1 Model C60
	512924-00X	225A	1-4 Model C30's, 1-2 Model C60's
	512925-00X	400A	1-8 Model C30's, 1-4 Model C60's
	512926-00X	600A	1-13 Model C30's, 1-6 Model C60's
	512927-00X	800A	1-17 Model C30's, 1-8 Model C60's
	512928-00X	1200A	1-26 Model C30's, 1-12 Model C60's
380 – 420	512914-00X	125A	1-2 Model C30's, 1 Model C60
	512915-00X	225A	1-4 Model C30's, 1-2 Model C60's
	512916-00X	400A	1-8 Model C30's, 1-4 Model C60's
	512917-00X	600A	1-13 Model C30's, 1-6 Model C60's
	512918-00X	800A	1-17 Model C30's, 1-8 Model C60's
	512919-00X	1200A	1-26 Model C30's, 1-12 Model C60's
440 – 480	512801-00X	125A	1-2 Model C30's, 1 Model C60
	512503-00X	225A	1-4 Model C30's, 1-2 Model C60's
	512504-00X	400A	1-8 Model C30's, 1-4 Model C60's
	512505-00X	600A	1-13 Model C30's, 1-6 Model C60's
	512506-00X	800A	1-17 Model C30's, 1-8 Model C60's
	512507-00X	1200A	1-26 Model C30's, 1-12 Model C60's

Theory of Operation

MicroTurbine(s) operate in Grid Connect mode when the utility grid is performing normally and outputting power on a consistent basis. However, during a utility power outage, many applications require power generation to automatically switch to Stand Alone mode operation to supply current for protected loads.

The DMC enables MicroTurbines to automatically transition from Grid Connect operation to Stand Alone operation when a utility power outage occurs. A motor-operated switch in the DMC isolates the MicroTurbine(s) and protected loads during Stand Alone operation.

When utility power is restored, the DMC can be set to automatically return the MicroTurbine(s) and protected loads to Grid Connect operation. The DMC also allows the MicroTurbine(s) to be used as an automatically dispatched standby generator for Protected loads.

An overall DMC block diagram is provided in Figure 2.

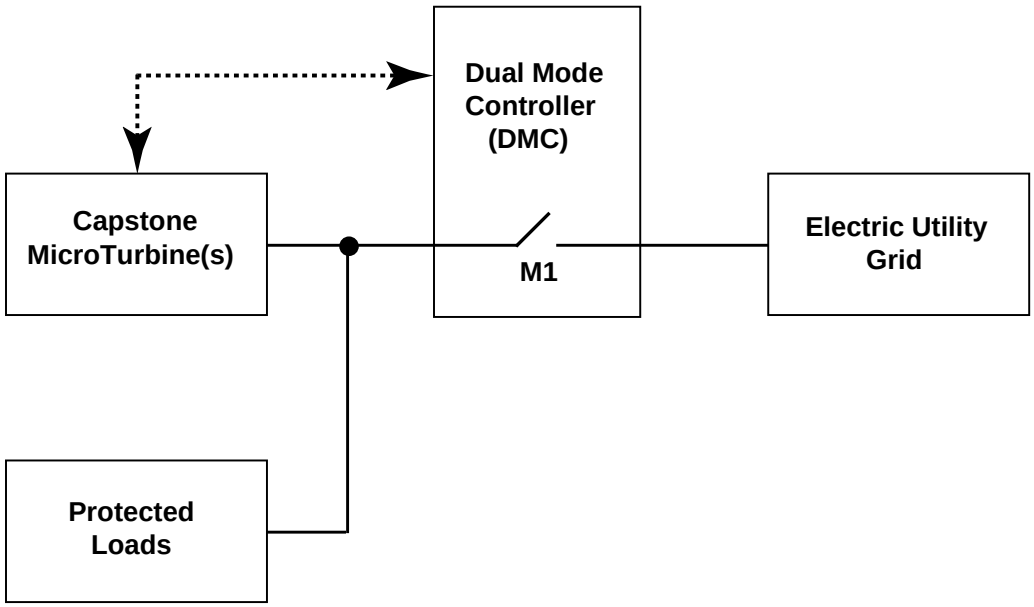

Figure 2. DMC Block Diagram

Safety Interlocks

In a Dual Mode installation, the MicroTurbine has a set of safety interlocks designed to prevent the unit from operating in Stand Alone when connected to the utility. These interlocks interface with an auxiliary contact of the Isolation switch inside the DMC to isolate the MicroTurbine from the utility. Utility companies are concerned that utility worker safety may be compromised if they come in contact with a de-energized line section that becomes energized by a distributed or standby generator.

When operating in Grid Connect mode, the MicroTurbine contains protective relay functions to ensure that the unit does not energize the utility lines unless the frequency and voltages on each phase are within operating limits defined in the interconnection agreement with the utility. These protective functions are designed to prevent a MicroTurbine operating in Grid Connect mode from energizing a line that has been de-energized by the utility.

When operating in Stand Alone mode, the MicroTurbine(s) is designed to be the sole source of power in the local power system comprising the MicroTurbine(s) and the Stand Alone loads. In this mode, MicroTurbine(s) are capable of energizing a de-energized power system. Therefore, it is important that the MicroTurbine(s) are always operating in Grid Connect mode when running in parallel with the utility and should only be operated in the Stand Alone when they are isolated from the utility.

The DMC provides a second level of interlock with the MicroTurbine(s), which operates independently from an auxiliary contact-based interlock. In this interlock level, a solid-state relay in the Communications Bay of the UCB is programmed to close when MicroTurbines enter the Stand Alone Load state. When the relay closes, it immediately energizes the shunt trip of the isolation device in the DMC and removes power to the motor operator, keeping the isolation device in the open state.

In a MultiPac system, the interlocks are only required on the master turbine. The master communicates the status of the interlocks and the operating mode to the subordinate MicroTurbines. If communication fails to a subordinate unit, the subordinate will shutdown.

Safety Precautions

Only Capstone Authorized Service Providers (ASP's) should open the MicroTurbine enclosure or the DMC enclosure due to the inherent danger of multiple power sources. Observe the following Safety Precautions when servicing the DMC:

- ❑ Command the MicroTurbine system to OFF (if not OFF already).
- ❑ Open and lock the dedicated disconnect switch to de-energize the MicroTurbine from the utility grid, and isolate the MicroTurbine from loads.
- ❑ Isolate and lockout all sources of power to the DMC.
- ❑ Disconnect all incoming fuel sources to the MicroTurbine.
- ❑ Set the Stand Alone battery circuit breaker to OFF (if installed)
- ❑ Wait at least 5 minutes after disconnection from the utility grid before servicing to allow for electrical energy dissipation.
- ❑ Open the DMC enclosure and verify that no voltage is present on any electrical terminals.
- ❑ Conduct maintenance operations in a clean and well-lighted area.
- ❑ Handle electronic components using best practice safety guidelines to prevent damage to equipment and preclude injury.

Read and adhere to the instructions contained in this document completely, prior to installing or operating the DMC, or installing or operating MicroTurbines connected to the DMC.

User Controls and Indicator Lamps

The DMC has two user controls: POWER ON and MODE SELECT, and three indicator lamps: MICROTURBINE AWAKE status, LOAD POWER and LINE POWER.

Figure 3 shows the front panel location of the user controls and indicator lamps.

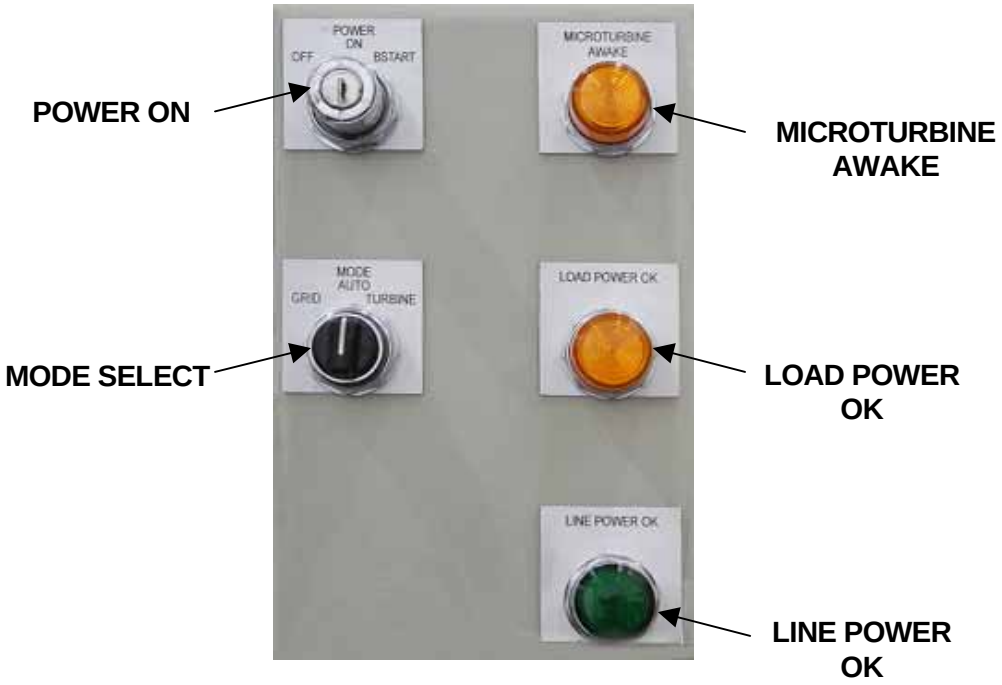

Figure 3. DMC Front Panel

POWER ON Switch

The DMC may be set to ON or OFF and the key may be removed in either position.

When the DMC is set to OFF, the MicroTurbine(s) will be shutdown and protected loads will be isolated from the utility, provided that 12 or 24 volts DC is available from the MicroTurbine(s) to trip the Isolation switch (M1).

When the DMC is set to ON, the operating state of the MicroTurbine(s) and the Isolation switch (M1) will depend on the utility voltages and the dispatch settings on the DMC and the MicroTurbine(s).

When the DMC is set to BSTART, the MicroTurbine awakens if it has entered the battery-saving sleep state. The spring-return action switch quickly returns to the ON position. Do NOT use the BSTART position if the MICROTURBINE AWAKE lamp is illuminated. Only use the BSTART position to awaken the MicroTurbine(s) immediately prior to a Stand Alone start to prolong battery life.

The table below summarizes the POWER switch position options.

S/W Position	POWER Switch Parameters
OFF	MicroTurbine(s) are shutdown. Protected loads and MicroTurbine(s) are isolated from the utility; that is if 12 or 24 volts DC is available from the MicroTurbine(s) to trip Isolation switch (M1).
ON	The MicroTurbine operating mode and Isolation switch status are controlled by the MODE switch and by MicroTurbine dispatch settings.
BSTART	Provides a momentary signal to awaken MicroTurbine(s) that may have been in sleep mode.

MODE Switch

The MODE and dispatch setting of the MicroTurbine(s) may be set with this rotary switch for the Grid Connect Only mode, Automatic Transition mode, or for the Stand Alone Only mode. The table below summarizes the MODE switch position options.

S/W Position	MODE Switch Parameters
GRID	MicroTurbines may be dispatched in Grid Connect mode only. During a utility outage, the MicroTurbines will shutdown, and protected loads will not receive power.
AUTO	The MicroTurbine(s) are dispatched automatically in Grid Connect mode when the utility lines are energized, and in Stand Alone mode during a utility outage. When a utility outage occurs, protected loads will be without power for approximately 2-4 minutes. When utility power is restored, the protected loads will be re-connected to the utility within 5 seconds. However, the MicroTurbine may be down (offline) for up to 45 minutes.
TURBINE	The MicroTurbine(s) may be dispatched in Stand Alone only. MicroTurbines and protected loads are electrically isolated from the utility, only if 12 or 24 VDC is available to trip the Isolation switch (M1).

LOAD POWER (LP1) Indicator Lamp

The LOAD POWER lamp illuminates when protected loads are energized by either the utility, or the MicroTurbine(s).

LINE POWER (LP2) Indicator Lamp

The LINE POWER lamp illuminates when the utility voltages are at an acceptable level and of the correct rotational sequence (L1- L2-L3). If the LINE POWER lamp does not illuminate when the DMC is first energized by the utility, check the utility supply for both correct voltage and for correct rotational sequence.

MICROTURBINE AWAKE (LP3) Indicator Lamp

The MICROTURBINE AWAKE lamp illuminates when the MicroTurbine controls are energized. In a MultiPac system, this lamp illuminates when the master MicroTurbine controls are energized.

Dispatch Modes

Grid Connect Operation Settings

Device/ Parameter	Setting	Location
POWER Switch (S1)	ON	DMC Front Panel
MODE Switch (S2)	GRID	DMC Front Panel

NOTE: Protected loads will be connected to the utility, provided utility power is available to close the Isolation switch (M1).

Stand Alone (Standby) Operation Settings

Device/ Parameter	Setting	Location
POWER Switch (S1)	ON	DMC Front Panel
MODE Switch (S2)	TURBINE	DMC Front Panel

NOTE: Protected loads will be isolated from the utility, provided 12 or 24 volts DC is available from the MicroTurbine(s) to open the Isolation switch (M1).

Dual Mode (Grid Connect/Standby) Operation Settings

These settings are required to configure the DMC and MicroTurbines to perform an automatic transition between Grid Connect and Stand Alone modes during a utility outage, and return to the Grid Connect mode as utility voltage is restored.

Device/ Parameter	Setting	Location
DMC POWER (S1) Switch	ON	DMC Front Panel
DMC MODE (S2) Switch	AUTO	DMC Front Panel
Battery Circuit Breaker on MicroTurbine(s)	ON	Refer to the site documentation for circuit breaker location
MicroTurbine Power Connection	DUAL MODE	MicroTurbine Display Panel/CRMS
MicroTurbine Auto Restart	ON	MicroTurbine Display Panel/CRMS
MicroTurbine Auto Load	ON	MicroTurbine Display Panel/CRMS
MicroTurbine Start Input (Configured as Grid Connect and as a standby generator)	GC USER/ SA REMOTE	MicroTurbine Display Panel/CRMS
MicroTurbine Start Input (Auto dispatched as Standby generator only)	REMOTE	MicroTurbine Display Panel/CRMS
MicroTurbine UCB Solid State Relay Output # N (wired to DMC terminals 9 & 10)	SA LOAD, ACTIVE CLOSED	MicroTurbine Display Panel/CRMS

Internal Components

DMC internal components are shown (480V, 125A model) in Figure 4:

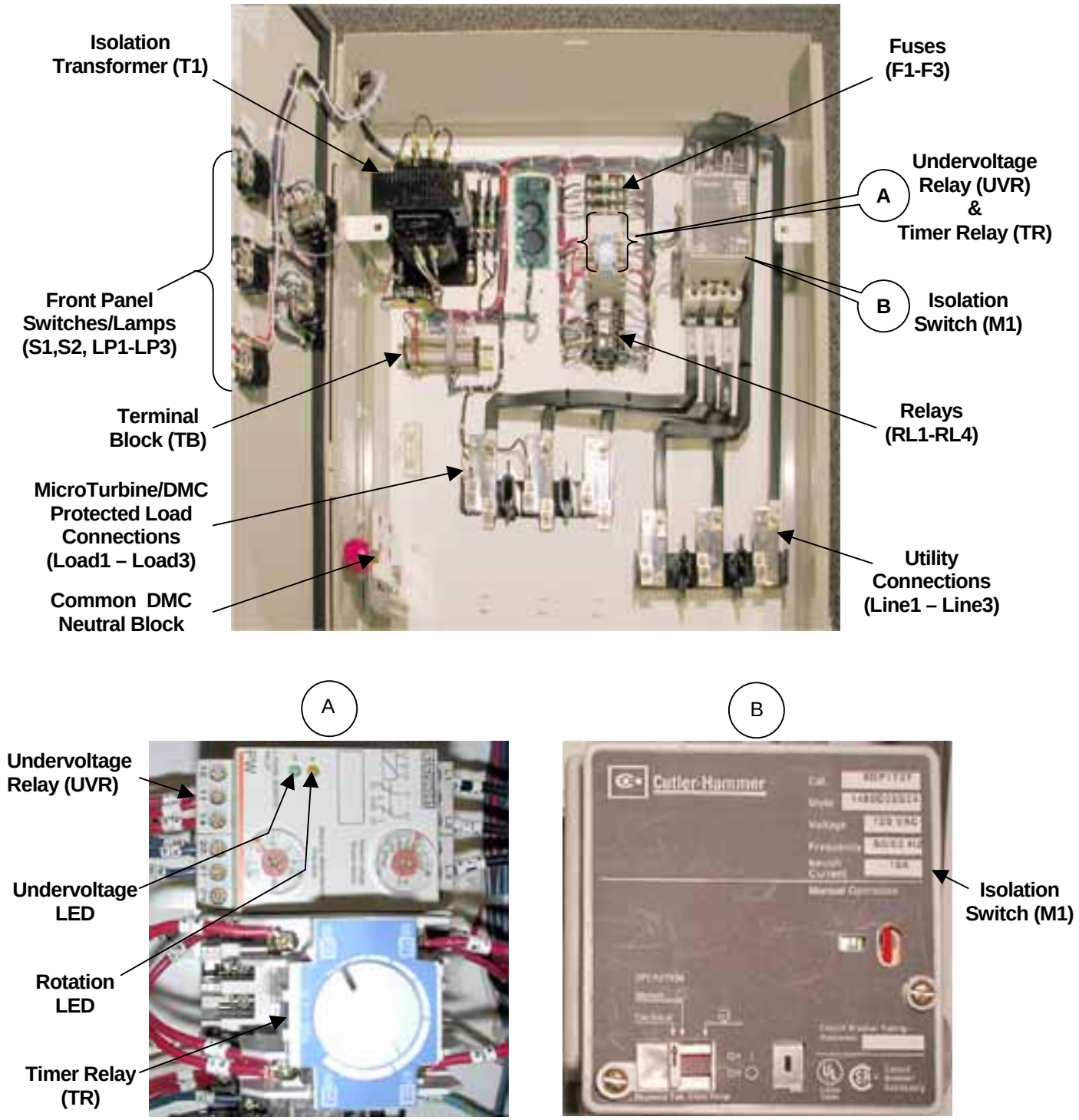

Figure 4. DMC Internal Components

Commissioning

NOTE	Verify the following contents before installation: DMC cabinet and assembly items, keys for the Power Switch, and all applicable mechanical and electrical drawing packages.

Commissioning Sequence

Perform DMC commissioning in the sequence listed:

1. Perform pre-installation verification test (see *Pre-installation Verification Test*)
2. Perform DMC installation (see *Installation* section)
    - Set DMC switches/settings
      (see *Typical DMC Voltage Ranges, Control Power Transformer Configuration, DMC Isolation Switch Logic, Undervoltage Relay and Timer Relay Settings*)
    - Perform power connections and check phase rotation (see *Power Connections*)
    - Perform control signal connections (see *Control Signal Connections*)
3. Configure MicroTurbine UCB.
4. Apply DMC/MicroTurbine power.

Pre-Installation Verification Test

NOTE	This procedure should be performed before connecting ANY power or signal connections between the DMC and the MicroTurbine(s) and customer load.

A pre-installation verification check must be performed to verify the DMC is functioning properly. Complete the following steps:

1. Verify the M1 Isolation switch slider switch is set for electrical operation.
2. Perform all steps listed in the Commissioning Checklist Procedures Work Instructions (440052), “Dual Mode Controller Commissioning” section.
3. If the Isolation switch closes, there should be an audible click.
4. If the Isolation switch does not close, perform the test again and observe the “Rotation” LED on the Undervoltage relay.

   If the LED does not illuminate, the possibility exists that the DMC is out of phase with the utility. Temporarily interchange either the utility grid line connections to the DMC, or the terminal leads to the Undervoltage relay marked “L1”, “L2”, “L3”, and retry the test.

4. If the Isolation switch still does not close, contact Capstone Technical Support.

Installation

Installation Parameters

The DMC must be mounted within 100 cable feet of the MicroTurbine. For a MultiPac installation, the DMC must be within 100 cable feet of the master MicroTurbine/ PowerServer.

The DMC is designed to accommodate all connections through conduit brought into the bottom of the DMC cabinet. On 400A, 600A, 800A and 1200A units, removable floor stands are also provided for installation purposes. For indoor installations, connections may be brought into the top or sides of the cabinet if this is more convenient.

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A typical indoor installation shown with conduit connections is shown in Figure 5.

Figure 5. Typical Indoor DMC Installation

Typical DMC Voltage Ranges

The DMC will typically operate within the voltage ranges noted below.

DMC Operating Voltage	DMC Nominal Line Voltage
208 Volts	200 to 220 VAC (± 5%) @ 50/60 Hz
240 Volts	220 to 240 VAC (± 5%) @ 50/60 Hz
380 Volts	380 to 420 VAC (± 5%) @ 50/60 Hz
480 Volts	440 to 480 VAC (± 5%) @ 50/60 Hz

DMC Isolation Switch Logic

Conditions for Isolation Switch (M1) operation are as follows:

1. Conditions to close the Isolation Switch (M1):
   - POWER switch (S1) is in the ON or BSTART position
   - AND, the MODE switch (S2) must be in the AUTO or GRID position
   - AND, utility voltage must be within acceptable range of undervoltage relay
   - AND, the MicroTurbine(s) must not be in the Stand Alone Load state.
2. Conditions to open the Isolation Switch (M1):
   - POWER switch (S1) must be in the OFF position
   - OR, the MODE switch (S2) is in TURBINE position
   - OR, the MODE switch (S2) is in AUTO position AND utility voltage is not within acceptable range of undervoltage relay
   - OR, MicroTurbine(s) are in Stand Alone Load state.

   IN ALL CASES, 12V/24V power MUST be available from the MicroTurbine(s) to trip Isolation switch S1.

Control Power Transformer Configuration

The DMC contains a Control Power Transformer (CPT) that provides 120 volts (nominal) for use by the components internal to the DMC.

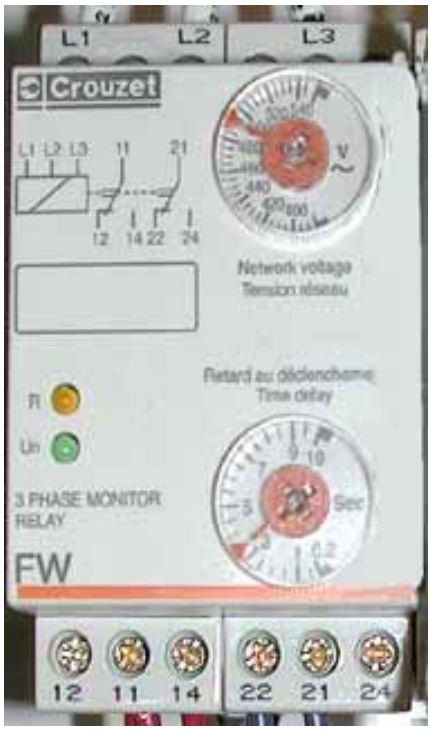
The CPT contains various taps on the primary and secondary. The taps are configured for the correct voltage range prior to shipping from the factory and DO NOT require adjustment at installation.

As a check, verify that the DMC voltage range is correctly rated for the line voltage at the point of installation. The voltage rating is displayed on the DMC door.

Undervoltage and Timer Relay Settings

Undervoltage Relay

The DMC contains an undervoltage relay that determines whether and/or when to isolate the MicroTurbine(s) and protected loads from the utility grid. The undervoltage relay (UVR) setting can only be changed from inside the DMC cabinet and its function is independent of the protective functions within the MicroTurbine Refer to the Protective Relays Technical Reference manual (410033).



The undervoltage relay isolates protective loads when any phase voltage of the utility grid falls to 85 percent of the trip setting. If the illuminated LED “UV” turns off, the DMC has failed to reach the required voltage in a preset amount of time.

The trip setting is adjustable (upper dial) from the front of the relay. Typically, this should be set to the nominal line voltage. As shipped, the undervoltage relay is set to match the voltage rating of the voltage-rated DMC. However, this setting can be changed at installation.

The undervoltage relay also ensures that DMC phase sequence is consistent with the utility phase rotation. If incorrect phase rotation wiring is detected, the illuminated LED “R” will turn off and Grid Connect operation is disallowed. The utility, MicroTurbine(s) and protected loads MUST ALL be connected in a consistent phase rotation sequence. Normally, this sequence is L1-L2-L3. However, in cases where the utility phase rotation is determined to be OTHER THAN L1-L2-L3, the MicroTurbine, M1 Isolation switch, undervoltage relay and protected load connections must ALL be re-wired for consistent phase rotation with the utility.

The UV time delay setting (lower dial) allows the user to manually configure the time lapse (1 to 10 sec) before the DMC undervoltage relay trips. The delay is only effective if L1-L2 voltage remains greater than 50 percent of nominal. Otherwise, the relay will drop out immediately.

Timer Relay

The DMC contains a timer relay dial (.1 to 30 sec) that sets the delay between the solenoid operator controlling the M1 Isolation switch, as it moves from trip to OFF, then OFF to ON. The installer SHOULD NOT adjust this dial – the dial is factory preset to 1 second. This relay is not related to the undervoltage user settings associated with the MicroTurbine.

Power Connections

WARNING	All sources of electrical power to the DMC cabinet MUST BE isolated prior to opening the cabinet door. This includes both the electrical utility grid, and the MicroTurbine(s).

The real power and line current requirements of protected loads must be less than the real power and line current rating of the MicroTurbine (or MultiPac) to support protected loads in Stand Alone operation. Consult MicroTurbine Performance technical reference manuals for power ratings at the local temperature and elevation. The in-rush current of the protected loads must also be considered when sizing the MicroTurbine(s).

Some load types are sensitive to phase sequence and may operate incorrectly or unsafely when connected to a source of incorrect phase sequence. Before operating protected loads, verify the utility supply and MicroTurbines are connected to the DMC in a consistent L1-L2-L3 phase sequence, and protected loads are compatible with a L1-L2-L3 sequence. The undervoltage relay will prevent Grid Connect operation unless the utility phase sequence is L1-L2-L3.

For MultiPac installations, interconnections between the MicroTurbine(s) must be made in accordance with the MultiPac Operation Technical Reference (410032). Refer to the Electrical Installation Technical Reference manual (410009) for electrical wiring for utility and protected loads.

Control Signals Connections

Cable Requirements

A 10-conductor shielded cable should be used to make the control signal connections from the DMC to the UCB Communications Bay in the (master) MicroTurbine.

NOTE	The maximum length for this cable must not exceed 100 feet.

Wiring parameters include the following items:

- The shielded cable wire must be 18 to 10 AWG, inclusive.
- The cable must be rated for at least 24 Vdc.

The shield itself should be connected to the CHASSIS terminal at the MicroTurbine UCB end only.

Connection Requirements

NOTE	In a MultiPac system, DMC control signal connections are made to the MicroTurbine master turbine only. The master communicates all necessary information to the subordinate units.

Perform the following steps to configure DMC control signals.

1. Program an available solid-state output relay in CRMS to SA LOAD, ACTIVE CLOSED prior to performing any UCB communications bay hardware connections. Relay 1 is used in the figures as an example. But any of the output relays may be used. The relay output MUST BE configured PRIOR to connection on the MicroTurbine UCB to prevent possible damage to the DMC.

CAUTION	If the Isolation switch (M1) cycles open and closed more than three times, DE-ENERGIZE the DMC immediately, and re-check wiring and/or the configuration of the selected solid-state relay output.

2. Connect DMC terminal block pins 9 and 10 to the pre-selected MicroTurbine UCB or PowerServer solid-state output relay. The selected output relay number must correspond to the assignment in CRMS (see step 1).
3. Connect the DMC Stand Alone Enable interlock to digital ground. This is done via a normally closed auxiliary contact on the isolation device (DMC terminals 1 and 3). Also, the Grid Connect Enable interlock connects to digital ground via a normally open auxiliary contact of the Isolation switch (DMC terminals 1 and 2).
4. For DMC to PowerServer interface, an additional connection must be made between the MicroTurbine and PowerServer to enable battery wakeup.

Control signal connections between the DMC and C30/C60 MicroTurbines are presented in Figures 6 and 7. Connections between the DMC and the (optional) Capstone PowerServer are presented in Figure 8. The MicroTurbine connections shown are representative of similar connections to a MultiPac Master turbine.

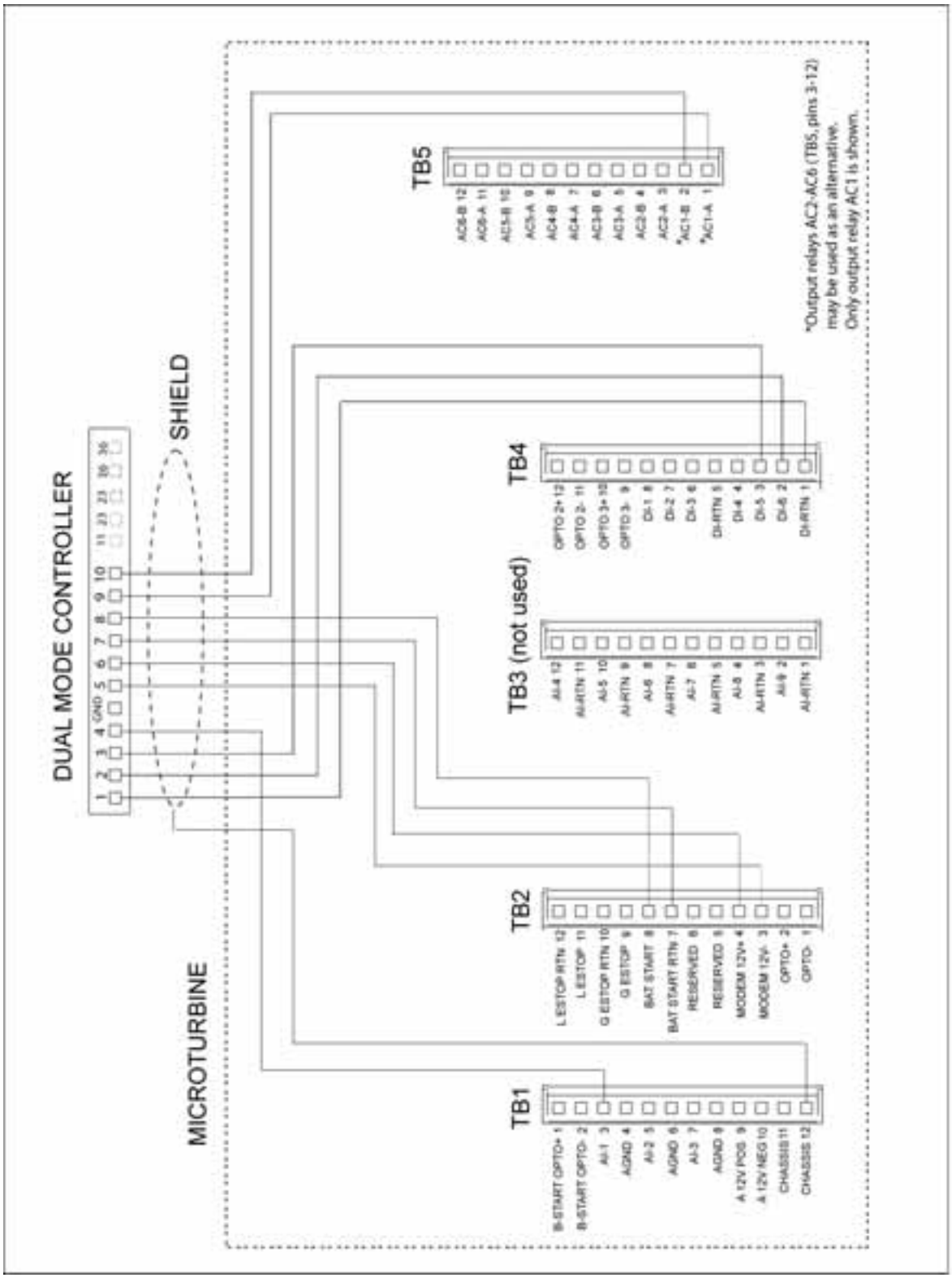


Figure 6. DMC to Model C30 Control Signal Connections

The control signal connections for the Model C30 are detailed in the table below.

Model C30 – Control Signal Connections

DMC Terminal #	Description	Model C30 UCB Connection
1	Signal Ground	TB4-1 DI-RTN
2	GC Enable	TB4-2 DI-6 (Remove all existing jumpers)
3	SA Enable	TB4-3 DI-5 (Remove all existing jumpers)
4	Run/Stop	TB1-3 AI-1
5	DC Power Ground	TB2-3 MODEM 12V-
6	12 Volt DC Power Positive	TB2-4 MODEM 12V+
7	Battery Start A	TB2-7 BAT-START RTN
8	Battery Start B	TB2-8 BAT-START
9	SA Load Active Closed A	TB5-(2N-1) $1 \leq N \leq 6$ AC (N)-A
10	SA Load Active Closed B	TB5-2N AC (N)-B
No Connection	Cable Shield	TB1-12 CHASSIS

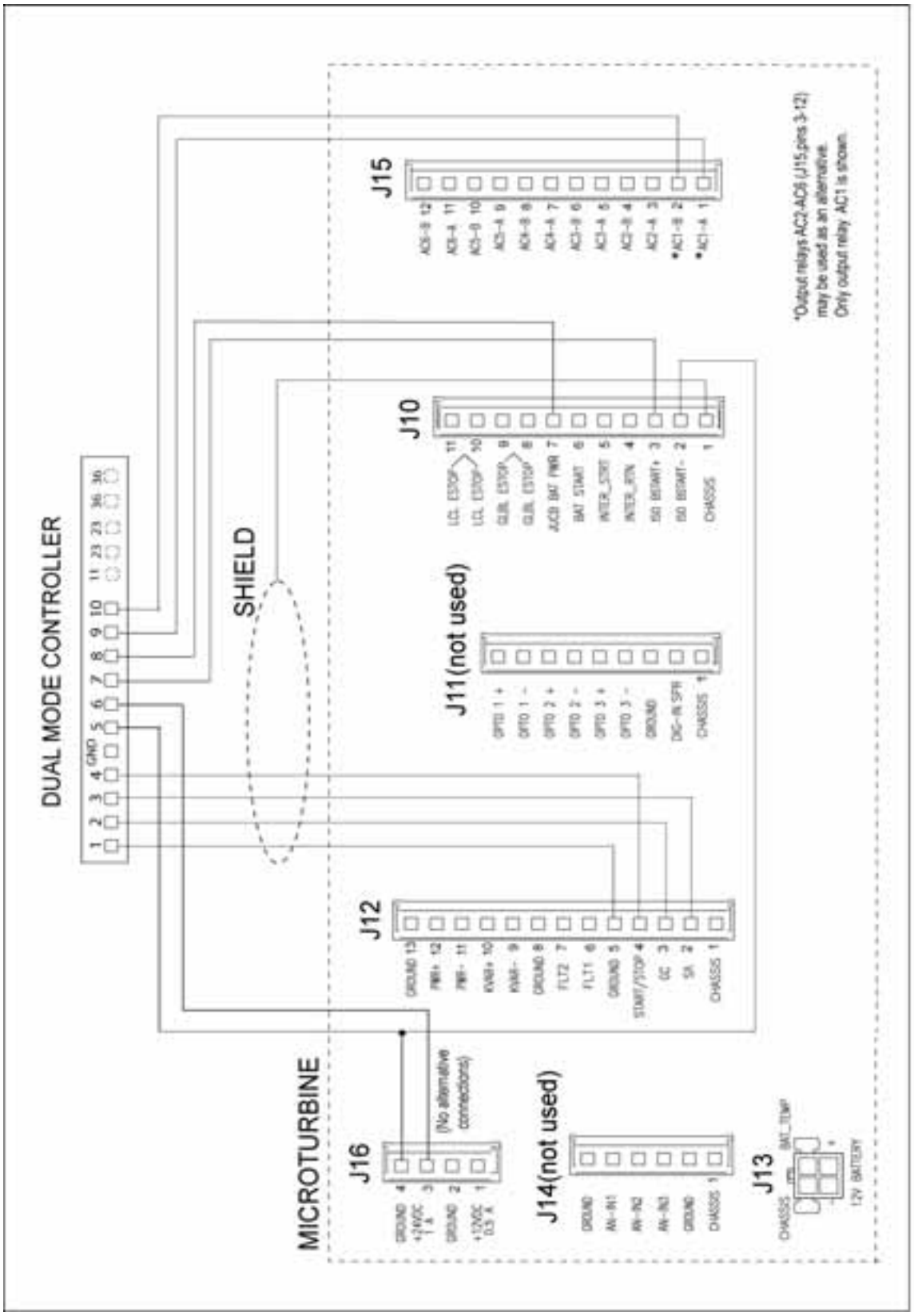
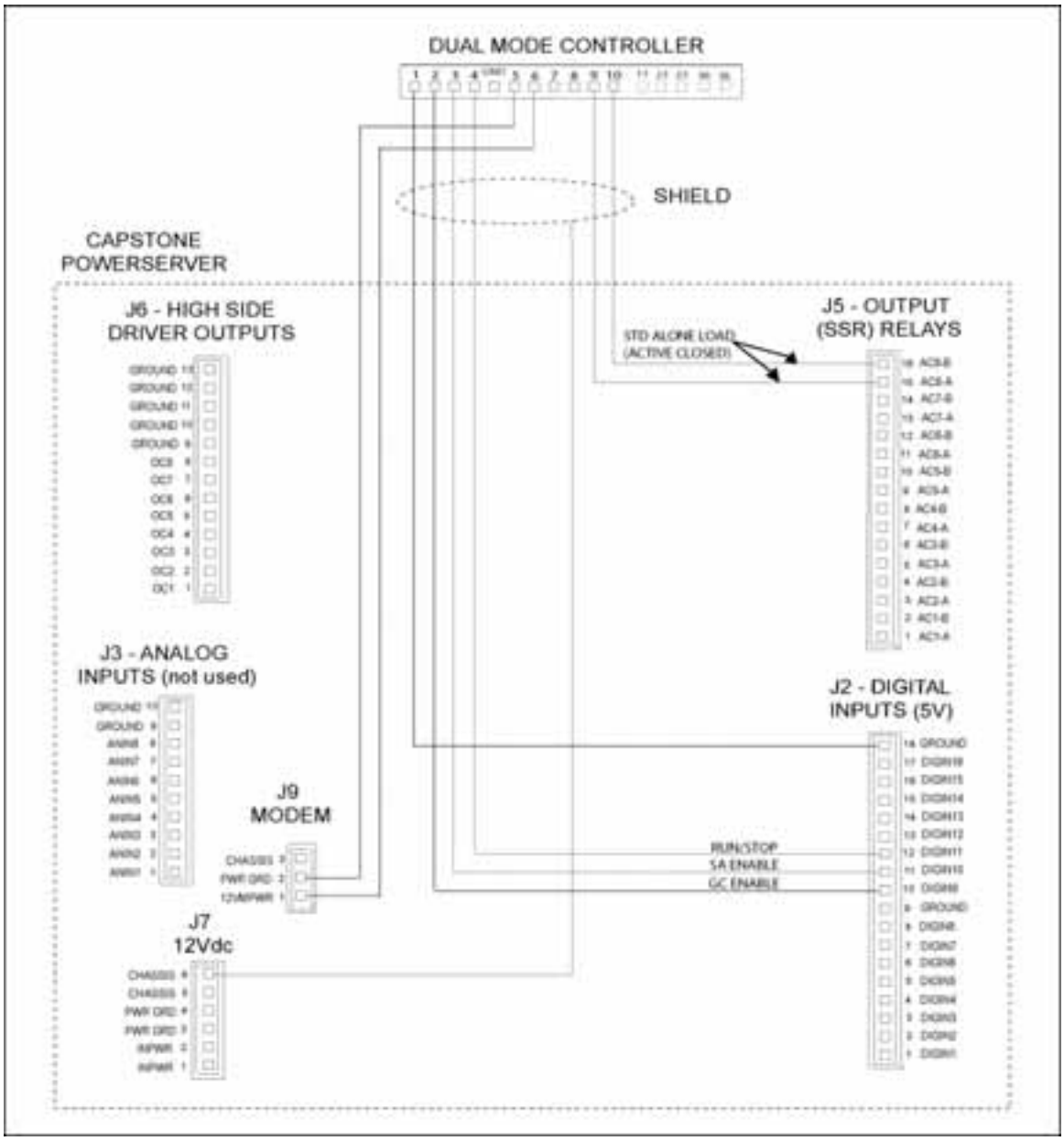


Figure 7. DMC to Model C60 Control Signal Connections

The control signal connections for the Model C60 are detailed in the table below.

Capstone C60 – Control Signal Connections

DMC Terminal #	Description	JUCB Connection
1	Signal Ground	J12-5 GROUND
2	GC Enable	J12-3 GC (Remove all existing jumpers)
3	SA Enable	J12-2 SA (Remove all existing jumpers)
4	Start/Stop	J12-4 START/STOP
5	DC Power Ground	J16-4 GROUND J10-2 ISO BSTART-
6	24 Volt DC Power Positive	J16-3 +24 VDC
7	Battery Start A	J10-3 ISO BSTART+
8	Battery Start B	J10-7 JUCO BAT PWR
9	SA Load Active Closed A	J15-(2N-1) $1 \leq N \leq 6$ AC (N)-A
10	SA Load Active Closed B	J15-(2N) AC (N)-B
No Connection	Cable Shield	J10-1 CHASSIS



Also, external signal connections must be established from the PowerServer to the MicroTurbine to establish a battery start command. These signals are available on Capstone RJ-485 interconnection cable 513087. Connections are as shown:

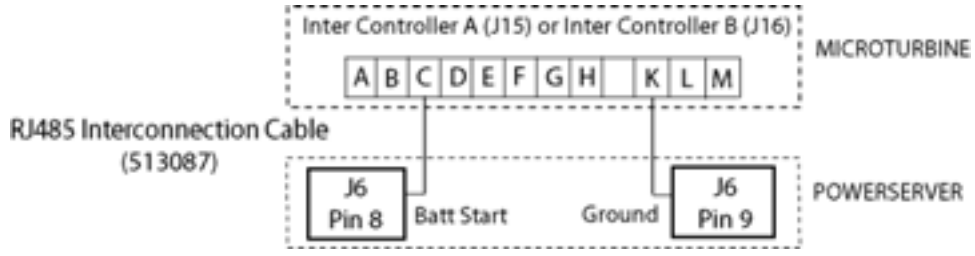


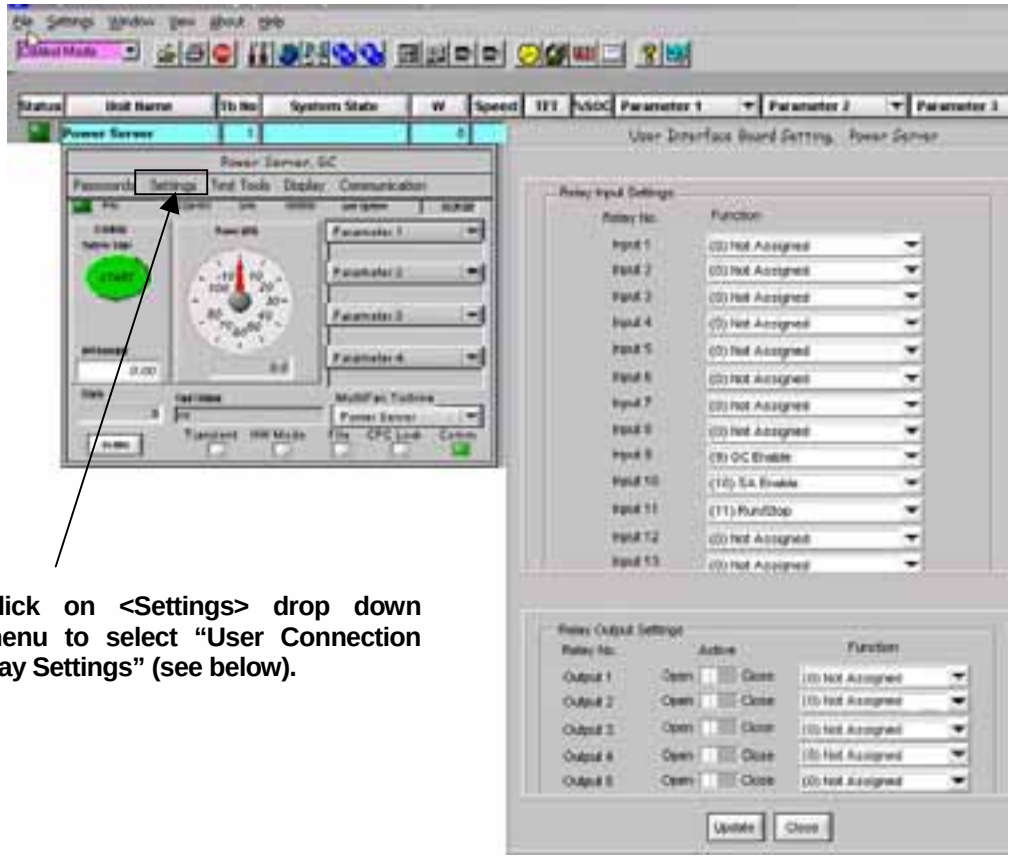
Figure 8. DMC to PowerServer Control Signal Connections

MicroTurbine Software Settings

There are two user software settings which need to be configured to associate PowerServer relay functionality with the User Interface Board. These can be accomplished using CRMS or the Display Panel.

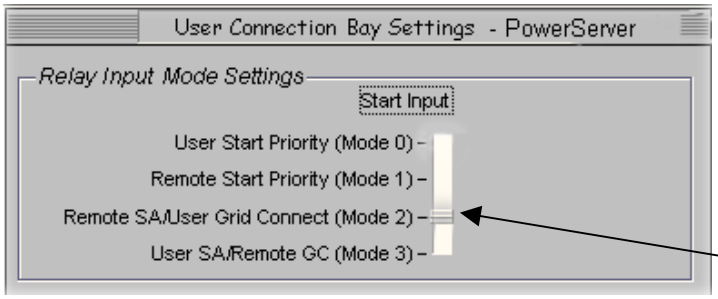
- Start Input
- Input/Output Relay settings.

CRMS



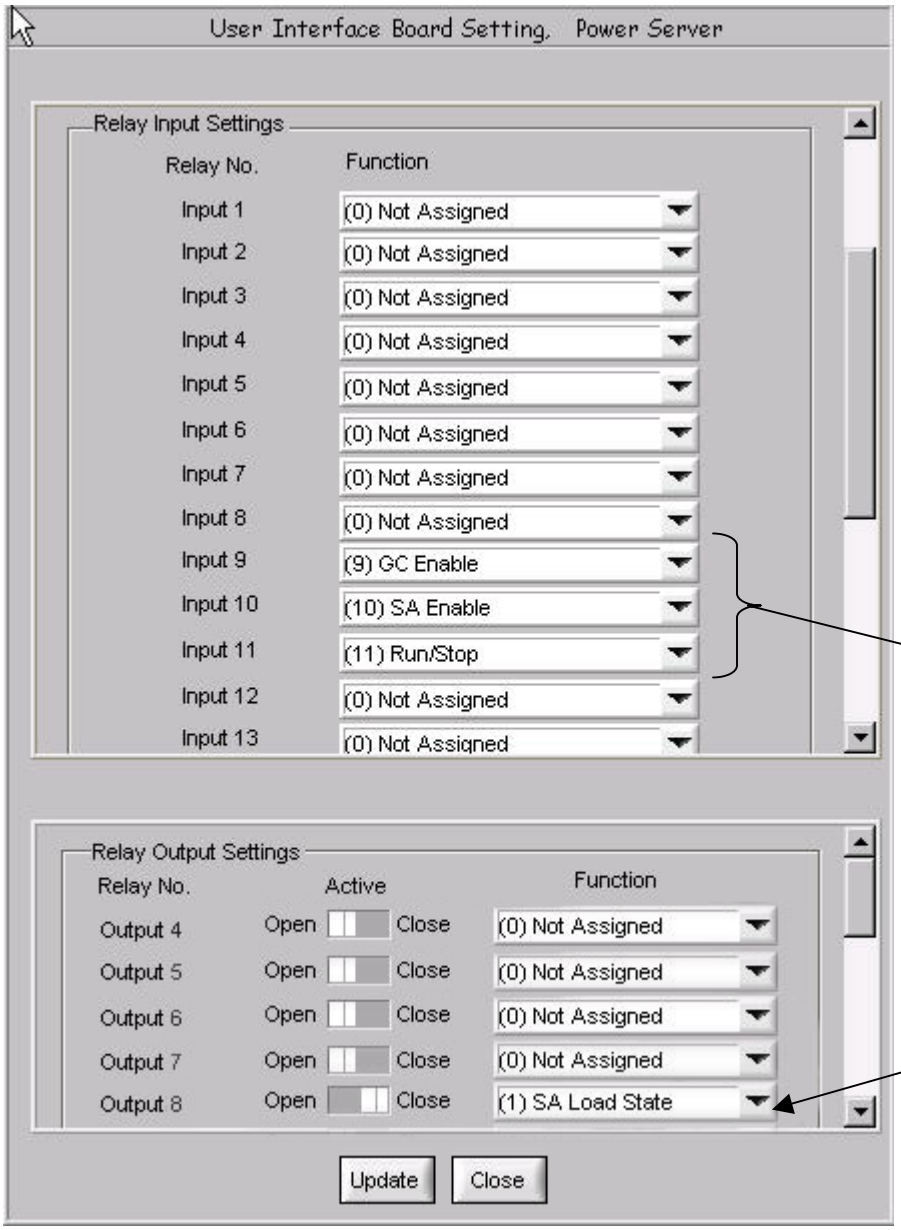
Click on <Settings> drop down menu to select "User Connection Bay Settings" (see below).

1. In the **User Interface Board Setting – PowerServer** screen, set the Start input slider to "*Remote SA/User Grid Connect (Mode 2)*"



Set to MODE 2 – "Remote SA/ User GC"

2. Assign Input and Output Relays as follows:



Default input relay settings shown in Fig. 8.

Output Relays #8 has been selected to match Figure 8.

NOTE: Any output relay (1-8) may be selected, but must match the UCB board connections.

Display Panel

1. Set the Start input option to: *System Data > System Configuration >Start Input* and then select option 3, "Remote_GC_User_SA".

System Configuration	Parameter Description	Parameter Value	Default
REMOTE_SA_USER_GC	Sets GC start priority and the remote switch priority in Stand Alone	3 – Remote SA/ User GC	No

2. Assign output relays as follows:

UCB RELAYS	Parameter Description	Parameter Value	Default
Relay No (1-8)	Selection of output relay to be used	1-8	N/A
<STATE>	Establishes logic of the User Interface Board output.	0 – Open 1 – Closed	0
<OPTION>	Establishes Stand Alone Load State	(1) SA LOAD STATE	0

<RELAY NUMBER>

Select output relay number 1-8.

<STATE>

Adjusts the OPEN /CLOSED condition of the output. The default state for all relays is active OPEN (digital outputs are high)

ACTIVE OPEN (OPEN = 0)

Normally Closed relay contact opens when function is true.

ACTIVE CLOSED (CLOSED = 1)

Normally Open relay contact closes when function is true.

EXAMPLE:
If relay 1 is programmed to show the stand-by condition and is programmed ACTIVE OPEN, 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).

<OPTION>

The following options are required:

SA_LOAD_STATE (Function #1)

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.

Normal Transition Sequence

When the utility voltage is acceptable, the DMC will connect the MicroTurbine(s) and protected loads to the utility.

If the MicroTurbine Start Input is configured as REMOTE, the unit will act as a standby generator and will never start in Grid Connect mode. The MicroTurbine(s) will periodically charge the batteries using power from the utility.

If the MicroTurbine Start Input is configured as GC USER/SA REMOTE, the unit will start and dispatch power in Grid Connect mode according to the settings for User Start, User Power Level, Time of Use, and Load Following. The MicroTurbine(s) will periodically charge the batteries using power from the grid or from the engine if the MicroTurbine is operating.

When a utility outage occurs, the DMC will isolate the MicroTurbine(s) and protected loads from the utility and will automatically dispatch the MicroTurbine(s) to start in the Stand Alone mode, regardless of the Grid Connect dispatch control settings.

Grid Connect-to-Stand Alone Transition

The following sequence occurs during the automatic transfer from Grid Connect mode to Stand Alone mode.

1. The utility voltage is acceptable. The undervoltage relay in the DMC is not tripped. The DMC POWER Switch (S1) is set to ON and the MODE Switch (S2) is set to AUTO. The Isolation switch (M1) is closed. The MicroTurbine(s) and protected loads are connected to the utility. The MicroTurbine(s) is either in the Standby state, or operating in the Grid Connect mode, depending on the dispatch settings.
2. A utility outage begins. The undervoltage relay in the DMC senses the utility outage, and then opens the normally open UVR contacts and closes the normally closed UVR contacts.
3. The LINE POWER lamp (LP2) extinguishes.
4. Relay RL1 de-energizes. This closes the normally closed contacts RL1, which is one of the conditions required for Stand Alone operation.
5. Relay RL3 energizes. This closes the normally open contacts RL3 and energizes the shunt trip of Isolation switch (M1).
6. Isolation switch (M1) moves into the tripped position. This isolates the MicroTurbine(s) and protected loads from the utility. Auxiliary contacts M1-A1 close and auxiliary contacts M1-A2 open. This has no effect at this stage. The motor operator remains de-energized due to the normally open UVR contacts - therefore M1 cannot close.
7. The LOAD POWER lamp (LP1) extinguishes.

8. Auxiliary contacts M1-A3 close and the MicroTurbine Stand Alone Enable line is pulled low (enabled). Auxiliary contacts M1-A4 open and the MicroTurbine Grid Connect enable is pulled high (disabled). The MicroTurbine(s) may now operate in Stand Alone mode, but not Grid Connect mode. The MicroTurbine run/stop signal is also pulled low, via diode D1 - this enables the MicroTurbine(s) to start.

9. If the MicroTurbine(s) had been operating in Grid Connect mode, an orderly shutdown (warmdown) is initiated. This shutdown may have been triggered by the protective relay functions of the MicroTurbine(s), before the under voltage relay in the DMC tripped. The MicroTurbine(s) completes the warmdown cycle and enters the Grid Connect Standby state in 2 to 3 minutes. If the MicroTurbine(s) had not been operating in Grid Connect mode at the time of the utility outage, they would have been in the Grid Connect Standby state from Step 1.

10. The Grid Connect Enable is pulled high (disabled) and the Stand Alone Enable is pulled low (enabled), so the MicroTurbine(s) leaves the Grid Connect Standby state immediately, passes through the Invalid state, and enters the Stand Alone Standby state.

11. The Run/Stop signal is pulled low, so the MicroTurbine(s) initiates a start in Stand Alone mode. If the MicroTurbine(s) had been operating previously in the Grid Connect mode, it takes approximately one minute to complete the Stand Alone Start sequence, before being ready to reach to Stand Alone Load state. If the MicroTurbine(s) had been in the Grid Connect Standby state, this can take up to two minutes.

12. Once the Stand Alone Start sequence is completed, the MicroTurbine(s) will transition to the Stand Alone Load state, provided that Auto Load is enabled. The MicroTurbine(s) will then provide power to the protected loads.

13. The LOAD POWER lamp (LP1) illuminates.

14. The Solid State Relay in the User Connection Bay (UCB) programmed SA LOAD ACTIVE CLOSED and connected to terminals 9 and 10 of the DMC will close.

15. Relay RL4 energizes. This closes normally open contacts RL4 and relay RL3 is energized regardless of the state of the undervoltage relay contacts. Also, normally closed contacts RL4 open and relay TR is de-energized, regardless of the state of the undervoltage relay contacts - therefore, Isolation switch (M1) will not close.

Stand Alone-to-Grid Connect Transition

The following sequence of events occurs during the automatic transfer from Stand Alone mode to Grid Connect mode.

1. The utility voltage is not acceptable (undervoltage relay in the DMC is tripped). The DMC POWER switch (S1) is set to ON, and the MODE switch (S2) is set to AUTO. The Isolation switch (M1) is open. The MicroTurbine(s) and protected loads are isolated from the utility. The MicroTurbine(s) are operating in Stand Alone mode and are providing power to protected loads.
2. The utility outage ends. Following a fixed 0.5 second time delay set on the undervoltage relay in the DMC, the normally open contacts UVR close, and the normally closed contacts UVR open.
3. The LINE POWER lamp (LP2) illuminates.
4. Relay RL1 energizes. This opens normally closed contacts RL1 and the MicroTurbine Stand Alone enable is pulled high (disabled). Also, the run/stop signal is pulled high (stop).
5. The MicroTurbine(s) initiate an orderly shutdown, transitioning from the Stand Alone Load state to the Stand Alone Recharge state. The MicroTurbine(s) output is shutdown and the output contactor(s) open. Protected loads are de-energized.
6. The LOAD POWER lamp (LP1) extinguishes.
7. The Solid State Relay in the User Connection Bay (UCB) programmed SA LOAD ACTIVE CLOSED and connected to terminals 9 and 10 of the DMC will open.
8. Relay coil RL4 de-energizes. This opens normally open contacts RL4, and relay RL3 is de-energized, removing power from the shunt trip of Isolation switch (M1). In addition, the normally closed contacts RL4 close.
9. Timer Relay TR is energized. This closes normally open contacts TR and starts the delayed contact transition.
10. Delayed contact TR (NCTO) is closed and delayed contact TR (NOTC) is open. The OFF line of the motor operator is energized and the ON line of the motor operator is de-energized. The motor operator moves the Isolation switch (M1) to the OFF position.

11. Timer delay TR activates the delayed contacts. Delayed contact TR (NCTO) opens and delayed contact TR (NOTC) closes. The OFF line of the motor operator is de-energized and the ON line of the motor operator is energized. The motor operator moves the Isolation switch (M1) to the ON position. Auxiliary contacts M1-A1 open, timer relay TR de-energizes, contacts TR and TR (NOTC) open and contact TR (NCTO) closes. Both the ON and OFF lines of the motor operator are now de-energized. Therefore, the Isolation switch (M1) remains in the closed position. Auxiliary contacts M1-A2 close, but this has no effect. Auxiliary contacts M1-A3 open, which has no effect at this time. Auxiliary contacts M1-A4 close and the MicroTurbine Grid Connect enable is pulled low (enabled).
12. When Isolation switch (M1) closes, the MicroTurbine(s) and protected loads are connected to the utility. At this point, protective loads are re-energized. The total time protected loads are without power is approximately five seconds.
13. The LOAD POWER lamp (LP1) illuminates.
14. The MicroTurbine(s) complete a battery recharge and cool down cycle. This can take up to 45 minutes, depending on the battery state-of-charge. Then, the MicroTurbine(s) then enters the Stand Alone Standby state.
15. The MicroTurbine Stand Alone Enable is pulled high (disabled) and the Grid Connect Enable is pulled low (enabled), so the MicroTurbine(s) leaves the Stand Alone Standby state immediately, pass through the Invalid state, and then move to the Grid Connect Stand-by state.
16. Depending on the dispatch mode set up from Grid Connect, the MicroTurbine(s) either remain in the Grid Connect Standby state or will start and dispatch power in the Grid Connect Load state. The Grid Connect restart sequence can take up to two minutes.

Capstone Technical Support

If questions arise regarding Dual Mode Controller operation, please contact Capstone Turbine Technical Support for assistance and information.

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