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Technical Reference

Dual Mode Controller Technical Information

Publisher

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PRODUCT OVERVIEW

Safety Precautions

WARNING	Do not work on MicroTurbines, the Dual Mode Controller or related equipment if gas odor is detected.

Read and understand the Safety Information section of the Capstone MicroTurbine™ User's Manual (400001 for C60 or 400017 for C65) before working on the Capstone MicroTurbines, the Dual Mode Controller and related equipment. Failure to obey all safety precautions and general instructions may cause personal injury and/or damage to the equipment.

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.

Symbols

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

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

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

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

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/C65 MicroTurbines to allow MicroTurbines to operate in the Grid Connect mode and transition MicroTurbine output power to protected loads during an electric utility outage.

The DMC is available in four different nominal operating voltages: 208V, 240V, 380V, and 480V. Each operating voltage is full current-rated between 125A and 1200A, depending on the number of configured MicroTurbines in the system.

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

Figure 1. Dual Mode Controller (DMC)

An optional DMC Annunciator Panel (see Figure 2), when connected to the DMC, displays the MicroTurbine status and mode of operation, and can shut down the MicroTurbine(s) when an emergency situation occurs.

Figure 2. DMC Annunciator Panel

Product Description

MicroTurbine(s) operate in Grid Connect mode when the utility grid is performing normally. However, during a utility power outage, many applications require generators to support Stand Alone operation to provide power for protected loads.

The DMC enables the C60/C65 MicroTurbines to automatically transition from Grid Connect operation to Stand Alone when a utility power outage occurs. A motor-operated switch in the DMC isolates the MicroTurbine(s) and protected loads from the grid during Stand Alone operation. When utility power is restored, the DMC automatically reconnects the protected loads to utility grid.

The DMC also allows the MicroTurbine(s) to be automatically dispatched as a standby generator for protected loads.

An overall DMC block diagram is provided in Figure 3.

An optional Capstone Protective Relay, hereafter referred to as CPR, when connected to the DMC, can be used as an external trip device.

An optional Capstone Advanced Power Server, hereafter referred to as APS, can be used to interface with the DMC. In this configuration, the DMC allows the APS to control and enable Capstone C30 and C60/C65 MicroTurbines to operate in Grid Connect mode and transition MicroTurbines output power to protected loads during an electric utility outage.

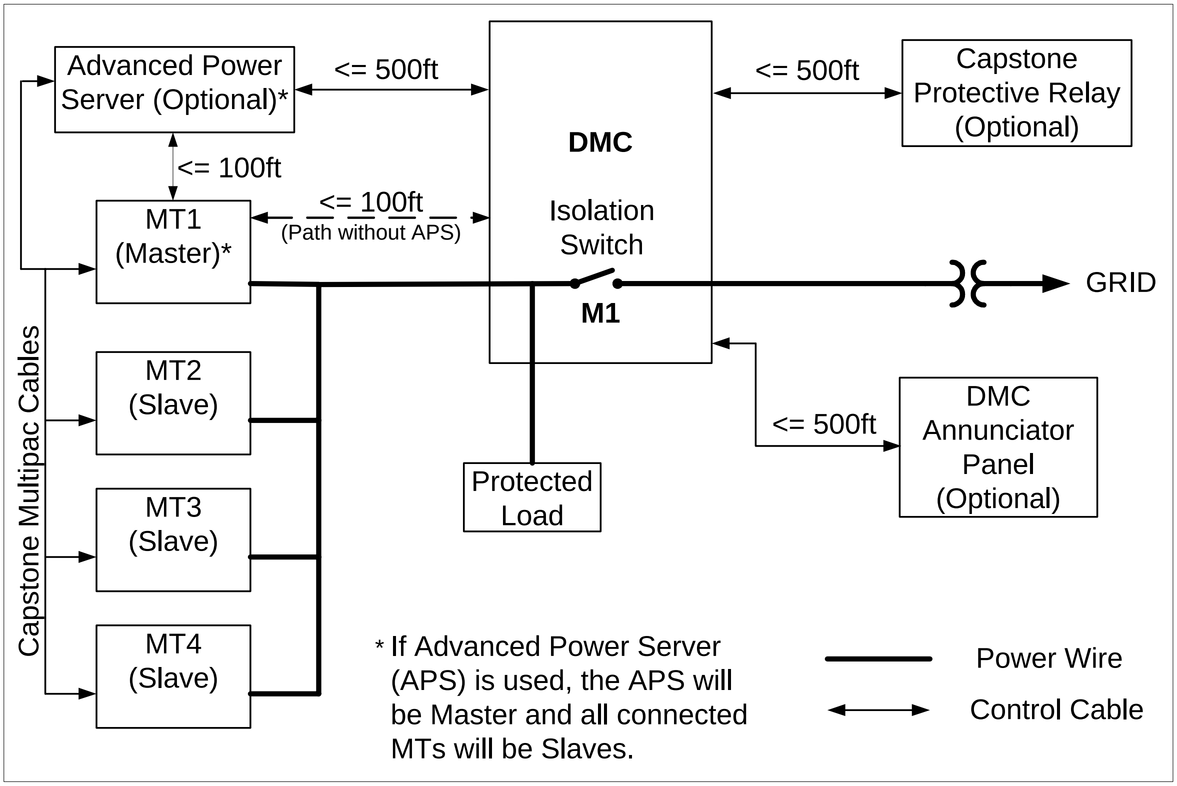


Figure 3. DMC Block Diagram

Fast Transfer Capability

The fast transfer capability of the DMC enables C60/C65 MicroTurbines, with software version 4.5 or higher, to automatically transition from Grid Connect operation to Stand Alone operation within 10 seconds of a utility power outage. Refer to the DMC Fast Transfer Specification section in this document for details.

The earliest DMC configuration, identified by the suffix -001 in the part number, did not have fast transfer capability. Capstone supplies an upgrade kit, as specified in Work Instruction 440123, which adds the fast transfer capability to existing DMC models with the -001 part number suffix. This upgrade re-identifies a modified DMC by changing the part number suffix to -003. DMC configurations whose part numbers include the suffix -002 are manufactured with the fast transfer capability and do not require an upgrade.

Appendixes at the end of this document contain wiring diagrams and schematics for all DMC configurations. Refer to Table 1 for a description of each DMC configuration as it relates to fast transfer capability, as well as the applicable Appendix.

Table 1. DMC Configuration Cross Reference

DMC P/N Suffix	Description	Appendix
-001	No fast transfer capability.	A
-003	Fast transfer retrofit.	B
-002	Manufactured with fast transfer capability.	C

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.

DMC 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 4 shows the front panel location of the user controls and indicator lamps. Refer to DMC User's Manual (400009) for details of the user controls and indicators.

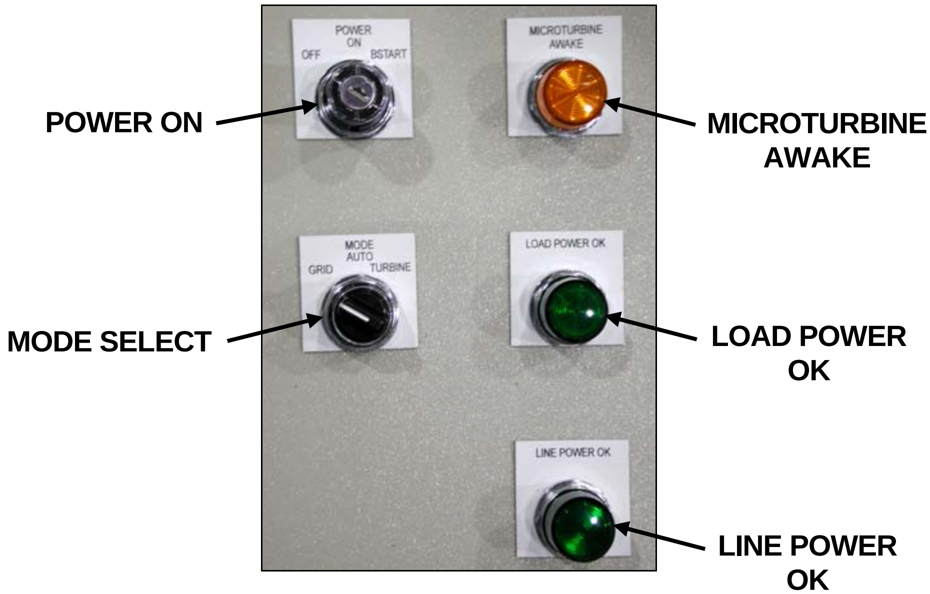


Figure 4. DMC Front Panel

DMC Annunciator Panel

The optional DMC Annunciator Panel displays the status of the MicroTurbines and the power availabilities of utility and protective load.

Figure 5 shows the front panel layout for the DMC Annunciator Panel. Refer to DMC User's Manual (400009) for panel details.

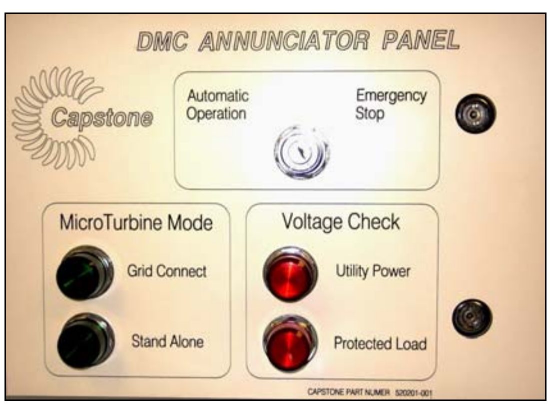


Figure 5. DMC Annunciator Panel

Internal Components

Figure 6 shows internal components for a DMC in the -001 or -003 configuration, and Figure 7 shows internal components for a DMC in the -002 configuration. Both figures show the 480V, 125A model.

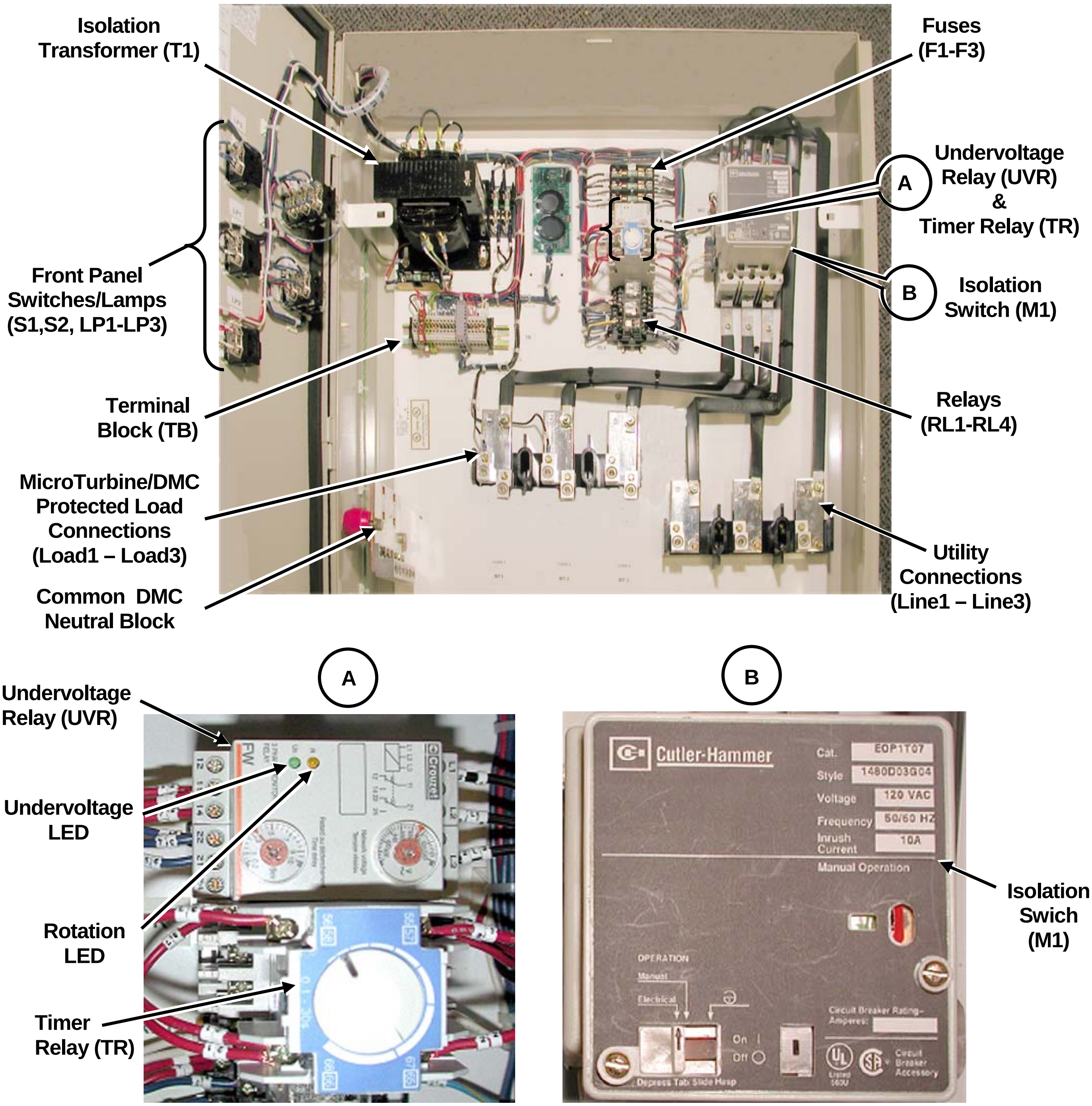


Figure 6. DMC Internal Components (-001 or -003)

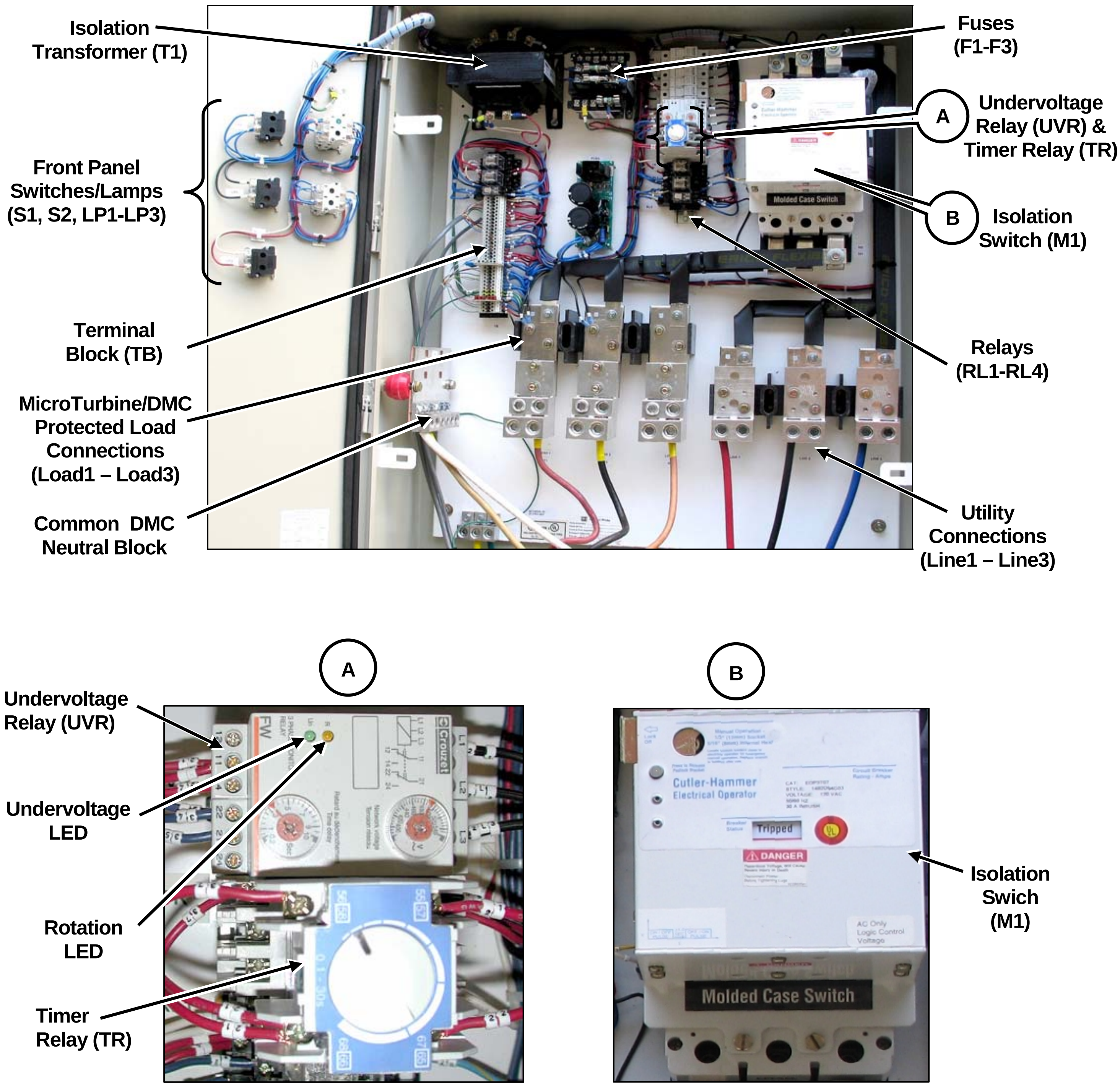


Figure 7. DMC Internal Components (-002)

Control Cable Specification

The control cable requirements for DMC interface are as follows:

DMC Annunciator Panel Control Cable

DMC interfaces with DMC Annunciator Panel through a shielded cable with multiple conductors (up to 500 ft). The wires can be 18 to 22 AWG. The wires are rated at 600V, 105 °C.

Capstone Protective Relay Control Cable

DMC interfaces with the CPR through a shielded 2-conductor (or multi-conductor) cable (up to 500 ft). The wires can be 18 to 22 AWG. The wires are rated at 300V, 75 °C.

MicroTurbine Control Cable

DMC interfaces with the MicroTurbine through a shielded cable with multiple conductors (up to 100 ft). The wires can be 18 to 22 AWG. The wires are rated at 300V, 75 °C.

Advanced Power Server Control Cable

DMC interfaces with the APS through a shielded cable with multiple conductors (up to 500 ft). The wires can be 18 to 22 AWG. The wires are rated at 300V, 75 °C.

Electrical Specification

DMC Operating Voltages

DMC operates within the voltage ranges shown in Table 2.

Table 2. DMC Operating Voltage Ranges

DMC Operating Voltage	DMC Line Voltage Range
208 Volts	187 to 229 VAC (208 ± 10%) @ 50/60 Hz
240 Volts	216 to 264 VAC (240 ± 10%) @ 50/60 Hz
380 Volts	342 to 418 VAC (380 ± 10%) @ 50/60 Hz
480 Volts	432 to 528 VAC (480 ± 10%) @ 50/60 Hz

DMC Annunciator Panel

The voltage source used to light the status lamps is provided by the DMC. The 115VAC or 120VAC voltage is supplied by the DMC through a fuse.

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 M1.

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.

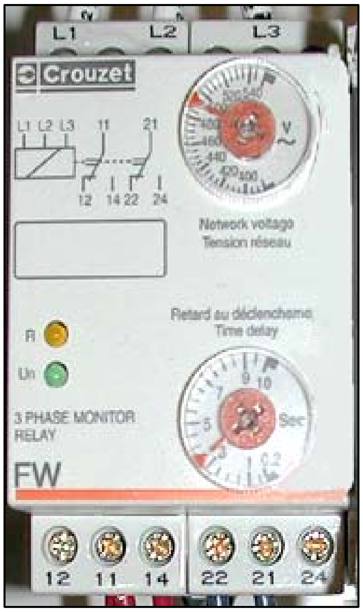
The CPT contains various taps on the primary and secondary. The taps are configured for the correct voltage range prior to shipping from the factory and **do not** require adjustment at installation.

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 (410004 for C30, 410005 for C60, or 410048 for C65) 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 (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 APS 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 APS interface, an additional connection must be made between the MicroTurbine and APS to enable battery wakeup.

Control signal connections between the DMC and C30/C60/C65 MicroTurbines are presented in Figure 8 through Figure 11. Connections between the DMC and the (optional) APS are presented in Figure 12. The MicroTurbine connections shown are representative of similar connections to a MultiPac Master turbine.

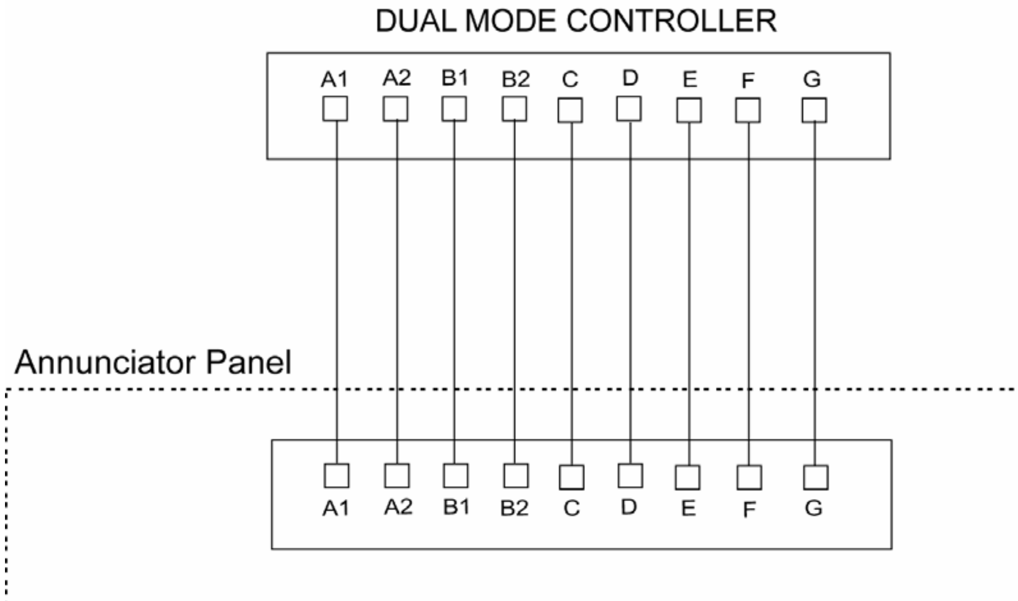


Figure 8. DMC to Annunciator Panel Connections

The control signal connections for the DMC Annunciator Panel are detailed in Table 3.

Table 3. Annunciator Panel Control Signal Connections

DMC Terminal #	Description	Annunciator Panel Terminal #
A1	Auto Stop	A1
A2	Auto Stop	A2
B1	Auto Stop	B1
B2	Auto Stop	B2
C	GC Mode	C
D	SA Mode	D
E	Load Power	E
F	Grid Power	F
G	Neutral	G

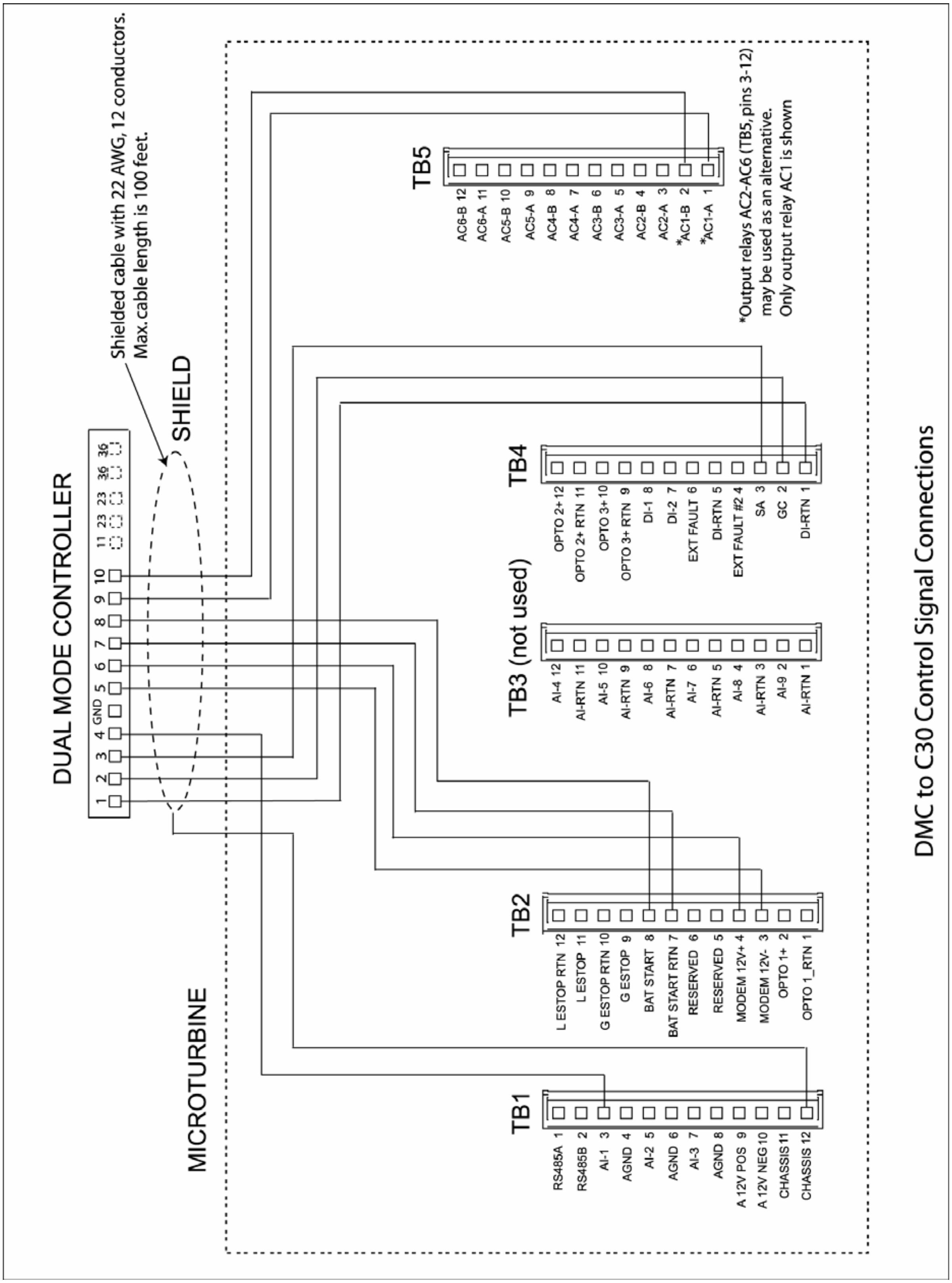


Figure 9. DMC to Model C30 Control Signal Connections

The control signal connections for the Model C30 are detailed in Table 4.

Table 4. 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	Start/Stop	TB1-3 AI-1
5	DC Power Ground	TB2-3 MODEM 12V-
6	12 VDC Power (+)	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< N< 5 AC (N)-A
10	SA Load Active Closed B	TB5-2N AC (N)-B
11	N/A	N/A
12	Run Active Closed A*****	TB5-2N AC(N+1)-A
13	Run Active Closed B*****	TB5-2N AC(N+1)-B
No Connection	Cable Shield	TB1-12 CHASSIS

* Used only for Annunciator Panel.

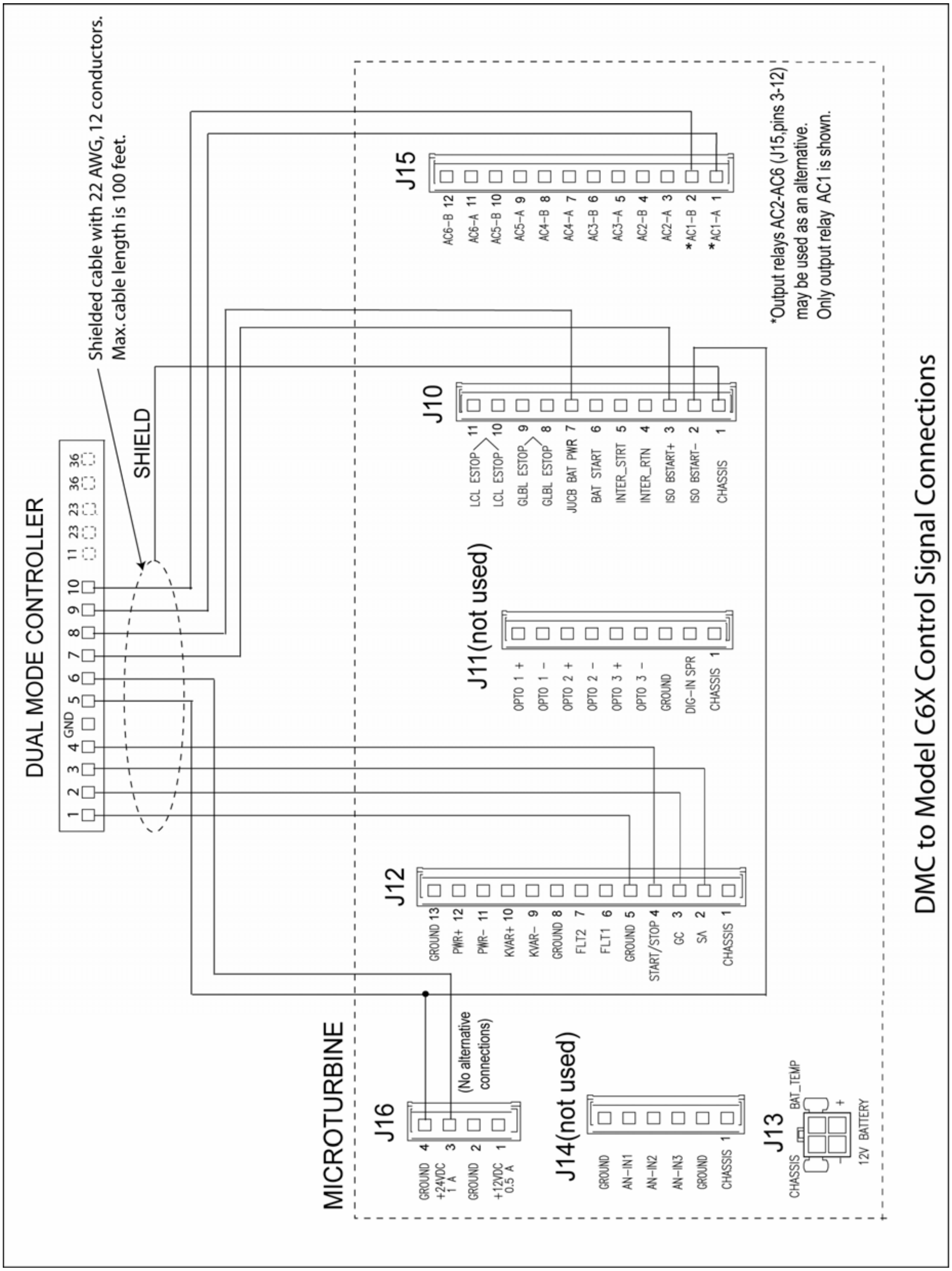


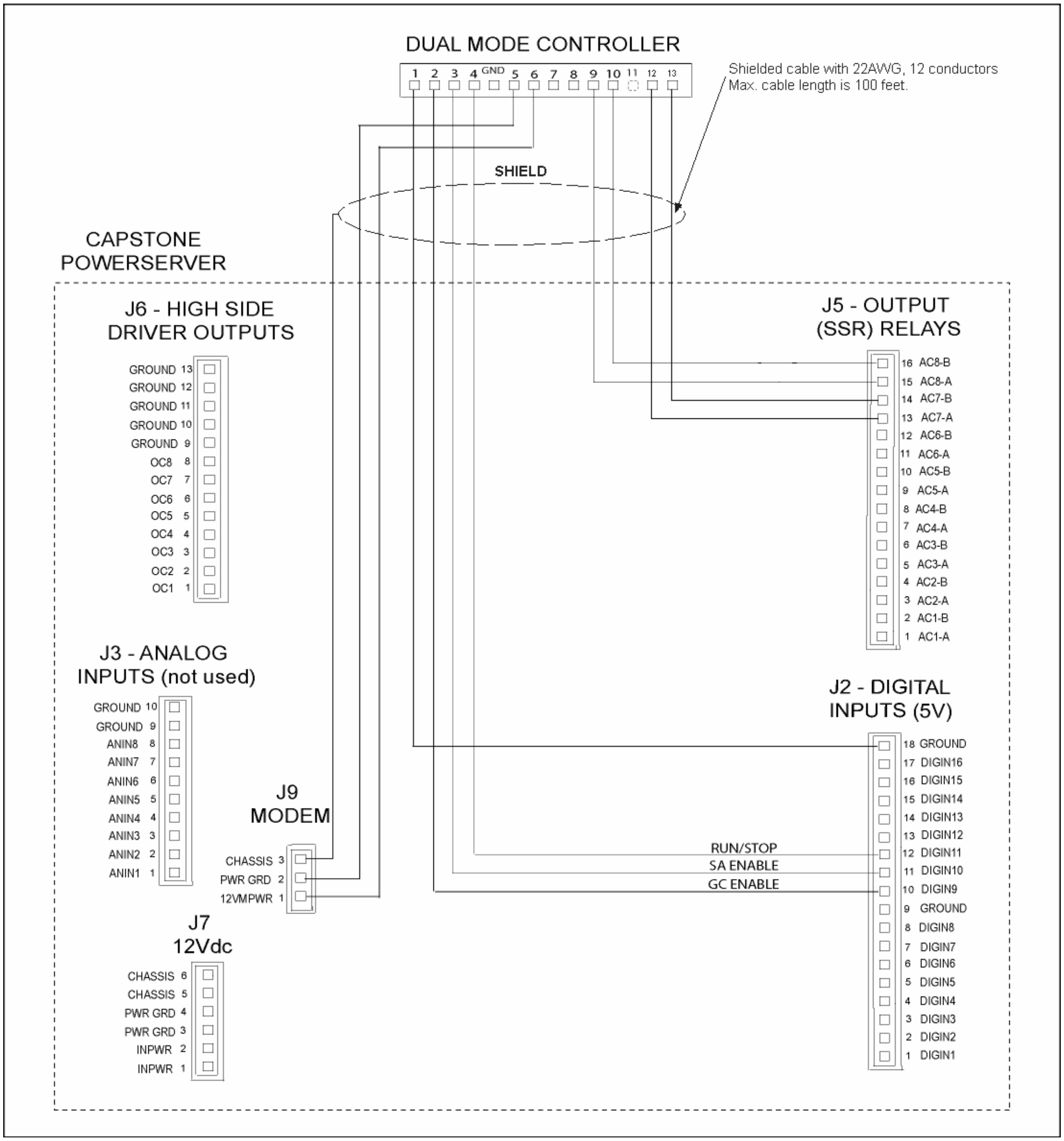
Figure 10. DMC to Model C6X Control Signal Connections

The control signal connections for the Model C60/C65 are detailed in Table 5.

Table 5. Model C60/C65 – 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 VDC Power (+)	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
11	N/A	N/A
12	Run Active Closed A*****	J15-(2N+1) AC(N+1)-A
13	Run Active Closed B*****	J15-(2N+2) AC(N+1)-B
No Connection	Cable Shield	J10-1 CHASSIS

* Used only for Annunciator Panel.



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:

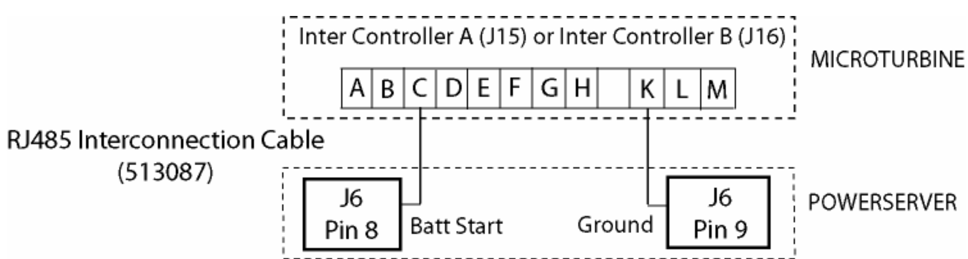


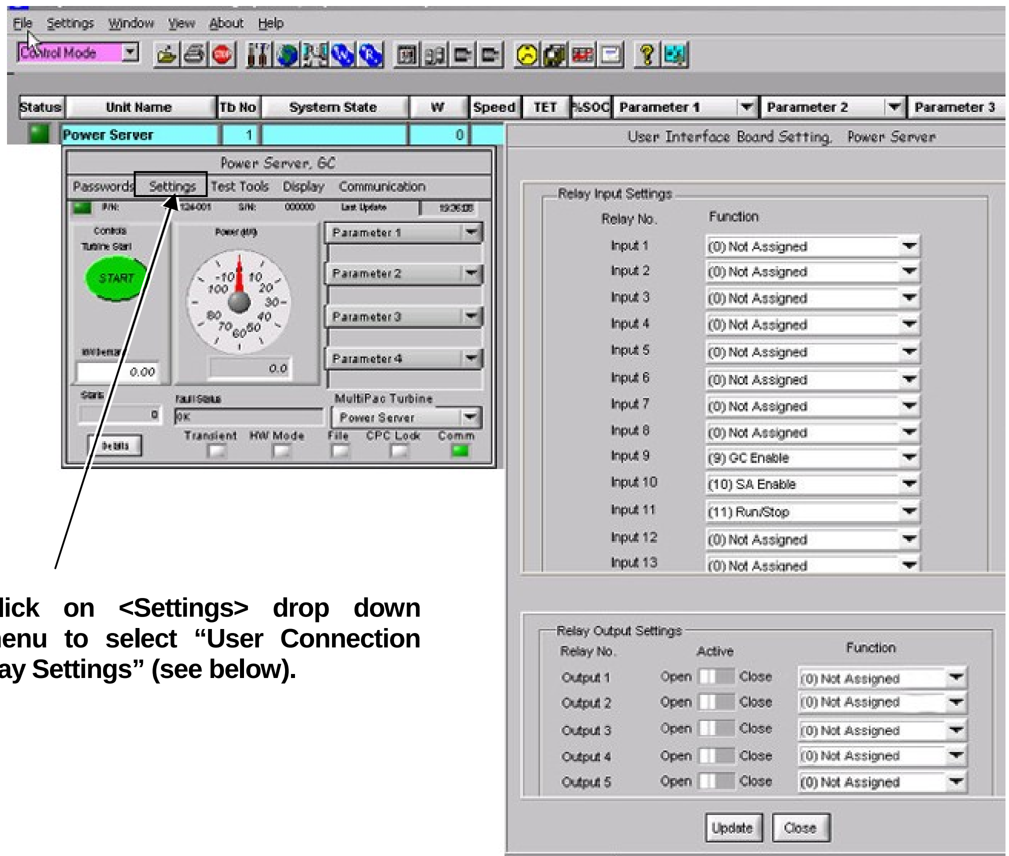
Figure 11. DMC to PowerServer Control Signal Connections

MicroTurbine Software Settings

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

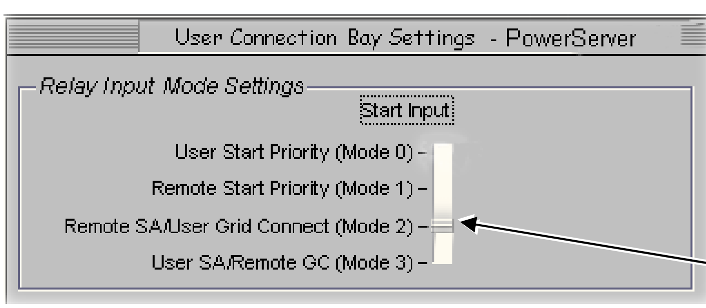
- Start Input
- Input/Output Relay settings.

<u>CRMS</u>



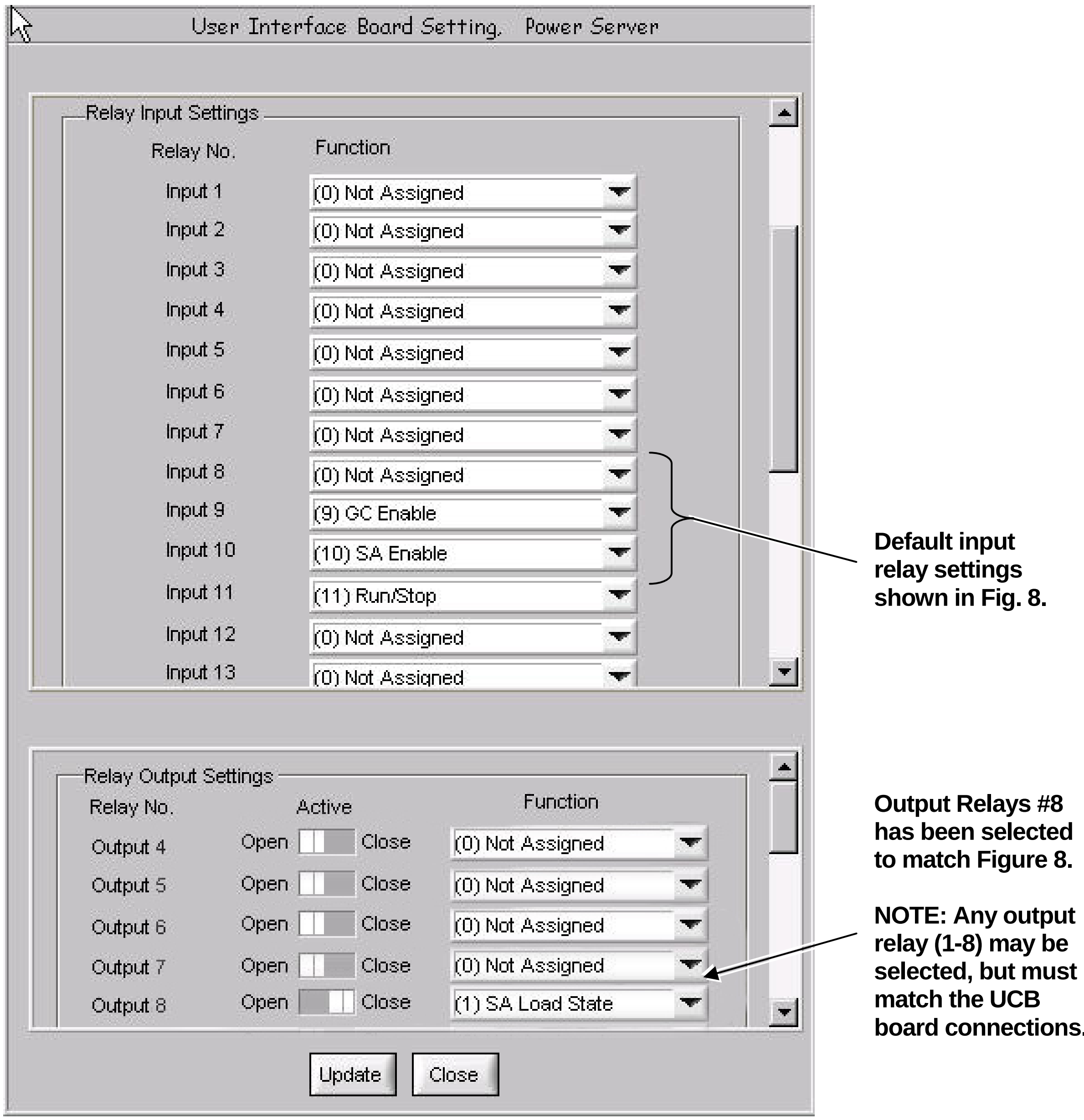
Click on <Settings> drop down menu to select "User Connection Bay Settings" (see below).

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:



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.

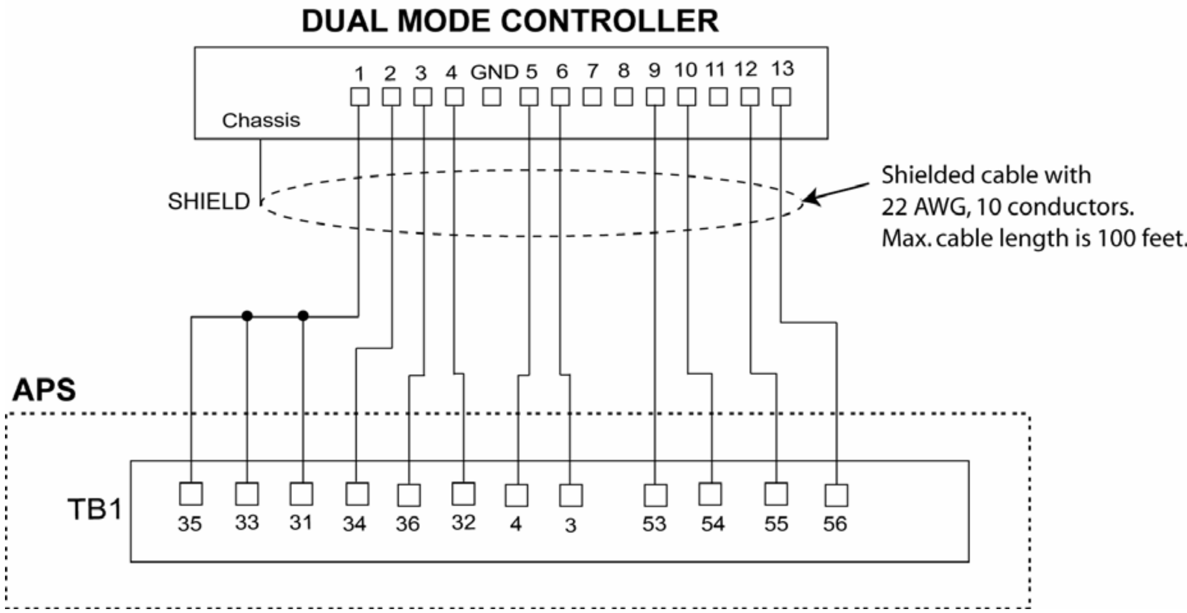


Figure 12. DMC to APS Connections

The control signal connections for the Advanced Power Server are detailed in Table 6.

Table 6. APS Control Signal Connections

DMC Terminal #	Description	APS Terminal #
1	Common	TB1-31, 33, 35
2	GC Enable	TB1-34
3	SA Enable	TB1-36
4	Start/Stop	TB1-32
5	0VDC	TB1-4
6	12/24 VDC Power(+)	TB1-3
7	N/A	N/A
8	N/A	N/A
9	DMC Active Closed A	TB1-53
10	DMC Active Closed B	TB1-54
11	N/A	N/A
12	Run Active Closed A*	TB1-55
13	Run Active Closed B*	TB1-56
Chassis	Cable Shield	No Connection

* Used only for Annunciator Panel.

Normal Transition Sequence

NOTE	Effective August, 2005, Capstone incorporated a set of hardware and software changes to increase transition speed between Stand Alone and Grid Connect modes. Refer to DMC Modifications – C60/C65 Fast Transfer Functionality Work Instructions (440123) to upgrade older units. These Work Instructions apply only to a DMC that has the suffix -001 in its part number. The upgrade changes the part number suffix to -003. DMC models with the part number suffix -002 are manufactured with the fast transfer capability and do not require an upgrade.

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 (warm-down) 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 warm-down 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 less than 10 seconds 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.

NOTE	The 10 second maximum time to complete the Stand Alone Start sequence is due to the fast transfer capability. The DMC configuration identified by the part number suffix -001 does not have fast transfer capability and takes approximately one minute to complete this sequence. DMC models with part number suffix -001 are upgraded to the fast transfer capability by Work Instruction 440123.

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 shut down 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. The MicroTurbine(s) then enter 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) leave 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.

DMC Fast Transfer Specification

This section explains the performance and switching logic between Grid Connect and Stand Alone modes of operation for the Capstone C60/C65 and C60/C65 ICHP Dual Mode MicroTurbines with software version 4.50 or higher, which includes the ability for "Fast Transfer" between Grid Connect and Stand Alone operating modes. This section also describes operation of the DMC in combination with the C60/C65 to achieve Fast Transfer.

The C60/C65 Dual Mode version MicroTurbines with software version 4.50 and higher can transition from Grid Connect to Stand Alone within 10 seconds. They can also go into Hot Standby mode when returning to Grid Connect operation to enable a quick transition back to Stand Alone mode if necessary. Capstone calls this capability "Fast Transfer", which can be extremely beneficial for protected loads that value high availability of power. The following paragraphs provide the details on how the C60/C65 MicroTurbine and DMC function to accomplish this high level of load protection. Note that the Fast Transfer capability does not apply to C30 MicroTurbines at the present time.

UL 1741 Requirements for Utility Interconnection

C60/C65 MicroTurbines are UL listed to 2200 and 1741, and meet the harmonics requirements of IEEE 519. They are also pre-certified for utility interconnection by many local jurisdictions to simplify connecting to the utility grid, such as in California and New York. These local certifications often rely on the UL 1741 listing, which defines how power inverters must react to disturbances on the utility grid. Before describing the Fast Transfer capability of the C60/C65 Dual Mode version MicroTurbines, it may be useful to review how the C60/C65 achieves the UL 1741 listing and how it operates under typical utility grid disturbances.

Figure 13 shows a one-line schematic of a C60/C65 Grid Connect version MicroTurbine connected to the utility grid. In this example, short circuit and overload protection is provided by the circuit breaker CB1 between the MicroTurbine and the utility grid. The protective relay functionality required by UL 1741 is integral to the C60/C65 firmware, and includes voltage, frequency, and anti-islanding functions. Following is a short description of how the basic C60/C65 Grid Connect version (not a Dual Mode version) reacts to a utility disturbance.

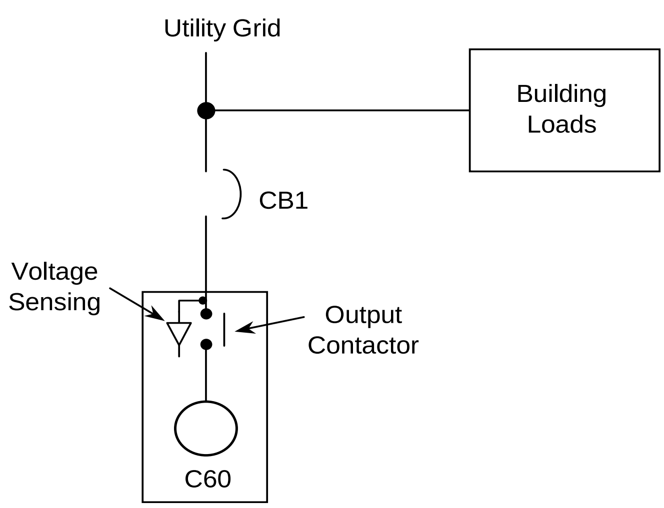


Figure 13. One-line Diagram of C60/C65 Connected to Utility Grid

In normal Grid Connect operation, the output contactor in the C60/C65 is closed and the MicroTurbine is generating power. The MicroTurbine's output power flows out to the remainder of the distribution circuit, and is consumed by the building loads. Normally, power is not exported to the utility grid.

In the event of a disturbance on the utility grid, voltage and current sensing integral to the C60/C65 MicroTurbine will cause the internal contactor to open and the MicroTurbine to go through a shutdown procedure. The response time will, of course, depend on the type and severity of the disturbance and the protective relay settings in the MicroTurbine. Refer to Technical Reference 410033 for details on these protective relay functions and set points.

With the MicroTurbine output contactor open, utility voltage can still be sensed by the C60/C65 circuitry. When utility voltage returns, the MicroTurbine senses it and an internal "reconnect" timer is started. UL 1741 requires that the MicroTurbine not reconnect to the grid for at least 5 minutes after the utility voltage and frequency have been restored to the normal operating ranges. The Capstone C60/C65 provides for user adjustment of this internal reconnect timer from 5 to 30 minutes.

Some local interconnection regulations may also require manual intervention before reconnecting any power source to the utility grid. To address this case, the C60/C65 MicroTurbine firmware also provides for a manual command on the display or through the RS232 communications port. When this manual utility reconnect control function is enabled, the MicroTurbine will reconnect to the grid as soon as a manual command has been sent to permit reconnection.

Capstone's remote monitoring software (CRMS) provides a user interface for issuing this manual "permission to reconnect" command. A communications command can also be transmitted through the RS232 port in the case that a PLC or other digital control equipment is used. The C60/C65 MicroTurbine display panel also provides for this manual reconnection using the "Start" command.

When the conditions have been met to allow reconnection to the utility grid, the MicroTurbine will automatically close its output contactor, use the utility grid to start the MicroTurbine, and begin generating power again in Grid Connect mode. Figure 14 shows a timeline of this sequence for a typical utility fault, followed by an outage.

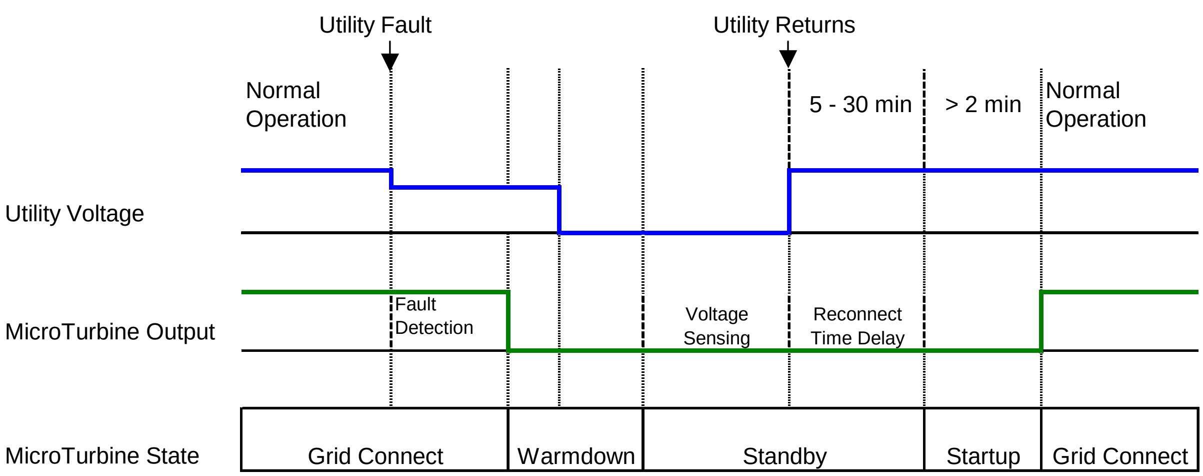


Figure 14. Timeline of Typical Utility Fault

Dual Mode Functionality

When the Capstone C60/C65 MicroTurbine includes the Dual Mode feature, it is capable of providing power either connected to a utility grid (Grid Connect mode) or without presence of a utility voltage (Stand Alone mode). Since the operating characteristics between these two modes are different, the MicroTurbine must be told which mode to be in.

The User Connection Bay (UCB) terminal J12 has two hardware interfaces to enable Grid Connect (GA Enable pin 2) or Stand Alone operation (SA Enable – pin 3). If the user wants to operate in only one of these modes, a hardware jumper must be connected from pin 2 or 3 to ground to enable the desired mode, and the desired mode must be selected under "Power Connect" on the MicroTurbine display or CRMS software.

Alternatively, the MicroTurbine can be set up for automatic transition between these two modes by wiring control logic between the two mode-enable inputs and ground. The MicroTurbine must then be set for Dual Mode operation in the "Power Connect" menu. Fast Transfer only applies when the MicroTurbine is set to Dual Mode operation, and the mode-enable inputs are properly wired and controlled. Note that "Active" is defined for these mode-enable inputs as being connected to ground (or "Low").

Additionally, the Start/Stop input to the MicroTurbine (UCB terminal J12, pin 4) is used to control the desired mode of operation, as described below, where "Start" means pin 4 is connected to ground (or "Low").

Grid Connect to Stand Alone Mode

When the GC Enable and SA Enable inputs are toggled, and the Start/Stop input is set to "Start", the MicroTurbine passes through the following transition states, as shown in Figure 15.

- Output contactor is opened within about 50 milliseconds to stop export of power from the C60/C65 MicroTurbine,
- The MicroTurbine generator continues to produce power, which is available to recharge the battery pack,
- The MicroTurbine firmware transfers to the new output mode,
- The output contactor closes, making the MicroTurbine power available to the system in the Stand Alone operating mode.

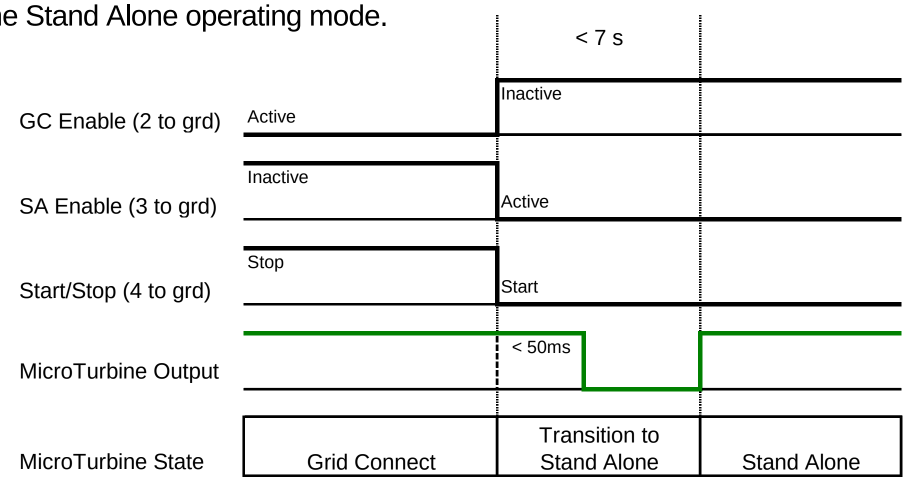


Figure 15. Fast Transfer from Grid Connect to Stand Alone

By default, the transition time between Grid Connect and Stand Alone modes is less than seven seconds, but will be delayed if the sensed voltage at the MicroTurbine output is maintained above 50V peak (for example by rotating machines with high inertial loads). Additional delay time can be added to the transition time by setting the Fast Transfer Delay time through either CRMS or display panel.

The transfer from Grid Connect to Stand Alone operation is extremely fast, and may not necessarily provide the desired total system functionality. For example, if an external control system toggles the input signals as noted in Figure 15, but the associated isolation device has not completely disconnected from the utility grid within the transition time of the MicroTurbine, a fault condition may exist that could damage equipment. For this reason, the operation of the input signals should assure that conditions are right for the Fast Transfer operation.

Capstone's Fast Transfer firmware allows an intentional delay time between Grid Connect and Stand Alone operation by using the SA Enable and Start/Stop inputs as shown in Figure 16. For the MicroTurbine to discontinue operation in Grid Connect mode, only the GC Enable input needs to become inactive. For transition to Stand Alone operation, both the SA Enable and the Start/Stop inputs must become active (the example shows both operating at the same time, but it is possible to have either one lead the other).

Until both SA Enable and Start/Stop become active, the MicroTurbine will operate in "Hot Standby" mode for up to two hours, or until the batteries are completely recharged, whichever is longer. In this Hot Standby mode, the engine is on (flame is lit) and the output contactor is open. Power from the MicroTurbine is used to recharge the batteries, as needed, but no power is exported. Note that this "Hot Standby" mode is termed the "Stand Alone – Recharge" state in Technical Reference 410028.

When the SA Enable and Start/Stop inputs become active, the MicroTurbine enters the transition state and will begin exporting power in Stand Alone mode within the transition time (seven seconds + the setting of the Fast Transfer Delay, which has a default value of 0 and can be set through either CRMS or display panel). Note that if a valid control input is not received before the MicroTurbine completes its Hot Standby timeout, the MicroTurbine will shut down and remain in normal Standby until valid control inputs tell it to restart in Grid Connect or Stand Alone mode.

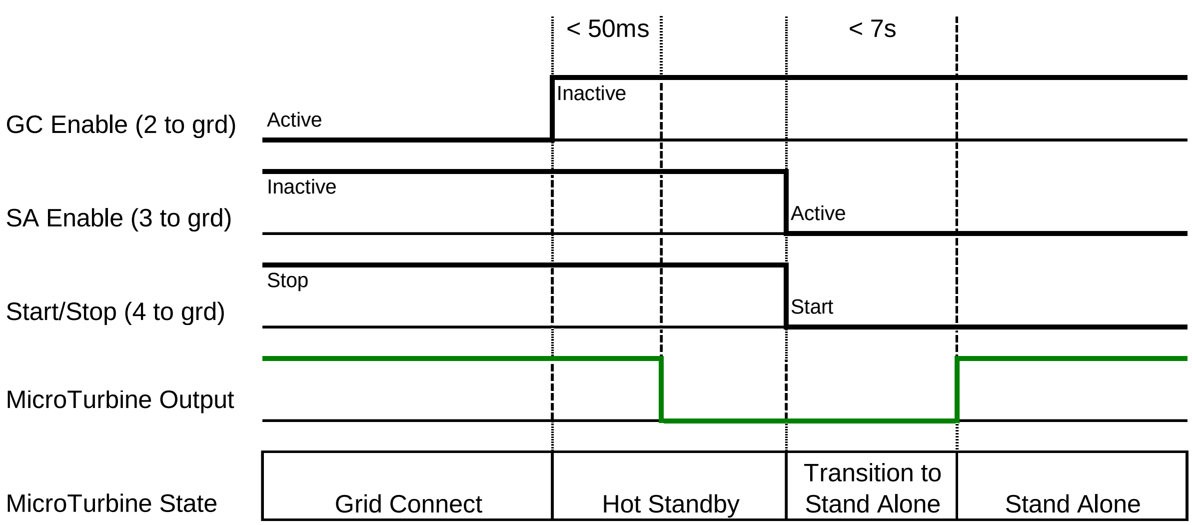


Figure 16. Grid Connect to Stand Alone with Intentional Delay

The above scenarios explain how an external system can use inputs to the MicroTurbine to force transition from Grid Connect to Stand Alone operation with or without intentional delay. However, the MicroTurbine itself includes built in protective relay functions that may operate before any external control system has responded. This is, in fact, the more probable scenario, and is Capstone's recommended operating scheme. By letting the MicroTurbine respond directly to a utility fault, the protected loads may actually have more continuity of power if they are not automatically transferred to Stand Alone mode.

Figure 17 shows operation of the MicroTurbine from Grid Connect to Stand Alone, where the MicroTurbine initiates the transfer. For simplicity of explanation, the example shows a drop in utility voltage as the fault. Of course, it could be other fault conditions that cause this operation, such as over or under frequency, over voltage, or anti-islanding protection.

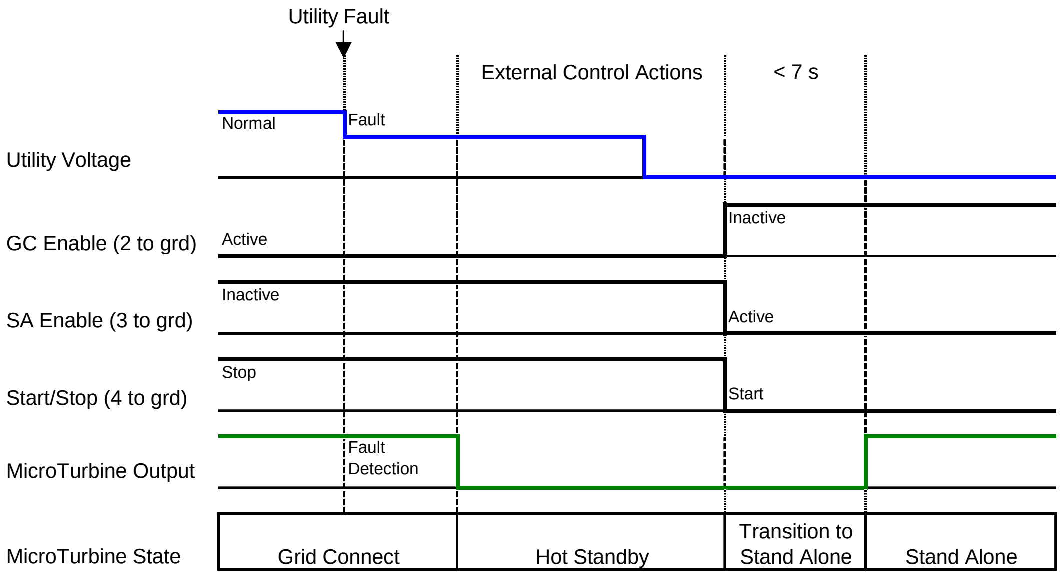


Figure 17. Grid Connect to Stand Alone Initiated by MicroTurbine

In this case, the MicroTurbine reacts to the fault first, with the external control system toggling the GC Enable, SA Enable, and Start/Stop inputs thereafter. The time delay is controlled by the external system, however there are some conditions that must be considered for this control action.

While the GC Enable is active, the MicroTurbine will automatically start its internal reconnect sequence and prepare to reconnect to the utility grid. During this process, the MicroTurbine will look for presence of stable utility voltage at its terminals (just as described in the Grid Connect only operation above). As soon as utility voltage is sensed, the MicroTurbine will start its reconnect timer. If GC Enable is not deactivated prior to reaching the set reconnect time delay (or activation of any manual reconnect controls), the MicroTurbine will automatically re-synchronize with and reconnect to the utility grid.

If there is no utility grid present, the MicroTurbine will continue in Hot Standby mode for up to two hours, waiting for the presence of utility voltage prior to starting its reconnect time delay sequence. Note that if normal utility voltage does not return, or a valid control input is not received, before the MicroTurbine completes its Hot Standby timeout, the MicroTurbine will shut down and remain in normal Standby until valid control inputs tell it to restart in Grid Connect or Stand Alone mode.

Note that there are two possible scenarios in the transition out of Grid Connect mode:

1. An external control system forces the transition from Grid Connect to Stand Alone, with or without the MicroTurbine responding directly to a utility fault condition, or
2. An external control system does not force a transition from Grid Connect to Stand Alone, but the MicroTurbine responds directly to a utility fault, and then automatically enters its reconnect sequence to transition back to Grid Connect operation.

Scenario 1 represents “Fast Transfer” between the two modes of operation. In this case, any protected loads will see an interruption in power of several seconds going to Stand Alone operation (depending on the control system), followed by another interruption of several seconds when the system transfers back to Grid Connect mode. Scenario 2 represents a utility disturbance only. The protected load will see the transient that caused the MicroTurbine to disconnect, and may not see any power interruption at all.

Stand Alone to Grid Connect Mode

The transfer back from Stand Alone to Grid Connect operation includes a one minute fixed time delay after the SA Enable signal becomes inactive, followed by the standard reconnect sequence used for any transfer to Grid Connect operation. As shown in Figure 18, the MicroTurbine continues in Stand Alone operation for one minute after the SA Enable signal goes inactive, then automatically stops power output and goes into Hot Standby mode. As an interlock control signal, one of the output relays on UCB terminal J15 can be programmed to indicate when the MicroTurbine is supplying power to the load in Stand Alone mode (“SA Load” in Figure 18).

The opening of the selected SA Load output relay terminals A to B can initiate an external logic sequence that reconnects the MicroTurbine and protected loads to the utility grid, activates the GC Enable input to the MicroTurbine, and switches the Start/Stop input to Stop. This will cause the utility voltage to be sensed at the MicroTurbine output terminals, and the MicroTurbine will now begin its reconnect time delay sequence, resynchronize, and output power in Grid Connect mode if the utility voltage remains within the protective relay setting limits for the reconnect time delay.

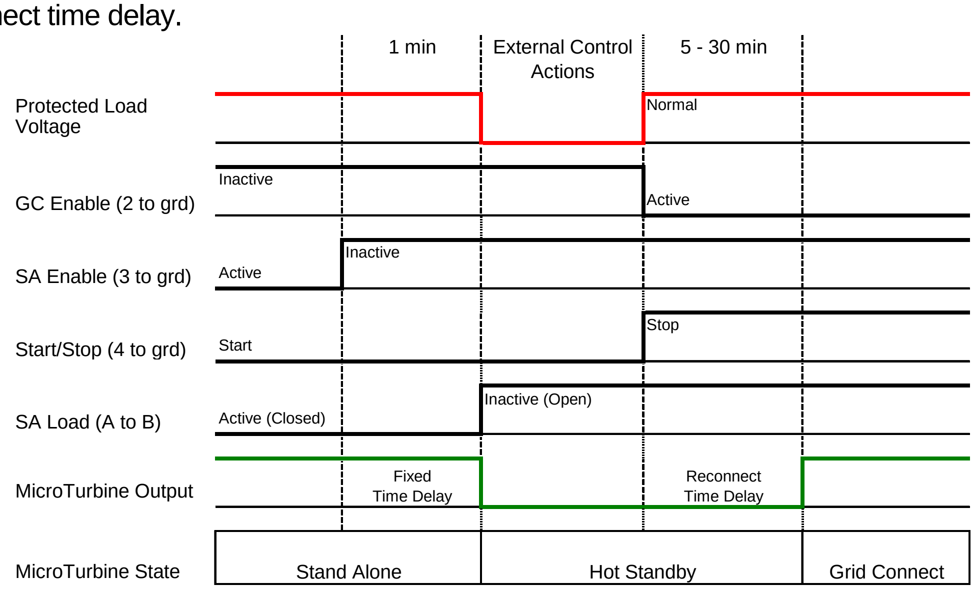


Figure 18. Fast Transfer from Stand Alone to Grid Connect

Note that if the utility voltage experiences disturbances outside the protective relay limits during the reconnect time delay, the MicroTurbine will wait until sensed voltage is back within limits and then restart the reconnect sequence. Also note that the MicroTurbine may not continue in Hot Standby for more than two hours, and will shut down if it is not able to either transition to Grid Connect mode or if it is not commanded to go back to Stand Alone operation.

Also note that Capstone has included a second timer that is initiated when the SA Enable signal goes inactive, in order to prevent repeated cycling between Stand Alone and Hot Standby modes. If the MicroTurbine is commanded to transition to Hot Standby, and subsequently is commanded to return to Stand Alone, this second timer delays transition back to Hot Standby for ten minutes after the initial SA Enable signal went inactive.

Since some types of loads require a minimum power off period before its power is re-applied, Capstone MicroTurbine firmware has a function to insert a time delay between stopping its power output and disabling its SA-load signal. This Fast Transfer Delay time has a default value of 0, and can be set through either CRMS or display panel.

External Controller Concerns

Since control of the MicroTurbine is now being set by external signals, it is important that the logic and sequence of operations be correct to avoid misapplication.

WARNING	Externally connecting a MicroTurbine operating in Stand Alone mode to an energized utility grid may cause damage to loads that are being powered by the MicroTurbine if they are not reconnected in phase with the utility source. Other equipment may also be damaged as a result, including the distribution system and even the MicroTurbine itself. To avoid this, make sure that power connection is not made to a utility source when the MicroTurbine is operating in Stand Alone mode.

CAUTION	Causing the Grid Connect and Stand Alone enable inputs to be connected at the same time will cause automatic shutdown of the MicroTurbine and faults to be logged. To avoid this, make sure the control logic to the mode-enable inputs does not allow simultaneous activation of Grid Connect and Stand Alone enable signals.

CAUTION	Commanding the MicroTurbine to operate in an incorrect mode will also cause it to automatically shut down and log the appropriate fault history. For example, the MicroTurbine will not provide voltage output to support a Stand Alone load if it is commanded to operate in Grid Connect mode. To avoid this, make sure the control logic is enabling the correct mode of operation.

CAUTION	Commanding a MicroTurbine to reconnect to the utility grid may violate utility interconnection regulations that require a manual reconnect procedure. To avoid this, any external control logic must be commanded to operate in accordance with local utility interconnection regulations.

Dual Mode Controller Functionality

DMC provides the external control and isolation functions to take advantage of the MicroTurbine's Fast Transfer functionality described above. Figure 19 shows a simple one-line diagram of the DMC with utility grid, C60/C65 MicroTurbine, and protected load. The DMC includes a motor-operated isolation switch M1, an undervoltage relay (UVR) that senses the utility grid voltage, and control logic to operate M1 and send and receive signals from the C60/C65 MicroTurbine.

This section presents an overview of the automatic operation between Grid Connect and Stand Alone modes. Note that the C60/C65 MicroTurbine provides 24VDC power to the DMC.

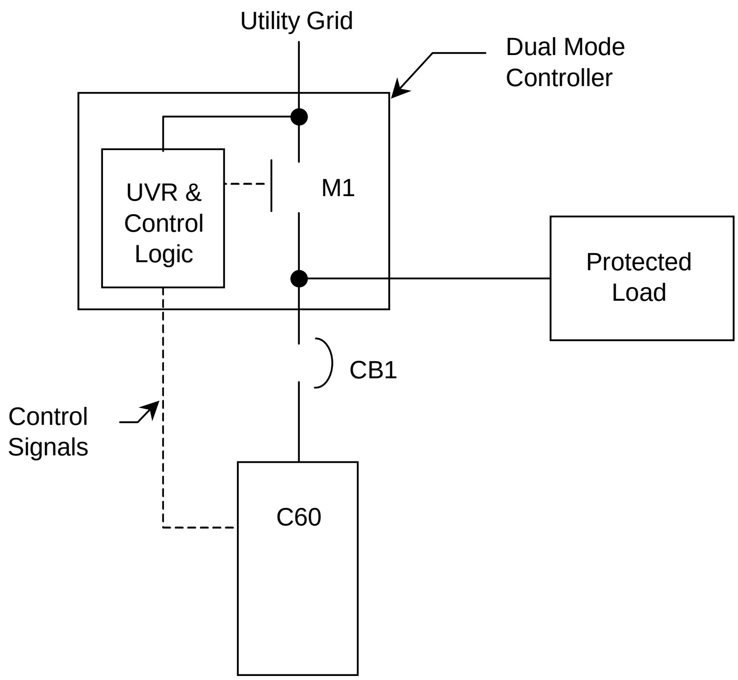


Figure 19. One-line Diagram of Typical Dual Mode Application

The control signals of interest for the Fast Transfer functionality are summarized in Table 7, as described above and repeated here for reference.

Table 7. Fast Transfer Control Signals

Control Signal	MicroTurbine Input or Output	DMC Terminal #	Function
GC Enable	Input	2	Active for MicroTurbine to be in GC mode
SA Enable	Input	3	Active for MicroTurbine to enter SA mode
Start/Stop	Input	4	"Start" to Operate in SA mode
SA Load	Output Relay	9 & 10	Active (closed) when MicroTurbine in SA mode

Normal operation is when the utility grid is providing stable electrical power, isolation switch M1 is closed, and the C60/C65 MicroTurbine is providing power in Grid Connect mode. Figure 20 provides a schematic of the control logic used by the DMC to toggle the GC Enable, SA Enable, and Start/Stop signals.

When the utility grid experiences an undervoltage disturbance, the UVR in the DMC closes output relay contact RL1 in Figure 20. The auxiliary contacts M1-A3 in the motor operated isolation switch are normally open and contact M1-A4 normally closed, so the SA Enable and GC Enable signals are not yet toggled.

Not shown in Figure 20 is the circuit that also uses an output command from the UVR to trip the motor operated isolation switch M1 open within 5 seconds. When M1 opens, auxiliary contacts M1-A3 and M1-A4 toggle so that M1-A3 is now closed and M1-A4 is open (as shown in Figure 20). If the manually operated DMC switch contacts S1B and S2A are also closed, then SA Enable is activated and GC Enable is deactivated. The Start/Stop signal is also activated. This will cause the MicroTurbine to transition from Grid Connect mode to Stand Alone mode, as shown in Figure 21.

Note that the use of the auxiliary contacts in the isolation switch M1 assures that the MicroTurbine will not be commanded to the Stand Alone mode unless it is isolated from the utility grid. The complete transition from initial utility voltage fault to Stand Alone will typically take less than 10 seconds, depending on the severity of the fault, protective relay delay settings in the MicroTurbine and the time delay in the DMC's UVR control circuit.

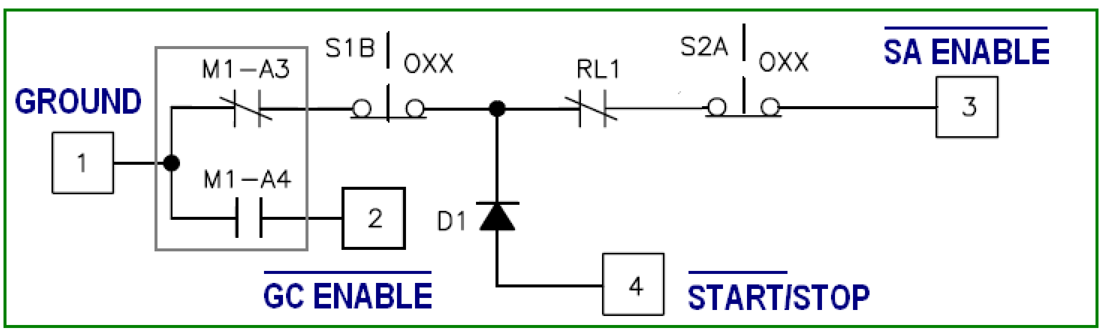


Figure 20. Control Circuit to Toggle GC and SA Enable Signals

Once the utility voltage has returned to normal, the UVR will open contact RL1 in Figure 20. This will inactivate the SA Enable input to the MicroTurbine, as shown in Figure 21. After a fixed one-minute delay, the MicroTurbine will automatically transition to Hot Standby mode, and the SA Load output signal will go inactive. The DMC uses the SA Load inactive signal to allow the isolation switch M1 to close. Once M1 closes, the Start/Stop signal is opened by auxiliary switch contact M1-A3 causing it to become inactive, and the GC Enable signal is activated through aux switch M1-A4 (reference Figure 20). These inputs cause the MicroTurbine to begin the reconnect sequence to Grid Connect mode while the utility grid powers the protected load. Figure 21 shows the timeline for this sequence, if the Fast Transfer Delay time is set to its default value of 0.

Note that the total time the protected load is without normal voltage is typically less than 10 seconds after the initial utility fault, and less than 5 seconds when the DMC transfers back to utility Grid Connection (M1 closes)

Utility faults can occur for many reasons, resulting in a variety of transient voltage conditions. The most frequent faults are sags of relatively short duration due to short circuits on the distribution network. Depending on the impedance of the short circuit and its distance from the MicroTurbine, the resulting voltage sags are often less than (1) second, and quickly return to normal voltage when re-closing devices isolate the faulted feeder. For this reason, Capstone has designed the DMC control logic and coordinated the DMC UVR with the MicroTurbine's internal protective relay so that the DMC only opens for more severe faults.

Figure 22 shows how the DMC's UVR and the MicroTurbine's undervoltage settings are coordinated so that the MicroTurbine will be the first to respond. This means that there will be some situations where a fault is just a temporary voltage sag that causes the MicroTurbine to automatically disconnect, but does not persist long enough to cause the DMC to open the isolation switch M1. In this case, the protected load will only see the utility voltage sag, and no interruption (and no Fast Transfer) will occur. Figure 23 shows a timeline of this scenario.

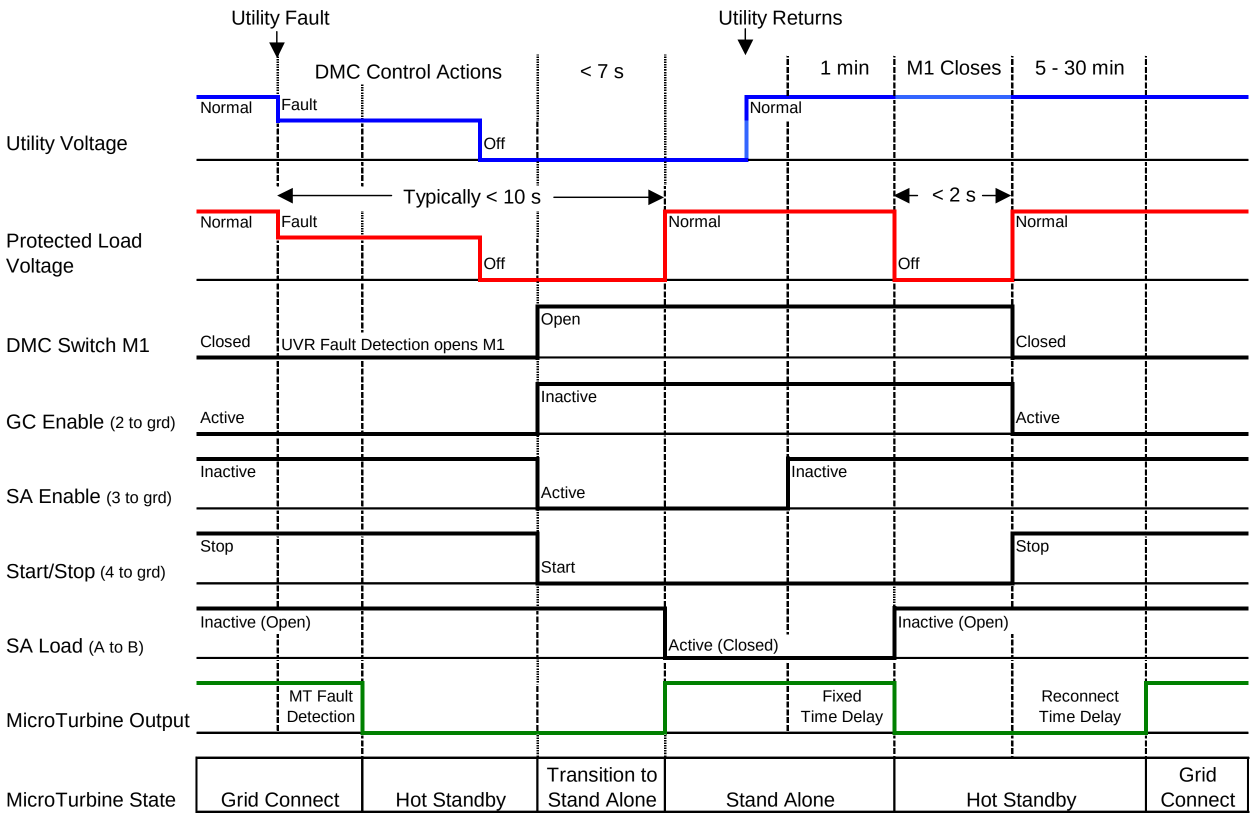


Figure 21. Fast Transfer with DMC – GC to SA to GC

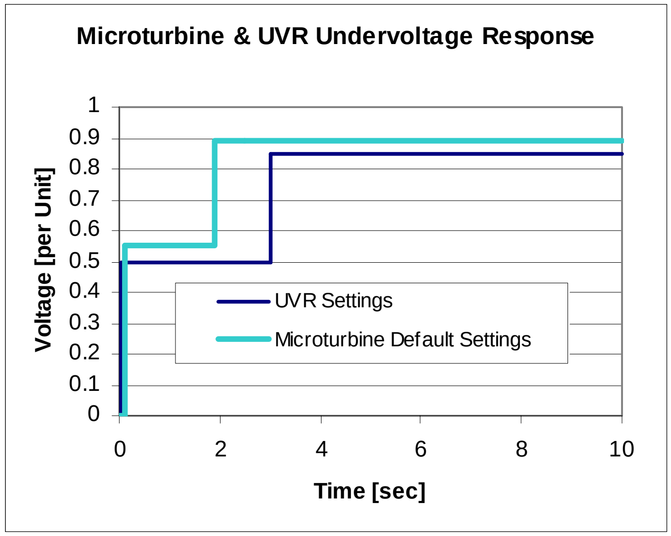


Figure 22. MicroTurbine and UVR Coordination

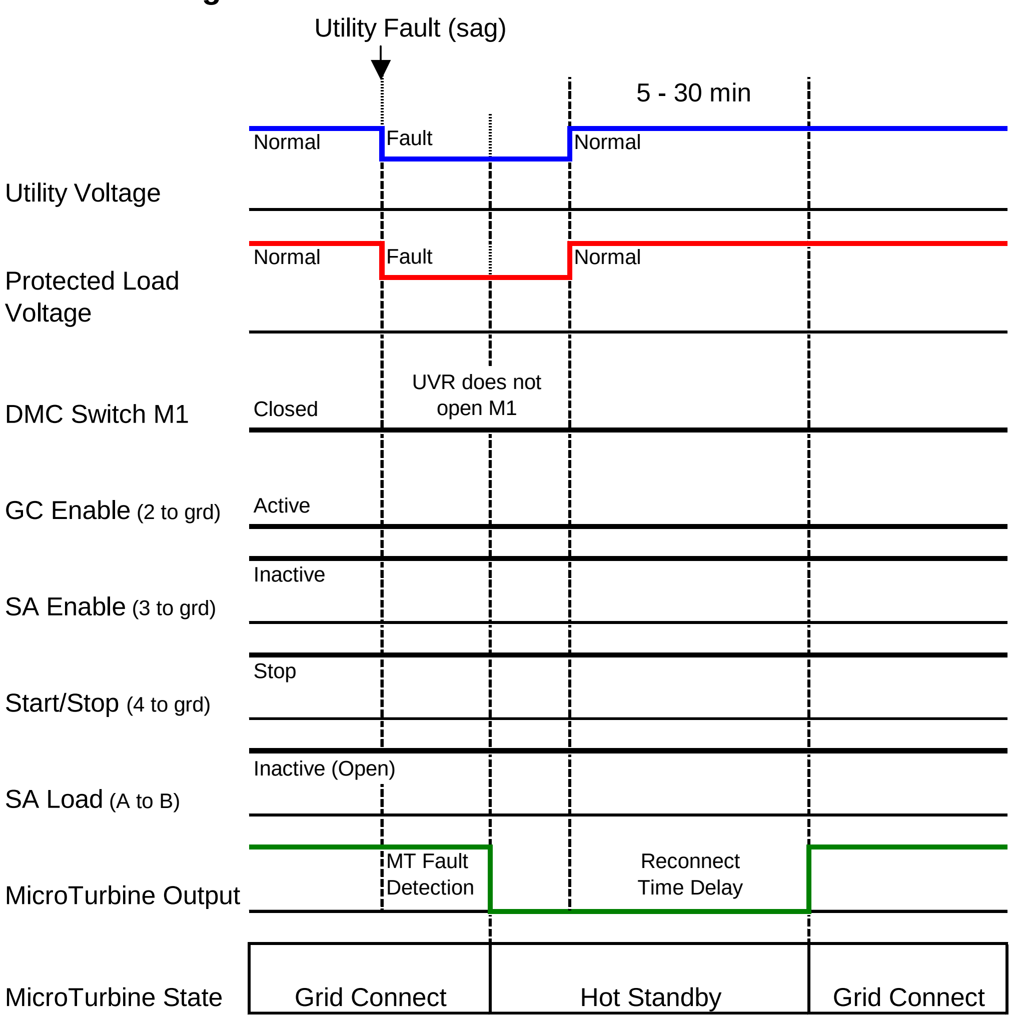


Figure 23. Fast Transfer with DMC – GC to Hot Standby to GC

MultiPac Operation with Fast Transfer

The descriptions of operation above show a single C60/C65 or C60/C65 ICHP MicroTurbine. When connecting several C60/C65's in a MultiPac, the control wiring goes to the master unit, which in turn coordinates operation of the slave units. It is recommended that a second MicroTurbine be wired in parallel with the master so that it can be manually programmed to act as the master when the master unit is taken out of service. Note that Fast Transfer cannot be used with the Capstone Power Server, and control signals must be wired into a MicroTurbine master.

Since the master MicroTurbine must receive the input signals, take the appropriate actions, and then communicate to the slave units, the transition time to Stand Alone mode for a MultiPac may take slightly longer than the transition times indicated in the preceding figures, depending on the number of MicroTurbines in the MultiPac, but will still typically transition in less than 10 seconds, if the Fast Transfer Delay time is set to its default value of 0.

Refer to Capstone MultiPac Operation Technical Reference (410032) for additional details.

C60/C65 ICHP Operation with Fast Transfer

The C60/C65 ICHP can be programmed to operate is several heat recovery modes. If set to Electric Priority (with thermal tracking) or Thermal Bypass, there will be no change in the operating mode when switching between Grid Connect and Stand Alone modes of operation. If the C60/C65 ICHP is set for Thermal Priority for Grid Connect operation, it will automatically switch to Electric Priority (with thermal tracking) when operating in Stand Alone or Hot Standby modes, and switch back to Thermal Priority when operating in Grid Connect mode.

Refer to Capstone C60/C65 Integrated CHP Technical Reference (410043) and Application Guide 480007/480014 for additional details about the CHP modes of operation.

External Protective Relay Operation with Fast Transfer

An external protective relay may be required in some applications to meet local utility interconnection requirements, or to provide additional protective functionality. For example, reverse power protection may be required to prevent inadvertent export under certain situations. For these requirements, the external protective relay should simply trip a circuit protective device that is located between the utility grid and the DMC. The C60/C65 MicroTurbine and DMC will then respond to the loss of voltage at the input terminals to the DMC, as shown in Figure 14.

When utility voltage is returned to normal, the circuit protective device can be re-closed, which will re-establish utility voltage at the DMC input terminals and cause the DMC's UVR to close isolation switch M1. Note that the C60/C65 MicroTurbine will then monitor the utility voltage for the preset reconnect time prior to reconnecting in Grid Connect mode, in accordance with UL 1741 requirements.

RELATED DOCUMENTATION

Table 8 lists applicable Capstone documentation.

Table 8. Related Documents

Document No.	Document Title
400009	Dual Mode Controller User's Manual
410009	MicroTurbine Electrical Installation Technical Reference
410028	Capstone Stand Alone Operation Technical Reference
410032	Capstone MultiPac Operation Technical Reference
410033	Capstone Protective Relay Functions Technical Reference
440123	DMC Retrofit Kit - C60/C65 Fast Transfer Functionality

CAPSTONE CONTACT INFORMATION

If you have additional questions or need further assistance, please call Capstone Technical Support:

Capstone Technical Support

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Appendix A

DMC Configuration Without Fast Transfer (-001 Series)

This Appendix contains the wiring diagrams and schematics for the DMC basic model, identified by the suffix -001 in the part number. Refer to the following table for an index of the wiring diagrams and schematic drawings related to each DMC part number.

DMC Part Number	Description	Wiring Diagram	Figure Number	Schematic Drawing	Figure Number
512802-001	125A, 208V	270741D2, Rev. C	A-1	270730D2, Rev. D	A-2
512508-001	225A, 208V				
512509-001	400A, 208V				
512510-001	600A, 208V				
512511-001	800A, 208V				
512512-001	1200A, 208V				
512923-001	125A, 240V	270789D2, Rev. A	A-3	270786D2, Rev. B	A-4
512924-001	225A, 240V				
512925-001	400A, 240V				
512926-001	600A, 240V				
512927-001	800A, 240V				
512928-001	1200A, 240V				
512914-001	125A, 380V	270790D2, Rev. C	A-5	270787D2, Rev. A	A-6
512915-001	225A, 380V				
512916-001	400A, 380V				
512917-001	600A, 380V				
512918-001	800A, 380V				
512919-001	1200A, 380V				
512801-001	125A, 480V	270791D2, Rev. B	A-7	270788D2, Rev. B	A-8
512503-001	225A, 480V				
512504-001	400A, 480V				
512505-001	600A, 480V				
512506-001	800A, 480V				
512507-001	1200A, 480V				

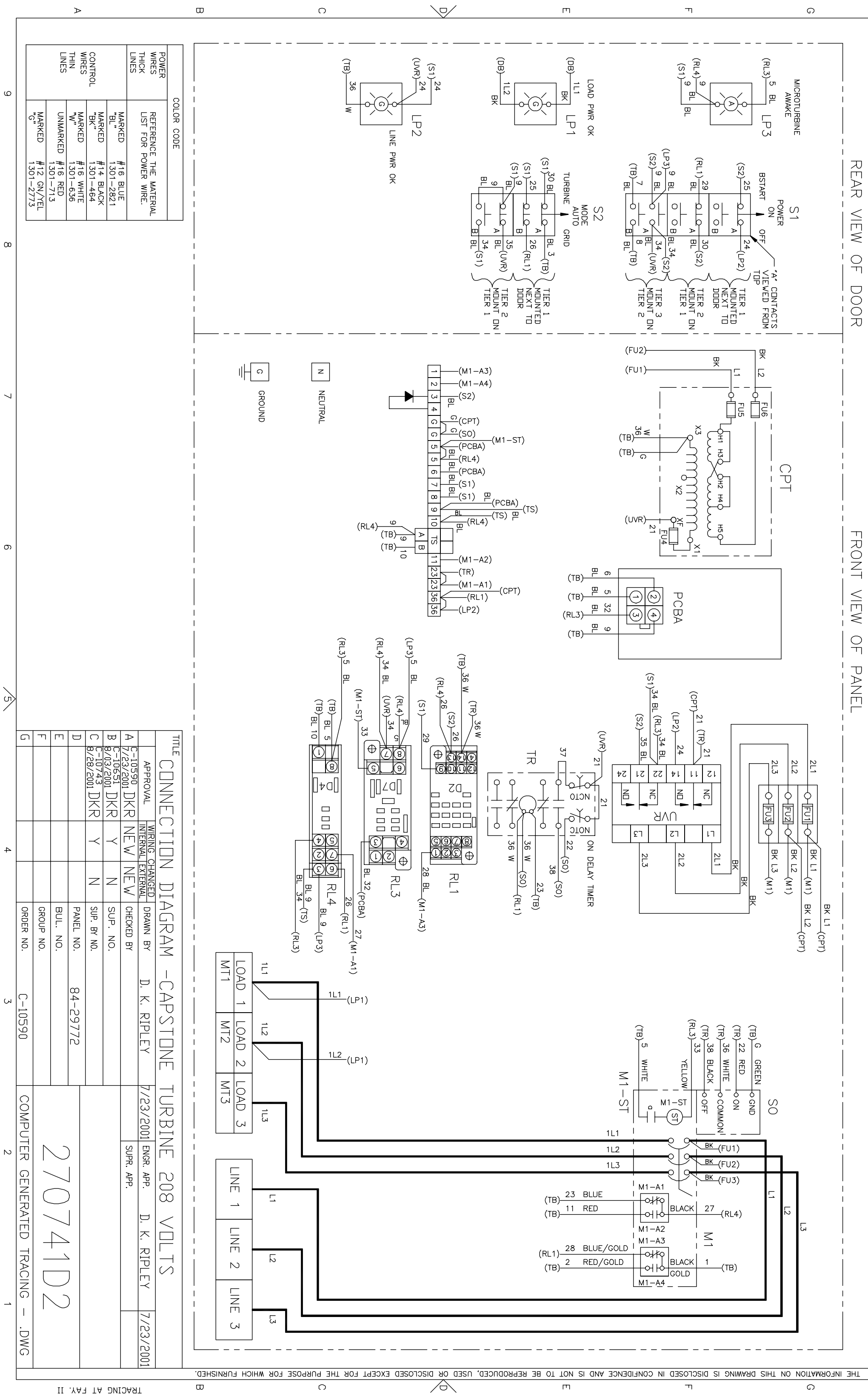
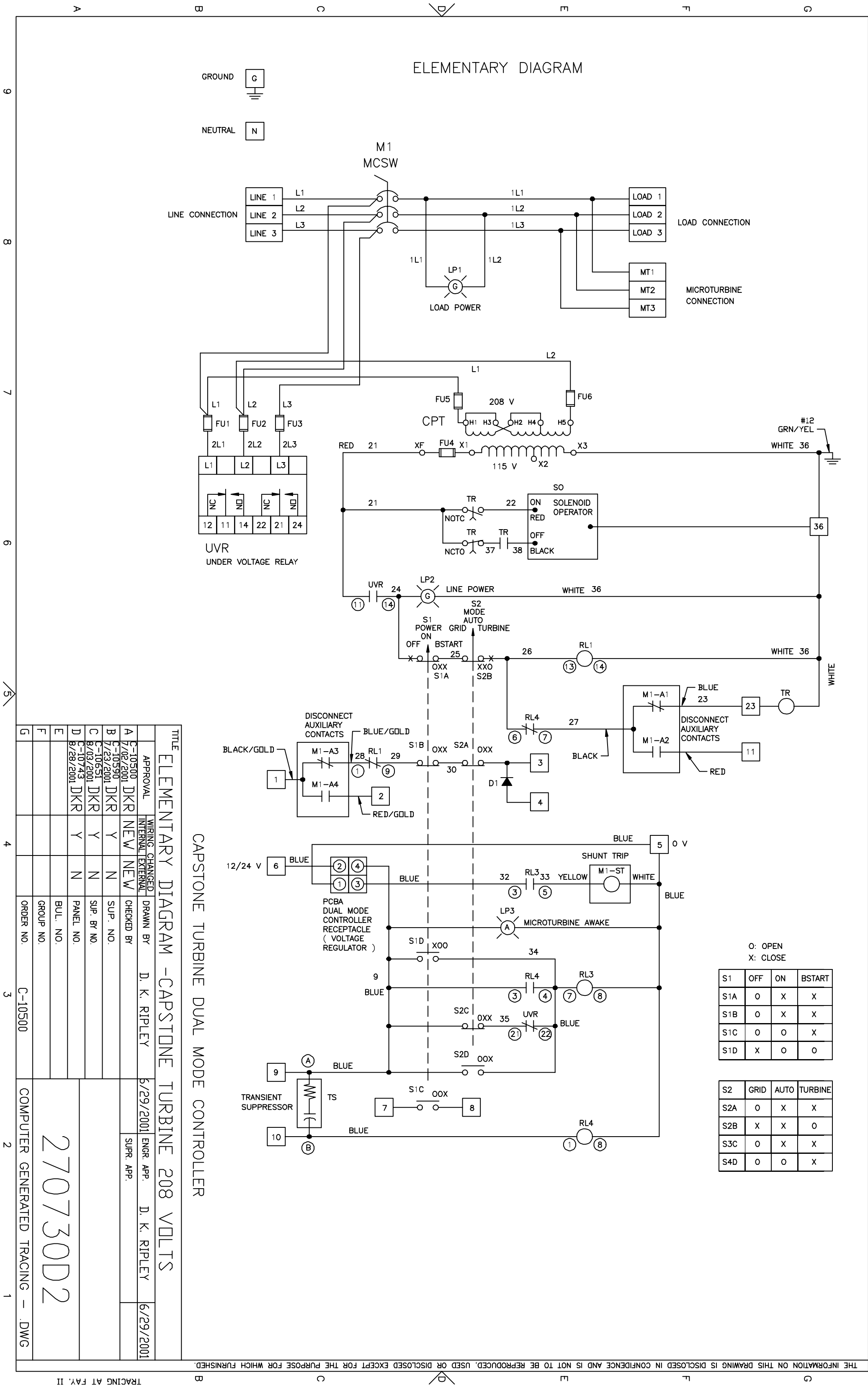


Figure A-1. DMC -001 Series Wiring – 208 Volts (270741D2, Rev. C)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure A-2. DMC -001 Series Schematic – 208 Volts (270730D2, Rev. D)

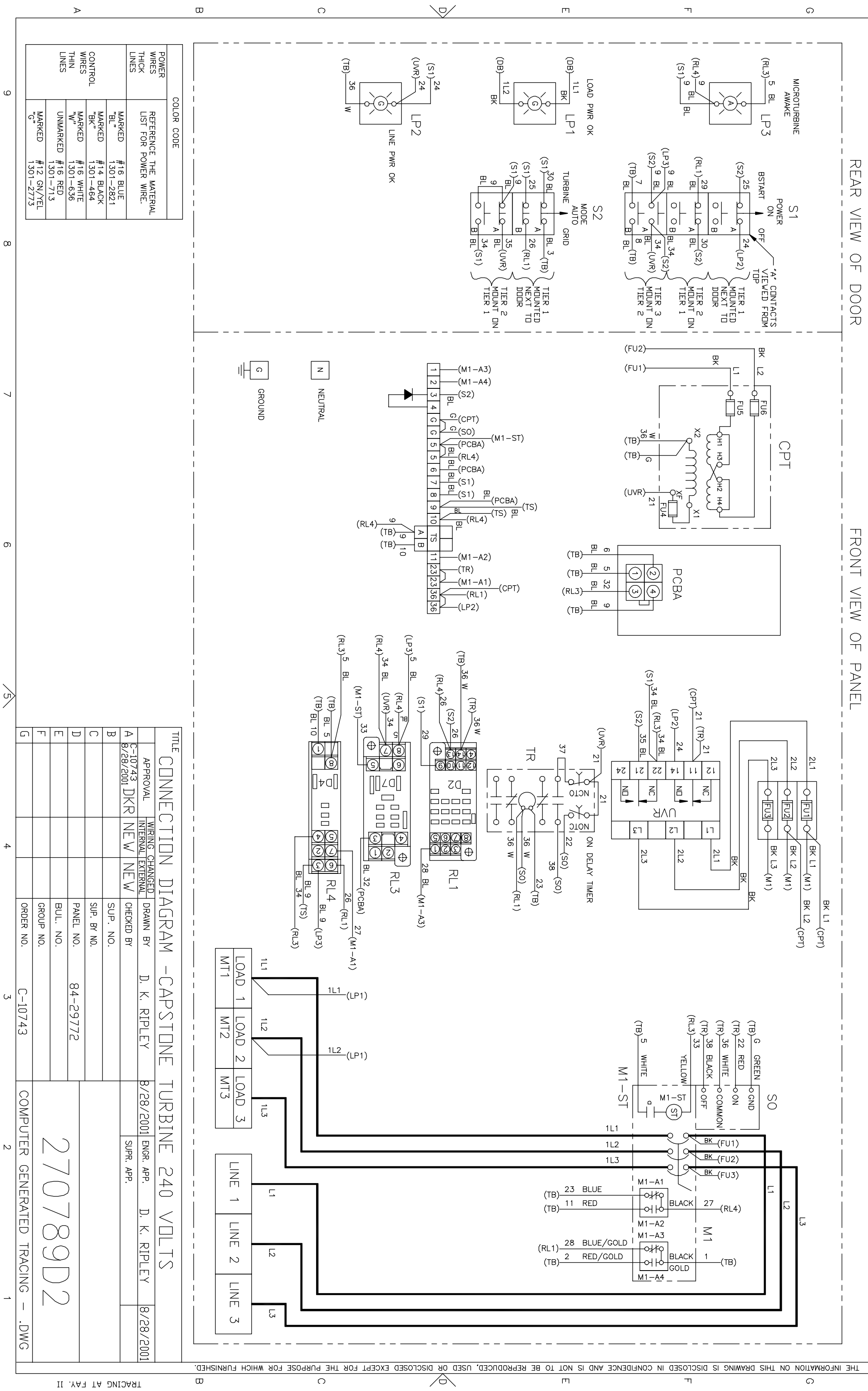
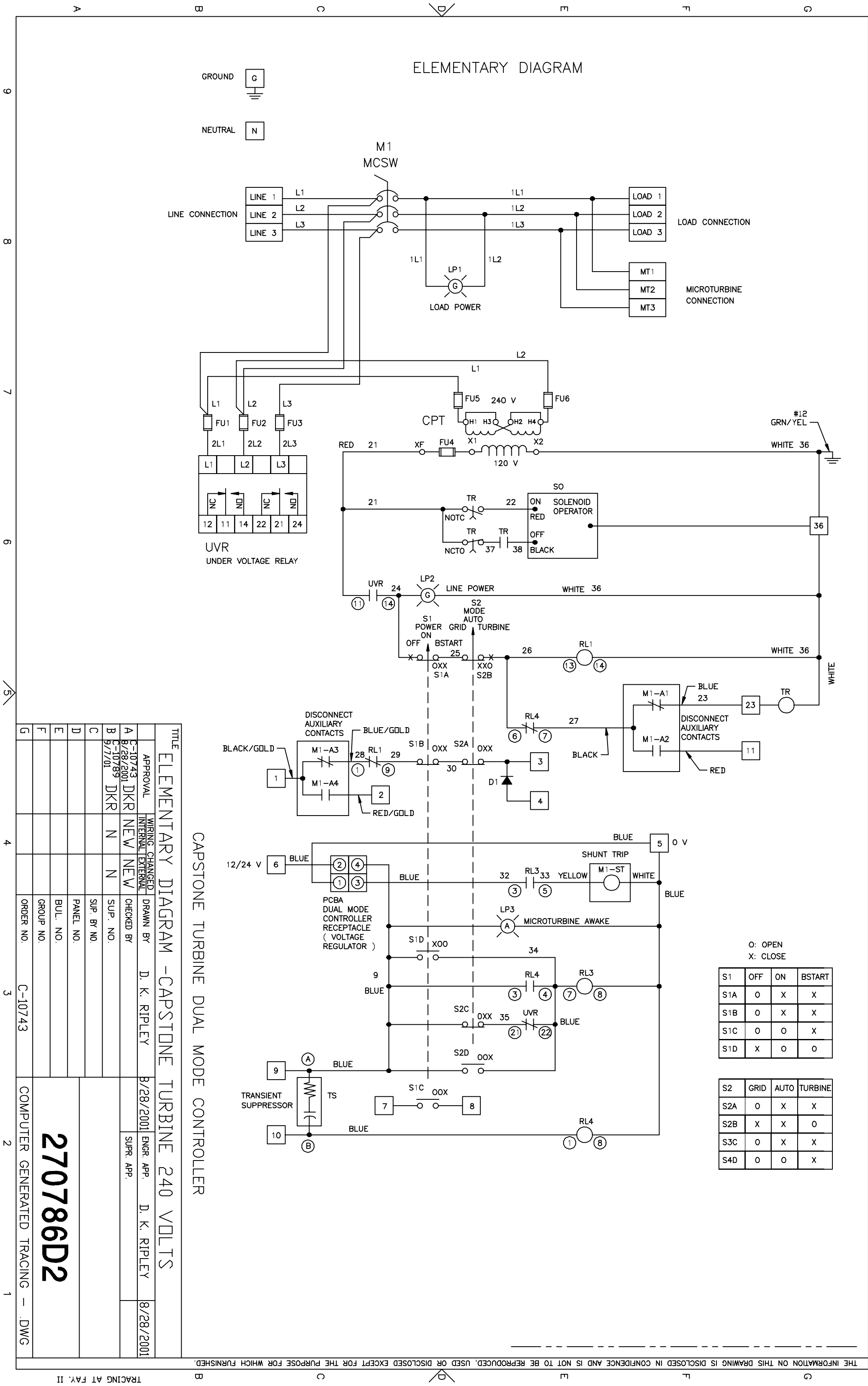


Figure A-3. DMC -001 Series Wiring – 240 Volts (270789D2, Rev. A)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure A-4. DMC -001 Series Schematic – 240 Volts (270786D2, Rev. B)

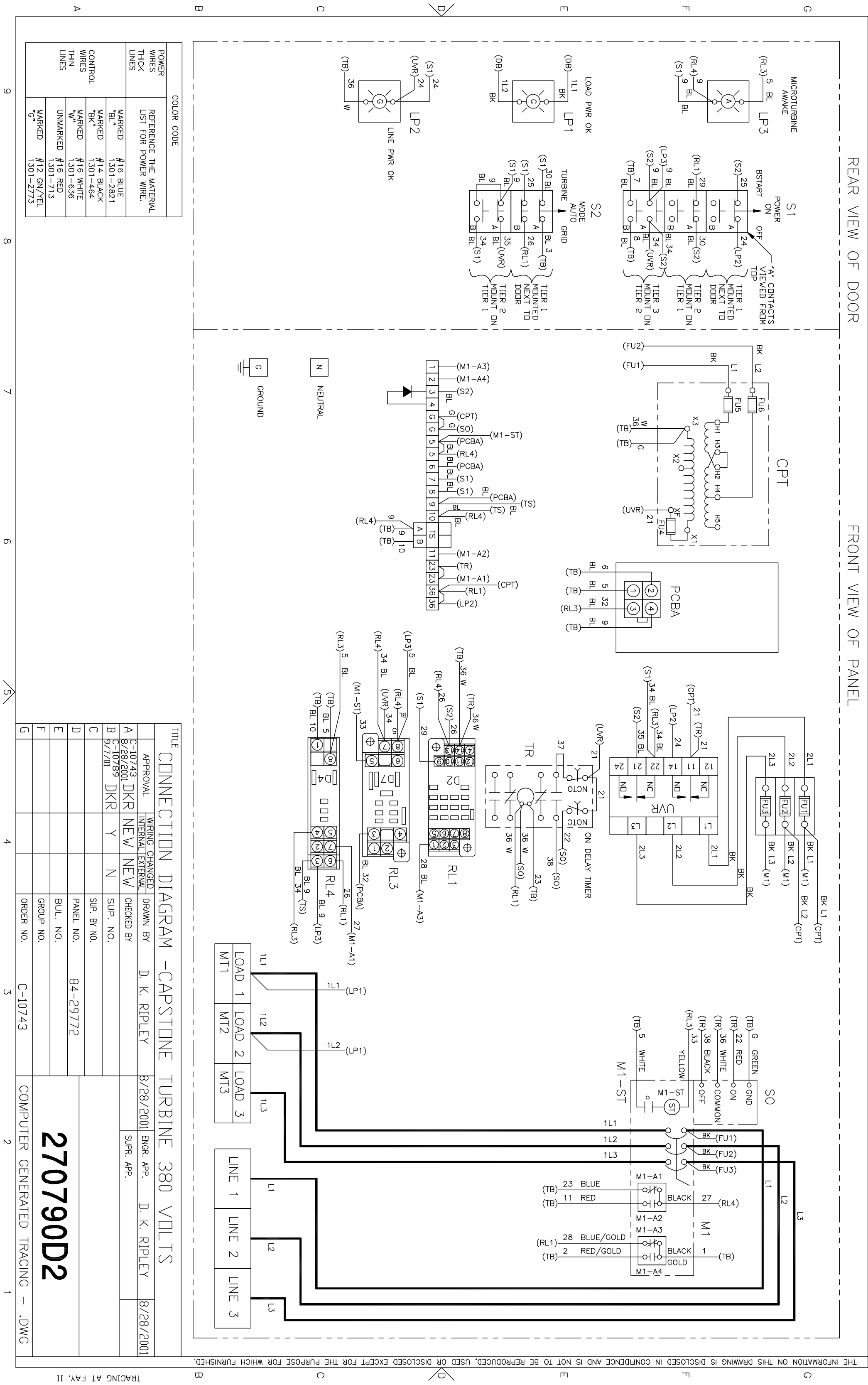


Figure A-5. DMC -001 Series Wiring – 380 Volts (270790D2, Rev. B)

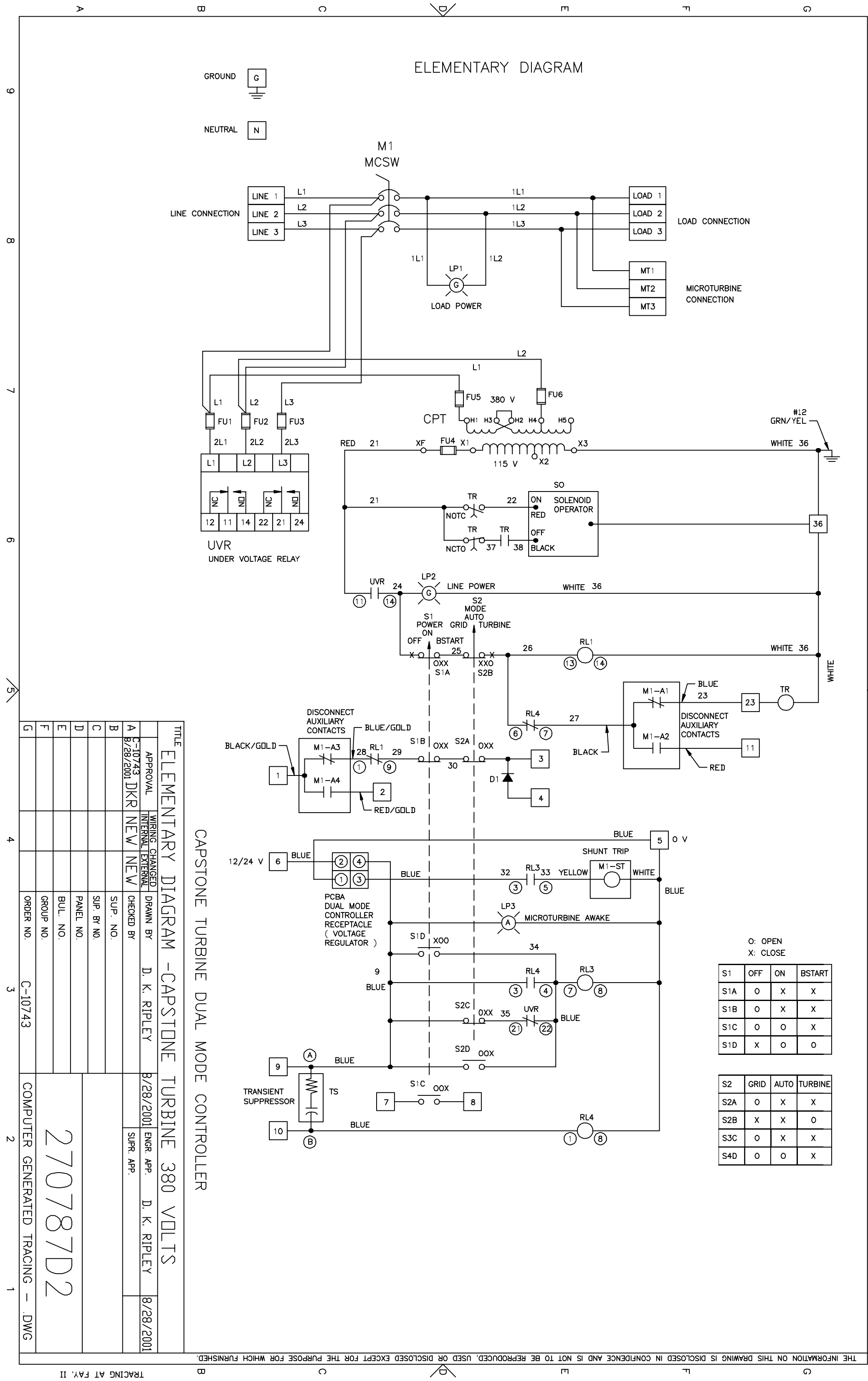


Figure A-6. DMC -001 Series Schematic – 380 Volts (270787D2, Rev. A)

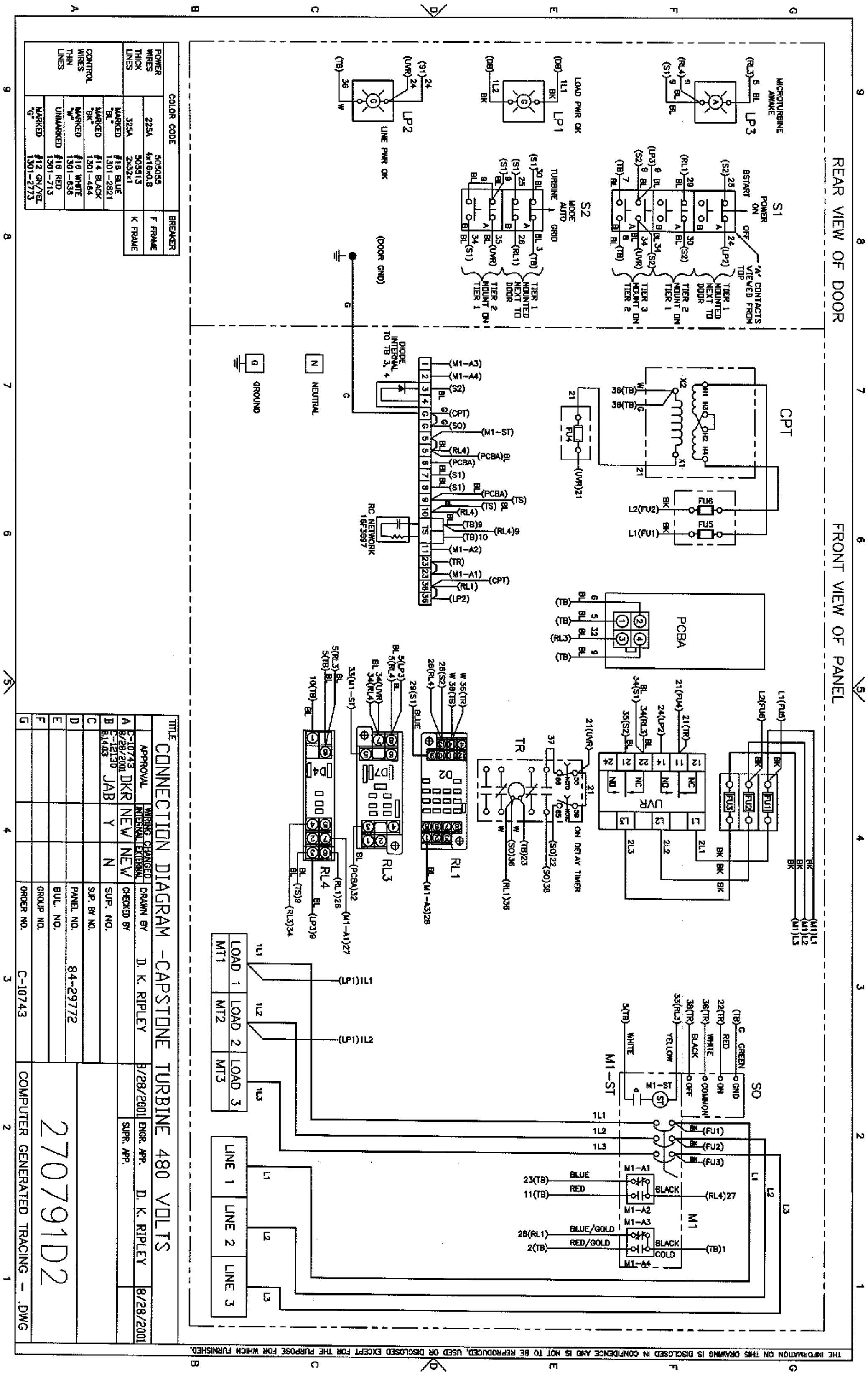
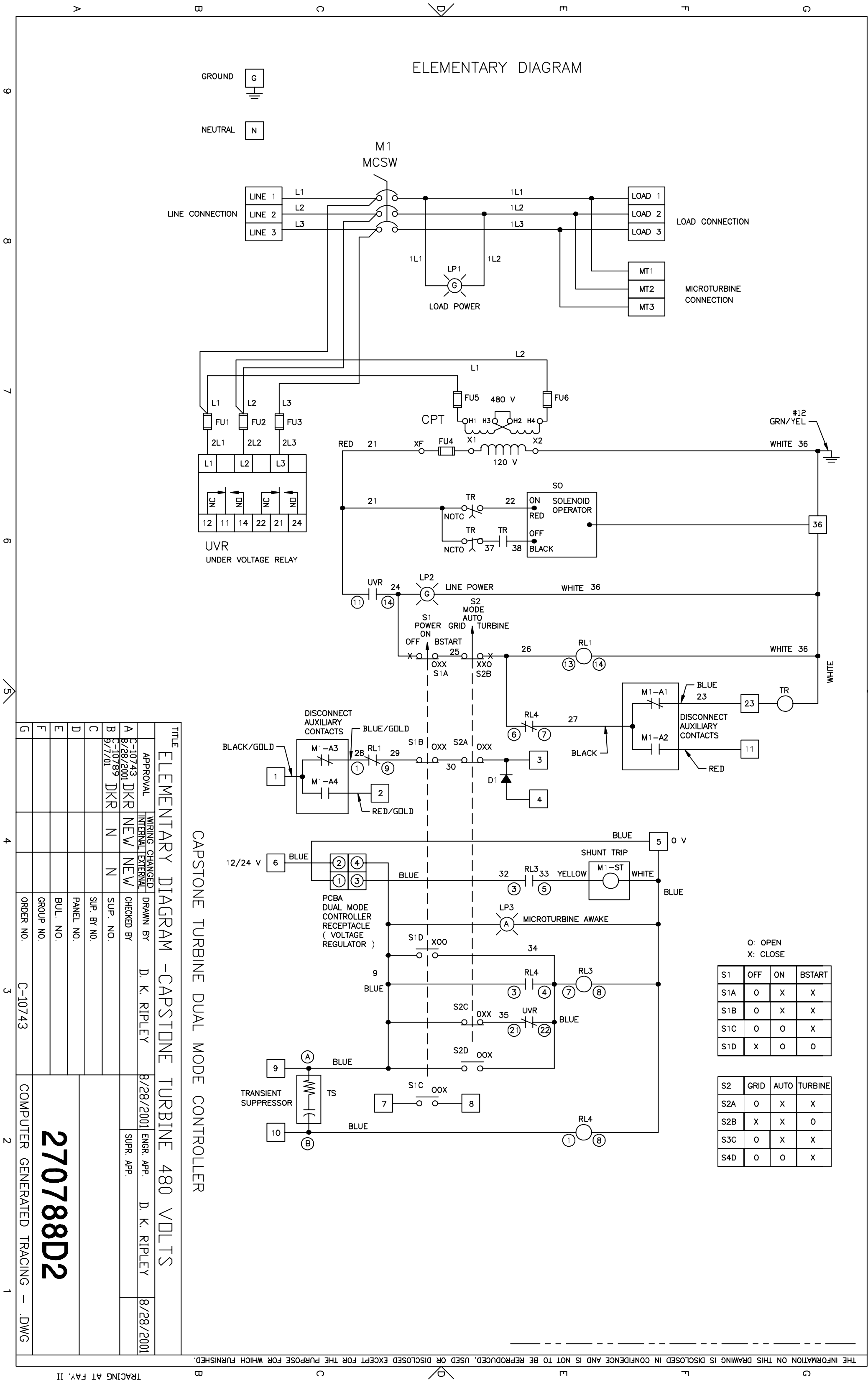


Figure A-7. DMC -001 Series Wiring – 380 Volts (270791D2, Rev. B)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure A-8. DMC -001 Series Schematic – 380 Volts (270788D2, Rev. B)

Appendix B

DMC Fast Transfer Upgrade (-003 Series)

This Appendix contains the wiring diagrams and schematics for the DMC Fast Transfer upgrade model, identified by the suffix -003 in the part number. Refer to the following table for an index of the wiring diagrams and schematic drawings related to each DMC part number.

DMC Part Number	Description	Wiring Diagram	Figure Number	Schematic Drawing	Figure Number
512802-003	125A, 208V	270741D2, Rev. D	B-1	270730D2, Rev. E	B-2
512508-003	225A, 208V				
512509-003	400A, 208V				
512510-003	600A, 208V				
512511-003	800A, 208V				
512512-003	1200A, 208V				
512923-003	125A, 240V	270789D2, Rev. B	B-3	270786D2, Rev. C	B-4
512924-003	225A, 240V				
512925-003	400A, 240V				
512926-003	600A, 240V				
512927-003	800A, 240V				
512928-003	1200A, 240V				
512914-003	125A, 380V	270790D2, Rev. C	B-5	270787D2, Rev. B	B-6
512915-003	225A, 380V				
512916-003	400A, 380V				
512917-003	600A, 380V				
512918-003	800A, 380V				
512919-003	1200A, 380V				
512801-003	125A, 480V	270791D2, Rev. C	B-7	270788D2, Rev. C	B-8
512503-003	225A, 480V				
512504-003	400A, 480V				
512505-003	600A, 480V				
512506-003	800A, 480V				
512507-003	1200A, 480V				

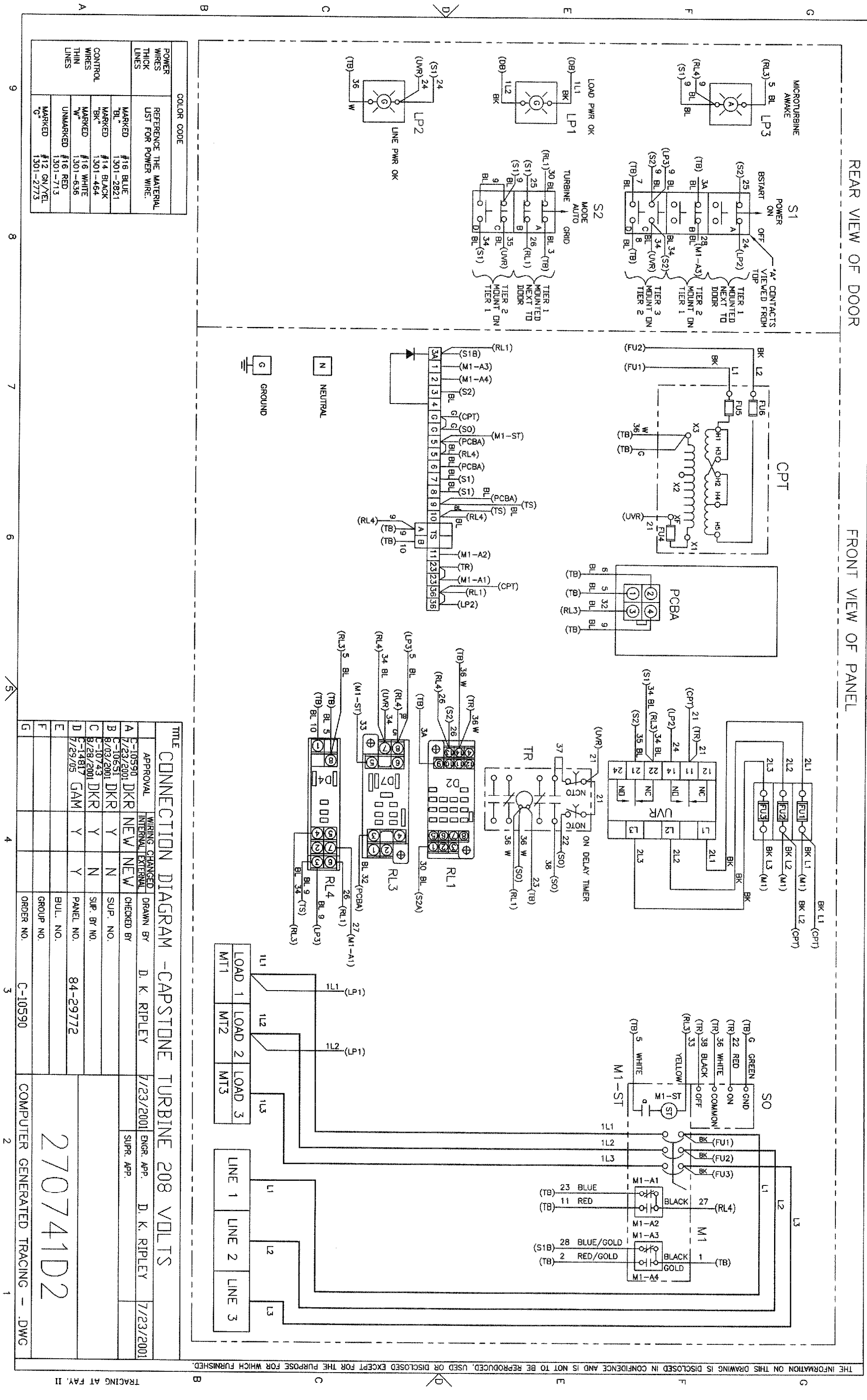


Figure B-1. DMC -003 Series Wiring – 208 Volts (270741D2, Rev. D)

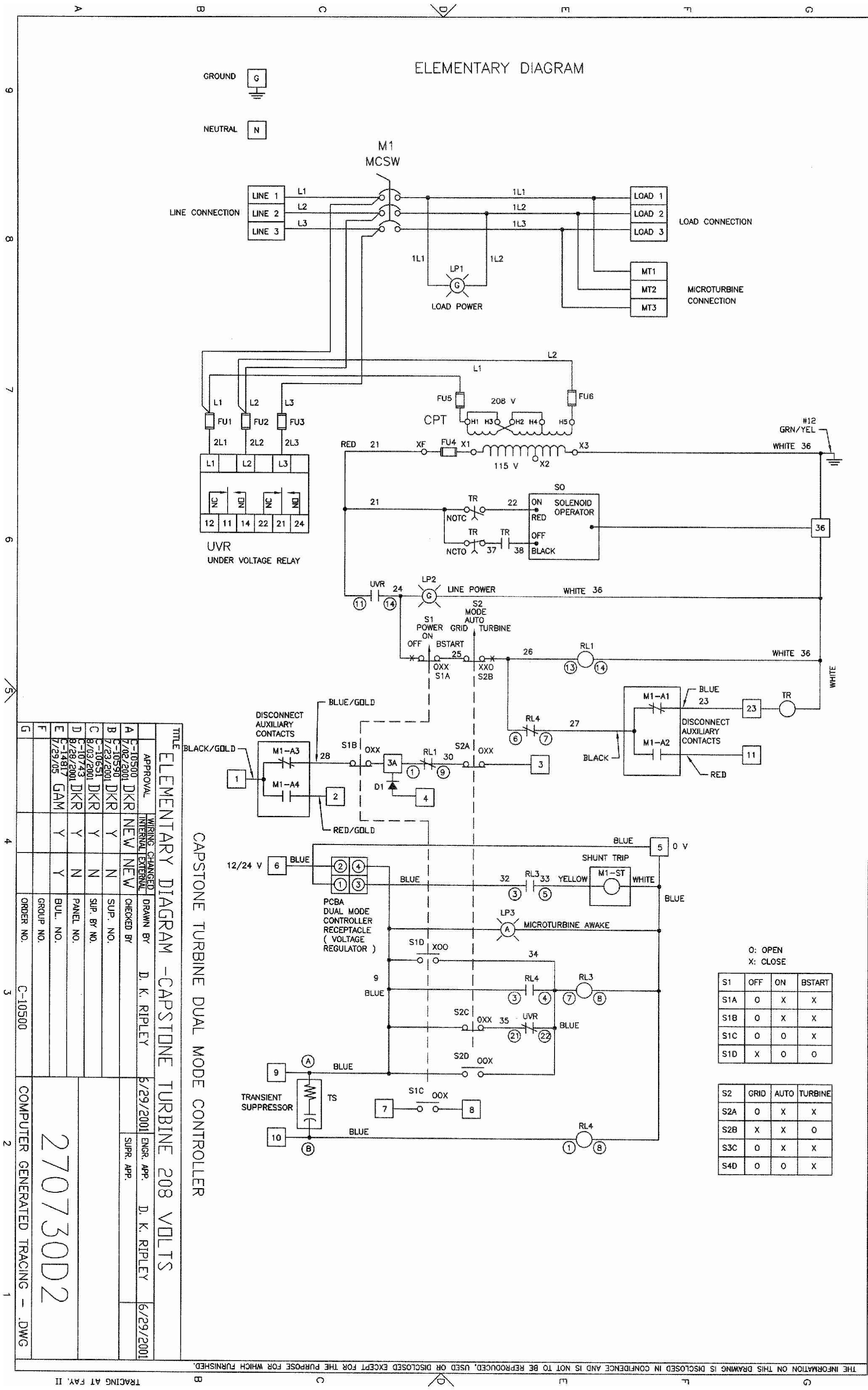


Figure B-2. DMC -003 Series Schematic – 208 Volts (270730D2, Rev. E)

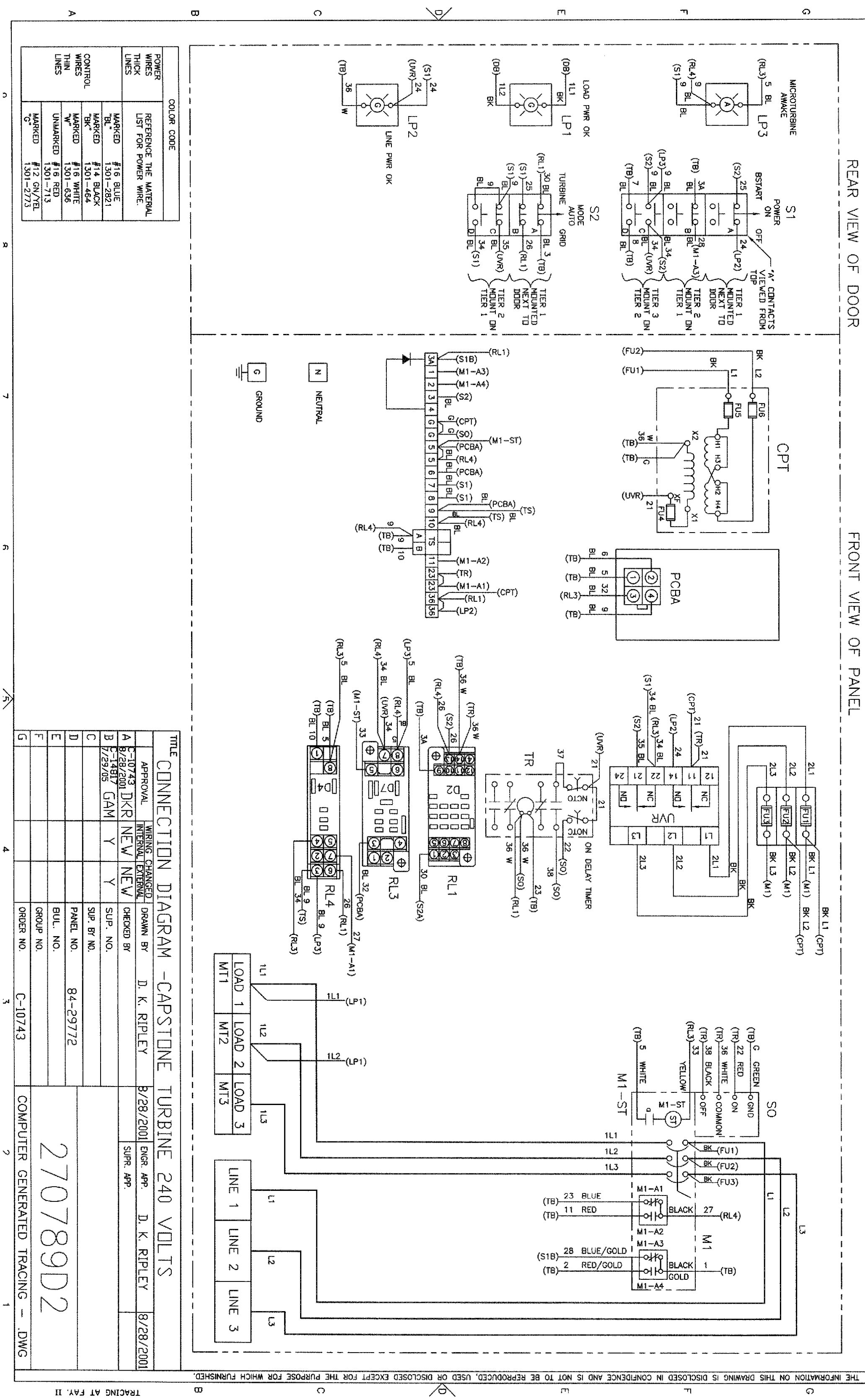
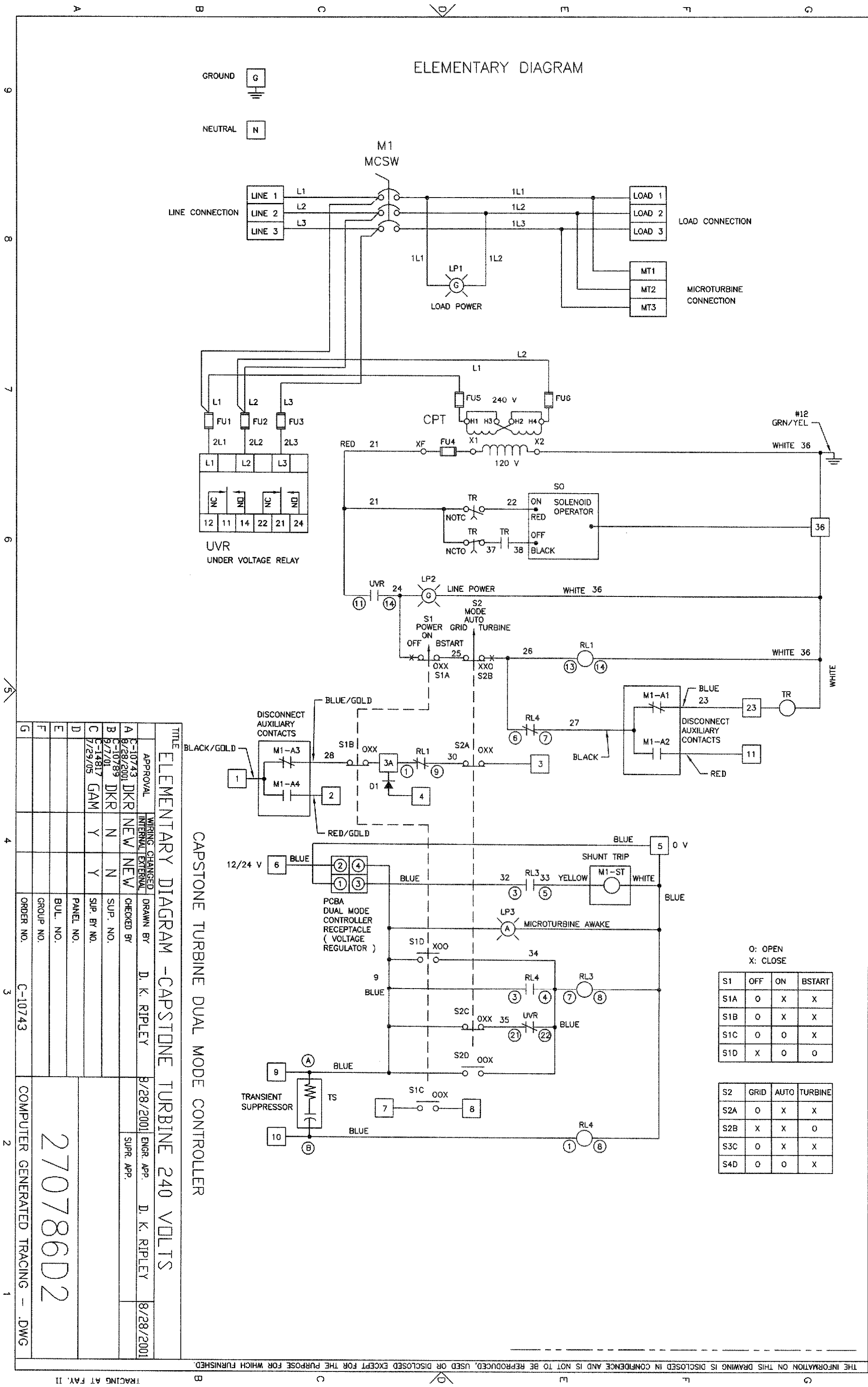


Figure B-3. DMC -003 Series Wiring – 240 Volts (270789D2, Rev. B)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure B-4. DMC -003 Series Schematic – 240 Volts (270786D2, Rev. C)

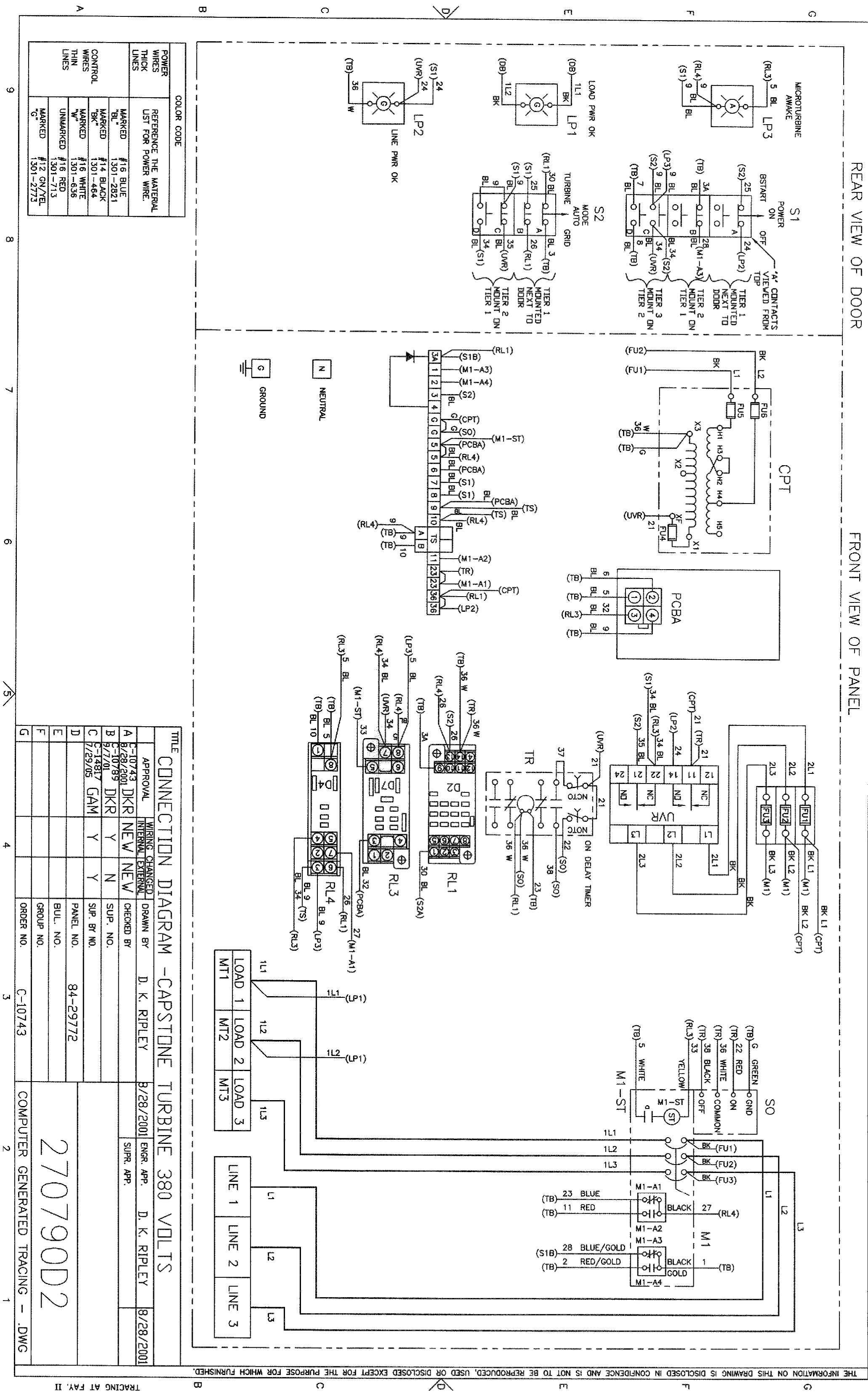
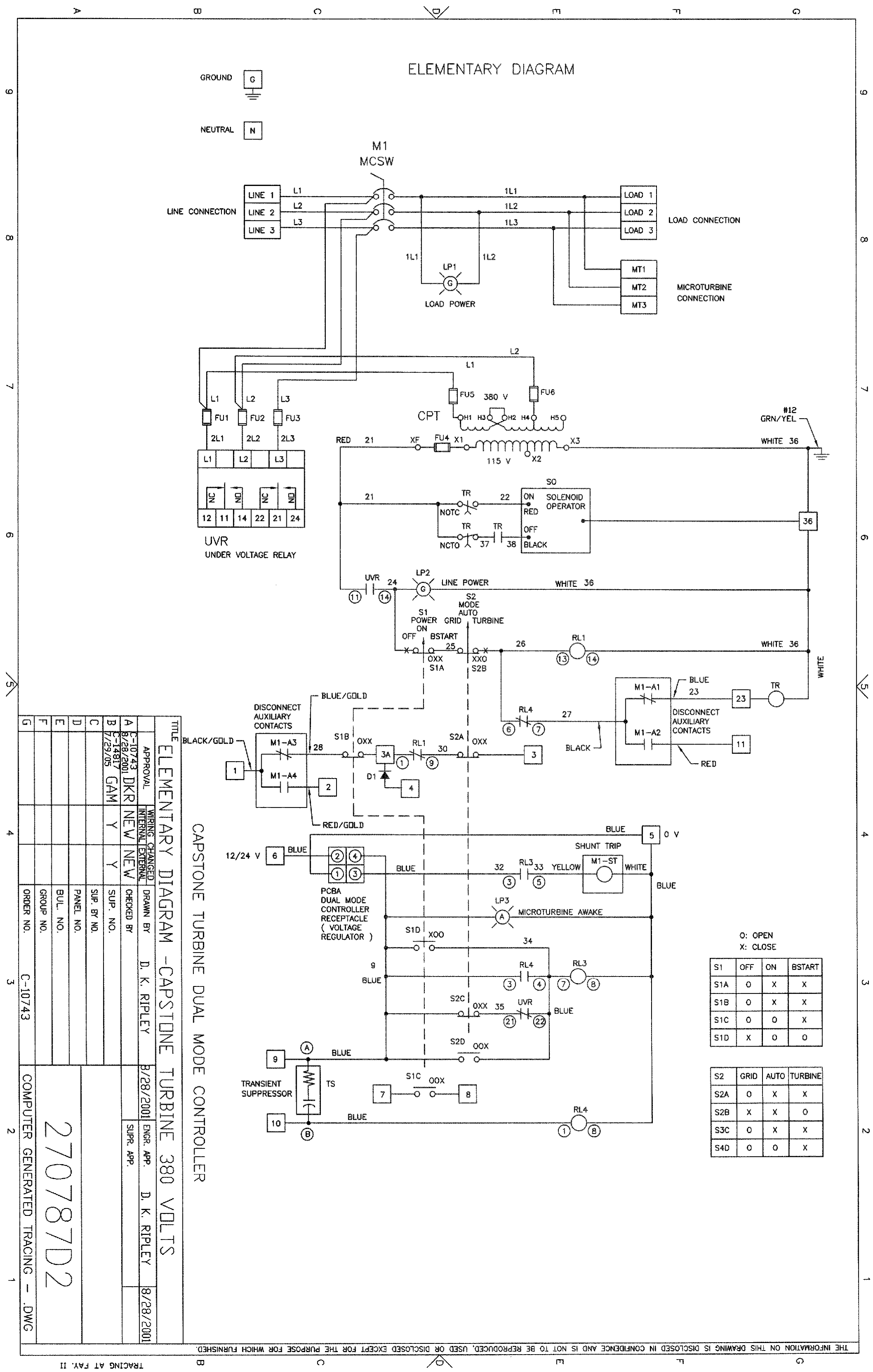


Figure B-5. DMC -003 Series Wiring – 380 Volts (270790D2, Rev. C)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure B-6. DMC -003 Series Schematic – 380 Volts (270787D2, Rev. B)

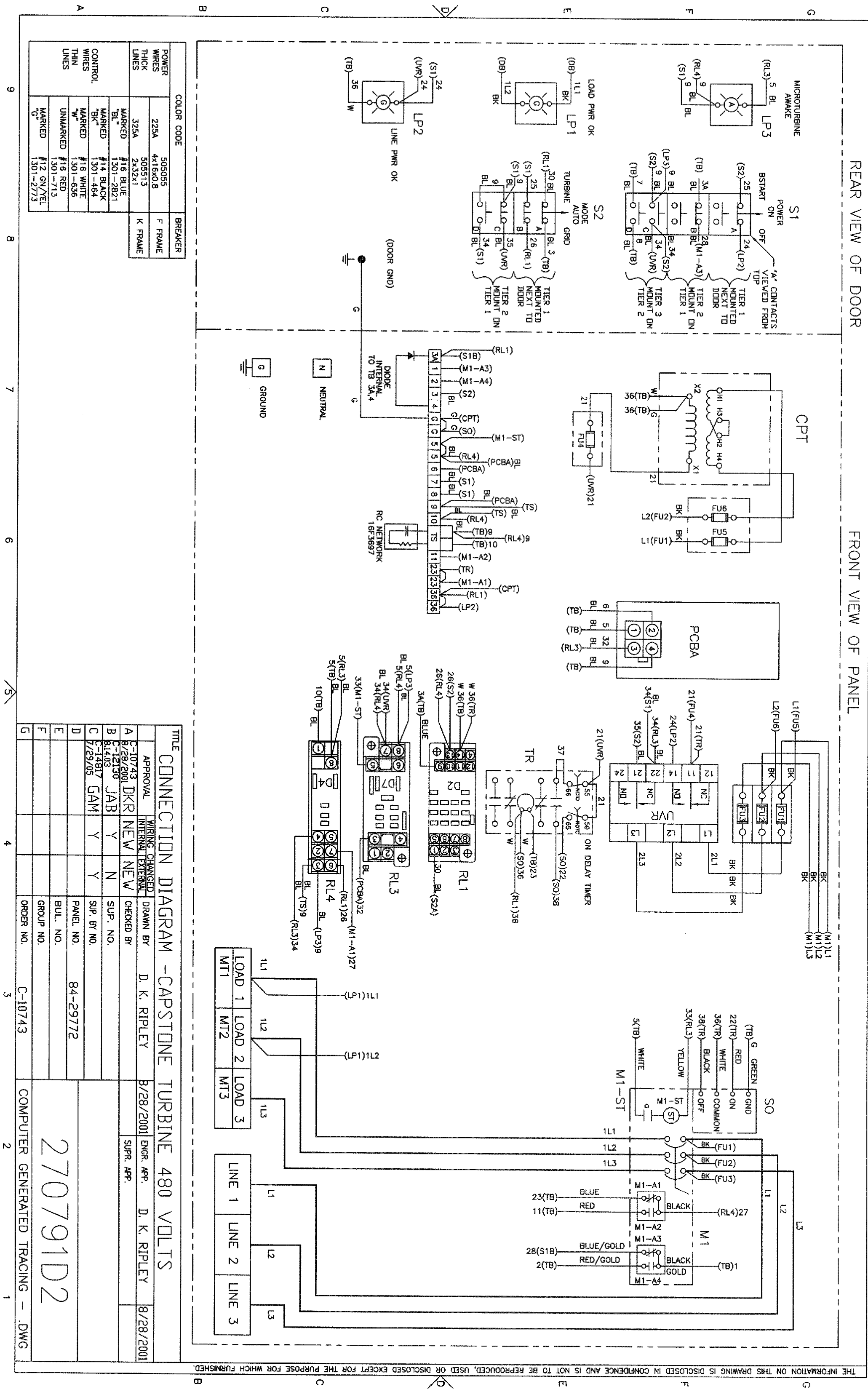
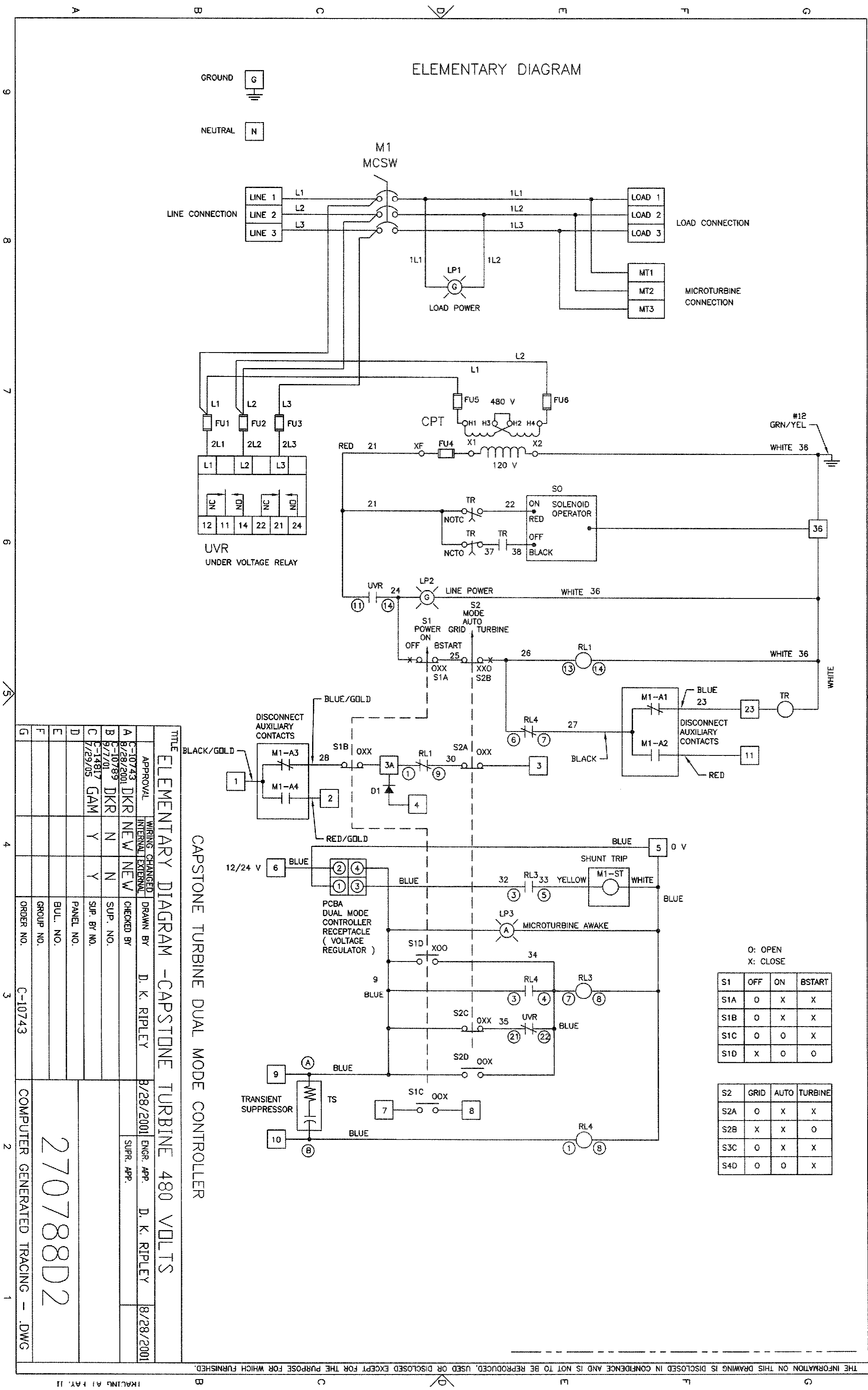


Figure B-7. DMC -003 Series Wiring – 480 Volts (270791D2, Rev. C)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S3C	O	X	X
S4D	O	O	X

Figure B-8. DMC -003 Series Schematic – 480 Volts (270788D2, Rev. C)

Appendix C

DMC Fast Transfer Production Model (-002 Series)

This Appendix contains the wiring diagrams and schematics for the DMC Fast Transfer production model, identified by the suffix -002 in the part number. Refer to the following table for an index of the wiring diagrams and schematic drawings related to each DMC part number.

DMC Part Number	Description	Wiring Diagram	Figure Number	Schematic Drawing	Figure Number
All	Annunciator Panel	284666D3, Rev. A	C-1	--	--
512802-002	125A, 208V	284669D2, Rev. 2	C-2	283127D2, Rev. A	C-3
512508-002	225A, 208V				
512509-002	400A, 208V				
512510-002	600A, 208V				
512511-002	800A, 208V				
512512-002	1200A, 208V				
512923-002	125A, 240V	284670D2, Rev. 2	C-4	283129D2, Rev. A	C-5
512924-002	225A, 240V				
512925-002	400A, 240V				
512926-002	600A, 240V				
512927-002	800A, 240V				
512928-002	1200A, 240V				
512914-002	125A, 380V	284671D2, Rev. 2	C-6	283128D2, Rev. A	C-7
512915-002	225A, 380V				
512916-002	400A, 380V				
512917-002	600A, 380V				
512918-002	800A, 380V				
512919-002	1200A, 380V				
512801-002	125A, 480V	284668D2, Rev. 2	C-8	283130D2, Rev. C	C-9
512503-002	225A, 480V				
512504-002	400A, 480V				
512505-002	600A, 480V				
512506-002	800A, 480V				
512507-002	1200A, 480V				

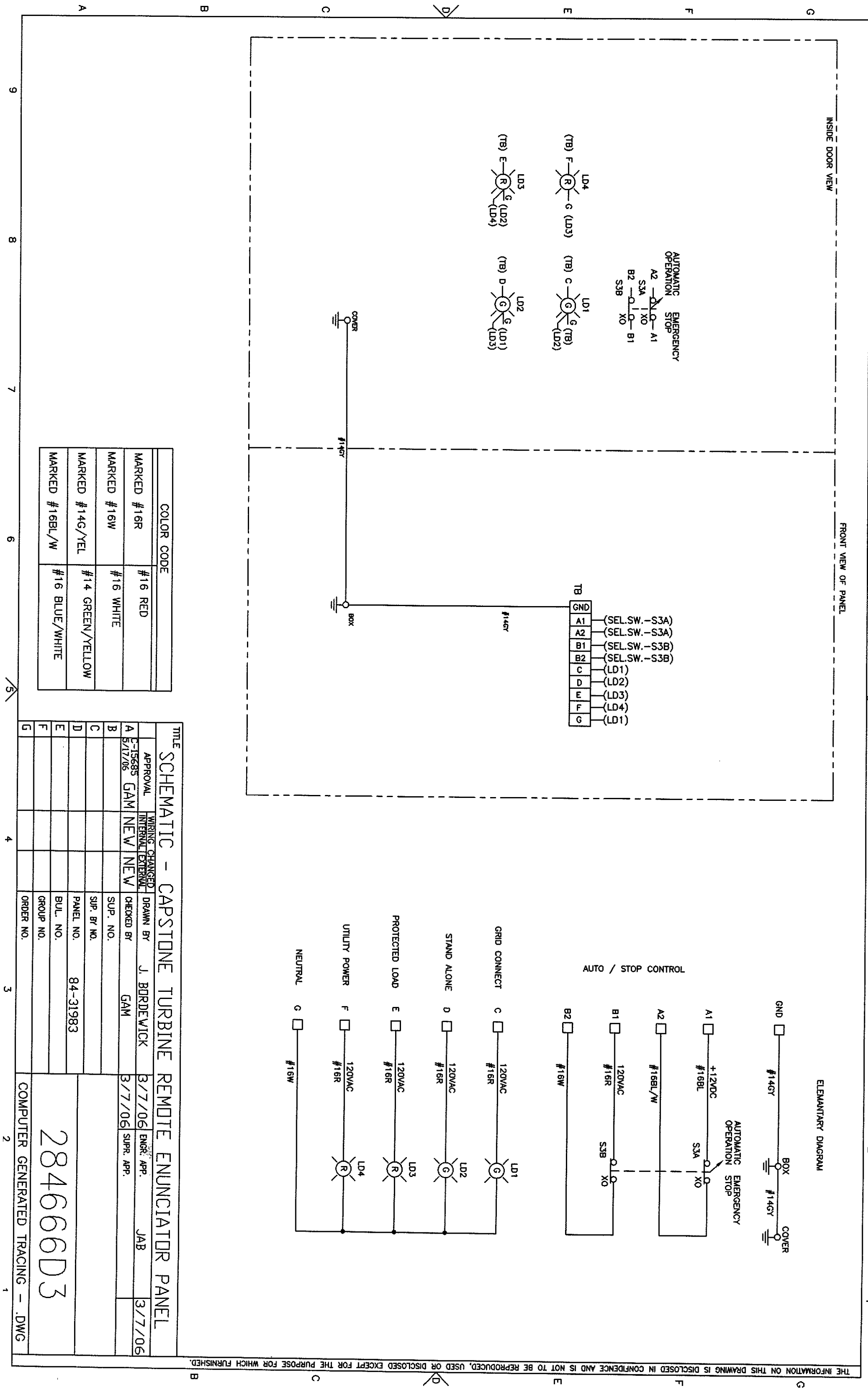


Figure C-1. Schematic – Remote Annunciator Panel (284666D3, Rev. A)

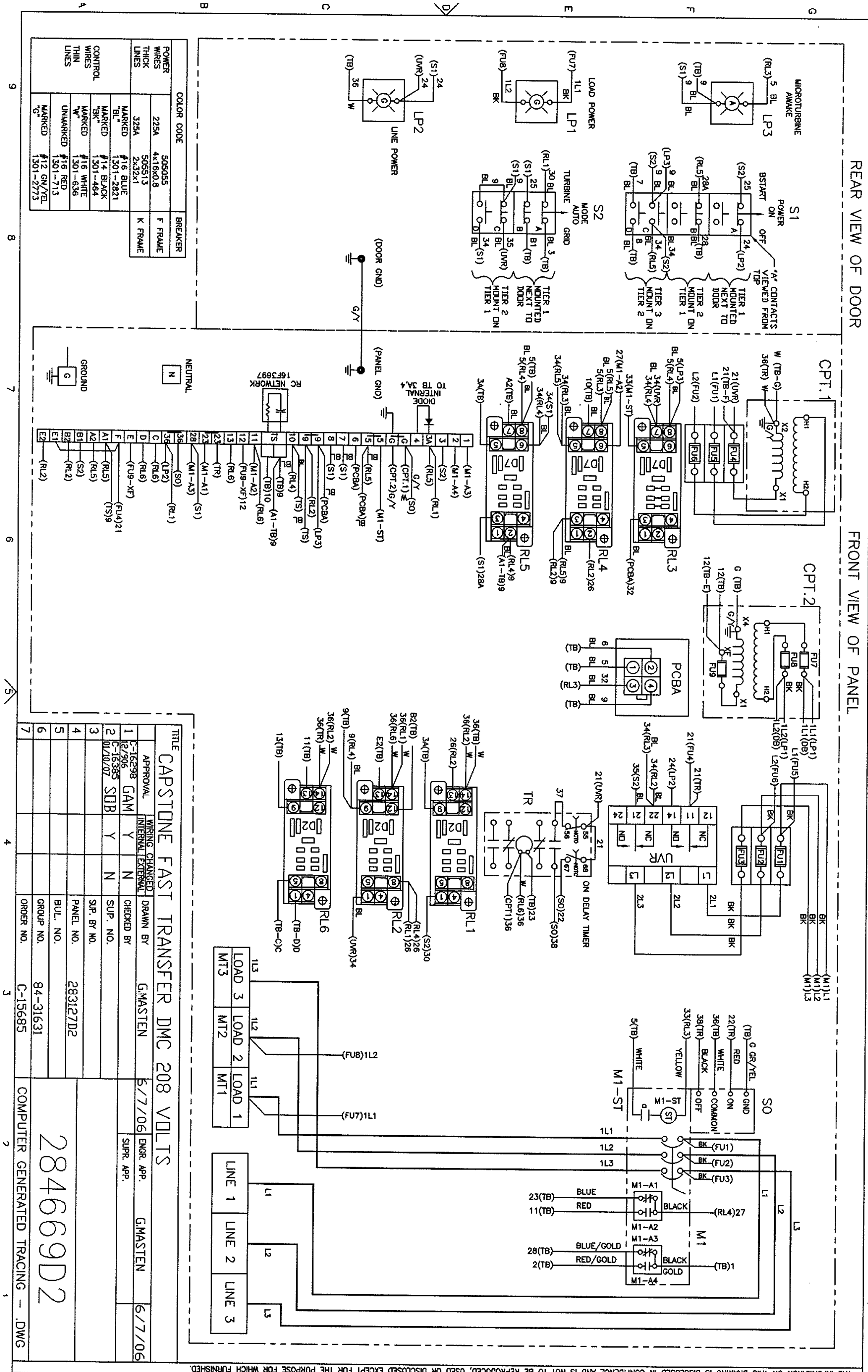


Figure C-2. DMC -002 Series Wiring – 208 Volts (284669D2, Rev. 2)

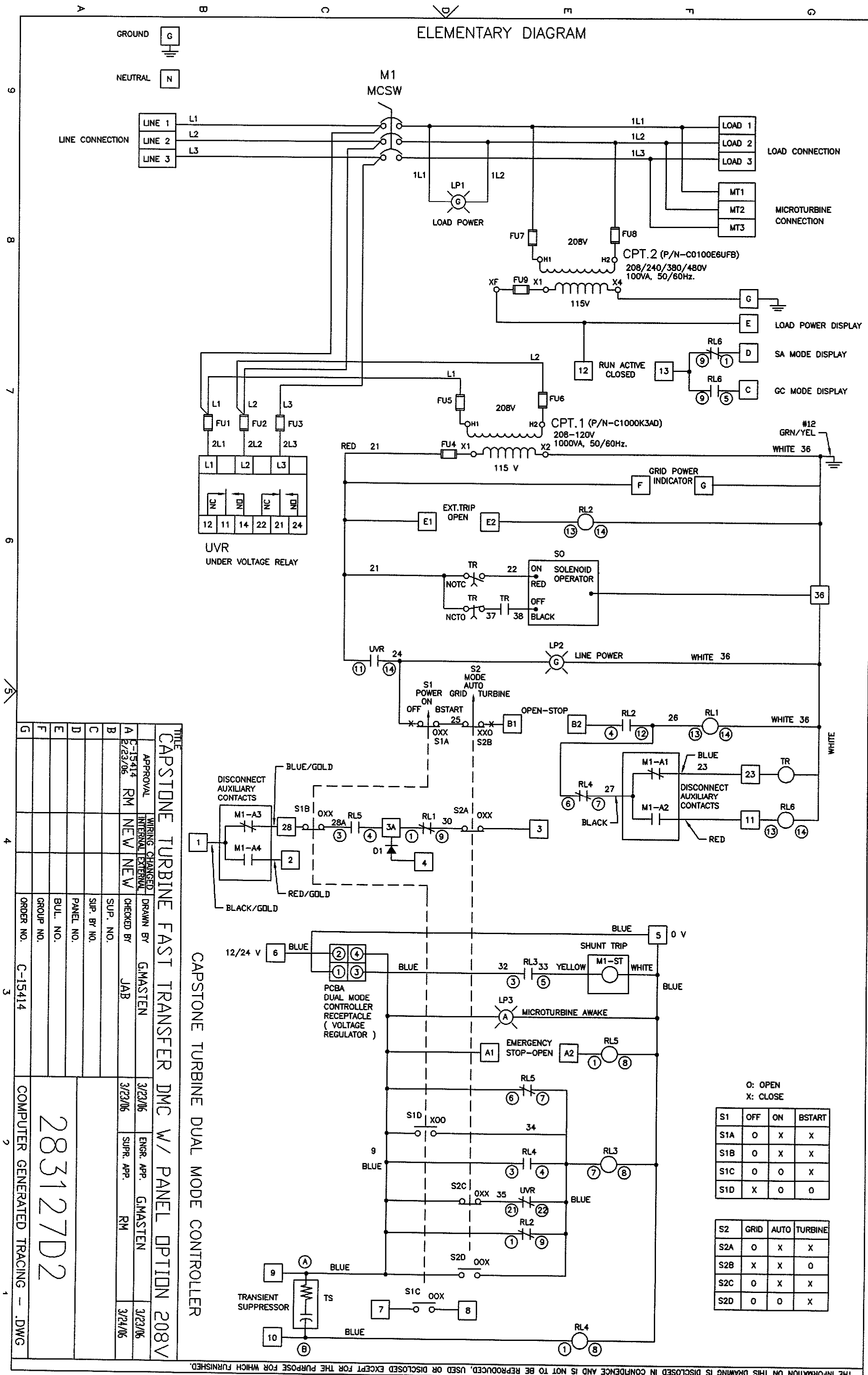


Figure C-3. DMC -002 Series Schematic – 208 Volts (283127D2, Rev. A)

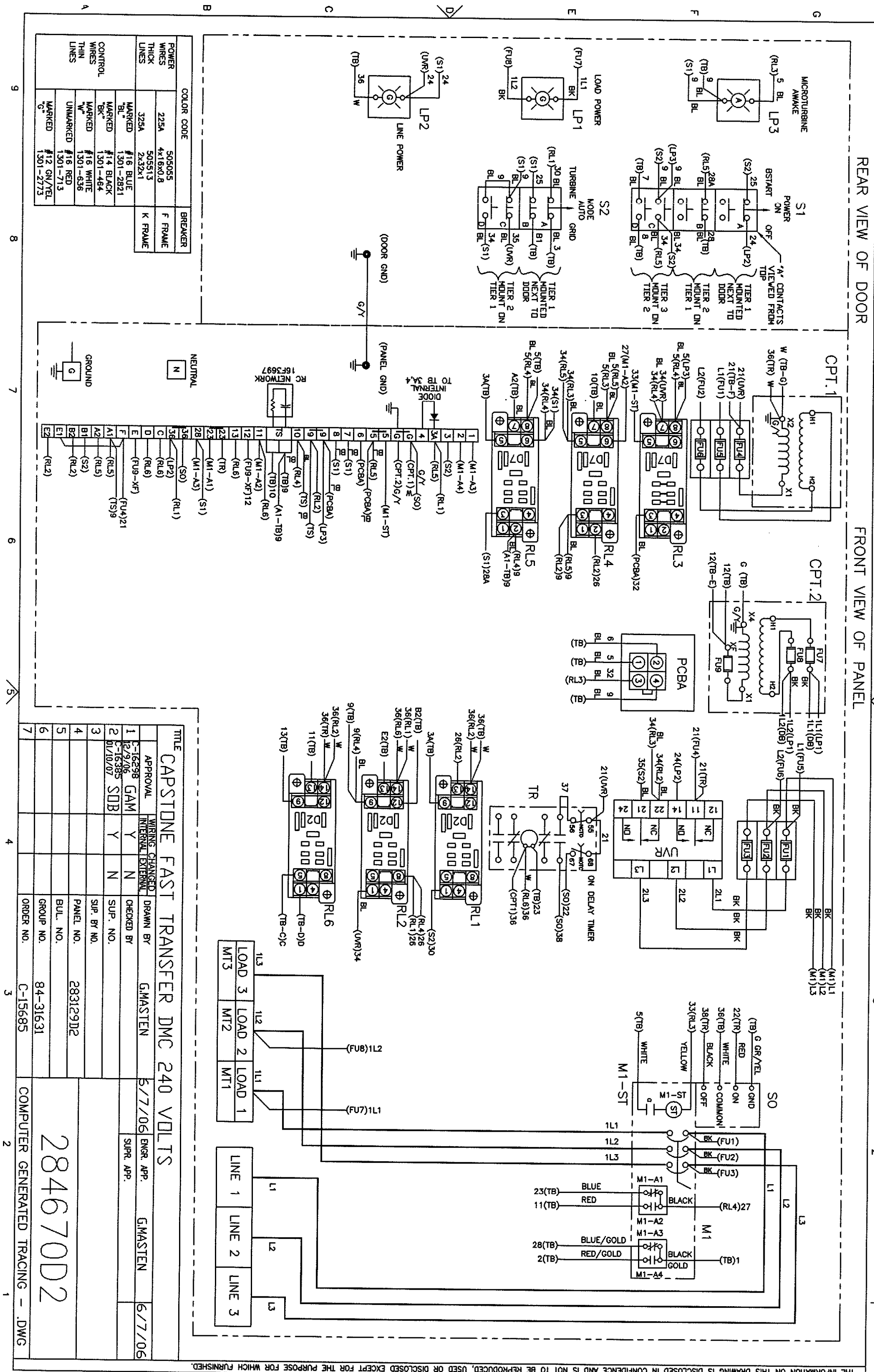
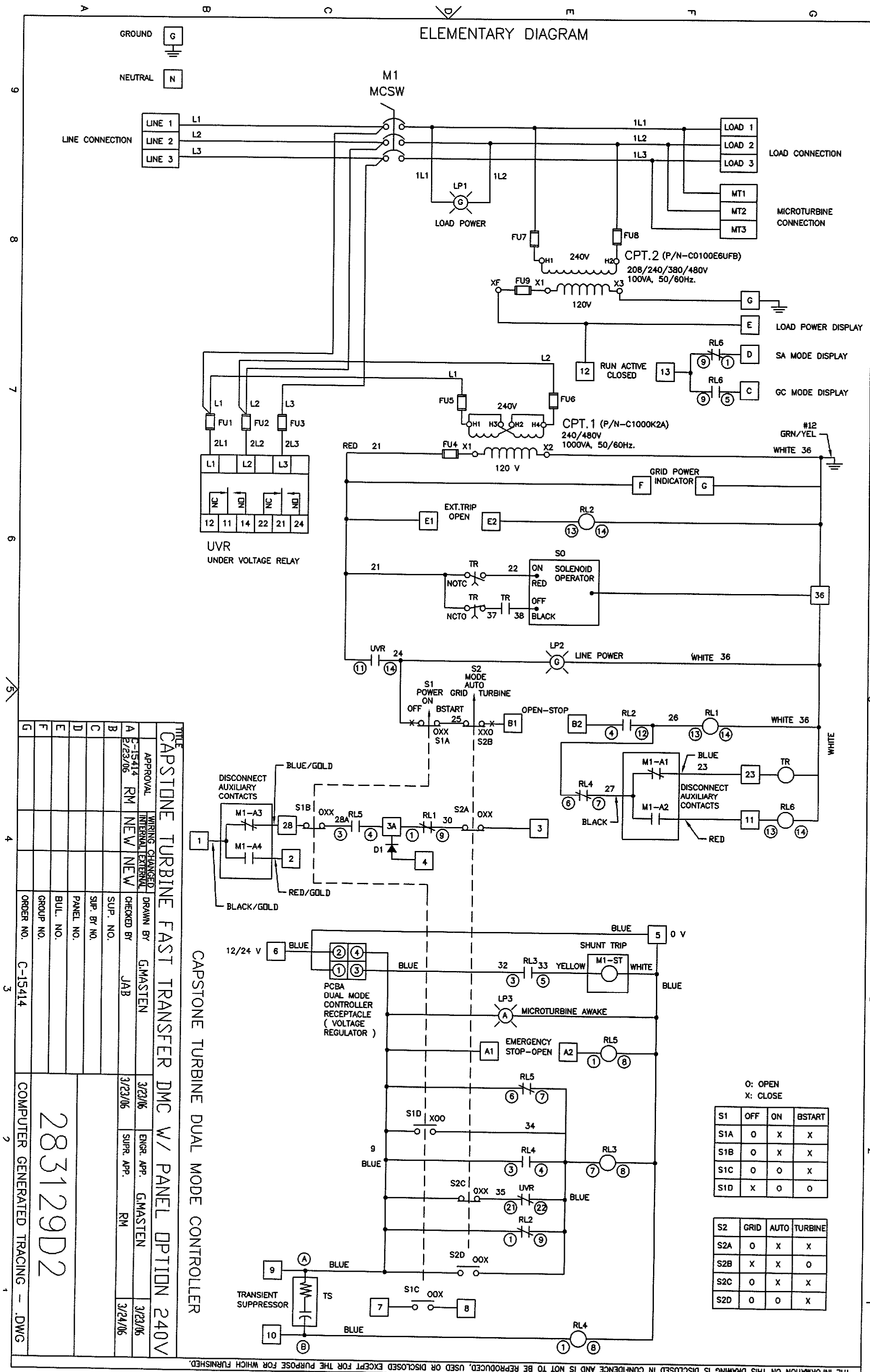


Figure C-4. DMC -002 Series Wiring – 240 Volts (284670D2, Rev. 2)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S2C	O	X	X
S2D	O	O	X

Figure C-5. DMC -002 Series Schematic – 240 Volts (283129D2, Rev. A)

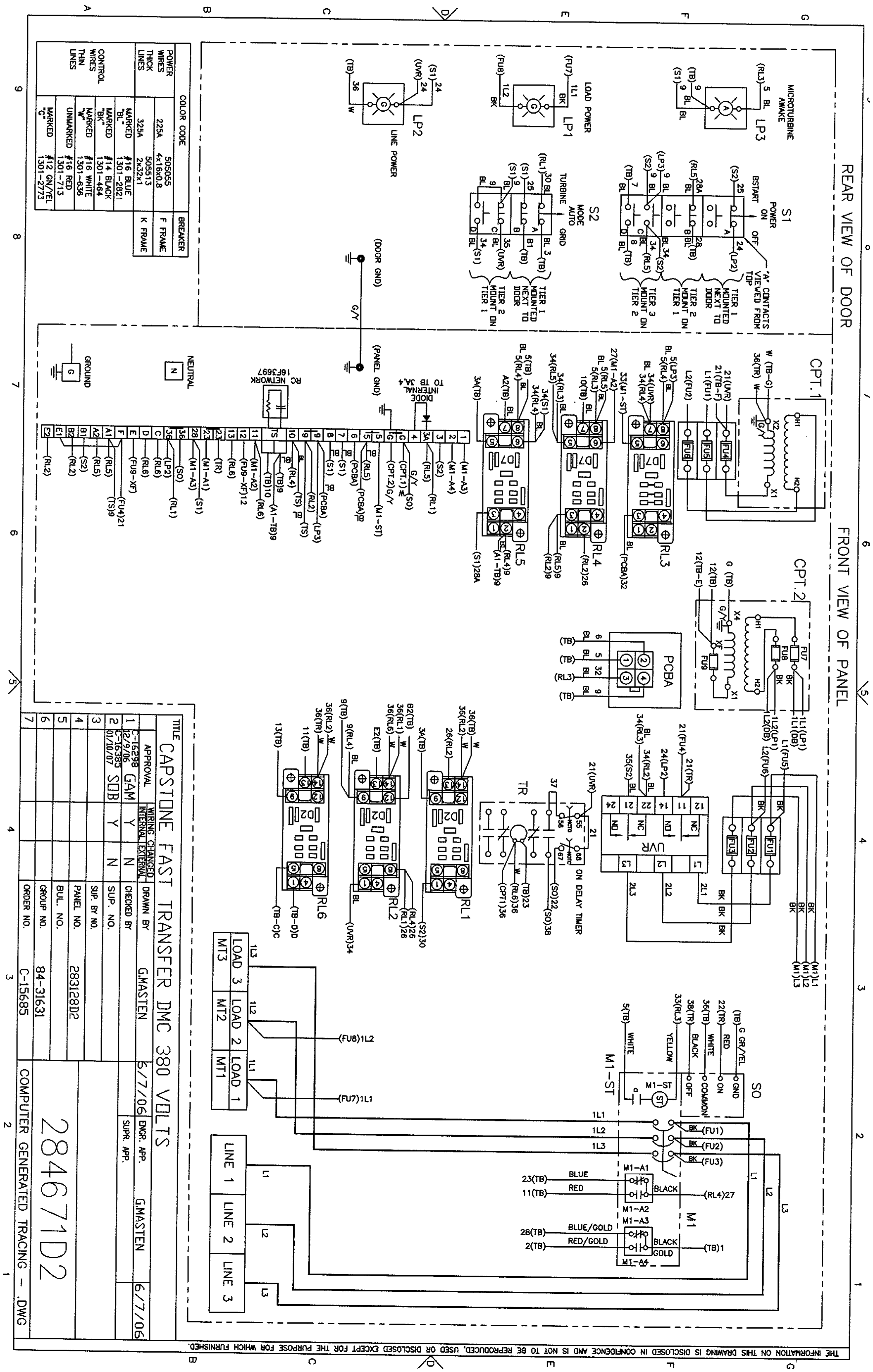
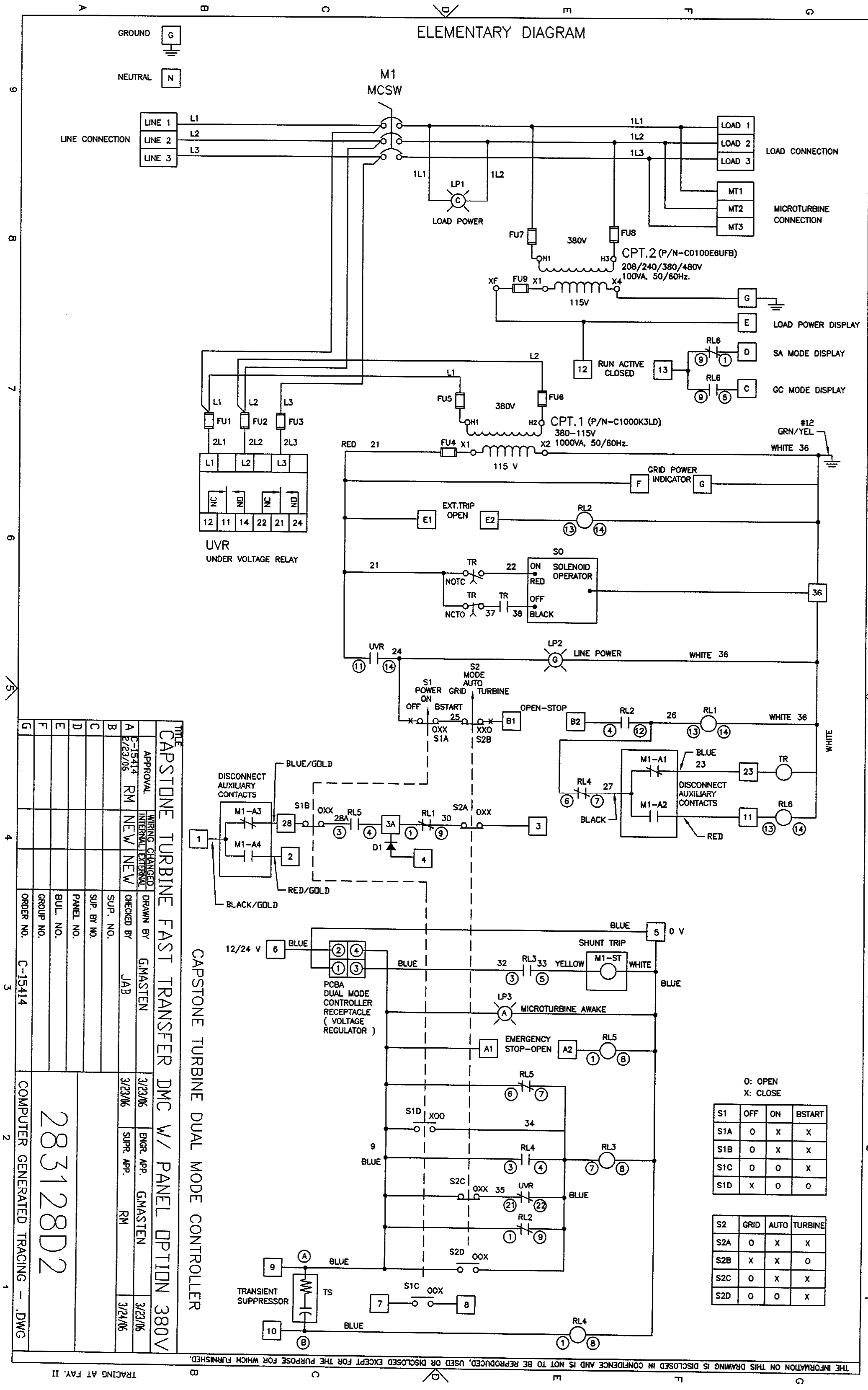


Figure C-6. DMC -002 Series Wiring – 380 Volts (284671D2, Rev. 2)



S1	OFF	ON	BSTART
S1A	O	X	X
S1B	O	X	X
S1C	O	O	X
S1D	X	O	O

S2	GRID	AUTO	TURBINE
S2A	O	X	X
S2B	X	X	O
S2C	O	X	X
S2D	O	O	X

Figure C-7. DMC -002 Series Schematic – 380 Volts (283128D2, Rev. A)

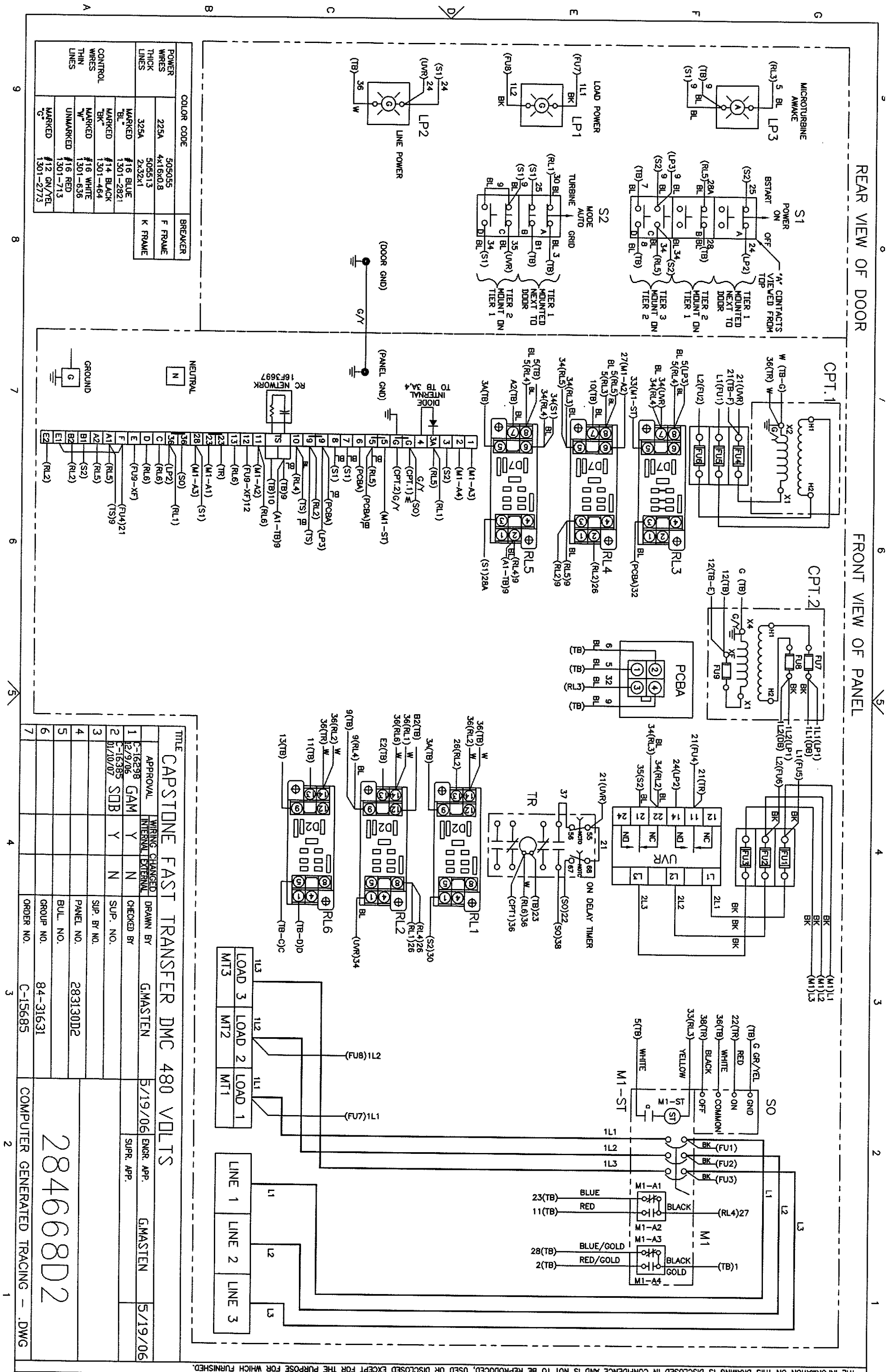


Figure C-8. DMC -002 Series Wiring – 480 Volts (284668D2, Rev. 2)

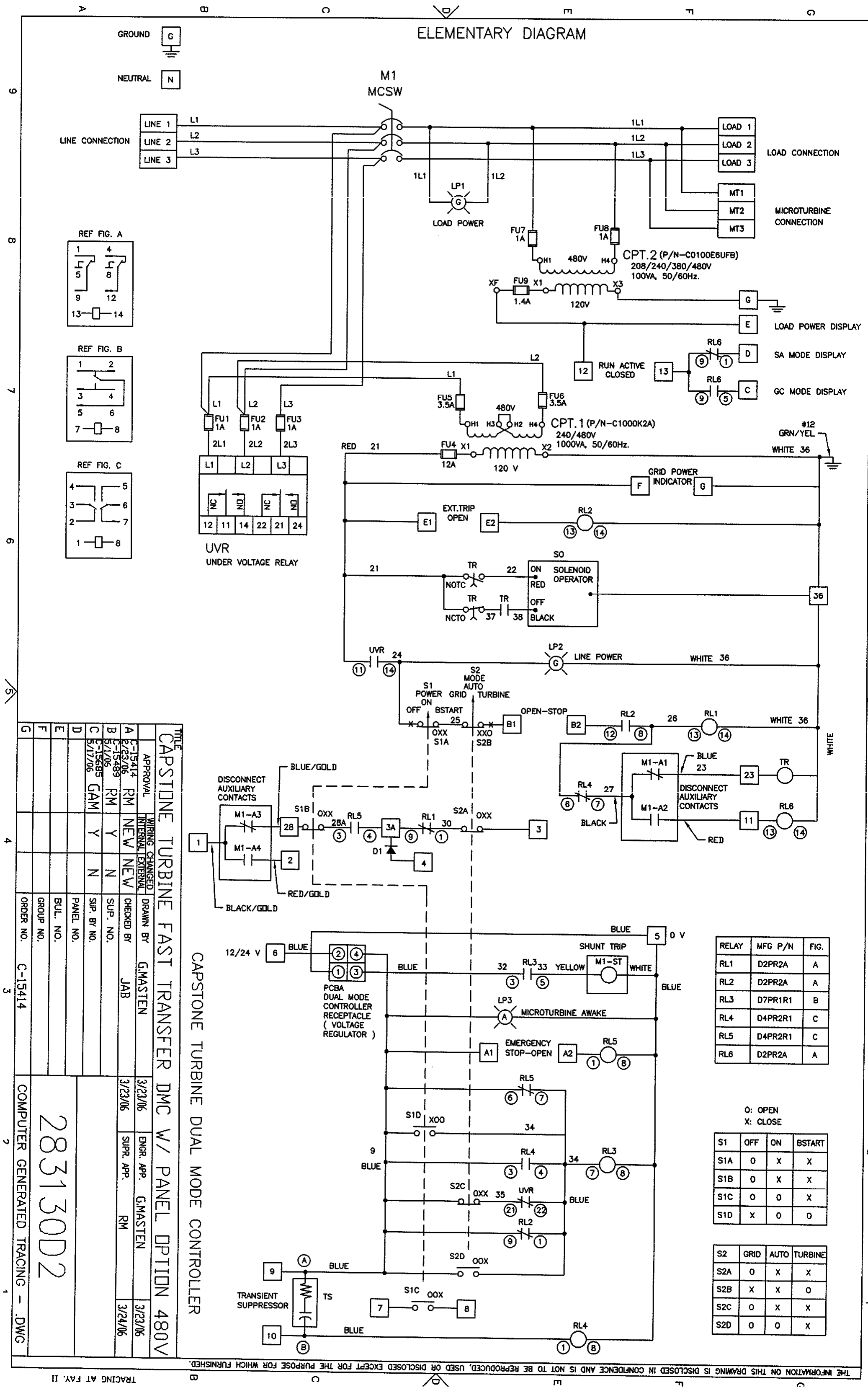


Figure C-9. DMC -002 Series Schematic – 480 Volts (283130D2, Rev. C)