



*WCL488 Series
Water Cooled
Electronic Loads
Operation & Programming Manual*

TDI-Dynaload[®] Division

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Chapter 1 — Overview

Introduction

The WCL488 Water Cooled Electronic Loads are ideal for high current/high power battery, power supply and fuel cell testing. Standard systems from 12kW to 120kW are configured using 12kW standard products in a master/slave configuration. Each 12kW unit is rated at 0-100V or 0-400V, 0-1000A (1200A for the 50V model), not to exceed 12,000W. Larger systems are available upon request.

The WCL488 master unit measures 5-1/4 inches high and the slave unit measures 3-1/2 inches high and both fit into a standard 19-inch wide equipment rack. The compact size of the units and our unique plumbing design allows 120kW of power dissipation in a single 60 high rack.

Systems may be upgraded by adding slave units. The manifold plumbing design and complete DC bus structure allow for simple upgrade in the field.

Individual units' electrical inputs and water inlet and output connections are located on the rear of each unit. Single connections are provided for systems unless otherwise specified.

Standard features for the WCL488 Series include the following:

- Operation below 1 Volt at 10,000 Amps (50 Volt model only)
- Five modes of operation: Constant Current, Constant Resistance, Constant Power, Constant Voltage, Pulse Mode
- Full Scale Range Switching: When a scale is selected, it changes the controls and instrumentation to correspond with the selected scale, for increased resolution and accuracy.
- Synchronized paralleling creates larger systems controlled as a single unit
- Automated flow regulation to eliminate condensation
- Lab View drivers are available for computer control
- Self configuring based on number of slaves in use
- Units available include:
 - 50 Volts, 1200 Amps, 12000 Watts
 - 100 Volts, 1000 Amps, 12000 Watts
 - 400 Volts, 1000 Amps, 12000 Watts.
- Highest Density Solution: Complete 120kW system only 60 inches tall
- Constant Current, Resistance, Voltage, Power
- Modular design using standard building blocks

- Low water flow (3gpm at 10°C / 12kW)
- Range switching for increased resolution and accuracy
- WCL488 Dimensions: 19 inches W x 5.22 inches H x 24 inches D
- WCS Dimensions: 19 inches W x 3.47 inches H x 24 inches D.

The Dynaload modes of operation are described in the sections that follow and are thoroughly detailed in *Chapter 2 — Installation and Wiring*.

Modes of Operation

The Dynaload is a precision instrument that simulates DC loads to test power supplies, generators, servo systems, batteries and similar DC sources.

The WCL488 series provides four basic modes of operation: Constant Current, Constant Resistance, Constant Voltage, Constant Power and Pulse Mode. Complete control is available through the full feature front panel, IEEE-488 bus or optional RS232 interface. A 0-10V analog programming input is also available in all of the four modes of operation. The connections for IEEE-488 and analog programming are located at the rear of the unit. Refer to Figure 1 through Figure 4 and the four modes of operation explanations that follow.

□ Constant Current Mode

Referring to Figure 1, the Dynaload will sink the set current regardless of the input voltage.

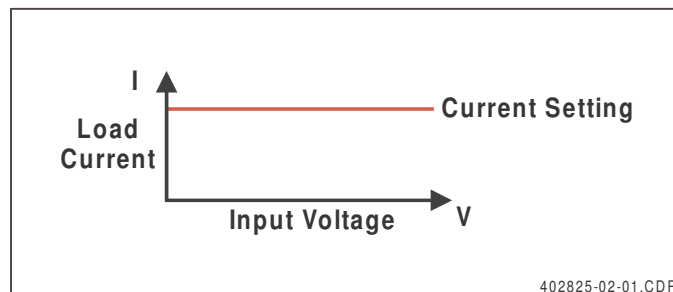


Figure 1. Constant Current Mode

❑ Constant Resistance Mode

Referring to Figure 2, the Dynaload will sink current linearly proportional to the input voltage. This is set in Amps/Volt, (1/R), or ohms.

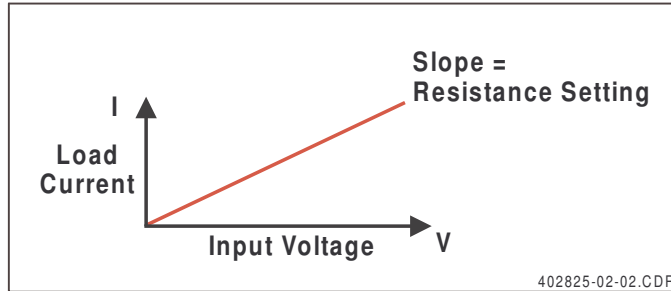


Figure 2. Constant Resistance Mode

❑ Constant Voltage Mode

Referring to Figure 3, the Dynaload will sink the current required to maintain the voltage of the source connected to it.

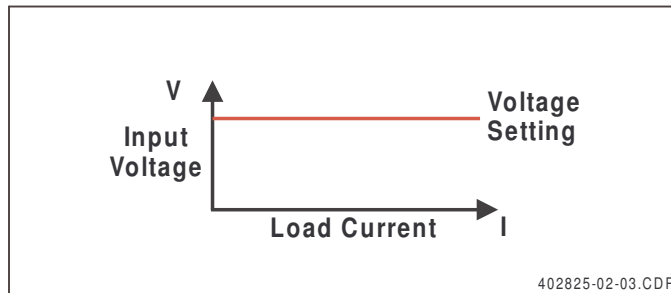


Figure 3. Constant Voltage Mode

❑ Constant Power Mode

Referring to Figure 4, the Dynaload will sink the current required at its present input voltage to maintain the desired power level.

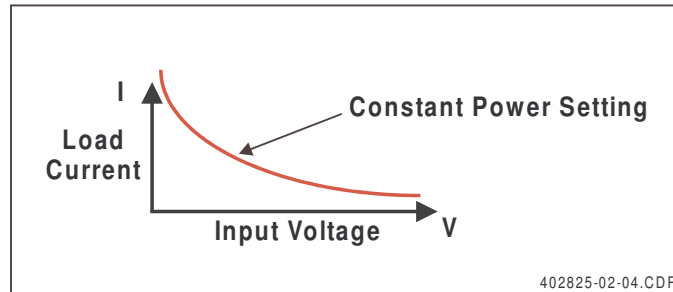


Figure 4. Constant Power Mode

❑ Pulse Mode

This mode can be used with any of the four preceding modes. Pulse mode is an enhancement that allows for operation between two predefined levels of current, resistance, voltage or power.

❑ Full Scale Range Switching

The WCL488 series provides selection of one of three full-scale input voltage ranges and one of three full scale input current ranges. The full-scale voltage and current ranges may be selected in any combination resulting in nine operational ranges per unit. These are selectable over the bus as ranges (1 through 9 refers to IEEE-488 syntax section).

The selectable ranges provide increased resolution. For example: Setting 10 amps may be difficult using the 1000 amp full scale. By selecting a lower full scale, 100 amps, the resolution of the meters, IEEE-488 control, programming input and the current sample output are greatly increased.

WCL488 Front Panel Features and Controls

To better understand the features and controls of the front panel, refer to Figure 5 and Table A. The item numbers in the figure directly correspond to the item numbers in the table.

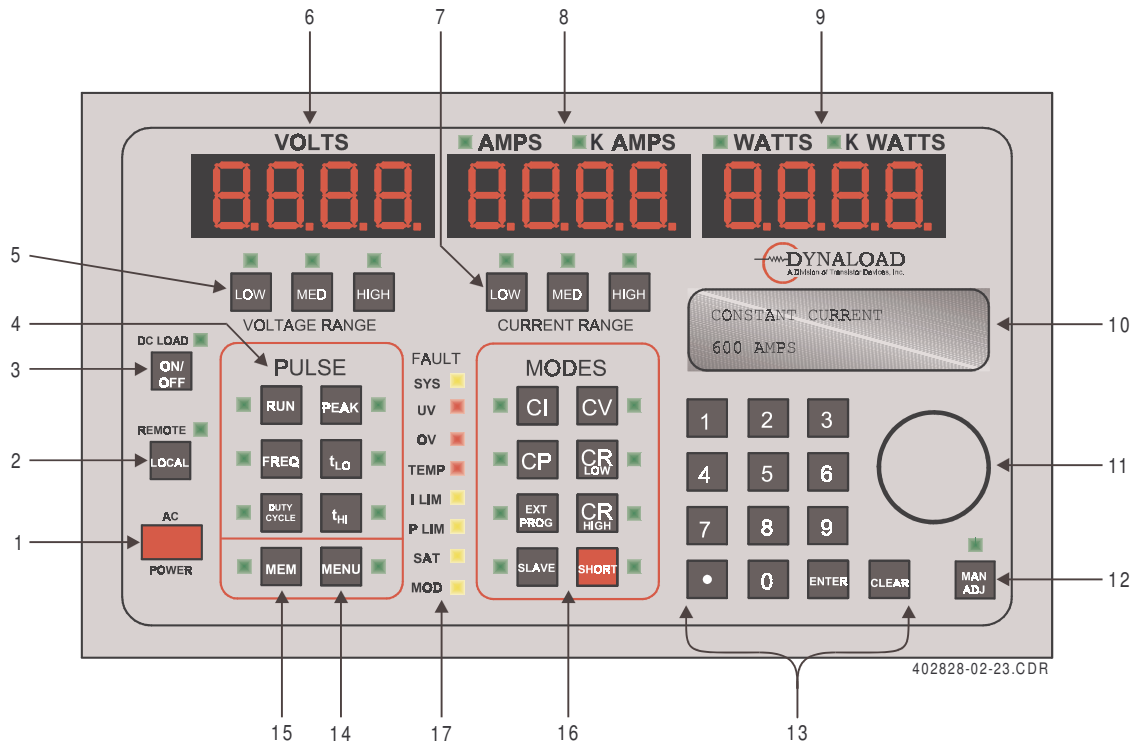


Figure 5. WCL488 Front Panel Features and Controls

Table A. WCL488 Front Panel Features and Controls

Item Number	Description
1	AC Power (Power On, Power Off)
2	IEEE-488 Local Select
3	DC Load (On, Off)
4	Pulse Mode Controls RUN: Pulse Mode On/Off PEAK: Sets peak amplitude of pulse FREQ: Sets frequency of pulse DUTY CYCLE: Sets duty cycle of pulse tLO: Sets duration of the low portion of pulse tHI: Sets duration of the high portion of pulse

Item Number	Description
5	Voltmeter/Voltage Full Scale Range Selection*
6	Voltmeter (4 digit)
7	Ammeter/Current Full Scale Range Selection*
8	Ammeter (4 digit. Includes two range indicators. AMPS displays actual current. For K AMPS, multiply the display by 1000 for the actual current.)
9	Wattmeter (4 digit. Includes two range indicators. WATTS displays actual power. For K WATTS, multiply the display by 1000 for the actual power.)
10	Backlit Alphanumeric Display (This display indicates data input from the front panel controls [range, mode, and setpoint as entered by the user]. This will also display other data as selected through the menu selector.)
11	Manual Adjust Knob
12	Manual Adjust Enable
13	Keypad (for numerical entry)
14	Menu Select
15	MEM Preset (up to 10 configurations)
16	Mode Select CI: Constant Current Mode Select CV: Constant Voltage Mode Select CP: Constant Power Mode Select CR LOW: Constant Resistance (Low Ohm) Mode Select CR HIGH: Constant Resistance (High Ohm) Mode Select EXT PROG: Remote Programming Mode Select SLAVE: Slave Detection SHORT: Inactive on this product
17	Fault And Warning Status Indicators SYS: System Fault Indicator UV: Undervoltage Fault Indicator OV: Overvoltage Fault Indicator TEMP: Over Temperature Fault Indicator I LIM: Current Limit Warning Indicator P LIM: Power Limit Warning Indicator SAT: Saturation Warning Indicator MOD: Module Fault Warning Indicator

* The WCL488 Series offers the selectable full-scale ranges for current and voltage. When a full scale is selected it changes the full scale of the meter, the current sample, the front panel adjustments, IEEE controlled adjustments and the analog programming input. This provides an increase in accuracy and resolution. There are three standard full-scale current ranges and three standard full-scale voltage ranges.

Chapter 2 — Installation and Wiring

Operator Safety Instructions and Symbols

It is very important that these safety instructions and operation instructions are read and understood prior to the installation and use of this electronic load. Failure to follow these basic guidelines could result in serious injury or death.

This electronic load is inherently safe by design. It cannot produce any hazardous voltages or currents; however, when in use it may expose the operator to the hazards of the DC source to which the load is connected. This equipment is intended for use by trained personnel and there are no operator serviceable parts inside. All service and calibration must be performed by authorized personnel. Table B describes the safety symbols and their definitions. Safety symbols are placed to ensure the safety of Dynaload operators and should never be covered or removed from the equipment.






WARNING:

Ensure that all AC and DC power for both the load, the test source, and any peripheral equipment are OFF prior to making any connections to the load. Also ensure that the proper AC input range is selected before attaching the line cord; and that the load selected is properly rated for the voltage and current generated by the DC source; and that all connections are correct and secure, and that all safety covers are in place before applying power.

If the unit is to be mounted, please consider the weight and position of the equipment to prevent the rack from becoming top heavy. A top-heavy rack can create a tip over hazard. All air intake and exhaust ports should be kept clear of obstructions.

Table B. Equipment Safety Symbols

Symbols	Definitions	Publication Numbers
	CAUTION, RISK OF ELECTRIC SHOCK	ISO 3864, No. B.3.6
	CAUTION, REFER TO INSTRUCTION MANUAL	ISO 3864, No. B.3.1
	EASILY TOUCHED HIGHER TEMPERATURE PARTS	ISO 3864

Cooling Connections and Requirements



IMPORTANT:

Before using this product, you must fully understand the relationship between the water temperature, flow rate, and power dissipation. Failure to meet the cooling requirements could result in an unexpected system shutdown or a catastrophic failure.

Also, users of ethylene glycol and similar products should refer to the special section “Special Information for Ethylene Glycol Users” that immediately follows this section.

The WCL Series of Electronic Loads requires a sustained flow of coolant in order to operate. The load is protected against overtemperature through the use of a thermostat that will shut down the load if the heat sink temperature exceeds 70°C (158°F). The unit is designed to operate to its full power rating with a minimum flow rate of three gallons per minute (GPM) of coolant at 10°C (50°F). Operation at other flow rates and inlet temperatures based on power dissipation can be derived from the graphs (figures) and tables that follow in the next section, *Thermal Transfer Characteristics*. If you are unsure about your requirements please consult the factory.

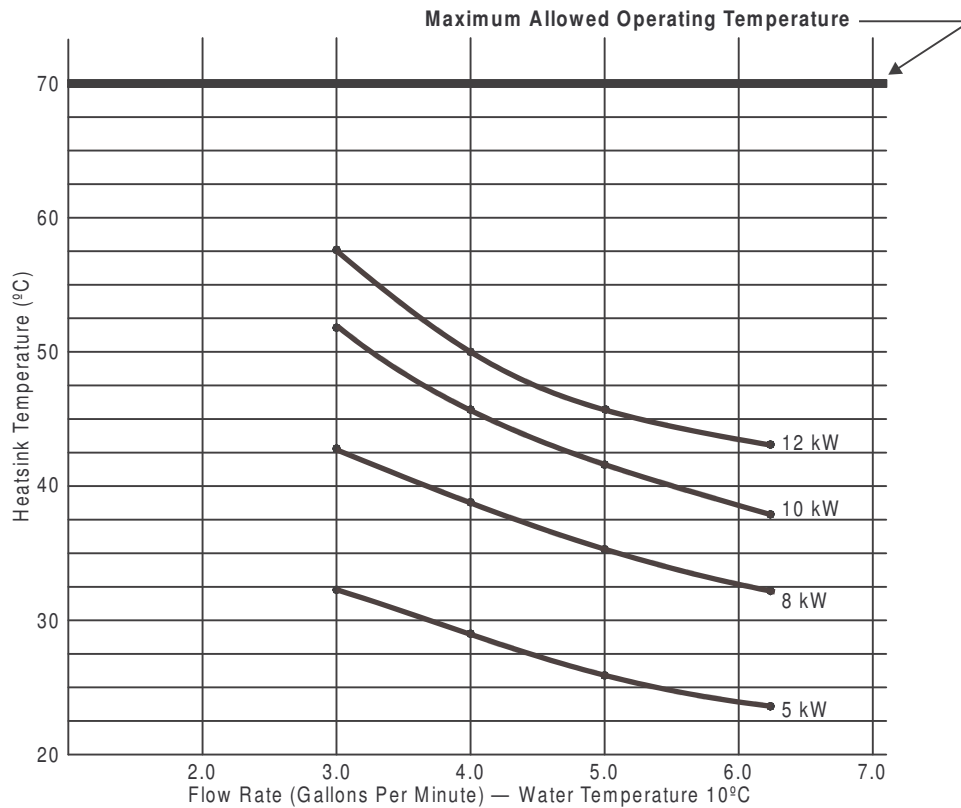
Each master load assembly or slave assembly has one inlet and one outlet water connection. They are 1/2-inch NPT female thread. A multitude of adapters can be found at your local hardware store if the connection size needs to be changed. Do not reduce the water lines below 3/8-inch inner diameter, as improper water flow will result.

If you are using a “chiller” to regulate the water temperature, be sure to properly size the device to match or exceed your cooling requirements. The specifications for the wattage capacity and flow rates are provided from all chiller manufacturers. If your location can provide “processed water” be sure the maximum pressure does not exceed 120 PSI.

Though the temperature graphs indicate that the load will operate to full power with only three gallons per minute flow using 20°C (68°F) water, we recommend that the heat sink temperature not exceed 60°C (140°F). This will provide a substantial margin for safety by lowering the stress level on the power tray and extend the life of the product.

□ Thermal Transfer Characteristics

Figure 6 and Table C relate to operation at various flow rates with an inlet temperature of 10°C, based on power dissipation levels of 5, 8, 10, and 12 kilowatts. For the same type of operation information with an inlet temperature of 20°C, refer to Figure 7 and Table D.

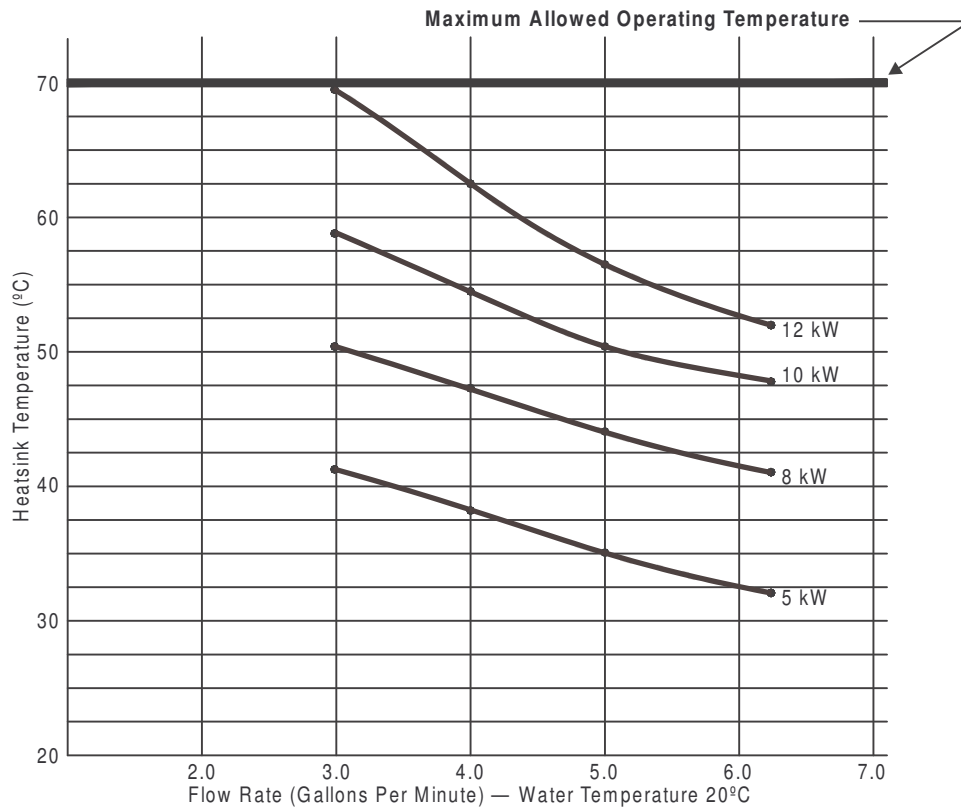


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Figure 6. Thermal Transfer Characteristics (Rate/Temperature) — Inlet Temperature 10°C

Table C. Outlet Temperature with 10°C Inlet

Outlet Temperature with 10°C Inlet				
Flow Rate	Power Level			
	5 kW	8 kW	10 kW	12 kW
3 GPM	22.1°C	29.8°C	35.6°C	37.4°C
4 GPM	20.3°C	26.2°C	30.1°C	32.3°C
5 GPM	18.3°C	22.8°C	26.7°C	29.6°C



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Figure 7. Thermal Transfer Characteristics (Rate/Temperature) — Inlet Temperature 20°C

Table D. Outlet Temperature with 20°C Inlet

Outlet Temperature with 20°C Inlet				
Flow Rate	Power Level			
	5 kW	8 kW	10 kW	12 kW
3 GPM	30.8°C	38.2°C	42.5°C	47.8°C
4 GPM	28.7°C	34.5°C	38.2°C	42.8°C
5 GPM	27.2°C	31.8°C	35.2°C	39.3°C

❑ Special Information for Ethylene Glycol Users

The WCL and WCS series of water-cooled electronic loads are designed to operate using water as the cooling fluid. The use of an antifreeze such as ethylene glycol in the coolant water will affect the thermal efficiency of the system. Since ethylene glycol is not as efficient as water for cooling, a higher flow rate and/or a lower coolant inlet temperature is needed. Otherwise, the maximum power of the system must be de-rated. The following graph shows the recommended de-rating requirements verses flow rate for different percentages of ethylene glycol (inlet temperature of 10°C). Other types of glycols, such as propylene glycol, have approximately the same de-rating requirements.

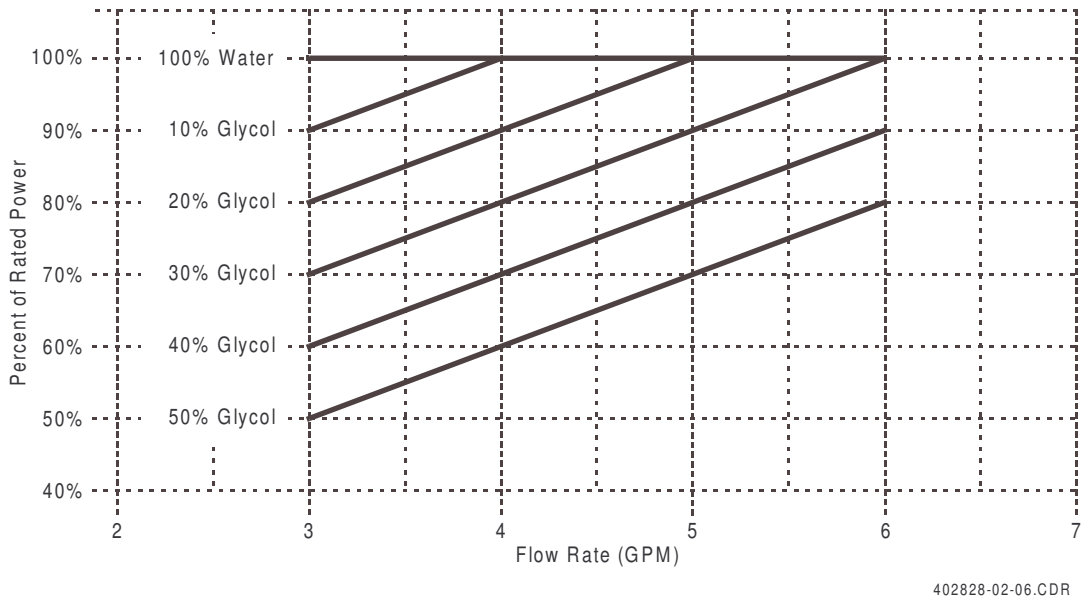


Figure 8. Recommended Power De-rating Versus Flow Rate for Different Ethylene Glycol Levels

Working within the design limitations of 120 PSI it may not be practical to raise the input pressure of the system in order to achieve the required flow rate. It is best to use pure water with no additives to reach full power ratings.

If the use of a high percentage of glycol mix cannot be avoided, and acceptable flow rates can not be achieved, we suggest the use of a fluid/fluid heat exchanger and pump to create a secondary cooling loop so water can be used for the load requirements. Remember that the same transfer inefficiencies will exist in the fluid/fluid heat exchanger as would exist in the load. Careful calculations should be used when choosing the heat exchanger.

There are several other factors to take into account. Thermal transfer as a function of flow rate is an inverse log graph and there are only minimal gains to be made above 6 GPM. The use of glycol will also change the viscosity of the coolant, which will have an effect on the flow rate verses pressure.

WCL488 Typical Rear Panel Connections

Electrical and plumbing connections are made on the rear panel of the unit. Typical rear panel connections are detailed in Figure 9 (Terminal Block Cover shown installed in Rear View).

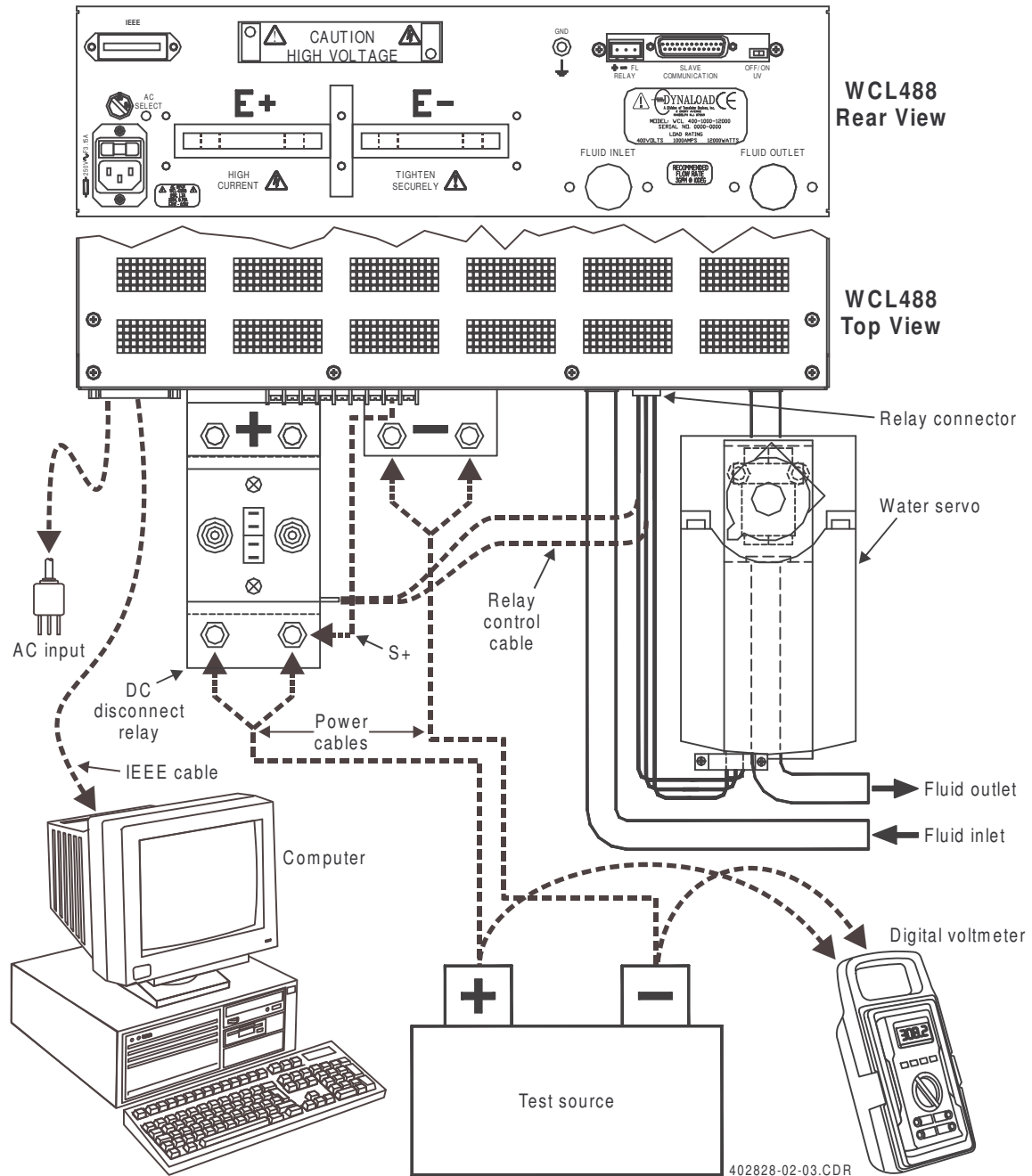


Figure 9. WCL488 Typical Rear Panel Connections

WCL488 Rear Panel Electrical Connections

All electrical and electronic connections are made on the unit's rear panel and are detailed below in Figure 10. The rear panel also has terminal block connections that are described later in this section as is an optional equipment wiring diagram using the terminal block connections.

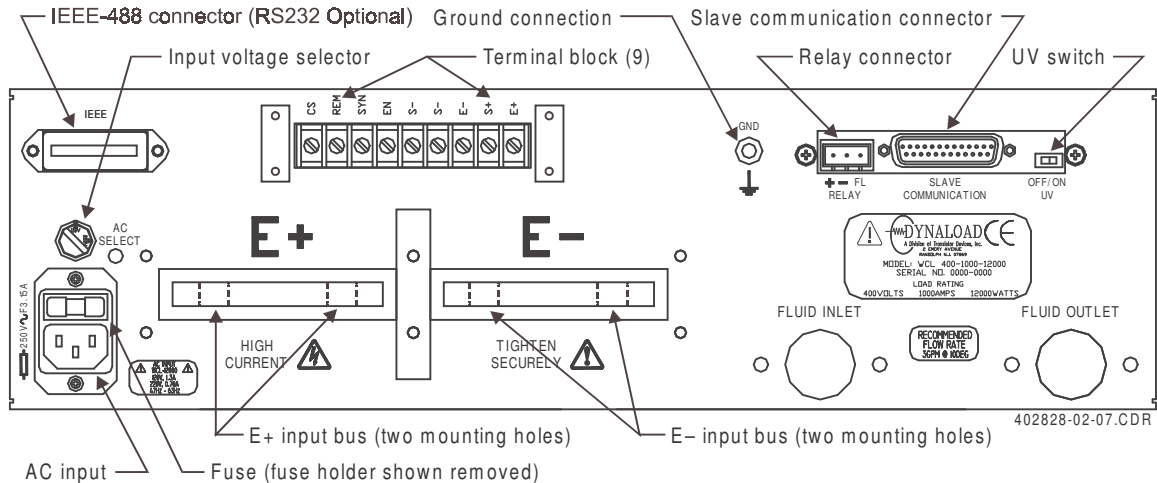


Figure 10. WCL488 Rear Panel Detail

❑ WCL488 E+ and E– Power Input Buses

Install the disconnect relay first. Use the “unswitched” side of the relay as the E+ input. Remove the S+ to E+ jumper from the terminal block. Add a 22-gauge wire from S+ to the unswitched side of the relay. It is important to note that voltage must be monitored outside the disconnect relay.

Referring to Figure 9 and Figure 10, the main DC power inputs are labeled E+ and E– and are the power input buses for connecting the power source to be monitored or tested. The E+ and E– power inputs are the two sets of two mounting holes (and related hardware) found on each of the two input buses located on the left side of the rear of the unit. The input buses are separated by an insulator for safety and require lugs with a 7/16-inch diameter hole.



CAUTION:

Only the power source-to-load connections are to be made to these buses. Always be sure these connections are securely tightened. A loose connection will result in a high temperature at the connection.

WCL488 E+ and E– Wiring Tips

Use the shortest cables that are large enough in cross-section to handle the power source's current output. Twist and/or bundle the E+, E– cable(s) as a means of reducing self-inductance. Also, use lugs to secure the E+, E– cables to the mounting hardware. Connect only the power source to load cables to the mounting bases; all other connections must be made via the terminal block located above the buses.

❑ **WCL488 The “IEEE-488” Connector (RS232 Optional)**

This is used for computer control and uses a standard IEEE-488 cable (refer to Figure 10).

❑ **WCL488 AC Input**

This connection provides the Dynaload with its operating power and its safety ground (refer to Figure 11). Power requirements are user selectable and described below in Table E.

Table E. WCL488 AC Input Power Requirements

Switch Setting	Operation Range
110V	103.5 Vac – 126.5Vac at 1.5A
220V	187 Vac – 242Vac at 0.8A

NOTE: The operational frequency range is 47Hz – 63Hz.

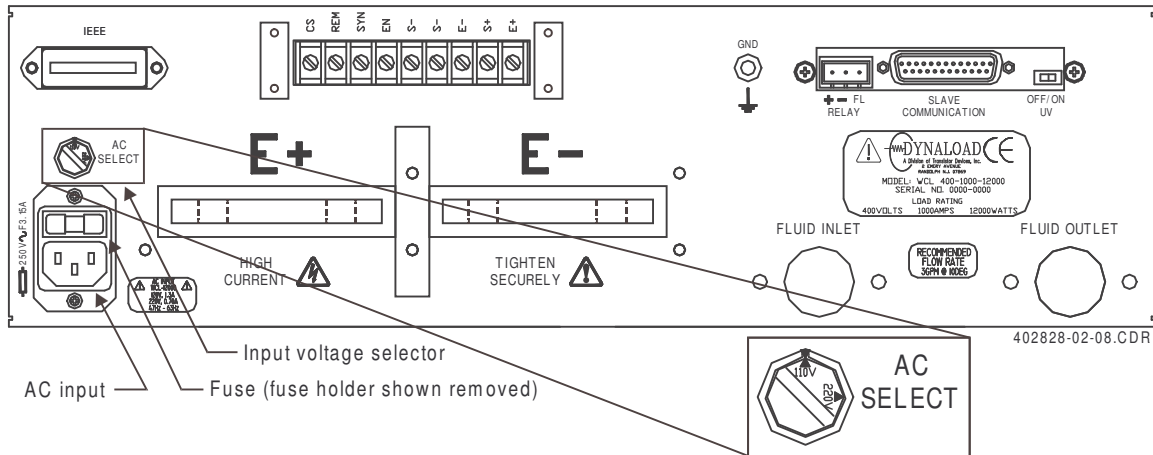


Figure 11 WCL488. AC Input, Fuse and Input Voltage Selector

❑ **WCL488 Input Voltage Selector**

The Input Voltage Selector (refer to Figure 11) is mounted on the rear panel immediately above the AC input and fuse assembly.



WARNING:

Ensure that the power cord is removed before making changes to the voltage selector tab.

❑ **WCL488 Fuse Replacement**

Referring to Figure 11, the AC input fuse is located above the AC Input and below the Input Voltage Selector. The fuse replacement part numbers for the Dynaload are MDA-3 (3 Amp, 250

Volt, slow blow, 1-1/2 inch American version) or equivalent **OR** GDC-3.15A-250V (3.15 Amp, 250 Volt, slow blow, 20 mm European version) or equivalent.

WCL488 AC Input Wiring Tips

A standard U.S. three-prong cord is provided with your Dynaload. The Input Voltage Selector is mounted above of the three-prong AC connector and fuse (see Figure 11 and refer to the *WCL488 Input Voltage Selector* section that follows).



WARNING:

The power cord provides a chassis ground through a third conductor. Make sure that your power outlet is of the 3-conductor type with the correct pin connected to earth ground. Always Connect the AC cord first to your Dynaload and THEN to the utility outlet.

❑ WCL488 Slave Communication Connector

This DB25 “D” connector is located in the upper right corner of the rear panel and is used for synchronized parallel Dynaload operation (see Figure 10). This connector is labeled “SLAVE COMMUNICATION”.

NOTE:

There are no user signals or inputs in this connector.

WCL488 Slave Communication Connector Wiring

This 25-pin “D” connector is used to link the master unit to slave units. If you are purchasing cables, be sure the PIN configuration is always 1 to 1 (not all cables are provided this way and a crossover of PINS will cause erroneous operation).

❑ WCL488 UV (Undervoltage Lockout) Switch

Referring to Figure 12, the UV switch has two positions, ON and OFF. This switch is described in detail in the Operating Instructions chapter of this manual. Refer to the *Undervoltage Lockout* section later in this chapter.

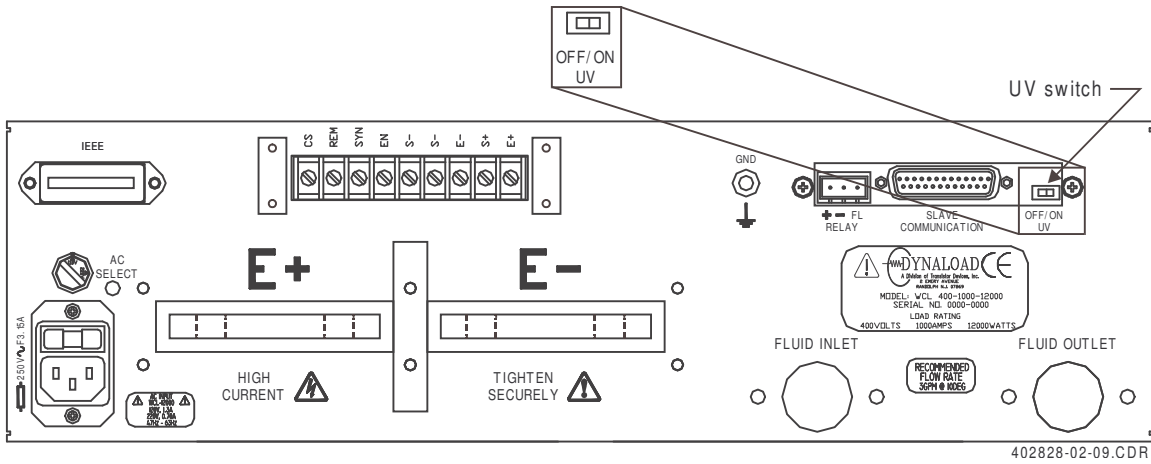


Figure 12. WCL488 UV Switch Detail

❑ WCL488 Relay Connector

Referring to Figure 13 below and Figure 18 (on page 38), the three-pin relay connector is used for controlling the DC relay (master), the main water servo unit, the water shutoff valves, and the optional water shutoff override switch. The connector's FL pin provides the control signal for the water servo valve.

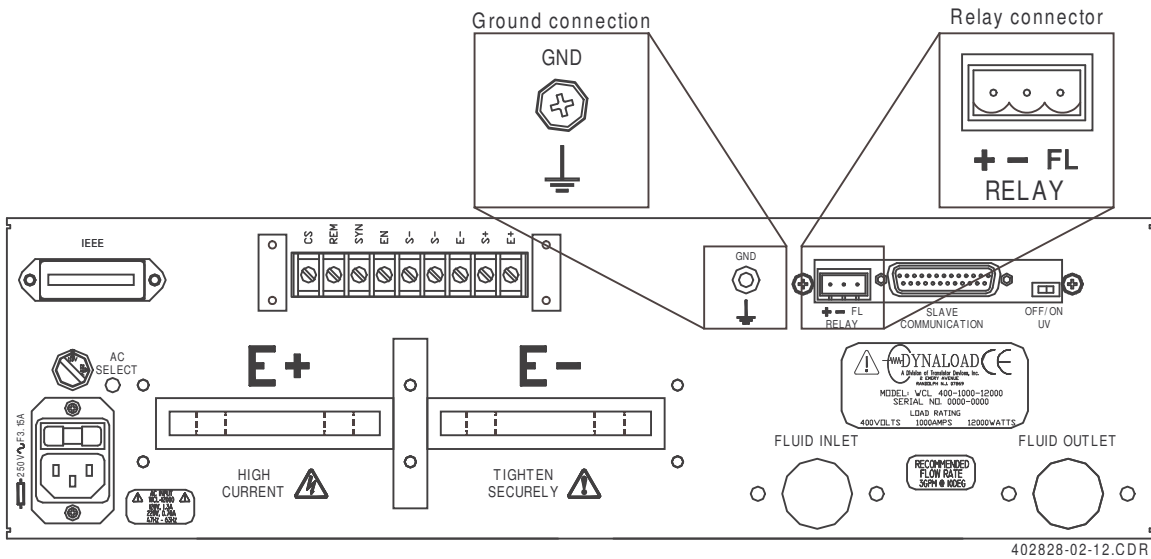


Figure 13. WCL488 Relay Connector and Chassis Ground Connection

❑ WCL488 Chassis Ground Connection

Referring to Figure 13 above, the chassis ground connection is used to ground the third wire of

the water shutoff relay.

□ The WCL488 Terminal Block and Terminal Block Connections

Refer to Figure 14 through Figure 16, and the sections that follow to better understand the wiring connections that can be made to the terminal block.

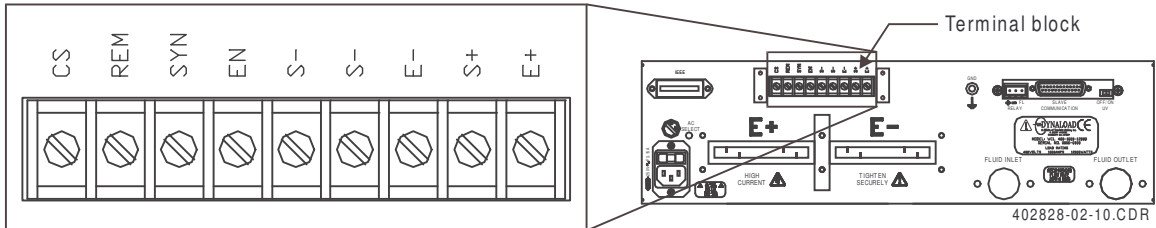


Figure 14. WCL488 Terminal Block Detail

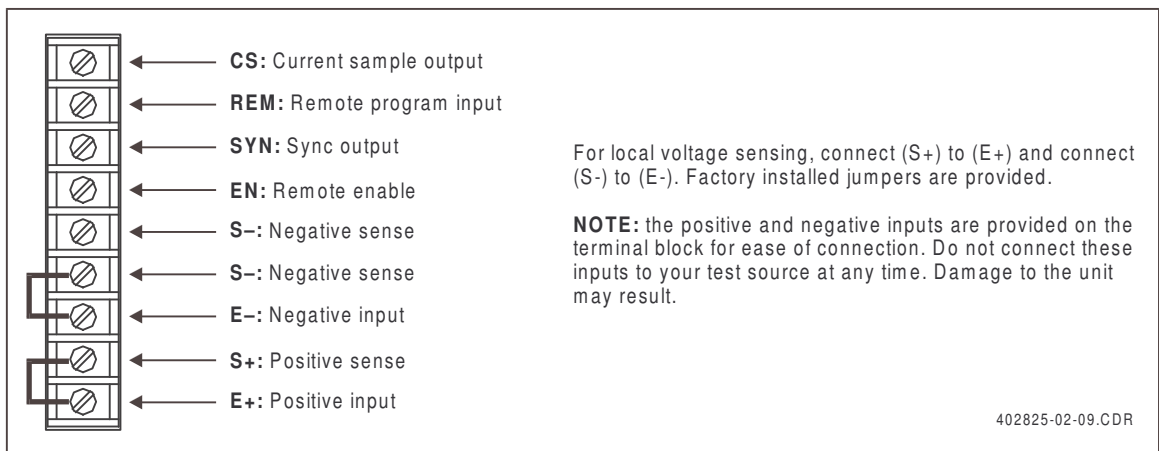


Figure 15. WCL488 Terminal Block Connections

CS (Current Sample)

The CS (Current Sample Output) terminal is provided for the current sample output signal. The current sample output should be referenced to the S- terminal.

A 0-10V signal representing 0-full scale current in each of the selected current ranges is generated. This signal is a true representation of the current level and waveform being generated by the load. Connect an oscilloscope or other external instruments to this terminal as monitoring devices. The instruments should be referenced to terminal S-. Shielded wire is recommended.

REM (Remote or External Programming)

The REM (Remote Program Input [External Modulation]) terminal is the connecting point for remote programming from an external programming source. This input is referenced to S-. This is the remote control input signal. 0 to 10 volts in yields 0 to full scale loading in whatever mode and range is selected. When a signal or waveform is presented at this input it will translated directly into your current level and waveform. The signal source should be referenced to S-.

SYN (Synchronized Output Signal)

The SYN (Synchronized Output) terminal supplies a 15V sync signal for triggering external instrumentation. For instrumentation triggering purposes a 15V square wave synchronous to the internal pulse generator is supplied. This signal is incorporated on the rear panel terminal block on WCL488 IEEE models. On non-IEEE models this signal is provided on the front panel. As with all signals in or out, it is referenced to S (-). The signal is generated with a 10Kohm pull-up resistor to 15V, and an open collector pull-down to S-. The amplitude of the square wave may be externally limited without damage to the load. When not in pulse mode, this output remains high until a current change is executed. At this time, the output is pulsed low for scope triggering.

EN (Remote Enable)

The EN (Remote Enable) terminal is the remote DC enable. Connection between EN and S- must be connected in order to turn the DC on.

This input is typically used for remote Emergency Power Off (EPO) operation of the DC on/off function. This input operates in series with the front panel control. If the front panel is in the ON position, the enable can function to turn the DC on and off.

S- and S+ (Voltage Sense)

There are two S- terminals and one S+ terminal. The S- and S+ (Sense Negative and Sense Positive) terminals are used to sense the load voltage.



IMPORTANT:

The S+ (Sense Positive) terminal must always be connected on the side of the disconnect relay that is connected to the source.

S- and S+ (Voltage Sense) Wiring Tips

The S- and S+ terminals may be connected at the back of the Dynaload, or remotely at the source. In addition, all input and output signals are referenced to S-. In any single or multiple load system, S- should be connected to E- (or the negative of the source) **at one and ONLY one point**.



CAUTION:

Damaging current loops could result from multiple connections to E-.

S- must only be connected to the E- source at the master Dynaload in a master/slave (parallel) configuration. The D connector cable(s) between master and slave(s) provide the S- loop to the

slave(s). The Dynaload is supplied with two metal straps between the S-, E- terminals and between the S+, E+ terminals on the terminal strip. These are to facilitate voltage sense wiring when sensing locally.

The S- and S+ external sense leads can be connected anywhere between the power source and the Dynaload. However, it is recommended that the voltage sense wires are connected to the power source terminals. This will eliminate potential errors due to voltage drop in the cable. It is also recommended to use shielded wire for remote voltage sense leads to prevent external noise from being introduced into the system.

In a master/slave (parallel) configuration, S- must only be connected to the E- source at the master Dynaload. The D connector cable(s) between master and slave(s) provides the S- reference to the slave(s).

E- and E+ (Input)

E- and E+ are connected internally to the power input buses. They are to be used only as a convenient connection point for the sense terminals when sensing the voltage locally.

WCL488 Terminal Block Connections Optional Equipment Wiring

The terminal block may also be used to include various optional equipment to the Dynaload. In the example shown in Figure 16 an oscilloscope, function generator and remote DC ON/OFF switch are shown installed to the Dynaload.

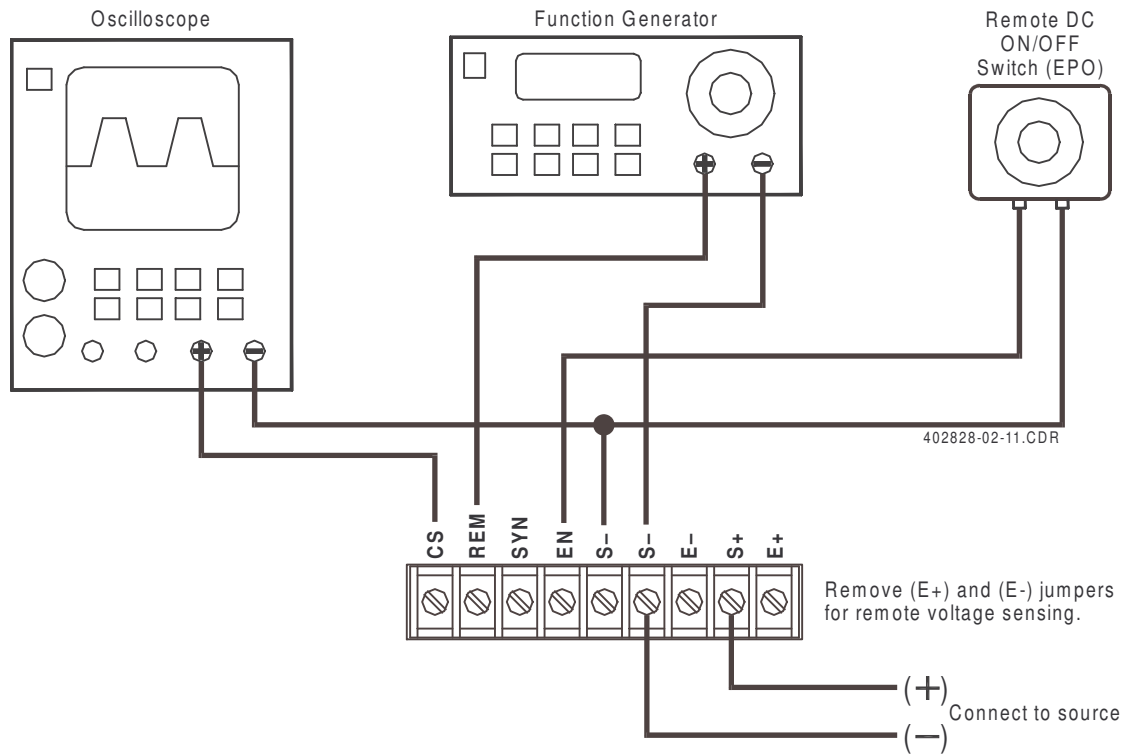


Figure 16. WCL488 Terminal Block Connections Optional Equipment Wiring

Recommended Operating Procedure

The following procedure is the recommended procedure for Dynaload operation:

- (1) AC switch should be turned off.
- (2) Connect DC source to E+ and E-. Always watch for correct polarity.
- (3) If external analog programming is to be used, connect signal source. If IEEE-488 or RS232 (optional) is to be used, connect the cable.
- (4) Connect AC power. Be sure you have selected the correct AC input position on the load.
- (5) Be sure **ALL** electrical connections, including peripheral equipment, are secure and in the correct polarity before applying AC or DC voltages to the load.
- (6) Turn on AC power; meters should come on and fan should run.
- (7) Step through the Menu settings to be sure the set points are appropriate to the application. Check to see that the voltage and current ranges selected are correct.
- (8) Press the DC-ON button, or send the LOAD ON command via the IEEE controller. This will close the relays and connect the source to the power dissipating circuitry. The DC on LED will illuminate.
- (9) Turn on the power source to be tested.
- (10) Press the mode select button for the mode you wish to operate in. The LCD display will prompt you for a numeric value. Enter an appropriate number for the level desired then press ENTER. The load will now be operating at the set level.

NOTE:

For computer controlled operation, Begin sending the appropriate commands. (See IEEE-488 syntax for command listing.)

Operating Mode Guidelines

❑ CI — Constant Current Mode (Basic Mode)

This mode of operation allows the user to set a fixed current. This set level will not change regardless of changes in the source voltage. Some power sources such as variable power supplies are rated at a fixed maximum load current and adjustable over a predetermined voltage range. For example, 5-30V @ 20A. If the resistive load characteristic were used for this type of a test, it would be necessary to reset the load each time the power supply voltage was changed in order to maintain desired load current. However, if the load is in the constant current mode, the current is constant regardless of input voltage fluctuations.

It should be noted that many power supplies are designed for short circuit protection by internal current limiting and foldback; therefore, the supply may not start up into a constant current load. Accordingly, it is suggested that the Constant Resistance mode be used as a load when simulating short circuit protection and recovery of most power supplies, unless otherwise specified by the manufacturer.

NOTE:

The constant current mode should never be used to test a constant current source. The regulation of the two units will fight for control of the current and an unstable oscillation will result.

❑ CR — Constant Resistance Mode (Basic Mode)

The constant resistance mode regulates the load current in direct proportion to the load voltage. There are eighteen different resistance ranges available. These are derived from the nine different voltage and current combinations available, and the two different resistance modes (HIGH and LOW). The actual resistance values, expressed in Ohms, are outlined in the specification section of this manual. In general, select the appropriate voltage and current range for the source, and then determine if the high resistance range or the low resistance range is required. Other ranges may be selected to tailor the response to a particular application.

EXAMPLE:

Given a 48V source capable of 60A, select the 200V, and 200A ranges. If the high resistance mode is selected, the maximum current capability is $0.5 \text{ Amps/Volt} \times 48 \text{ Volts} = 24 \text{ Amps MAX.}$ — Too Low!

Select the low resistance mode: $5 \text{ Amps/Volt} \times 48 \text{ Volts} = 240 \text{ Amps MAX.}$ — sufficient current capability.

The resolution of the load may be improved by selecting the 400V range. This yields: $2.5 \text{ Amps/Volt} \times 48 \text{ Volts} = 120 \text{ Amps MAX.}$ This provides double the resolution, but it reduces voltage sensitivity.

NOTE:

The resistance may be entered in Ohms or Amps/Volt (1/R). This option is selected through the front panel menus.

❑ CV — Constant Voltage Mode (Basic Mode)

The constant voltage mode can best be described as a shunt regulator or a zener diode. The load will not conduct any current until the source voltage tries to exceed the voltage set point. Once the source voltage is high enough the load will shunt current in order to regulate the voltage. The regulating voltage is adjustable from full scale of the range selected to approximately zero. The constant voltage mode is used to simulate a battery to a battery charger or for special applications, such as a shunt regulator.

NOTE:

Never use the constant voltage mode for testing a constant voltage source. The regulators of the two devices will buck each other trying to gain control of the voltage, which in turn will lead to an unstable condition.

❑ CP — Constant Power Mode (Basic Mode)

In constant power mode, the Dynaload will dissipate a set wattage anywhere up to the maximum power rating of the unit. The Dynaload will automatically adjust the current level inversely in response to a change in voltage. The constant power mode is *NOT* affected by changes of the voltage or current range.



CAUTION:

If the source voltage decays to zero volts the load will attempt to draw infinite current.

❑ Short Circuit

Due to the intended use and power levels involved, “Short Circuit” is not available on WCL or WCS products.

❑ MEM — Memory Recall Locations

The configuration of the load may be stored in 10 settable memory locations labeled 0 through 9. To recall a memory location, press the MEM key on the front panel. Enter the numeric location number, then press ENTER. When using the IEEE-488 bus the setup can be stored with the MS command and recalled with the MR command.

NOTE:

Memory location “0” is reserved for initialization of the Dynaload.

❑ Manual Adjust

The round knob above the MAN ADJ key is used to manually adjust all settable features within the Dynaload. This knob can be activated by pressing the MAN ADJ key. The resolution of the knob is set through the menu.

❑ Remote Programming

The WCL series is analog programmable in all four modes of operation. The loading in a particular voltage or current range is directly proportional to the 0-10 volt programming input. For example: If the constant current mode is selected and the 200A range is selected, a

programming voltage of 5 volts is required to program the load to 100A. Waveforms can be programmed with the remote programming input as long as they do not exceed the capability of the load. The slew rate setting is set at the factory for 100 microseconds for a 0 to selected full scale transition, but is adjustable from the front panel by the menus, or through the IEEE-488 bus.

❑ Local Control

The local button on the front panel will allow the user to resume front panel control of the load when operating through the IEEE-488 bus. Pressing this button will enable all the front panel controls (until any instruction is given by the controlling computer). By pressing the LOCAL button a second time, the unit will return to IEEE control. This key will not function if password lockout is enabled. (See section on password protection, *Password Change*, later in this chapter.

NOTE:

A controlling computer program must be stopped before local control will function. The Dynaload always selects computer control over local control. Any command or query issued by the computer will clear the local control functions.

❑ Fault Indicators

The Dynaload fault indications include both major and minor faults.

Major faults are an alarm and are displayed in red. If they occur, the Dynaload will shut down, however, the fan will continue to run.

Minor faults are a warning and are displayed in yellow. If they occur, the Dynaload may continue to operate, however, it may be out of regulation.

Refer to Table F for additional information about fault indicators.

Table F. Major and Minor Fault Indicators

Fault		
-------	--	--

Category	Fault Indicator	Description
Major Faults	UV — Undervoltage	DC ON will not function until voltage is greater than 0.4 Volts (override switch provided on rear panel). See the <i>Undervoltage Lockout</i> section below.
	OV — Overvoltage	Unit will disconnect from source.
	OT - Overtemperature	Unit will shut down.
Minor Faults	OC — Overcurrent	Unit has reached the set current limit or the current limit of the selected range.
	OP — Overpower	Unit has reached the set power limit.
	SAT — Saturation	Saturation condition whereby one or more of the electronic power components are completely saturated. This may be due to insufficient source voltage, inadequate wiring, or excessive line loss. This may also indicate an open power device.
	MOD — Module	Indicates that there is an abnormal operating condition at the module level.

Undervoltage Lockout

The UV switch on the rear panel has two positions, ON and OFF. When the switch is ON, the DC relay will not engage and the SYS and UV fault indicators will be on until there is greater than 0.4 volts applied to the DC inputs. Anytime the voltage drops below 0.4 volts the relays will disengage and the UV alarm will be latched. Please note that the DC relays will re-engage and the SYS fault LED will extinguish when the input voltage goes over 0.4 volts, but the UV fault indication remains until cleared with the LOAD ON command over the IEEE bus or by depressing the DC ON button on the front panel. When the UV switch is in the OFF position this action is inhibited allowing for load operation under 0.4 volts.

This function is separate and distinct from the programmable undervoltage function.

Programmable Under Voltage

In addition to the Undervoltage Lockout, the load also has a Programmable Under Voltage feature. This feature provides a means to have the load automatically stop loading when the input voltage from the device under test drops below the defined threshold.

Unlike the Undervoltage Lockout, the Programmable Under Voltage can be set to generate a fault when the Voltage drops below its defined Voltage. The Voltage level can be programmed through menu item #18 or the through the IEEE 488 (or RS232) interface using the UV command. Like the hardware Undervoltage Lockout, this will open the load connect relay and generate a UV fault. Other than its programmability, it differs from the Undervoltage Lockout in that once the input voltage has dropped below the Programmable Under Voltage threshold causing a UV fault; the load will not re-connect until a DC LOAD ON is commanded. For this reason the input Voltage must be above the Programmable Under Voltage setting before performing a DC LOAD ON. Otherwise a UV fault will occur immediately and the DC LOAD

ON will be cancelled. Setting the Programmable Under Voltage to zero disables this feature and does not affect the hardware Undervoltage Lockout.

□ Menu Commands

The menu commands are accessible through the front panel by pressing the MENU key. Continue to press the MENU key to toggle through the menu selections. Table G lists the menu commands and their relative number in appearance. The subsections in this section detail each of the menu commands. Referring to Table G, the menu features are as follows:

Table G. Menu Commands

Number	Menu Command
1	Current Limit Setting
2	Voltage Limit Setting
3	Power Limit Setting
4	Slew Rate Adjust
5	IEEE Address Setting
6	SF/SS (Fast Slew/Slow Slew)
7	Front Panel Configuration Memory Set
8	I Offset
9	V Offset
10	Encoder Resolution Setting (Amperes)
11	Encoder Resolution Setting (Microseconds)
12	Encoder Resolution Setting (Hertz)
13	Front Panel Lock
14	Password Change
15	Select AMPS/VOLT or OHMS
16	Terminator (CR/CR-LF)
17	Number of Pulses
18	Programmable UV level
19	LCD Contrast Adjustment
20	Check Firmware Revision

Current Limit Setting

The current limit function acts as a “brick wall”. The load will not permit the current to exceed the numeric set point. When prompted, press ENTER to select this as a function. Then simply enter the value using the numeric keypad and press ENTER. If the limit is achieved by the load, an alarm will be indicated and the load will continue at the limit point. This is considered a MINOR FAULT.

Range Switching and Current Limit Set Point

Unless set by the user, the default set point for current limit is 105% of the current range selected. This default is affected by current range selection. A current limit cannot be set greater than 105% of range. If a unit is switched to a current range that is lower than the current limit set point, the 105% maximum of the range selected will overwrite the limit. If the unit is then returned to the higher current range, the current limit will remain at 105% of the previous range. It will be necessary to reset the limit point if higher current is desired. If the current limit is set to less than 105% of the lowest current range, the set point will not be affected by switching to a higher current range.

Voltage Limit Setting

The voltage limit function acts as a protection to both the load and the source under test. If the voltage limit point is achieved, the load will disconnect from the source. An alarm condition will be indicated and will be a MAJOR FAULT. The load will not reconnect until the input voltage is below the limit set point. When prompted, press ENTER to select the function, then enter the numeric value using the keypad and press ENTER.

Power Limit Setting

The power limit function acts as a “brick wall”. The load will not permit the power level to exceed the numeric set point. If the voltage continued to rise once in power limit the load will respond by continually reducing the current to meet the prescribed set point. If the set point is achieved an alarm will be indicated and will be a MINOR FAULT. When prompted, press ENTER to select the function, enter the numeric value using the keypad and press ENTER.

Slew Rate Adjustment

The slew rate adjustment sets both the rise and fall in time microseconds for a full-scale transition within the selected range. This is utilized to compensate for the inductance in long load input cables that could cause oscillation and/or overshoot. The slew rate setting is set at the factory for 100us and can be programmed from 10us and 4,000us when Fast Slew is selected (default). When Slow Slew is selected the slew rate can be set between 1,000us (1ms) and 400,000us (400ms). See Slew Fast/Slew Slow. When prompted press ENTER. Then enter the desired slew value in microseconds. Finish by pressing ENTER.

Encoder Resolution Setting

The rotary digital encoder used for manual adjust can be set to different resolution settings. This will allow the user to set for a fine or coarse knob control. This function is active in all modes of operation, but depending on the mode, a setting that seems good in the constant current mode

may be coarse in the constant resistance mode. It is up to the users discretion to decide what setting is appropriate.

Front Panel Configuration Memory Set

The Dynaload has the provision for memory presets. When a memory location is selected, the load will store the exact configuration and state that it currently is operating at. Items such as DC on, voltage range, current range, mode of operation, slew setting, limit settings and set current level will all be held in memory. To set a memory location, scroll through the menu to the memory set window. Press ENTER to select this function. Enter a location number (0 through 9), and press ENTER.

NOTE:

Memory location zero (0) is the start up location of the load. Each time the AC power is applied memory location zero is executed.

Front Panel Lock

The Dynaload will allow the user to “lock out” the front panel controls. When locked, the front panel controls become inactive and can only be restored by entering a password.

IEEE Address Setting

The IEEE-488 primary address must be set through the front panel numeric keypad. When prompted, press ENTER to select this function, enter the numeric address you wish the load to respond to and press ENTER.

Password Change

Through this screen the user can enter a password. When prompted, press ENTER. Then enter the new password. This is a numeric entry. Then press ENTER. The maximum number of characters is seven. The factory default is 1234. If a password is lost or forgotten, the “backdoor” code is 3962 (“DYNA” on a standard telephone keypad).

SF/SS (Slew Range)

The Dynaload provides for two different slew ranges. SF stands for Slew Fast and will allow slew settings from 10 μ s to 4000 μ s. SS stands for Slew Slow and will allow slew settings from 1000 μ s (1ms) to 400,000 μ s (400ms). When prompted press ENTER. Enter either a “1” for Slew Fast or “2” for Slew Slow. Finish by pressing ENTER.

Number Of Pulses

When operating in the pulse mode, the user has the option of setting a prescribed number of pulses. When prompted, simply enter the number of pulses to be executed and press ENTER. The maximum set number is 9,999,999. For continuous operation enter “0”.

Terminator (CR/CR-LF)

When operating using the IEEE-488 control input the user must select the line terminator. You must choose either CR (carriage return) or CR/LF (carriage return/line).

LCD Contrast Adjust

The user has the ability to set the contrast on the alphanumeric display. When prompted, press the ENTER button repeatedly until the contrast of the display is ideal. Then press the CLEAR button to exit this function.

Select Amps/Volt Or Ohms

This function refers to the constant resistance mode of operation. It allows the user to enter the resistance setting as a proportional ratio based on the input voltage (Amps/Volt) or to enter a numeric value directly in Ohms. When prompted, press ENTER to select this function. Enter the number “1” to select operation as a ratio of AMPS/VOLT or select “2” to operate in OHMS. Finish by pressing ENTER.

Check Firmware Revision

This displays the installed version of Dynaload firmware.

Programmable UV Level

The Programmable Under Voltage provides a means for having the load automatically stop loading when the input Voltage drops below a specified threshold. If the input Voltage level drops below the UV setting the load will disconnect from the source. A UV and MAJOR FAULT will be indicated. The load will not reconnect until a DC LOAD ON command is issued. When prompted, press ENTER to select the function. Then enter the numeric value using the keypad and press ENTER.

Pulse Mode

Pulse mode loading is available in all four basic modes of operation (Constant Current, Constant Resistance, Constant Voltage and Constant Power). Use the following steps when operating in pulse mode:

Manual Operation

To manually operate the Dynaload, use the following procedure:

- (1) Use the CI, CP, CV or CR button to set the baseline current, power, voltage, or resistance respectively.
- (2) Use the FREQ button to set the frequency.
- (3) Use the DUTY CYCLE button to set the duty cycle. For applications that require the period to be set, the ¹HI and ¹LO functions should be used. The ¹HI function will set the time that the pulse remains at the peak setting. The ¹LO function will set the time that the pulse remains at the baseline setting.

- (4) Use the PEAK button to set the amplitude of the pulse.

NOTE:

The peak setting is added to the baseline setting.

- (5) Use the menu button to scroll through the menu's to set the slew rate. This is set from the factory at 100 microseconds.
- (6) Use the RUN button to initiate pulse loading. Press RUN a second time to turn pulse off.
- (7) Use the SW command to initiate pulse loading.

The slew rate setting is set at the factory for 100 microseconds, but is adjustable through the front panel menu commands or the IEEE-488 bus.

It is recommended to monitor the current sample output with an oscilloscope to observe the actual current amplitude and waveform. If waveforms other than square waves are required, this can be accomplished by programming the loads using an external analog program source (refer to the *Remote Programming* section that follows).

NOTE:

In constant voltage mode the load current is increased by lowering the voltage. Therefore, in constant voltage pulse mode, the baseline voltage is higher than the peak setting. In constant resistance pulse mode, the baseline resistance is added in parallel with the peak resistance.

IEEE-488 Programming

This section covers basic operation only. For detailed information on pulse loading with the IEEE-488 commands, refer to the *IEEE-488 Commands and Programming* section and the *Language Elements* chapter later in this manual.

□ Effects of Cable Inductance On Pulse Loading

When the Dynaload is used for high current pulse loading, the effects of cable inductance must be considered. The critical parameters are the rise time and the minimum compliance specifications. If the inductance of the cables from the voltage source is great enough to cause the voltage at the Dynaload to go below the minimum compliance level, then excessive current waveform distortion will occur. This is the result of the power devices driving into saturation. They attempt to reach the programmed current, however they cannot because of the low drain voltage. Once in a saturated state, the response time is much slower. The result is a significant overshoot on the rising edge of the pulse.

In order to prevent this from occurring, it should be noted that:

- 1 microhenry = 2.4 feet of wire (total)
- 50A @ 50 microseconds rise time = 1 volt drop with 1 microhenry
- The inductive drop cannot exceed the difference between the source voltage and the minimum compliance.

EXAMPLE:

Referring to Equation 1 that follows, to test a 10V source with a 100A pulse, and assuming a 3 Volt minimum compliance, the maximum cable length would be:

$$\begin{aligned}
 E \text{ Max drop} &= 7V \\
 E &= L \left(\frac{di}{dt} \right) \quad 7V = L \left(\frac{100A}{50\mu s} \right) \\
 L &= 3.5 \text{ microhenries maximum}
 \end{aligned}$$

402825-02-12.CDR

Equation 1. Establishing Maximum Cable Length

In the example above, the maximum cable length is equal to 8.4 feet total or 4.2 feet per cable from the source to the Dynaload.

If the distance from the load to the source must be greater than this, there are several methods to increase the maximum distance. One way is to use several insulated conductors. This cuts the inductance in half if four are used instead of two, or by 1/3 if six are used. This double or triples the maximum length, respectively.

Another method is to slow down the rise time of the pulse generator before applying it to the regulation loop. Increasing the slew rate to 100 microseconds will double the maximum cable length.

The third method is to use a large electrolytic capacitor at the Dynaload studs that can supply current necessary to counteract the inductive drop of the cable.

EXAMPLE:

If the previous example required 15 feet of total cable length or 6.25 microhenries, which would be 12.5V of inductive drop, then the capacitor would have to supply 5.5V @ 100A for 50 microseconds. The capacitance of this capacitor is computed using Equation 2 below:

$C = \frac{I T}{E}$	Where: I is current in Amps (A) T is time in microseconds (μ s) E is Voltage in Volts (V) C is capacitance in microfarads (μ F)
Substituting the values from the example into this equation results in:	
$C = \frac{100A \times 50\mu s}{5.5V} = 910\mu F$	

402825-02-13.CDR

Equation 2. Formula to Establish Capacitor Requirements

Effects Of Cable Length

□ Current Oscillation

The Dynaload regulation loop is designed to operate at a maximum response time of 10 μ S. This is not affected by manipulating the slew rate. When operating in any of the constant DC modes, the external cable length can effect the performance of the load. If the total inductance of the power cables is excessive, a parasitic oscillation could occur. It is always recommended to monitor the current sample output to verify that the load is operating without current oscillation. If this situation occurs, refer to the *Effects of Cable Inductance On Pulse Loading* section earlier in this chapter.

□ Line Loss

If the Dynaload is not configured for remote voltage sensing, the voltage display and voltage readback will reflect what may appear to be an erroneous number. The voltage display will indicate the voltage present at the input terminals. This number will be affected by the current level. Wire is a resistor, and will lose voltage as the current is increased. A general rule of thumb is to size your wire at 500 circular mils per amp of load current. This will allow a maximum of 10 degrees centigrade rise in temperature of the wire. The resistance of wire is approximately 107 ohms per 1000 feet for 100 circular mils of cross-sectional area. Use Ohm's law ($E = I \times R$) to calculate the line losses for your particular application. For detailed information about the maximum current capacity of conductors refer to Table H.

Table H. Wire Gauge/Ampere Rating Reference Table

Size AWG	MIL-W-5088				NEC ¹	UL ²		AIA ³	500 c mils/A
	Copper		Aluminum			60°C	80°C		
	Single wire	Wire bundled	Single wire	Wire bundled					
30	—	—	—	—	—	0.2	0.4	—	0.20
28	—	—	—	—	—	0.4	0.6	—	0.32
26	—	—	—	—	—	0.6	1.0	—	0.51
24	—	—	—	—	—	1.0	1.6	—	0.81
22	9	5	—	—	—	1.6	2.5	—	1.28
20	11	7.5	—	—	—	2.5	4.0	3	2.04
18	16	10	—	—	6	4.0	6.0	5	3.24
16	22	13	—	—	10	6.0	10.0	7	5.16
14	32	17	—	—	20	10.0	16.0	15	8.22
12	41	23	—	—	30	16.0	26.0	20	13.05
10	55	33	—	—	35	—	—	25	20.8
8	73	46	58	36	50	—	—	35	33.0
6	101	60	86	51	70	—	—	50	52.6
4	135	80	108	64	90	—	—	70	83.4
2	181	100	149	82	125	—	—	90	132.8
1	211	125	177	105	150	—	—	100	167.5
0	245	150	204	125	200	—	—	125	212.0
00	283	175	237	146	225	—	—	150	266.0
000	328	200	—	—	275	—	—	175	336.0
0000	380	225	—	—	325	—	—	225	424.0

¹ National Electrical Code

² Underwriters Laboratory

³ American Insurance Association

□ Transconductance

One characteristic of power MOSFET'S is called transconductance. Today's MOSFET'S are designed for high-speed switch mode operation where the operation is full ON or full OFF. The Dynaload uses these FET's in their linear region where the transconductance effect becomes apparent. When the gate of a FET is pulsed, the drive circuitry must overcome the inherent miller capacitance to reach the desired gate voltage. When the pulsed gate signal is very small the transconductance of the component will limit the rise time of the FET.

When operating the Dynaload at pulsed currents less than 10% of full scale, the rise time of the current waveform will be much slower than expected. Since this roll off in response is dependent on the number of FET's used in the power tray and the actual current pulse desired, it is very difficult to provide exact equations to define the effect. It is suggested to select a load that will provide the desired pulse level while operating at current levels greater than 10% of the full current rating of the load. If the baseline current is greater than 10% of full scale current and the pulsed waveform is added above this baseline the effects of transconductance will be eliminated. The greatest distortion occurs when pulsing from a zero current baseline.

NOTE:

Range switching will have no effect on operation in the transconductance region.

□ Location, Airflow, Maintenance

The figures shown in *WCL488 Outline Drawings* are the dimensions of your Dynaload. In addition to the rack mounting ears, the use of slides or shelf type supports is required. The WCL chassis is equipped with mounting holes that match Jonathan 110QD-24-2 slides. The slide mounting screws *must* be #10 - 32 x 5/16 truss head.

The internal fan cools the unit by drawing in air from the front and exhausting it out the back. Keeping the airflow inlet and outlet screens open and free of dust and other airflow inhibitors will help keep your Dynaload unit's operating temperature within the intended design limits. We suggest that the loads be cleaned and free of dust build-up at least once a year.

The load can operate without performance derating over the temperature range of 0 to 40°C and with derated power dissipation capability up to 50°C.

WCL488/WCS Water Cooled Load Systems

The WCL series of water-cooled loads can be provided in a fully configured rack assembly. There are two standard sizes available: the full size rack measuring 60 inches tall, 22 inches wide and 36 inches deep and our Mini-rack which measures 42 inches tall by 22 inches wide by 36 inches deep. The full size rack accommodates one WCL488 master with a maximum of nine WCS slave units (up to 120kW) and the Mini-rack accommodates one WCL488 master and up to four WCS slave units (up to 60kW).

Each of these rack assemblies provides all the necessary power connections and water distribution needed for full operation. A system DC disconnect is provided as a functional disconnect and is integrated into the protection circuitry of the system. All internal AC distribution and master/slave interconnections are also provided. The power and water inputs are conveniently located at the rear of the rack for simplified system integration. The flow of water through the system is closely regulated in order to maintain the proper heat sink temperature and eliminate the possibility of condensation.

The WCS electronic load system consists of a master control unit in conjunction with up to nine (9) slave modules. The slave modules are dependent on the master to operate. Therefore, do not attempt to operate the slave units without a master control unit.

The WCS System is designed to automatically detect the presence of the slave units. In operation, the control display on the master will indicate the total system rating based on number of slave units detected. The voltage and current ranges selected will also be taken into account and reflected in the system rating. The user may choose to operate the system with any number of slaves. When the AC power is applied to the slave, it becomes active in the system. If the slave is not turned on the master will not detect it and will configure the system accordingly. There is no requirement to sequence the use of slaves. A system will operate normally regardless of which slave unit or units are selected.

❑ Synchronized Paralleling

The synchronized paralleling function allows the user to connect one (1) or more slave units in parallel. The master is controlled through normal operation; the slaves are connected via a twenty five-pin ribbon cable. For systems assembled at the factory, this cable is provided. This cable contains all the necessary signals for the slave to respond to the master unit. In all operating modes, the master and all slaves will share the current in proportion to the selected current range.



IMPORTANT:

Master/slave operation is intended as an extension of the current and power capabilities when testing a single output power source. The slave units cannot be connected to a second source or output. This will cause damage to any or all of the loads in the system.

❑ Slave Configuration

When configuring a master/slave system, each slave unit must have its bit identifier set in order to communicate correctly with the master. On the rear panel of each slave unit there is a set of DIP switches that must be set to a proper number. These are referred to as the Slave Bit Identifier Switches (refer to Figure 17). The switch on each slave unit must be set to a slave ID number. Starting at 1 set each sequential slave to the next number.



IMPORTANT:

You must be sure that no two slaves are set to the same number. Having two slaves set to the same number will confuse the master and it will not identify the second slave unit.

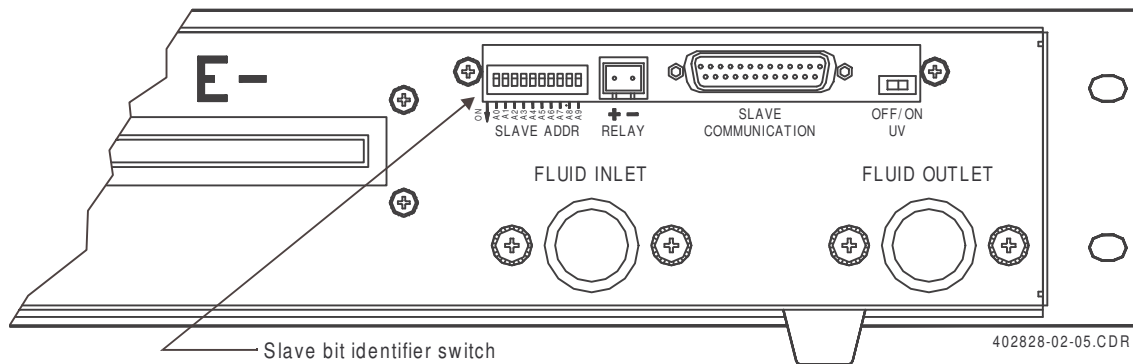


Figure 17. Slave Bit Identifier Switches

The master unit will detect all slaves present and self configure to reflect the full system rating. The master will report all system conditions, that is: current and power levels and all alarms including slave alarm status.

Not all slaves need to be used in order to operate. If a slave is turned off, the master detects this and configures based on the number of slaves. Pressing the “slave” button on the master will display the number of slave units detected in the system.

□ Water Cooled Load Systems Components and Wiring

The main components of Water Cooled Load Systems are as follows:

- Main servo unit
- DC relay (master)
- Relay (master load)
- Relay (slave load)
- Water shutoff valve (master)
- Water shutoff valve (one per slave)
- Optional water shutoff override switch (momentary)

To better understand the various components and related wiring of Water Cooled Load Systems, refer to Figure 18.

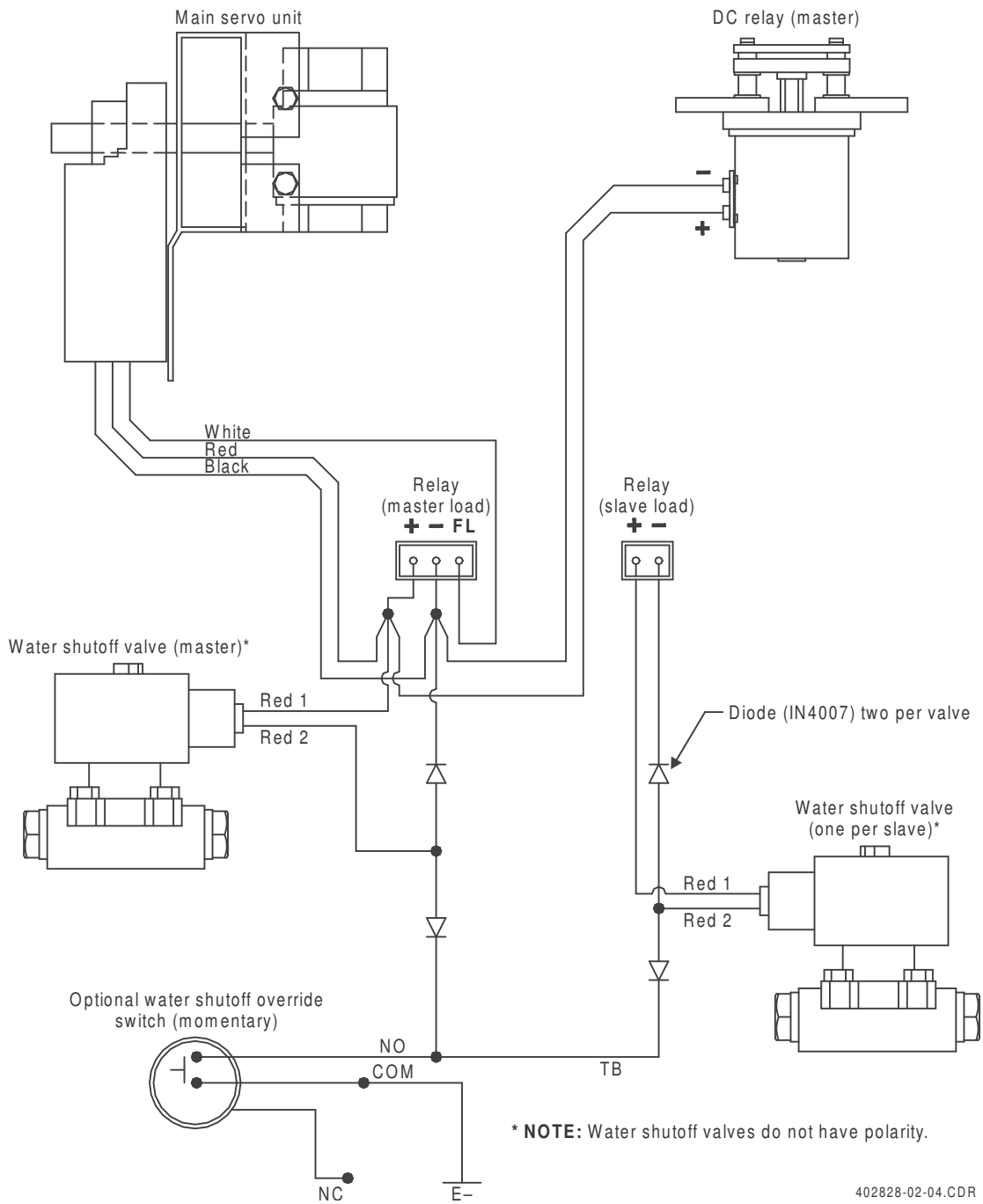


Figure 18. Water Cooled Load Systems Wiring Diagram

WCS Front Panel Features and Controls

To better understand the features and controls of the front panel, refer to the information below and Figure 19 (for clarity, the unit's rack-mount handles and equipment mounting details have been removed).

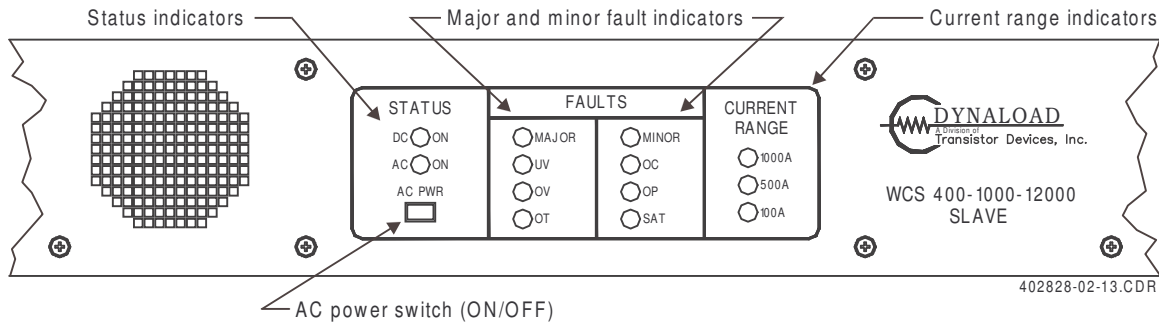


Figure 19. WCS Front Panel Features and Controls

Referring to Figure 19 above, the WCS front panel features and controls are as follow:

- **AC Power Switch** — The switch powers the WCS unit ON and OFF.
- **Status Indicators** — “AC ON” indicates that the WCS unit is powered on. “DC ON” indicates that the WCL488 is powered on and sending control information for use by the slave units.
- **Major and Minor Fault Indicators** — These indicators are discussed in detail in the *Fault Indicators* section later in this chapter.
- **Current Range Indicators** — These indicate the current range controlled by the master (WCL488).

WCS Rear Panel Electrical Connections

All electrical and electronic connections are made on the unit's rear panel and are detailed below in

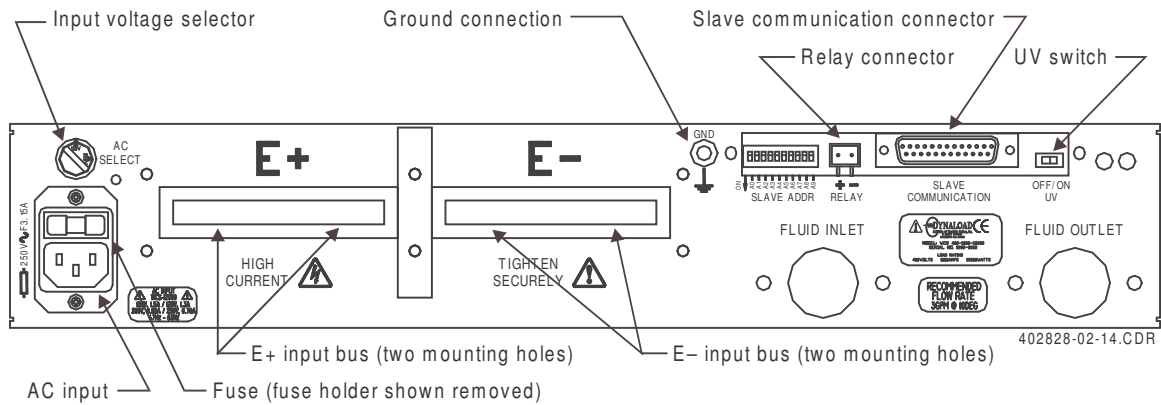


Figure 20. WCS Rear Panel Detail

❑ WCS E+ and E– Power Input Buses

Referring to Figure 20, the main DC power inputs are labeled E+ and E– and are the power input buses for connecting the power source to be monitored or tested. The E+ and E– power inputs are the two sets of two mounting holes (and related hardware) found on each of the two input buses located on the left side of the rear of the unit. The input buses are separated by an insulator for safety and require lugs with a 7/16-inch diameter hole.



CAUTION:

Only the power source-to-load connections are to be made to these buses. Always be sure these connections are securely tightened. A loose connection will result in a high temperature at the connection.

WCS E+ and E– Wiring Tips

It is the best practice to join the power buses together and run a single conductor set from the “ganged” inputs to the source under test. The external DC disconnect relay should be installed between the “ganged” positive input and the positive output of the source under test.

❑ WCS AC Input

This connection provides the Dynaload with its operating power and its safety ground (refer to Figure 21). Power requirements are user selectable and described below in Table I.

Table I. Input Power Requirements

Switch Setting	Operation Range
110V	103.5 Vac – 126.5Vac at 1.5A
220V	187 Vac – 242Vac at 0.8A

NOTE: The operational frequency range is 47Hz – 63Hz.

NOTE:

Each WCS (slave) **MUST** be set the same as the master WCL488.

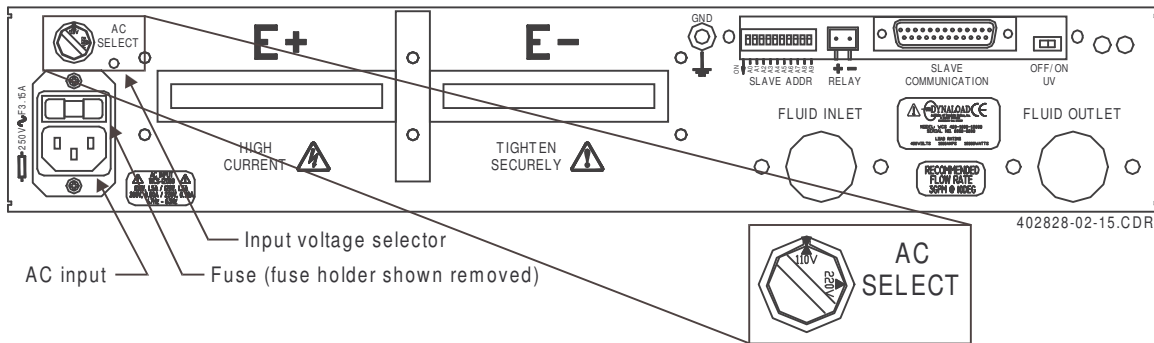


Figure 21. WCS. AC Input, Fuse and Input Voltage Selector

❑ WCS Input Voltage Selector

The Input Voltage Selector (refer to Figure 21) is mounted on the rear panel immediately above the AC input and fuse assembly.

NOTE:

Each WCS (slave) Input Voltage Selector **MUST** be set the same as the master WCL488.



WARNING:

Ensure that the power cord is removed before making changes to the voltage selector tab.

WCS AC Input Wiring Tips

A standard U.S. three-prong cord is provided with your Dynaload. The Input Voltage Selector is mounted above of the three-prong AC connector and fuse (see Figure 21 and refer to the *WCS Input Voltage Selector* section that follows).



WARNING:

The power cord provides a chassis ground through a third conductor. Make sure that your power outlet is of the 3-conductor type with the correct pin connected to earth ground. Always Connect the AC cord first to your Dynaload and THEN to the utility outlet.

❑ WCS Fuse Replacement

Referring to Figure 21, the AC input fuse is located above the AC Input and below the Input Voltage Selector. The fuse replacement part numbers for the Dynaload are MDA-3 (3 Amp, 250 Volt, slow blow, 1-1/2 inch American version) or equivalent **OR** GDC-3.15A-250V (3.15 Amp, 250 Volt, slow blow, 20 mm European version) or equivalent.

❑ WCS Slave Communication Connector

This DB25 “D” connector is located in the upper right corner of the rear panel and is used for synchronized parallel Dynaload operation (see Figure 20). This connector is labeled “SLAVE COMMUNICATION”.

WCS Slave Communication Connector Wiring

This 25-pin “D” connector is used to link the WCS slave units to the master units (and vice versa). If you are purchasing cables, be sure the PIN configuration is always 1 to 1 (not all cables are provided this way and a crossover of PINS will cause erroneous operation).

❑ WCS UV (Undervoltage Lockout) Switch

Referring to Figure 22, the UV switch has two positions, ON and OFF. This switch is described in detail in the *Undervoltage Lockout* section later in this chapter.

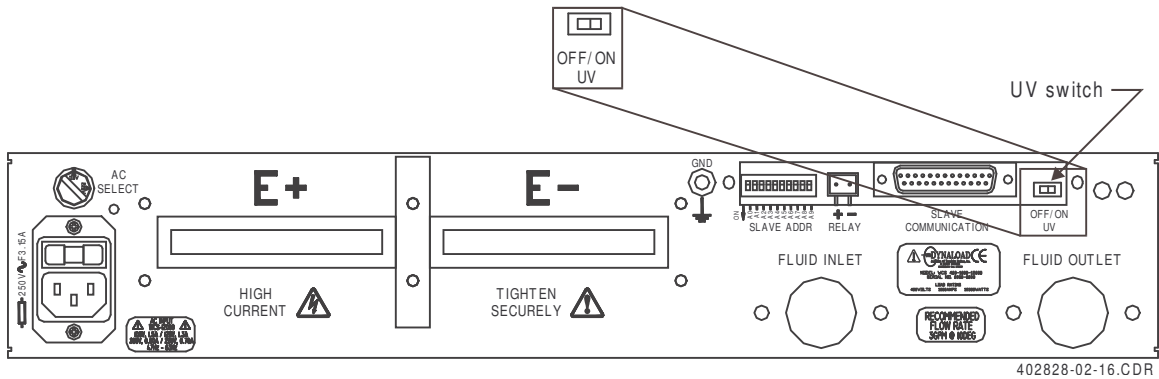


Figure 22. WCS UV Switch Detail

❑ WCS Relay Connector

Referring to Figure 23 below and Figure 18 (on page 38), this two-pin relay connector is used for controlling each individual slave’s water shutoff valve and DC disconnect relay in a high current system greater than 1200A.

Unlike the WCL488’s three-pin relay connector (see Figure 13, and Figure 18 [on page 38]), this connector does not have an FL pin (which on a WCL488, or master unit, controls the water servo).

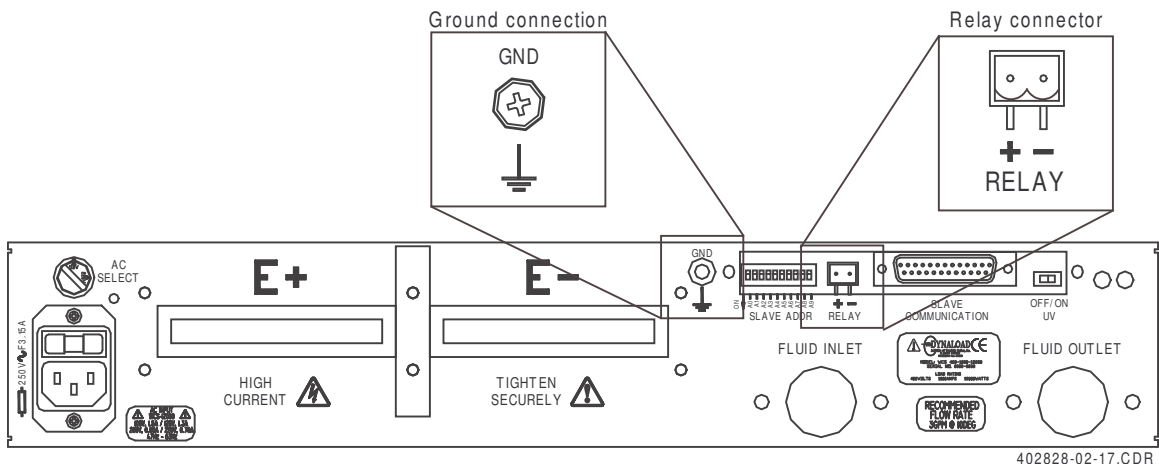


Figure 23. WCS Relay Connector and Chassis Ground Connection

❑ WCS Chassis Ground Connection

Referring to Figure 23 above, as with the WBL488, the chassis ground connection is used to ground the third wire of the unit's water shutoff relay.

❑ Slave Bit Identifier Switches

When configuring a master/slave system, each slave unit must have its bit identifier set in order to communicate correctly with the master. As shown in Figure 24, on the rear panel of each slave unit there is a set of DIP switches that must be set to a proper number. These are referred to as the Slave Bit Identifier Switches. The switch on each slave unit must be set to a slave ID number. Starting at 1 set each sequential slave to the next number. To enable the bit, the selected switch position must be placed the "OFF" position.



IMPORTANT:

You must be sure that no two slaves are set to the same number. Having two slaves set to the same number will confuse the master. The master will not identify the second slave unit and system errors will occur.

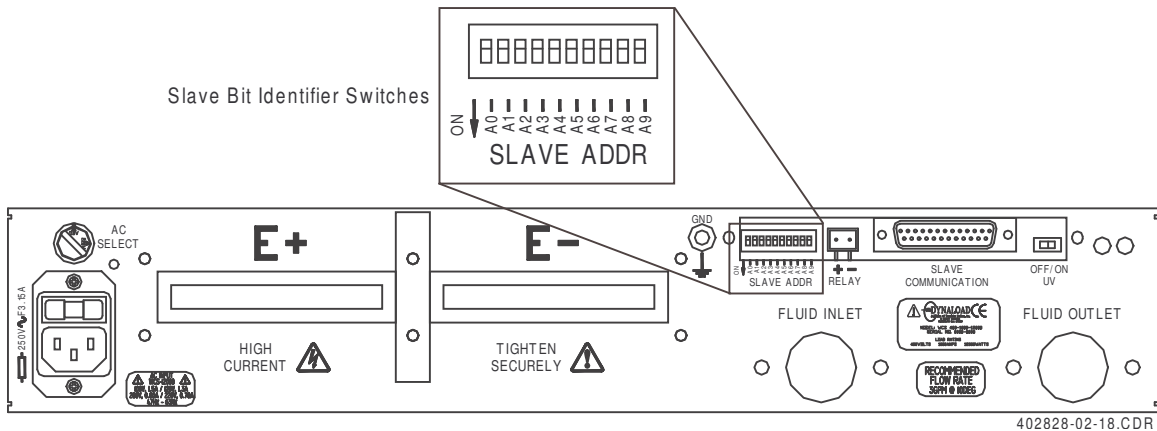


Figure 24. WCS Slave Bit Identifier Switches

The master unit will detect all slaves present and self configure to reflect the full system rating. The master will report all system conditions, that is: current and power levels and all alarms including slave alarm status.

Not all slaves need to be used in order to operate. If a slave is turned off, the master detects this and configures based on the number of slaves. Pressing the "slave" button on the master will display the number of slave units present in the system.

Chapter 3 — IEEE-488 Commands and Programming

Introduction

The purpose of this section is to describe the IEEE-488 commands for operating your programmable Dynaload. This section assumes that your WCL488 has been installed, is operating properly, and that an IEEE-488 bus controller has been attached to it. It is also assumed that the IEEE-488 address and terminator has been set through the front panel menu selections. Be sure to read *Chapter 2 — Installation and Wiring*, especially the *Operator Safety Instructions* section, before proceeding.

IEEE-488 Bus Subsets

The programmable Dynaload has the IEEE-488 bus subset capabilities indicated in Table J.

Table J. Bus Subset Capabilities

Subset	Category	Response
Acceptor Handshake	AH1	Full capability - the load can generate the handshake for receiving data.
Source Handshake	SH1	Full capability - the load can generate the handshake for transmitting data
Talker	T6	The load can: A. Transmit data B. Not be a talker and a listener at the same time. C. Respond to a bus serial poll with status information.
Listener	L1	The load can: A. Receive data B. Not be a talker and a listener at the same time.
Service Request	SR1	The load will set the SRQ line if there is an enabled service request condition.
Remote Local	RL1	The load can be switched to local operation.
Parallel Poll	PPO	No capability.
Device Clear	DC1	The Dynaload responds to device clear (DCL) and selected device clear (SDC) commands according to IEEE-488.2 specifications.
Device Trigger	DTO	No capability.

Data Separators

It is not necessary to separate numerical data from the previous command by any character. White space is ignored. The use of a space is recommended, however, as it aids in command string legibility.

Program Line Terminators

The terminator instructs the Dynaload that the end of an incoming command line has been reached and that command decoding can begin. In a like manner, the Dynaload terminates each of its outgoing response strings with a terminator.

Normally the terminator for command strings is appended automatically by the IEEE-488 bus controller in the system computer. The terminator must be established as both a carriage return and a line feed, or as a carriage return only by following the IEEE-488 bus configuration procedure.

Numerical Data Formats

The programmable Dynaload accepts the two numerical data formats listed below (see Table K). These are described in more detail in IEEE Standard 488.2 — *Standard Digital Interface for Programmable Instruments*.

Table K. Numerical Data Formats

Symbol	Data Form(s)
NR1	Digits with no decimal point. The decimal point is assumed to be to the right of the least significant digit. For example: 314, 0314.
NR2	Digits with a decimal point. For example: 314.0, 31.41, 0.0314

Numerical Data Units

The numerical units in which the WCL488 receives and transmits quantities are fixed. They are listed in Table L.

Incoming commands must not have any units transmitted with them, as this will cause an “unrecognized command” error.

Responses to queries in the TEXT ON (long format) mode are followed by the unit transmission format indicated in the table. In the TEXT OFF (short format) only the numbers are transmitted.

Table L. Numerical Data Units

Item	Description	Unit	Format
AV1	First resistance value (A/V mode)	Amps/Volt	Amps/Volt
AV2	Second resistance value (A/V mode)	Amps/Volt	Amps/Volt
AVH	Constant resistance setpoint	(High A/V) Amps/Volt	Amps/Volt
AVL	Constant resistance setpoint	(Low A/V) Amps/Volt	Amps/Volt
CI	Constant current setpoint	Amperes	Amps
CP	Constant power setpoint	Watts	Watts
CRH	Constant resistance setpoint	(High Ω) ohms	Ohms
CRL	Constant resistance setpoint	(Low Ω) ohms	Ohms
CV	Constant voltage setpoint	Volts	Volts
DU	Square wave duty cycle	Percent	%
FQ	Square wave frequency	Hertz	Hz
I?	Load current	Amperes	Amps
I1	First current value	Amperes	Amps
I2	Second current value	Amperes	Amps
P?	Load power	Watts	Watts
P1	First power value	Watts	Watts
P2	Second power value	Watts	Watts
R1	First resistance value (ohms mode)	Ohms	Ohms
R2	Second resistance value (ohms mode)	Ohms	Ohms
SR	Slew rate (1st and 2nd)	Microseconds	μ s
T1	First duration	Microseconds	μ s
T2	Second duration	Microseconds	μ s
V?	Load voltage	Volts	Volts
V1	First voltage value	Volts	Volts
V2	Second voltage value	Volts	Volts
XM PLUS (XM +)	External modulation constant current offset	Amperes	Amps

Power-on Defaults

The following table indicates the factory default conditions are in effect every time the load is switched on. This can be re-configured by the user in memory location zero (0).

Table M. Power-on Defaults

Parameter	Setting
CI — Constant current setpoint	0
CP — Constant power setpoint	0
CR — Constant resistance setpoint	∞
CV — Constant voltage setpoint	Vmax
DU — Square wave duty cycle	50%
FQ — Square wave frequency	1000 Hz
I1 — First current value	0
I2 — Second current value	0
IL — Current limit	105% of full scale
LOAD — Relay	Open
MODE — Mode	Constant current
P1 — First power value	0
P2 — Second power value	0
PL — Power limit	105% of full scale
R1 — First resistance value	∞
R2 — Second resistance value	∞
RNG — Range	High Volts, High Amps
T1 — First duration	500 microseconds
T2 — Second duration	500 microseconds
TEXT — Text	ON
V1 — First voltage value	Vmax
V2 — Second voltage value	Vmax
VL — Voltage limit	105% of full scale
XM — External modulation	OFF

Commands

The basis of the WCL488 syntax is the instrument control commands. Each command sends an instruction to the Dynaload. A query command requests information from the Dynaload.

Each element of the load syntax commands consists of two or more letters or a combination of letters and numbers. The simpler elements are mnemonic in nature while the longer elements explain a complete action.

EXAMPLE:

CI 10 This places the load in it's Constant Current Mode set at 10 amps
LOAD ON This closes the load's input relay.

Queries

Commands followed by a question mark “?” are queries. When received by the Dynaload, the appropriate information is stored for reading by the IEEE-488 bus controller. It is important to note that the results of a query must be read back before sending another command to the Dynaload. If this is not the case, the information requested is lost.

There are two categories of queries. One is a request for real time load values: voltage, current, and power. The second is request for the present value of programmed parameters or status.

Many of the commands may be turned into queries by the addition of a question mark (?). The Dynaload will respond with the requested information when the load is addressed to talk over the IEEE-488 bus.

EXAMPLE:

CI? This requests the present value of the Constant Current program.
LOAD? This requests the state of the load's input relay.

Command and Queries Listed Alphabetically

AV1 <NR2>	Set Amps/Volt pulse base level
AV1?	Read Amps/Volt pulse base setting
AV2 <NR2>	Set Amps/Volt pulse peak level
AV2?	Read Amps/Volt pulse peak setting
AV?	Read Amps/Volt setting
AVH <NR2>	Set Amps/Volt High mode
AVL <NR2>	Set Amps/Volt Low mode
CI <NR2>	Set Constant Current Mode
CI?	Read Constant Current setting
CON?	Read Condition register
CP <NR2>	Set Constant Power mode
CP?	Read Constant Power setting
CR?	Read Constant Resistance setting
CRH <NR2>	Set Constant Resistance High mode
CRL <NR2>	Set Constant Resistance Low mode
CV <NR2>	Set Constant Voltage mode
CV?	Read Constant Voltage setting
DU <NR2>	Set Duty Cycle
DU?	Read Duty Cycle setting
ERR?	Read Error Register
FQ <NR2>	Set Frequency
FQ?	Read Frequency Setting
I?	Read Current
I1 <NR2>	Set Constant Current pulse base level
I1?	Read Constant Current pulse base setting
I2 <NR2>	Set Constant Current pulse peak level
I2?	Read Constant Current pulse peak setting
ID?	Read Identification string
IL <NR2>	Set Current Limit
IL?	Read Current Limit Setting
LAT <NR1>	Set the fault Latch register
LAT?	Read the Latch register setting
LOAD OFF	Open load connect relay
LOAD ON	Close load connect relay

LOAD?	Read load connect relay setting
LOCK OFF	Unlock front panel
LOCK ON	Lock front panel
LOCK?	Read front panel lock setting
MODE?	Read mode
MR <NR1>	Memory Recall
MS <NR1>	Memory Save
P?	Read Power
P1 <NR2>	Set Constant Power pulse base level
P1?	Read Constant Power pulse base setting
P2 <NR2>	Set Constant Power pulse peak level
P2?	Read Constant Power pulse peak setting
PL <NR2>	Set Power Limit
PL?	Read Power Limit setting
R1 <NR2>	Set Constant Resistance pulse base level
R1?	Read Constant Resistance pulse base setting
R2 <NR2>	Set Constant Resistance pulse peak level
R2?	Read Constant Resistance pulse peak setting
RNG <NR1>	Set Voltage/Current Range
RNG?	Read Voltage/Current Range status
RST	Reset
SBE <NR1>	Set Summary Bit Enable register
SBE?	Read Summary Bit Enable register
SDN <NR1>	Set Shutdown register
SDN?	Read Shutdown register
SF	Set for Fast Slew rates
SR <NR2>	Set Slew Rate
SR?	Read Slew Rate settings
SRQ <NR1>	Set Service Request register
SRQ?	Read Service Request register
SS	Set for Slow Slew rates
STA?	Read Status register
SW [<NR1>]	Set Square Wave pulsing on
SW OFF	Set Square Wave pulsing off
T1 <NR2>	Set pulse base duration
T1?	Read pulse base duration
T2 <NR2>	Set pulse peak duration

T2?	Read pulse peak duration
TEXT OFF	Set numeric query responses
TEXT ON	Set descriptive query responses
TEXT?	Read Text on/off setting
UV <NR2>	Set programmable Under Voltage
UV?	Read programmable Under Voltage setting
V?	Read Voltage
V1 <NR2>	Set Constant Voltage pulse base level
V1?	Read Constant Voltage pulse base level
V2 <NR2>	Set Constant Voltage pulse peak level
V2?	Read Constant Voltage pulse peak level
VER?	Read software version string
VL <NR2>	Set Voltage Limit
VL?	Read Voltage Limit setting
WF [<NR1>]	Set Square Wave pulsing on
WF OFF	Set Square Wave pulsing off
XM ON	Set External Modulation on
XM OFF	Set External Modulation off
XM PLUS <NR2>	Set External Modulation with programmed offset
XM + <NR2>	Alternate Syntax for XM PLUS <NR2>
XM?	Read External Modulation setting

Commands and Queries Listed by Category

Configuration	
LAT <NR1>	Set the fault Latch register
LAT?	Read the Latch register setting
LOCK OFF	Unload front panel
LOCK ON	Lock front panel
LOCK?	Read front panel lock setting
MR <NR1>	Memory Recall
MS <NR1>	Memory Save
SDN <NR1>	Set Shutdown register
SDN?	Read Shutdown register
TEXT OFF	Set numeric query responses
TEXT ON	Set descriptive query responses
TEXT?	Read Text on/off setting
Identification	
ID?	Read Identification string
VER?	Read software version string
Limit Control	
IL <NR2>	Set Current Limit
IL?	Read Current Limit Setting
PL <NR2>	Set Power Limit
PL?	Read Power Limit setting
UV <NR2>	Set programmable Under Voltage
UV?	Read programmable Under Voltage setting
VL <NR2>	Set Voltage Limit
VL?	Read Voltage Limit setting
Load Control	
LOAD OFF	Open load connect relay
LOAD ON	Open load connect relay
LOAD?	Read load connect relay setting
RNG <NR1>	Set Voltage/Current Range

RNG?	Read Voltage/Current Range status
-------------	-----------------------------------

Operation Modes

AV?	Read Amps/Volt setting
AVH <NR2>	Set Amps/Volt High mode
AVL <NR2>	Set Amps/Volt Low mode
CI <NR2>	Set Constant Current Mode
CI?	Read Constant Current setting
CP <NR2>	Set Constant Power mode
CP?	Read Constant Power setting
CR?	Read Constant Resistance setting
CRH <NR2>	Set Constant Resistance High mode
CRL <NR2>	Set Constant Resistance Low mode
CV <NR2>	Set Constant Voltage mode
CV?	Read Constant Voltage setting
MODE?	Read mode
XM ON	Set External Modulation on
XM OFF	Set External Modulation off
XM PLUS <NR2>	Set External Modulation with programmed offset
XM + <NR2>	Alternate Syntax for XM PLUS <NR2>
XM?	Read External Modulation setting

Pulsing

DU <NR2>	Set Duty Cycle
DU?	Read Duty Cycle setting
FQ <NR2>	Set Frequency
FQ?	Read Frequency Setting
SW [<NR1>]	Set Square Wave pulsing on
SW OFF	Set Square Wave pulsing off
T1 <NR2>	Set pulse base duration
T1?	Read pulse base duration
T2 <NR2>	Set pulse peak duration
T2?	Read pulse peak duration
WF [<NR1>]	Set Square Wave pulsing on

WF OFF	Set Square Wave pulsing off
---------------	-----------------------------

Pulsing Level Parameters

AV1 <NR2>	Set Amps/Volt pulse base level
AV1?	Read Amps/Volt pulse base setting
AV2 <NR2>	Set Amps/Volt pulse peak level
AV2?	Read Amps/Volt pulse peak setting
I1 <NR2>	Set Constant Current pulse base level
I1?	Read Constant Current pulse base setting
I2 <NR2>	Set Constant Current pulse peak level
I2?	Read Constant Current pulse peak setting
P1 <NR2>	Set Constant Power pulse base level
P1?	Read Constant Power pulse base setting
P2 <NR2>	Set Constant Power pulse peak level
P2?	Read Constant Power pulse peak setting
R1 <NR2>	Set Constant Resistance pulse base level
R1?	Read Constant Resistance pulse base setting
R2 <NR2>	Set Constant Resistance pulse peak level
R2?	Read Constant Resistance pulse peak setting
V1 <NR2>	Set Constant Voltage pulse base level
V1?	Read Constant Voltage pulse base level
V2 <NR2>	Set Constant Voltage pulse peak level
V2?	Read Constant Voltage pulse peak level

Readbacks

I?	Read Current
P?	Read Power
V?	Read Voltage

Slew Rate Commands

SF	Set for Fast Slew rates
SR <NR2>	Set Slew Rate
SR?	Read Slew Rate settings
SS	Set for Slow Slew rates

Status Related Commands	
CON?	Read Condition register
ERR?	Read Error Register
LAT <NR2>	Set the fault Latch register
LAT?	Read the Latch register setting
SBE <NR1>	Set Summary Bit Enable register
SBE?	Read Summary Bit Enable register
SDN <NR1>	Set Shutdown register
SDN?	Read Shutdown register
SRQ <NR1>	Set Service Request register
SRQ?	Read Service Request register
STA?	Read Status register
Miscellaneous	
RST	Reset

Detail Language Elements

This is an alphanumerical listing that gives the syntax and required parameters for all elements in the programmable load's syntax. The syntax is generic for all load ratings.

The following section provides the following information below for each command:

- **DESCRIPTION:** Describes the function of the command and gives information about its use.
- **COMMAND SYNTAX:** Shows the proper form(s) of the command. Spaces are optional as the command processor ignores these.
- **EXAMPLE:** Gives an example of command usage.
- **QUERY SYNTAX:** Provides the proper query form.
- **RETURNED PARAMETERS:** Indicates the response format(s) to the query form of the command. Where the TEXT ON and TEXT OFF modes responses differ, both will be indicated.

AV1 Amps/Volt Pulsing Base Level

Description	This command is used to set the base level when pulse loading in the Amps/Volt mode. NOTE: AVL or AVH must have been previously set.
Command Syntax	AV1 <NR2>
Example	AV1 25.0 This will set the base Amps/Volt level to 25 amps/volt
Query Syntax	AV1?
Returned Parameters	TEXT ON: <NR2> amps/v TEXT OFF: <NR2>

AV2 Amps/Volt Pulsing Peak Level

Description	This command is used to set the peak level relative to the base level when pulse loading in the Amps/Volt mode. NOTE: AVL or AVH must have been previously set.
Command Syntax	AV2 <NR2>
Example	AV2 50.0 This will set the peak level to 50 Amps per Volt above the base level. Therefore if the base level setting is 25A, the peaks will be 75 Amps per Volt.
Query Syntax	AV2?
Returned Parameters	TEXT ON: <NR2> amps/v TEXT OFF: <NR2>

AV?

See query form of AVH and AVL that immediately follow.

AVH Amps/Volt High

Description	This command places the load into Amps/Volt High mode at the specified level.
Command Syntax	AVH <NR2>
Example	AVH 25.0 This will place the load in Amps/Volt High mode at 25 Amps per Volt.
Query Syntax	AV?
Returned Parameters	TEXT ON: <NR2> amps/v TEXT OFF: <NR2>

AVL Amps/Volt Low

Description	This command places the load into Amps/Volt Low mode at the specified level.
Command Syntax	AVL <NR2>
Example	AVL 2.5 This will place the load in Amps/Volt Low mode at 2.5 Amps per Volt.
Query Syntax	AV?
Returned Parameters	TEXT ON: <NR2> amps/v TEXT OFF: <NR2>

CI Constant Current

Set Constant Current mode and current value

Description	This command places the load into Constant Current mode at the specified level.
Command Syntax	CI <NR2>
Example	CI 10.5 This will place the load in Constant Current at 10.5 Amps.
Query Syntax	CI?
Returned Parameters	TEXT ON: <NR2> amps TEXT OFF: <NR2>

CON? Condition register

Description	<p>This query returns the contents of the Condition register and clears its contents. The response is either numeric or a text description depending on the TEXT ON/OFF setting.</p> <p>Each bit in this register provides information about the load's condition. A bit being set indicates that the condition is present or has occurred. Normally the bit will clear when the condition clears unless its respective bit in the Latch (LAT) register is set. Furthermore if its respective bit in the Shutdown (SDN) register is set the load will shutdown.</p> <p>The returned value will be between 0 and 255 and is the sum of the individual bit weights. The individual bits are defined below.</p> <table border="1" data-bbox="540 751 1378 1220"> <thead> <tr> <th>Bit</th> <th>Weight</th> <th>Description</th> <th>Text On Response Message</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>128</td> <td>Under Voltage</td> <td>UNDER VOLTAGE</td> </tr> <tr> <td>6</td> <td>64</td> <td>Over Voltage</td> <td>VOLTAGE LIMIT</td> </tr> <tr> <td>5</td> <td>32</td> <td>Over Temperature</td> <td>TEMPERATURE LIMIT</td> </tr> <tr> <td>4</td> <td>16</td> <td>—</td> <td>—</td> </tr> <tr> <td>3</td> <td>8</td> <td>Over Current</td> <td>CURRENT LIMIT</td> </tr> <tr> <td>2</td> <td>4</td> <td>Over Power</td> <td>POWER LIMIT</td> </tr> <tr> <td>1</td> <td>2</td> <td>Saturation</td> <td>LOAD SATURATED</td> </tr> <tr> <td>0</td> <td>1</td> <td>Module Fault</td> <td>MODULE FAULT</td> </tr> </tbody> </table> <p>The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set, "CLEAR" will be returned.</p>	Bit	Weight	Description	Text On Response Message	7	128	Under Voltage	UNDER VOLTAGE	6	64	Over Voltage	VOLTAGE LIMIT	5	32	Over Temperature	TEMPERATURE LIMIT	4	16	—	—	3	8	Over Current	CURRENT LIMIT	2	4	Over Power	POWER LIMIT	1	2	Saturation	LOAD SATURATED	0	1	Module Fault	MODULE FAULT
Bit	Weight	Description	Text On Response Message																																		
7	128	Under Voltage	UNDER VOLTAGE																																		
6	64	Over Voltage	VOLTAGE LIMIT																																		
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4	16	—	—																																		
3	8	Over Current	CURRENT LIMIT																																		
2	4	Over Power	POWER LIMIT																																		
1	2	Saturation	LOAD SATURATED																																		
0	1	Module Fault	MODULE FAULT																																		
Command Syntax	NONE																																				
Example	N/A																																				
Query Syntax	CON?																																				
Returned Parameters	<p>TEXT ON: <text response string></p> <p>TEXT OFF: <NR1></p>																																				

CP Constant Power

Description	This command places the load into Constant Power mode at the specified level.
Command Syntax	CP <NR2>
Example	CP 20.0 This will place the load in Constant Power at 20 Amps.
Query Syntax	CP?
Returned Parameters	TEXT ON: <NR2> watts TEXT OFF: <NR2>

CR?

See query form of CRH and CRL that immediately follow.

CRH Constant Resistance High

Description	This command places the load into Constant Resistance High mode at the specified level.
Command Syntax	CRH <NR2>
Example	CRH 100.0 This will place the load in Constant Resistance High mode at 100 Ohms.
Query Syntax	CR?
Returned Parameters	TEXT ON: <NR2> ohms TEXT OFF: <NR2>

CRL Constant Resistance Low

Description	This command places the load into Constant Resistance Low mode at the specified level.
Command Syntax	CRL <NR2>
Example	CRL 1.5 This will place the load in Constant Resistance Low mode at 1.5 Ohms.
Query Syntax	CR?
Returned Parameters	TEXT ON: <NR2> ohms TEXT OFF: <NR2>

CV Constant Voltage

Description	This command places the load into Constant Voltage mode at the specified level.
Command Syntax	CV <NR2>
Example	CV 100.0 This will place the load in Constant Voltage at 100 Volts.
Query Syntax	CV?
Returned Parameters	TEXT ON: <NR2> volts TEXT OFF: <NR2>

DU Duty Cycle

Description	This command is used to set the Duty Cycle for square wave pulsing. This defines the percentage of peak pulse time and will set the Pulsing Base Time (T1) and Pulsing Peak Time (T2) accordingly based upon the defined frequency.
Command Syntax	DU <NR2>
Example	DU 40.0 This will set the duty cycle to 40%. If the frequency was 100Hz meaning a pulse period of 10,000µs, T2 will be set to 4000µs and T1 will be set to 6000µs.
Query Syntax	DU?
Returned Parameters	TEXT ON: <NR2> % TEXT OFF: <NR2>

ERR? Error Register

Description	This query returns the contents of the Error register and then clears its contents. The response is either numeric or a text description depending on the TEXT ON/OFF setting.		
	The value in this register is a number between 0 and 255 and is the sum of the individual bit weights as defined below.		
	Bit	Weight	Description
	7	128	—
	6	64	—
	5	32	Command not allowed
	4	16	Command too long
	3	8	Numeric Error
	2	4	—
	1	2	Out of Range
	0	1	Unrecognized Command
	The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set, "NO COMMAND ERROR" will be returned.		
Command Syntax	NONE		
Example	N/A		
Query Syntax	ERR?		
Returned Parameters	TEXT ON: <text response string>		
	TEXT OFF: <NR1>		

FQ Frequency

Description	This command is used to set the Frequency in Hertz for square wave pulsing. The Pulsing Base Time (T1) and Pulsing Peak Time (T2) will be adjusted accordingly based upon the defined duty cycle.
Command Syntax	FQ <NR2>
Example	FQ 1000.0 This will set the frequency to 1000Hz. If the duty cycle was 30%, T2 will be set to 300 μ s and T1 will be set to 700 μ s.
Query Syntax	FQ?
Returned Parameters	TEXT ON: <NR2> Hz TEXT OFF: <NR2>

I? Read Current

Description	This query returns the actual current reading in Amps passing through the load.
Command Syntax	NONE
Example	N/A
Query Syntax	I?
Returned Parameters	TEXT ON: <NR2> amps TEXT OFF: <NR2>

I1 Constant Current Pulsing Base Level

Description	This command is used to set the base level when pulse loading in the Constant Current mode.
Command Syntax	I1 <NR2>
Example	I1 10.5 This will set the base Constant Current level to 10.5 Amps.
Query Syntax	I1?
Returned Parameters	TEXT ON: <NR2> amps TEXT OFF: <NR2>

I2 Constant Current Pulsing Peak Level

Description	This command is used to set the peak level relative to the base level when pulse loading in the Constant Current mode.
Command Syntax	I2 <NR2>
Example	I2 25.0 This will set the peak level to 25 Amps above the base level. Therefore if the base level setting is 10.5A, the peaks will be 35.5 Amps.
Query Syntax	I2?
Returned Parameters	TEXT ON: <NR2> amps TEXT OFF: <NR2>

ID? Identification

Description	This query returns the load's model identification string that includes its rated Voltage, power and current in the format: WCL <rated Voltage>-<rated power>-<rated current>
Command Syntax	NONE
Example	N/A
Query Syntax	ID?
Returned Parameters	WCL <Voltage>-<current>-<power>

IL Current Limit

Description	This command is used to set the Current Limit set point. The Current Limit circuit will not allow the load current to exceed this level.
Command Syntax	IL <NR2>
Example	IL 50.0 This will set the Current Limit to 50 Volts.
Query Syntax	IL?
Returned Parameters	TEXT ON: <NR2> amps TEXT OFF: <NR2>

LAT Latch register

Description	<p>This command provides access to the Latch register. The bits in this register define which bits of the Condition (CON) register will latch on if set until the CON register is read. Setting one bit by writing its bit weight into the LAT register enables its equivalent bit in the CON register.</p> <p>The individual bits are defined below. More than one bit can be enabled by writing a value that is a sum of the individual bit weights. The Over Voltage and Over Temperature bits in this register will remain set regardless of what value is written to this register. The value in this register is a number between 0 and 255 and is the sum of the individual bit weights as defined below.</p> <table border="1" data-bbox="548 709 1372 1144"> <thead> <tr> <th>Bit</th> <th>Weight</th> <th>Description</th> <th>Text On Response Message</th> <th>Default Value</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>128</td> <td>Under Voltage</td> <td>UV</td> <td>0</td> </tr> <tr> <td>6</td> <td>64</td> <td>Over Voltage</td> <td>OV</td> <td>0</td> </tr> <tr> <td>5</td> <td>32</td> <td>Over Temperature</td> <td>OT</td> <td>0</td> </tr> <tr> <td>4</td> <td>16</td> <td>—</td> <td>—</td> <td>0</td> </tr> <tr> <td>3</td> <td>8</td> <td>Over Current</td> <td>OC</td> <td>0</td> </tr> <tr> <td>2</td> <td>4</td> <td>Over Power</td> <td>OP</td> <td>0</td> </tr> <tr> <td>1</td> <td>2</td> <td>Saturation</td> <td>SAT</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>Module Fault</td> <td>MOD FLT</td> <td>0</td> </tr> </tbody> </table> <p>The query form of this command will either return a numeric or a text response depending on the TEXT ON/OFF setting. The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set “CLEAR” will be returned.</p>	Bit	Weight	Description	Text On Response Message	Default Value	7	128	Under Voltage	UV	0	6	64	Over Voltage	OV	0	5	32	Over Temperature	OT	0	4	16	—	—	0	3	8	Over Current	OC	0	2	4	Over Power	OP	0	1	2	Saturation	SAT	0	0	1	Module Fault	MOD FLT	0
Bit	Weight	Description	Text On Response Message	Default Value																																										
7	128	Under Voltage	UV	0																																										
6	64	Over Voltage	OV	0																																										
5	32	Over Temperature	OT	0																																										
4	16	—	—	0																																										
3	8	Over Current	OC	0																																										
2	4	Over Power	OP	0																																										
1	2	Saturation	SAT	0																																										
0	1	Module Fault	MOD FLT	0																																										
Command Syntax	LAT <NR1>																																													
Example	<p>LAT 12</p> <p>This will write the value of 12 into the LAT register. This enables bit 2 (Over Power) and bit 3 (Over Current) in the CON register so that if either is set they will remain set until the CON register is read. Since the Over Voltage and Over Temperature bits remain unaffected these will remain enabled. Therefore the value in the LAT after this command will be 108.</p>																																													
Query Syntax	LAT?																																													
Returned Parameters	<p>TEXT ON: <text response string></p> <p>TEXT OFF: <NR1></p>																																													

LOAD Load On/Off Control

Description	This command is used to instruct to load to close its load connect relay and apply loading, or to open its connect relay removing the load from the device under test.
Command Syntax	LOAD ON LOAD OFF
Example	LOAD ON This will close the load connect relay and start loading the device under test at the programmed settings. LOAD OFF This will open the load connect relay and stop loading.
Query Syntax	LOAD?
Returned Parameters	TEXT ON: LOAD ON LOAD OFF TEXT OFF: 1 (meaning On) 0 (meaning Off)

LOCK Front Panel Lock

Description	This command is used to lock or unlock the load's front panel. When locked, manual operation through the load's front panel is inhibited.
Command Syntax	LOCK ON LOCK OFF
Example	LOCK ON This will lock the front panel. LOCK OFF This will unlock the front panel.
Query Syntax	LOCK?
Returned Parameters	Text On: LOCK ON LOCK OFF Text Off: 1 (meaning On) 0 (meaning Off)

MODE? Operating Mode

Description	This query returns the load's operating mode. The response is either numeric or a text description depending on the TEXT ON/OFF setting. The returned value will be the sum of the individual bit weights of the mode plus any mode modifiers. The individual bits are defined below.		
	Mode Modifiers		
	Bit	Weight	Description
	8	256	Pulsing
	7	128	External Modulation
	Operating Modes		
	Bit	Weight	Description
	6	64	Slave Mode
	5	32	Constant Amps/Volt High
	4	16	Constant Amps/Volt Low
	3	8	Constant Resistance High
	2	4	Constant Resistance Low
	1	2	Constant Power
	0	1	Constant Voltage
	Default		Constant Current
The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If none of the mode bits are set, "CONSTANT CURRENT" will be returned as the mode.			
Command Syntax	NONE		
Example	N/A		
Query Syntax	MODE?		
Returned Parameters	TEXT ON: <text response string>		
	TEXT OFF: <NR1>		

MR Memory Recall

Description	This command recalls the load's setup stored in the specified memory location. The memory location number must be a value from 1 through 9.
Command Syntax	MR <NR1>
Example	MR 3 This will recall the setup stored in memory location 3.
Query Syntax	NONE
Returned Parameters	N/A

MS Memory Save

Description	This command saves the load's setup into the specified memory location. The memory location number must be a value from 1 through 9.
Command Syntax	MS <NR1>
Example	MS 3 This will store the load's current setup in memory location 3.
Query Syntax	NONE
Returned Parameters	N/A

P? Read Power

Description	This query returns the computed load power in Watts. This value is computed from the load's current (I?) and Voltage (V?) readings.
Command Syntax	NONE
Example	N/A
Query Syntax	P?
Returned Parameters	TEXT ON: <NR2> watts TEXT OFF: <NR2>

P1 Constant Power Pulsing Base Level

Description	This command is used to set the base level when pulse loading in the Constant Power mode.
Command Syntax	P1 <NR2>
Example	P1 25.3 This will set the base Constant Power level to 25.3 Watts.
Query Syntax	P1?
Returned Parameters	TEXT ON: <NR2> watts TEXT OFF: <NR2>

P2 Constant Power Pulsing Peak Level

Description	This command is used to set the peak level relative to the base level when pulse loading in the Constant Power mode.
Command Syntax	P2 <NR2>
Example	P2 20.0 This will set the peak level to 20 Watts above the base level. Therefore if the base level setting is 25.3, the peaks will be 45.3 Watts.
Query Syntax	P2?
Returned Parameters	TEXT ON: <NR2> watts TEXT OFF: <NR2>

PL Power Limit

Description	This command is used to set the Power Limit set point. The Power Limit circuit will not allow the load power to exceed this level.
Command Syntax	PL <NR2>
Example	PL 250.0 This will set the Power Limit to 250 Watts.
Query Syntax	PL?
Returned Parameters	TEXT ON: <NR2> watts TEXT OFF: <NR2>

R1 Constant Resistance Pulsing Base Level

Description	This command is used to set the base level when pulse loading in the Constant Resistance mode. NOTE: CRH or CRL must have been previously set.
Command Syntax	R1 <NR2>
Example	R1 10.0 This will set the base resistance to 10 Ohms.
Query Syntax	R1?
Returned Parameters	TEXT ON: <NR2> ohms TEXT OFF: <NR2>

R2 Constant Resistance Pulsing Peak Level

Description	This command is used to set the peak level relative to the base level when pulse loading in the Constant Resistance mode. This resistance will be applied in parallel to the base resistance. NOTE: CRH or CRL must have been previously set.
Command Syntax	R2 <NR2>
Example	R2 1.1 This will set the peak level to 1.1 Ohms that will be applied in parallel with the base level. Therefore if the base level setting is 10 Ohms, the peaks will be 0.99 Ohm.
Query Syntax	R2?
Returned Parameters	TEXT ON: <NR2> ohms TEXT OFF: <NR2>

RNG Range

Description	This command is used to set the load's Voltage and current range settings. This is done by writing a value from 1 through 9 as indicated below.		
	Range Number	Voltage	Current
	1	High	High
	2	Medium	High
	3	Low	High
	4	High	Medium
	5	Medium	Medium
	6	Low	Medium
	7	High	Low
	8	Medium	Low
	9	Low	Low
	The Query form of this command returns actual operating range. The text response to a query will be a string specifying the Voltage and current ranges. The numeric response will be the range number.		
Command Syntax	RNG <NR1>		
Example	RNG 2 This will set the load to the medium Voltage and high current range.		
Query Syntax	RNG?		
Returned Parameters	TEXT ON: <V range> VOLT, <I range> AMP TEXT OFF: <NR1>		

RST Reset

Description	This command resets the load to its factory default power-on settings.
Command Syntax	RST
Example	RST This will reset the load to its factory default power-on settings.
Related Query	NONE
Returned Parameters	N/A

SBE Summary Bit Enable register

Description	<p>This command provides access to the Summary Bit Enable register. The bits in this register define which bits of the Condition (CON) register will set the Major Fault and Minor Fault summary bits in the Status Register (STA). Setting one bit by writing its bit weight into the SBE register enables its equivalent bit in the CON register. The individual bits are defined below. More than one bit can be enabled by writing a value that is a sum of the individual bit weights.</p> <table border="1" data-bbox="548 548 1380 1081"> <thead> <tr> <th>Bit</th> <th>Weight</th> <th>Description</th> <th>Text On Response Message</th> <th>Default Value</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>128</td> <td>Under Voltage</td> <td>UV</td> <td>1</td> </tr> <tr> <td>6</td> <td>64</td> <td>Over Voltage</td> <td>OV</td> <td>1</td> </tr> <tr> <td>5</td> <td>32</td> <td>Over Temperature</td> <td>OT</td> <td>1</td> </tr> <tr> <td>4</td> <td>16</td> <td>—</td> <td>—</td> <td>0</td> </tr> <tr> <td>3</td> <td>8</td> <td>Over Current</td> <td>OC</td> <td>1</td> </tr> <tr> <td>2</td> <td>4</td> <td>Over Power</td> <td>OP</td> <td>1</td> </tr> <tr> <td>1</td> <td>2</td> <td>Saturation</td> <td>SAT</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>Module Fault</td> <td>MOD FLT</td> <td>1</td> </tr> </tbody> </table> <p>The query form of this command will either return a numeric or a text response depending on the TEXT ON/OFF setting. The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set “CLEAR” will be returned.</p>	Bit	Weight	Description	Text On Response Message	Default Value	7	128	Under Voltage	UV	1	6	64	Over Voltage	OV	1	5	32	Over Temperature	OT	1	4	16	—	—	0	3	8	Over Current	OC	1	2	4	Over Power	OP	1	1	2	Saturation	SAT	1	0	1	Module Fault	MOD FLT	1
Bit	Weight	Description	Text On Response Message	Default Value																																										
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1	2	Saturation	SAT	1																																										
0	1	Module Fault	MOD FLT	1																																										
Command Syntax	SBE <NR1>																																													
Example	<p>SBE 12 This will write the value of 12 into the SBE register. This enables bit 2 (Over Power) and bit 3 (Over Current) in the CON register so that if either is set the relevant summary bit(s) in the STA register will be set.</p>																																													
Related Query	SBE?																																													
Returned Parameters	<p>TEXT ON: <text response string> TEXT OFF: <NR1></p>																																													

SDN Shutdown register

<p>Description</p>	<p>This command provides access to the Shutdown register. The bits in this register define which bits of the Condition (CON) register will cause the load to shutdown. Setting one bit by writing its bit weight into the SDN register enables its equivalent bit in the CON register. The individual bits are defined below. More than one bit can be enabled by writing a value that is a sum of the individual bit weights. The Over Voltage and Over Temperature bits in this register will remain set regardless of what value is written to this register.</p> <table border="1" data-bbox="548 611 1380 1062"> <thead> <tr> <th>Bit</th> <th>Weight</th> <th>Description</th> <th>Text On Response Message</th> <th>Default Value</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>128</td> <td>Under Voltage</td> <td>UV</td> <td>0</td> </tr> <tr> <td>6</td> <td>64</td> <td>Over Voltage</td> <td>OV</td> <td>1</td> </tr> <tr> <td>5</td> <td>32</td> <td>Over Temperature</td> <td>OT</td> <td>1</td> </tr> <tr> <td>4</td> <td>16</td> <td>—</td> <td>—</td> <td>0</td> </tr> <tr> <td>3</td> <td>8</td> <td>Over Current</td> <td>OC</td> <td>0</td> </tr> <tr> <td>2</td> <td>4</td> <td>Over Power</td> <td>OP</td> <td>0</td> </tr> <tr> <td>1</td> <td>2</td> <td>Saturation</td> <td>SAT</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>Module Fault</td> <td>MOD FLT</td> <td>0</td> </tr> </tbody> </table> <p>The query form of this command will either return a numeric or a text response depending on the TEXT ON/OFF setting. The text response will return a string containing the Text On Response Message as listed in the table above for each bit that is set. These will be separated by commas. If no bits are set “CLEAR” will be returned.</p>	Bit	Weight	Description	Text On Response Message	Default Value	7	128	Under Voltage	UV	0	6	64	Over Voltage	OV	1	5	32	Over Temperature	OT	1	4	16	—	—	0	3	8	Over Current	OC	0	2	4	Over Power	OP	0	1	2	Saturation	SAT	0	0	1	Module Fault	MOD FLT	0
Bit	Weight	Description	Text On Response Message	Default Value																																										
7	128	Under Voltage	UV	0																																										
6	64	Over Voltage	OV	1																																										
5	32	Over Temperature	OT	1																																										
4	16	—	—	0																																										
3	8	Over Current	OC	0																																										
2	4	Over Power	OP	0																																										
1	2	Saturation	SAT	0																																										
0	1	Module Fault	MOD FLT	0																																										
<p>Command Syntax</p>	<p>SDN <NR1></p>																																													
<p>Example</p>	<p>SDN 12 This will write the value of 12 into the SBE register. This enables bit 2 (Over Power) and bit 3 (Over Current) in the CON register so that if either becomes set the load will shutdown. Since the Over Voltage and Over Temperature bits remain unaffected these will remain enabled. Therefore the value in the SDN register after this command will be 108.</p>																																													
<p>Related Query</p>	<p>SDN?</p>																																													
<p>Returned Parameters</p>	<p>TEXT ON: <text response string> TEXT OFF: <NR1></p>																																													

SF Slew Fast

Set for fast slew range

Description	This command is used to set the slew rate limiter to the fast range. In the fast range, full-scale rise and fall times can be programmed between 10 μ s and 4000 μ s using the SR, S1 or S2 commands. NOTE: Maximum slew rate is highly dependent on factors including power source, source to load wiring, and operating mode.
Command Syntax	SF
Example	SF Sets the slew rate limiter to the fast range.
Query Syntax	NONE
Returned Parameters	NONE

SR Slew Rate

Description	This command is used to set both the rise and fall time in microseconds for a full-scale transition within the selected range.
Command Syntax	SR <NR2>
Example	SR 200 Sets the rise or fall time for a full-scale transition to 200 microseconds.
Query Syntax	SR?
Returned Parameters	TEXT ON: <NR2> us TEXT OFF: <NR2>

SRQ Service Request Register

Description	<p>This command provides access to the Service Request register. In IEEE-488 equipped units the bits in this register define which bits of the Status Register (STA) will generate a service request. A query form is provided so the setting can be read back.</p> <p>The value in this register is a number between 0 and 255 and is the sum of the individual bit weights as defined below.</p> <table border="1" data-bbox="557 541 1372 1031"> <thead> <tr> <th>Bit</th> <th>Weight</th> <th>Description</th> <th>Text On Response Message</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>128</td> <td>Reserved</td> <td>RESERVED</td> </tr> <tr> <td>6</td> <td>64</td> <td>Change In Status</td> <td>STA CHANGE</td> </tr> <tr> <td>5</td> <td>32</td> <td>Single Shot Complete</td> <td>SINGLE SHOT COMPLETE</td> </tr> <tr> <td>4</td> <td>16</td> <td>Command Error</td> <td>COMMAND ERROR</td> </tr> <tr> <td>3</td> <td>8</td> <td>Minor Fault</td> <td>MINOR FAULT</td> </tr> <tr> <td>2</td> <td>4</td> <td>Major Fault</td> <td>MAJOR FAULT</td> </tr> <tr> <td>1</td> <td>2</td> <td>System Minor Fault</td> <td>SYSTEM MINOR</td> </tr> <tr> <td>0</td> <td>1</td> <td>System Major Fault</td> <td>SYSTEM MAJOR</td> </tr> </tbody> </table> <p>The query form of this command will either return a numeric or a text response depending on the TEXT ON/OFF setting. The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set "CLEAR" will be returned.</p>	Bit	Weight	Description	Text On Response Message	7	128	Reserved	RESERVED	6	64	Change In Status	STA CHANGE	5	32	Single Shot Complete	SINGLE SHOT COMPLETE	4	16	Command Error	COMMAND ERROR	3	8	Minor Fault	MINOR FAULT	2	4	Major Fault	MAJOR FAULT	1	2	System Minor Fault	SYSTEM MINOR	0	1	System Major Fault	SYSTEM MAJOR
Bit	Weight	Description	Text On Response Message																																		
7	128	Reserved	RESERVED																																		
6	64	Change In Status	STA CHANGE																																		
5	32	Single Shot Complete	SINGLE SHOT COMPLETE																																		
4	16	Command Error	COMMAND ERROR																																		
3	8	Minor Fault	MINOR FAULT																																		
2	4	Major Fault	MAJOR FAULT																																		
1	2	System Minor Fault	SYSTEM MINOR																																		
0	1	System Major Fault	SYSTEM MAJOR																																		
Command Syntax	SRQ <NR1>																																				
Example	<p>SRQ 12</p> <p>This will write the value of 12 into the SRQ register. This enables bit 2 (Major Fault) and bit 3 (Minor Fault) in the STA register so that if either is set a service request will be generated.</p>																																				
Query Syntax	SRQ?																																				
Returned Parameters	<p>TEXT ON: <text response string></p> <p>TEXT OFF: <NR1></p>																																				

SS Slew Slow

Description	This command is used to set the slew rate limiter to the slow range. In the slow range, full-scale rise and fall times can be programmed between 1,000 μ s and 400,000 μ s using the SR, S1 or S2 commands. NOTE: Maximum slew rate is highly dependent on factors including power source, source to load wiring and operating mode.
Command Syntax	SS
Example	SS Sets the slew rate limiter to the slow range.
Query Syntax	NONE
Returned Parameters	NONE

STA? Status Register

Description	This query returns the contents of the Status register and then clears its contents. The response is either numeric or a text description depending on the TEXT ON/OFF setting.		
	The value in this register is a number between 0 and 255 and is the sum of the individual bit weights as defined below.		
	Bit	Weight	Description
	7	128	Reserved
	6	64	Change In Status
	5	32	Single Shot Complete
	4	16	Command Error
	3	8	Minor Fault
	2	4	Major Fault
	1	2	System Minor Fault
	0	1	System Major Fault
	The text response will return a string containing the Text On Response Message as listed above for each bit that is set. These will be separated by commas. If no bits are set, "CLEAR" will be returned.		
Command Syntax	NONE		
Example	N/A		
Query Syntax	STA?		
Returned Parameters	TEXT ON: <text response string>		
	TEXT OFF: <NR1>		

SW Square Wave Pulsing

Description	<p>This command is used to turn on and off Square Wave pulsing. It functions exactly the same as the WF command with all the same forms. This is done to provide compatibility with other model types.</p> <p>Supplying the optional parameter sets the number of pulses that will be generated. The load will automatically return to the base drive level when the set number of pulses has completed.</p>
Command Syntax	<p>SW [<NR1>] SW OFF</p>
Example	<p>SW This will turn on Square Wave pulsing until explicitly turned off.</p> <p>SW 50 This will turn on Square Wave pulsing for 50 pulses and then return to the base drive level.</p> <p>SW OFF This will turn off Square Wave pulsing.</p>
Query Syntax	NONE
Returned Parameters	NONE

T1 Pulsing Base Time

Description	<p>This command is used to directly set the base time in microseconds for square wave pulsing. This will also set the Duty Cycle (DU) and Frequency (FQ) accordingly based upon the Pulsing Peak Time (T2).</p>
Command Syntax	T1 <NR1>
Example	<p>T1 2000 This will set the pulse base time to 2000μs. If T2 were 3000μs, the duty cycle (DU) would be 60% and frequency would be 200Hz.</p>
Query Syntax	T1?
Returned Parameters	<p>TEXT ON: <NR1> us</p> <p>TEXT OFF: <NR1></p>

T2 Pulsing Peak Time

Description	This command is used to directly set the peak time in microseconds for square wave pulsing. This will also set the Duty Cycle (DU) and Frequency (FQ) accordingly based upon the Pulsing Base Time (T1).
Command Syntax	T2 <NR1>
Example	T2 4000 This will set the pulse base time to 4000 μ s. If T1 were 6000 μ s, the duty cycle (DU) would be 40% and frequency would be 100Hz.
Query Syntax	T2?
Returned Parameters	TEXT ON: <NR1> us TEXT OFF: <NR1>

TEXT Text Mode

Description	This command is used to turn on or off the descriptive responses that are available on many queries.
Command Syntax	TEXT ON TEXT OFF
Example	TEXT ON This will turn on the descriptive responses. TEXT OFF This will turn off the descriptive responses.
Query Syntax	TEXT?
Returned Parameters	Text On: TEXT ON Text Off: 0 (meaning Off)

UV Under Voltage

Description	This command is used to set the Programmable Under Voltage threshold. When the input voltage drops below this threshold the load will disconnect from the device under test and indicate an Under Voltage fault. Unlike the hardware Under Voltage, the load will not automatically reconnect when the Voltage rises above the threshold. Setting the Programmable Under Voltage to zero will disable it. The programmable Under Voltage operation is not affected by the UV bit in the Shutdown (SDN) register.
Command Syntax	UV <NR2>
Example	UV 9.6 This will set the Programmable Under Voltage to 9.6 Volts. The load will shutdown if the Voltage on its input terminals drops below this threshold. UV 0 This will disable the Programmable Under Voltage feature.
Query Syntax	UV?
Returned Parameters	Text On: <NR2> volts Text Off: <NR2>

V? Read Voltage

Description	This query returns the actual Voltage in Volts measured at the load's Voltage sense terminals. NOTE: If remote Voltage sensing is not used, this voltage may differ from the output voltage of the device. This is due to the Voltage drops in the conductors between the load and the device under test. Therefore remote voltage sensing is recommended when high currents are involved.
Command Syntax	NONE
Example	N/A
Query Syntax	V?
Returned Parameters	TEXT ON: <NR2> volts TEXT OFF: <NR2>

V1 Constant Voltage Pulsing Base Level

Description	This command is used to set the base level when pulse loading in the Constant Voltage mode. NOTE: When pulsing in constant voltage mode, higher voltage corresponds to less drive. Therefore, V1 is a higher value than V2.
Command Syntax	V1 <NR2>
Example	V1 75.0 This will set the base Constant Voltage level to 75.0 Volts.
Query Syntax	V1?
Returned Parameters	TEXT ON: <NR2> volts TEXT OFF: <NR2>

V2 Constant Voltage Pulsing Peak Level

Description	This command is used to set the peak level relative to the base level when pulse loading in the Constant Voltage mode. In Constant Voltage, peak refers to peak drive hence lower Voltage. Therefore the peak level this command specifies is the Voltage to be subtracted from the base level (V1).
Command Syntax	V2 <NR2>
Example	V2 24.3 This will set the peak level to 24.3 Volts below the base level. Therefore if the base level setting is 75.0, the peaks will be 50.7 Volts.
Query Syntax	V2?
Returned Parameters	TEXT ON: <NR2> volts TEXT OFF: <NR2>

VER? Version

Description	This query returns the load's firmware version as a variable length alphanumeric string.
Command Syntax	NONE
Example	N/A
Query Syntax	VER?
Returned Parameters	<version string>

VL Voltage Limit

Description	This command is used to set the Voltage Limit trip level. The load will disconnect from the device under test if the Voltage exceeds this level.
Command Syntax	VL <NR2>
Example	VL 16.5 This will set the Voltage Limit to 16.5 Volts.
Query Syntax	VL?
Returned Parameters	TEXT ON: <NR2> volts TEXT OFF: <NR2>

WF Waveform

Description	<p>This command is used to turn on and off Square Wave pulsing. It functions exactly the same as the SW command with all the same forms. This is done to provide compatibility with other model types.</p> <p>Supplying the optional parameter sets the number of pulses that will be generated. The load will automatically return to the base drive level when the set number of pulses has completed.</p>
Command Syntax	<p>WF [<NR1>] WF OFF</p>
Example	<p>WF This will turn on Square Wave pulsing until explicitly turned off.</p> <p>WF 50 This will turn on Square Wave pulsing for 50 pulses and then return to the base drive level.</p> <p>WF OFF This will turn off Square Wave pulsing.</p>
Query Syntax	NONE
Returned Parameters	NONE

XM External Modulation

<p>Description</p>	<p>This command places the load in Remote Programming mode. In this mode a 0 to 10V signal at the load's Remote Programming Input terminal on the back of the unit will program the load from zero to full scale of the selected range. This is inverted when in Constant Voltage mode so that zero programs full scale while 10V programs zero.</p> <p>When in Constant Current mode a digitally programmed offset current can be specified. This is done using the "XM PLUS <NR2>" syntax. "XM + <NR2>" is an alternate syntax that can be used as well. In any mode other than Constant Current the offset specification will be ignored.</p> <p>The query form of this command returns only the XM ON/OFF status. The digitally programmed current offset issued with a XM PLUS (or XM +) command can be read back using either a CI? or I1? query.</p>
<p>Command Syntax</p>	<p>XM ON XM OFF XM PLUS <NR2> or XM + <NR2></p>
<p>Example</p>	<p>XM ON This will place the load in Remote Programming mode.</p> <p>XM PLUS 45.0 (or XM + 45.0) When in Constant Current mode this will place the load into Remote Programming and apply a digitally programmed offset of 45 Amps. In any mode other than Constant Current it will act the same as the XM ON command.</p> <p>XM OFF This turns off Remote Programming and resumes internal digitally programmed operation.</p>
<p>Query Syntax</p>	<p>XM?</p>
<p>Returned Parameters</p>	<p>Text On: EXTERNAL MODULATION ON EXTERNAL MODULATION OFF</p> <p>Text Off: 1 (meaning On) 0 (meaning Off)</p>

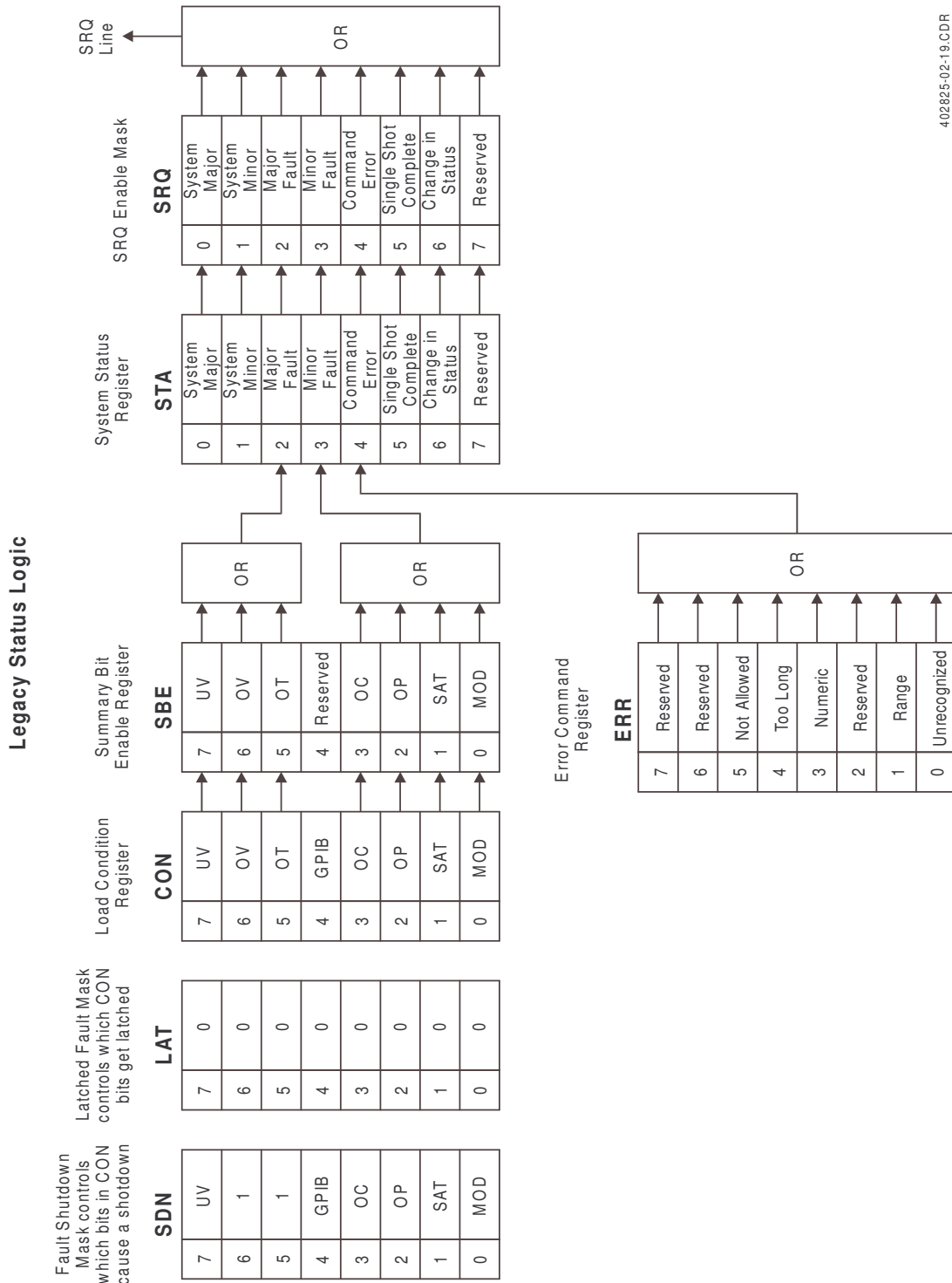
Status and Error Register

The load status drawing shows the logical relationship between the status registers. Three of the registers, the condition (CON) register, the error (ERR) register, and the status (STA) register reflect the condition of the load.

Two of the registers, the fault shutdown mask (SDN) and the fault latch mask (LAT) control which of the condition register bits cause a load shutdown (shutdown mask) and/or are latched until read (latch mask).

The summary bit enable (SBE) register controls that condition bits are passed through to the system status register (STA). The system status register is available either in response to an STA? query or in response to an IEEE-488 bus serial poll.

The service request (SRQ) enable mask controls which bits in the status register can assert the SRQ line.



402825-02-19.CDR

Figure 25. Load Status Structure

Glossary

This glossary includes explanations and definitions of terms that may be found in this manual or encountered while working with the Dynaload. Many of these words are commonly used in electrical, electronic and computer related technologies.

A

AC	<i>Alternating Current.</i>
AC Power Supply	Power supply that delivers an AC voltage.
A/D Conversion	<i>Analog-To-Digital Conversion.</i> The process of changing an analog signal into a digital value.
Alternating Current	Electric current that rises to a maximum in one direction, falls back to zero, and then rises to a maximum in the opposite direction and then repeats.
Ammeter	Instrument for measuring the current in amps, milliamps or microamps.
Ampere	Also referred to as an Amp. The unit of electrical current (represented by the symbol "A").
Amplitude	The highest value reached by voltage, current or power during a complete cycle.
Analog	System in which data is represented as a continuously varying voltage. Also spelled <i>Analogue</i> .
ANSI	<i>American National Standards Institute.</i>
ASCII	<i>American Standard Code for Information Interchange.</i> Standardized method of encoding alphanumeric characters into 7 or 8 binary bits.

Apparent Power	Power attained in an AC circuit as a product of effective voltage and current (which reach their peak at different times).
Astable	Circuit that does not have a stable state and as a result oscillates at a frequency dependent upon component values.
AWG	<i>American Wire Gauge</i> . A system that assigns a number value to the diameter of a wire.

B

Base	One terminal of a transistor that is usually the input lead. It separates the collector and emitter regions of a transistor.
Battery	DC voltage source containing two or more cells that convert chemical energy to electrical energy.
Baud	Unit of signaling speed equal to the number of signal events per second.
Binary	System based on the number 2. (The binary digits are 0 and 1.)
Binary-Coded Decimal	Code for representing decimal digits in a binary format. Also referred to as <i>BCD</i> .
Bit	<i>Binary Digit</i> . Smallest unit of binary data.
Bleeder Current	Current drawn continuously from a source and is used to stabilize the output voltage of a source.
Bus	In Electricity. A bus bar. In Computer Science. A parallel circuit that connects the major components of a computer, allowing the transfer of electric impulses from one connected component to any other.

Byte A sequence of adjacent bits operated on as a unit by a computer.

C

Capacitance Ability of a capacitor to store an electrical charge. The basic unit of capacitance is the Farad.

Capacitor Electronic component that stores an electrical charge.

Cascade Method of connecting circuits in series so that the output of one is the input of the next.

Charge Quantity of electrical energy.

Chassis Metal box or frame into which components are mounted.

Chassis Ground Connection to a chassis.

Choke Inductor designed to present a high impedance to alternating current.

Circuit Interconnection of components to provide an electrical path between two or more components

Circuit Breaker Protective device used to open a circuit when current is greater than a maximum value. A circuit breaker acts as a reusable fuse.

Circuit Diagram Structural or procedural diagram of an electrical system. Also see Schematic.

Closed Circuit Circuit having a complete path for current flow.

Coil Conductor wound in a series of turns.

Collector One of three terminals of a transistor.

Continuity The state that occurs when a complete path for current is present.

Current Passage of electrons measured in amps (milliamps and microamps).

D

D/A Conversion *Digital-To-Analog Conversion.* Translating discrete data into continuously varying signals.

DC *Direct Current.* Current that flows in one direction.

DC Power Supply Any source of DC power for electrical equipment.

Digital Electronics Branch of electronics dealing with information in binary form.

Distortion Amount by which a circuit or component fails to accurately reproduce the characteristics of the input.

Duplex Transmission Ability to both send and receive data at the same time over the same communications line.

E

Earth *Ground.* Connection to the earth itself or the negative lead to a chassis or to any point to zero voltage.

Electron Flow Direction in which electrons flow (from negative to positive since electrons are negatively charged).

EMF *Electromotive Force.* Force that causes the motion of electrons due to potential difference between two points (voltage).

Emitter One of three terminals of a transistor.

F

Farad Basic measuring unit of capacitance.

Feedback Portion of the output signal of an amplifier that is connected back to the input of the same amplifier.

Firmware Computer software usually permanently stored in a computer.

Fuse Protective device in the current path that melts or breaks when current is over a predetermined maximum value.

G

Gain Ratio of the output level of a circuit to the input.

GFCI *Ground Fault Circuit Interrupt*. Used for AC convenience outlets to provide maximum personal protection from electrical shock. A GFCI is not suitable for use with certain portable test equipment.

Ground A large conducting body, such as the earth or an electric circuit connected to the earth, used as an arbitrary zero of potential. A ground is often used as the common wiring point or reference in a circuit.

Ground Plane Earth or negative rail of a circuit and a considerable mass that presents the effect of earth (ground) to a signal.

H

Handshaking Exchange of signals (usually part of a communications protocol) between two devices to establish a connection.

Henry Basic unit of inductance.

Hertz Number of cycles per second for any periodic waveform (measured in cycles per second). One hertz is equal to one cycle per second.

I

Impedance Impedance is similar to resistance but applies to alternating current circuits and is measured in ohms (represented by the symbol “Z”).

Input The part of a circuit that accepts a signal for processing.

Insulator Material that resists the flow of current.

Interface Usually the hardware that provides communication between various items of equipment using common physical interconnection characteristics, signal characteristics, and meanings of interchanged signals.

Inverter A device used to convert direct current into alternating current.

I/O *Input/Output.*

K

Kilowatt - hour Unit of energy when one kilowatt of power is expended for one hour.
kWh

L

Leakage Passage of small electric current through an insulator or dielectric that is unintended and undesirable.

LED *Light-emitting diode*, a semi-conductor that emits light, used in displays such as meters, clocks and calculators.

Limiter Circuit or device that prevents some portion of its input from reaching the output.

Line Regulation Ability of a voltage regulator to maintain a constant voltage when the regulator input voltage varies.

Load Component or piece of equipment connected to a source and draws current from a source is a load on that source.

Load Current Current drawn from a source by a load.

Load Impedance Sum of reactance and resistance in a load.

Load Regulation Ability of a voltage regulator to maintain a constant output voltage under varying load currents.

Load Resistance The resistance of a load.

Logic The principle and applications of gates, relays and switches.

M

Matched Impedance	Condition that exists when the output impedance of a source is equal to the input impedance of a load.
Megohm	One million ohms (represented by the symbol “M”).
Mnemonic	Relating to, assisting, or intended to assist the memory. A device, such as a formula used as an aid in remembering.
MOSFET	<i>Metal Oxide Field Effect Transistor</i> . Field effect transistor with a metal oxide insulating layer between the gate electrode and the channel. Also referred to as an <i>insulated gate field effect transistor</i> .
Multimeter	Electronic test equipment that can perform multiple tasks (such as measuring AC and DC voltage, current and resistance. A digital multimeter is often referred to as a DVM.
Multiplexer	Device that sends messages or signals simultaneously using a multiplex system.
Mutual Inductance	The ability of one inductor’s lines of force to link with another inductor.
MUX	<i>Multiplexer</i> .

N

Noise	Unwanted electromagnetic radiation within an electrical system.
Normally Closed	When the contacts of a switch or relay are closed or connected when at rest. When activated, the contacts open or separate.

Normally Open When the contacts of a switch or relay are normally open or not connected. When activated the contacts close or are connected.

NPN Transistor using n-type p-type n-type semiconductor material.

O

Ohm Unit of resistance (represented by the Greek capital letter omega “ Ω ” and the symbol “R”).

Ohm’s Law $I=V/R$ where I is the current flowing, V is the voltage and R is the resistance.

Open Circuit Circuit having an incomplete path for current flow.

Oscilloscope Electronic instrument that produces an instantaneous trace on the screen of a cathode ray tube corresponding to oscillations of voltage and current.

Output Part of a circuit where the processed signal is available.

Output Impedance Impedance measured at the output terminals of a device, without a load connected.

Output Power Amount of power that a component, circuit or system can deliver to a load.

Overload Condition that occurs when the load is greater than a system can handle.

Overload Protection Protective device such as a circuit breaker that automatically disconnects a load when current exceeds a predetermined value.

P

Parallel Circuit	Circuit having two or more paths for current flow.
Passive Component	Component that does not amplify a signal (such as resistors and capacitors).
PCB	<i>Printed Circuit Board.</i> See also PWB.
Phase	The angular relationship between two waves.
Polarity	Terminology used to describe positive and negative charges.
Polarized	Component that must be connected in correct polarity to function and/or prevent destruction.
Power	The amount of energy converted by a circuit or component in a specific unit of time, normally seconds. Measured in watts.
Power Factor	The ratio of actual power to apparent power.
Power Loss	The ratio of power absorbed to power delivered.
Power Supply	Electrical equipment used to deliver either voltage (either AC or DC).
PNP	Transistor using p-type, n-type, n-type semiconductor material.
PWB	<i>Printed Wiring Board.</i> See also PCB.

R

Real Time	Data that is immediately acted upon rather than being accumulated and processed at a later time.
Rectifier	AC-to-DC converter with output typically connected in parallel with battery backup.
Regulated Power Supply	A power supply that maintains a constant output voltage under changing load conditions.
Relay	An electromechanical device that opens or closes contacts when current is passed through a coil.
Resistance	Opposition of a body or substance to current passing through it (resulting in a change of electrical energy into heat or another form of energy).
Resistor	Passive component with a known resistance.
Rheostat	Variable resistor used to control current.

S

Schematic	Structural or procedural diagram of an electrical or electronic circuit with the components represented by symbols. Also see Circuit Diagram.
Semiconductor	Any of various solid crystalline substances, such as silicon, having electrical conductivity greater than insulators but less than good conductors. Semiconductors' properties can be altered by a control voltage.
Series Circuit	Circuit in which the components are connected end to end so that current has only one path to follow.
Series Parallel Circuit	Circuit that contains components connected in both series and parallel.

Short-Circuit	Unintended path that conducts electricity that typically causes excessive current.
Signal	Impulse or a fluctuating electric quantity, such as voltage, current, or electric field strength, whose variations represent coded information.
Signal Generator	Circuit that produces a variable and controllable signal.
Simplex Transmission	Data transmission in only one direction at a time.
Sink	Load or other device that consumes power or conducts away heat from a circuit.
Source	A device that provides signal power or energy to a load.
Spike	A brief and sudden change (usually an increase) in the voltage on a power line. A surge is similar to a spike, but is of longer duration.
Step-Down Transformer	A transformer in which the output AC voltage is less than the input AC voltage.
Step-Up Transformer	A transformer in which the output AC voltage is greater than the input AC voltage.
Supply Voltage	The voltage that is provided by a power source.
Surge	A sudden change (usually an increase) in the voltage on a power line. A surge is similar to a spike, but is of longer duration.
Surge Current	The high charging current that flows into a power supply filter capacitor when power is first turned on.

Switch Device for connecting and disconnecting power to a circuit.

T

Telemetry Usually refers to transmission of alarm, status, and other information by an embedded data channel multiplexed into a digital bit stream.

Terminal A point at which electrical connections are made.

Test A methodical sequence of operations or steps intended to verify the correct operation or malfunctioning of a piece of a system or piece of equipment.

Thermistor Resistor that varies according to temperature.

Three Phase Supply AC power supply that has three AC voltages, 120° out of phase with each other.

Threshold Minimum point at which an effect is produced or detected.

Transducer Device that receives energy in one form and supplies an output in another form.

Transformer An inductor with two or more windings.

Transformer Coupling The coupling of two circuits using mutual inductance provided by a transformer.

Transistor Three-leaded device (Collector, Base, Emitter) used for amplifying or switching.

Trigger A pulse used to start a circuit action.

Trimmer Small value variable resistor, capacitor, or inductor used to finely adjust a larger value.

Troubleshooting A methodical or systematic series of steps for locating the cause of a fault or problem in an electronic circuit or system.

Tuned Circuit Circuit in resonance at a particular frequency.

U

Uncontrolled Environment In thermal and humidity terms this mean to be without heating or air-conditioning and therefore subject to the normal range of outdoor conditions. Electronics must generally be “hardened” for use in such an environment. In safety terms (for example, UL), a building or space in a building that is accessible by untrained personnel.

UPS *Uninterruptible Power Supply.*

V

VA *Volt Ampere.*

VFC *Voltage-To-Frequency Converter.* Device that converts an analog input voltage into a sequence of digital pulses.

Volt Unit of voltage.

Volt-ampere A unit of electric power equal to the product of one volt and one ampere, equivalent to one watt.

Voltage Electromotive force or potential difference, usually expressed in volts.

Voltage Drop Due to current flow, the voltage or difference in potential developed across a component.

Voltage Feedback Voltage feedback where a portion of the output voltage is fed back to the input of an amplifier.

Voltage Rating	The maximum voltage a component can withstand without breaking down.
Voltage Regulator	A circuit or device that maintains a constant output voltage even when there is changing line voltage and/or load current.
Voltage Source	Circuit or device that supplies voltage to a load.

W

Watt	Unit of power. One watt is the product of one volt and one amp (represented by the symbol "W").
Wattage	An amount of power, especially electric power, expressed in watts or kilowatts. Also, the electric power required by an appliance or a device.
Wattage Rating	The maximum amount of power a device can continuously safely handle.

X -Z

X-ON/X-OFF	<i>Transmitter On/Transmitter Off</i> . Used for flow control, instructing a terminal to start transmission and end transmission.
Zener Diode	Silicon semiconductor device used as a voltage regulator because of its ability to maintain an almost constant voltage with a wide range of currents.

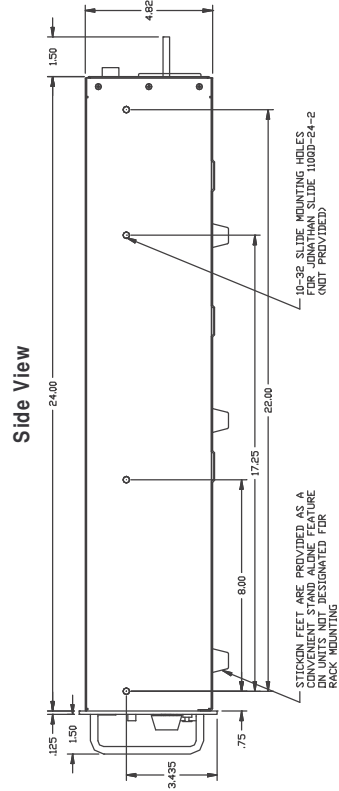
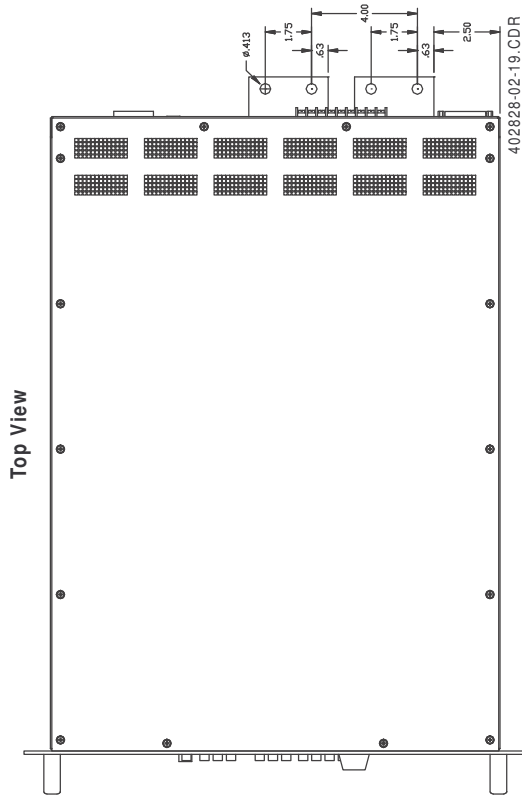
Appendix A — List of Commands

AV1 <NR2>	LOCK OFF	SW [<NR1>]
AV2 <NR2>	LOCK ON	SW OFF
AVH <NR2>	MR <NR1>	T1 <NR2>
AVL <NR2>	MS <NR1>	T2 <NR2>
CI <NR2>	P1 <NR2>	TEXT OFF
CP <NR2>	P2 <NR2>	TEXT ON
CRH <NR2>	PL <NR2>	UV <NR2>
CRL <NR2>	R1 <NR2>	V1 <NR2>
CV <NR2>	R2 <NR2>	V2 <NR2>
DU <NR2>	RNG <NR1>	VL <NR2>
FQ <NR2>	RST	WF [<NR1>]
I1 <NR2>	SBE <NR1>	WF OFF
I2 <NR2>	SDN <NR1>	XM OFF
IL <NR2>	SF	XM
LAT <NR2>	SR <NR2>	XM PLUS <NR2>
LOAD OFF	SRQ <NR1>	XM + <NR2>
LOAD ON	SS	

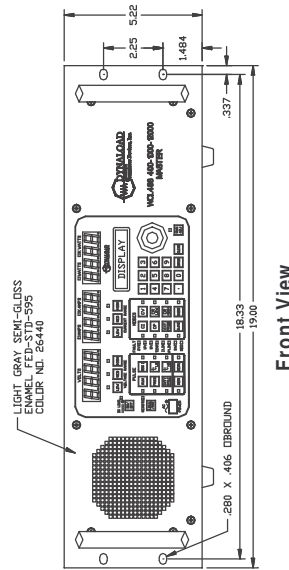
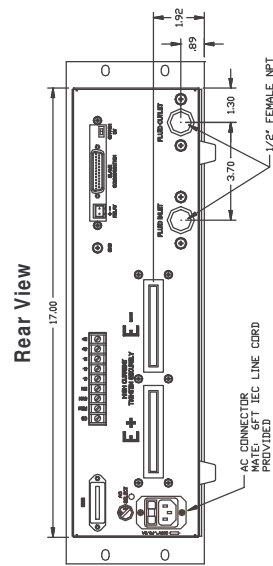
Appendix B — List of Queries

AV1?	ID?	SDN?
AV2?	IL?	SR?
AV?	LAT?	SRQ?
CI?	LOAD?	STA?
CON?	LOCK?	T1?
CP?	MODE?	T2?
CR?	P1?	UV?
CV?	P2?	V1?
DU?	P?	V2?
ERR?	PL?	V?
FQ?	R1?	VER?
I1?	R2?	VL?
I2?	RNG?	XM?
I?	SBE?	

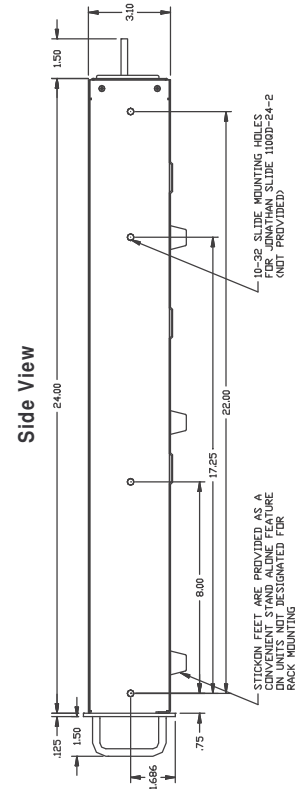
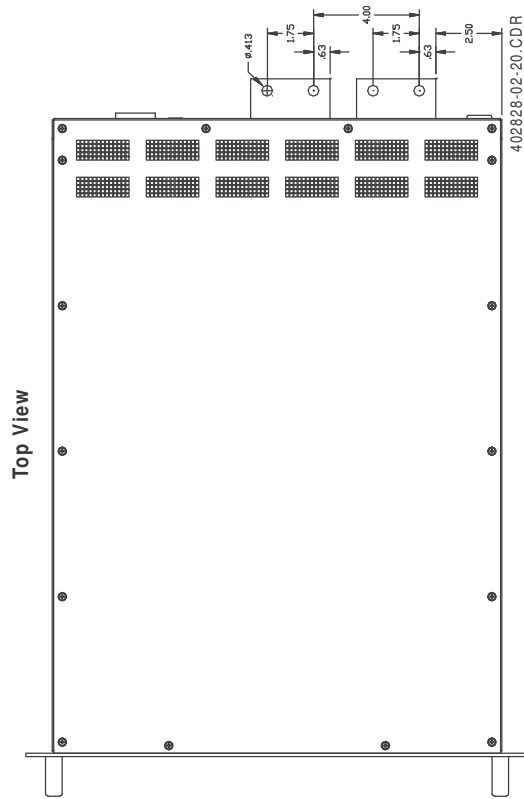
Appendix C — WCL488 Outline Drawings



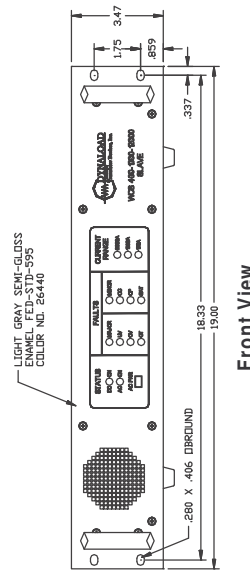
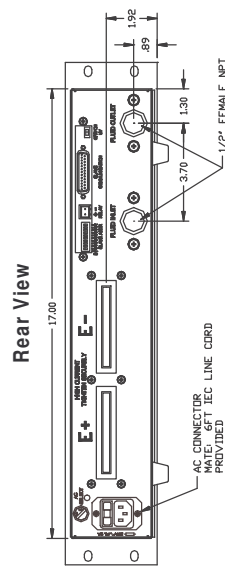
Weight = 68 pounds (without external accessories)



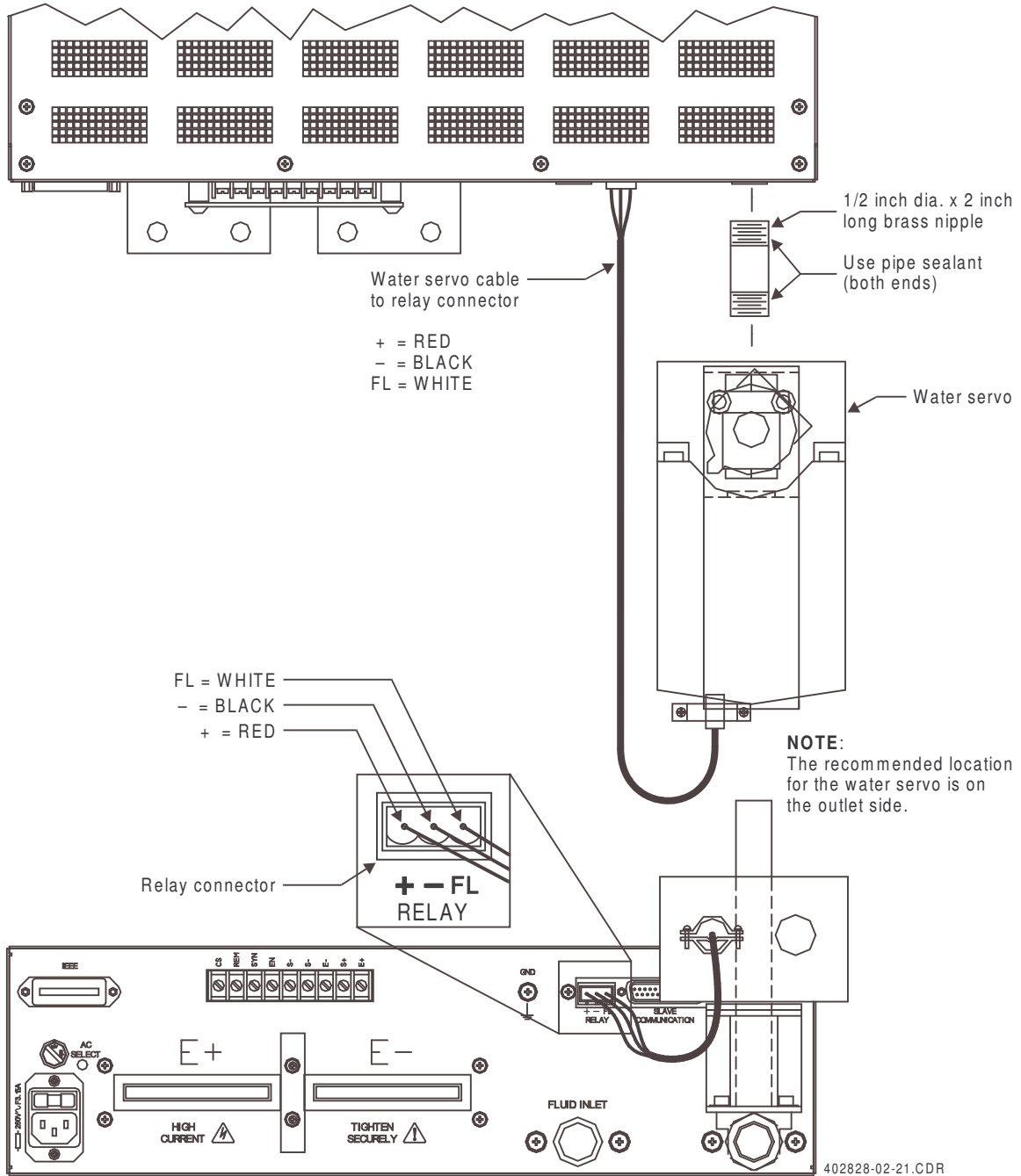
Appendix D — WCS Outline Drawings



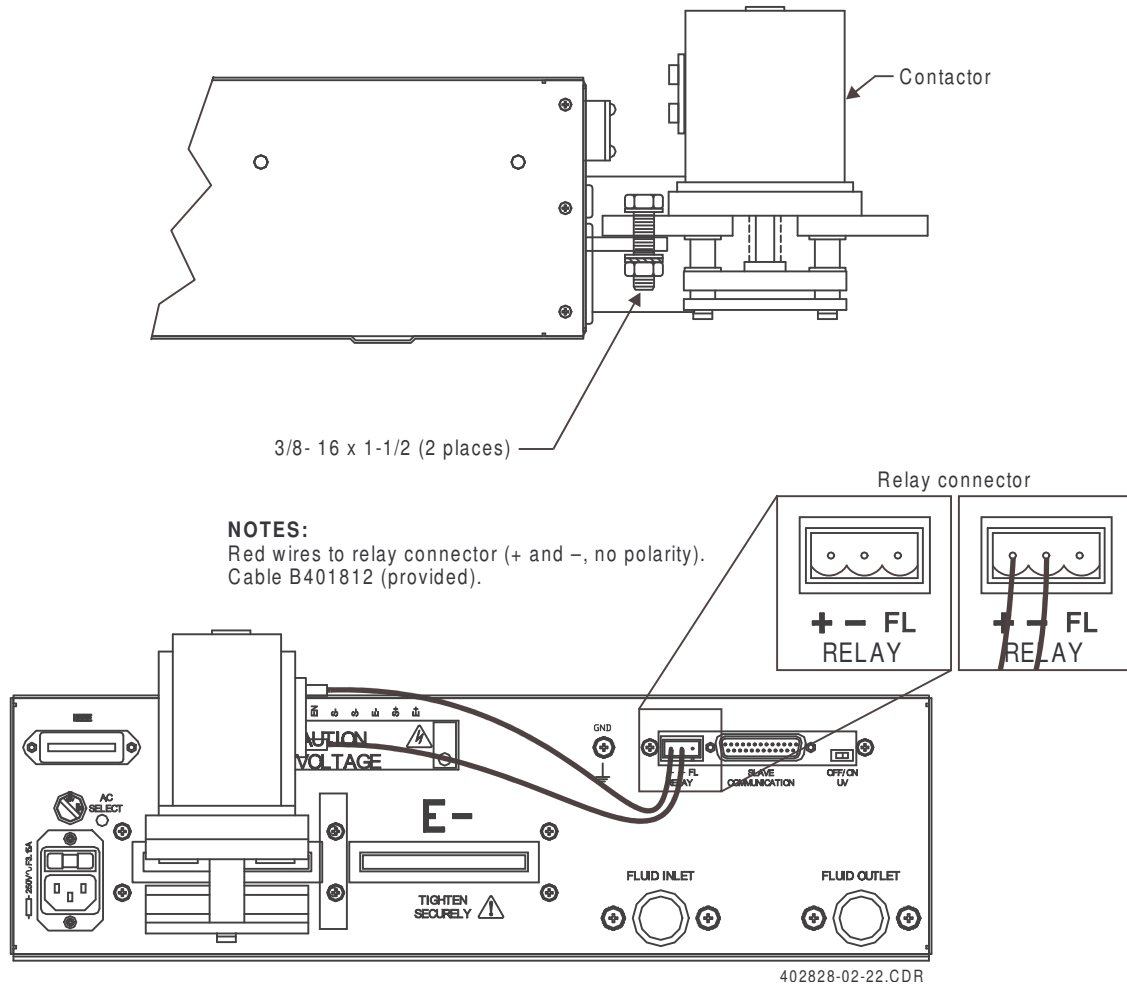
Weight = 64 pounds (without external accessories)



Appendix E — Flow Control Servo Installation



Appendix F — DC Power Contactor Recommended Installation



Appendix G — Troubleshooting Guide

The information immediately below includes a brief description of fault conditions and indicators. The balance of this appendix addresses symptoms, possible causes, and explanations and corrective actions.

Troubleshooting Fault Conditions and Indicators

“SYS” (System) Fault LED	<ul style="list-style-type: none"> ■ Lights red for a major fault. A major fault means the load will not draw current and will not connect to the source under test. Major faults include “OV”, “UV”, “OT” and AC fail. ■ Lights yellow for a minor fault. A minor fault will allow the unit to continue operating but may not be at the programmed setpoint due to a limit protection circuit. Minor faults include “I LIM”, “P LIM”, “SAT”, and “MOD” fault.
“OV” (Overvoltage) Fault LED	<ul style="list-style-type: none"> ■ Lights red when the loads input voltage exceeds the voltage limit setpoint menu item number 2. The DC load relay will not close until the input voltage is less than the setpoint.
“UV” (Undervoltage) Fault LED	<ul style="list-style-type: none"> ■ Lights red when the input voltage is between zero and 0.6 volts and the “UV” switch on the rear panel is on. The DC load relay will not close in a “UV” condition.
“TEMP” (Temperature) Fault LED	<ul style="list-style-type: none"> ■ Lights red when one or more internal power modules overheat. This will disconnect the load and reset once allowed to cool.
“I LIM” (Current Limit) Fault LED	<ul style="list-style-type: none"> ■ Lights yellow when the loads current reaches the current limit setpoint menu item number 1. This is a “minor” fault.
“P LIM” (Power Limit) Fault LED	<ul style="list-style-type: none"> ■ Lights yellow when the loads power reaches the power limit setpoint menu item number 3. This is a “minor” fault.
“SAT” (Saturation) LED	<ul style="list-style-type: none"> ■ Lights yellow when there is insufficient source voltage to support the programmed current.* ■ May also indicate one or more component failures in the loads power section. This is a “minor” fault.
“MOD” (Module) Fault LED	<ul style="list-style-type: none"> ■ This LED is inactive in the WCL488 and should never light.

* Compliance Voltage: The minimum input voltage at which the load can sink its maximum rated current. Loads can operate below the minimum compliance voltage but will not be able to achieve full rated current.

Troubleshooting (Symptoms/Possible Causes/Explanations and Corrective Actions)

Symptom	Possible Cause	Explanation/Corrective Action
AC power button does not function.	AC input fuse on the rear panel has blown.	Check fuse and replace as necessary.
	AC power cord is loose or not connected.	Secure AC power cord.
	AC select on the rear panel is not set properly.	<p><i>2-Position Switch Models</i> <i>Positions:</i> Low switch position 110 volts AC High switch position 220 volts AC</p> <p><i>4-Position Switch Models</i> <i>Positions:</i> Lowest switch position 100 volts AC Next switch position 120 volts AC Next switch position 200 volts AC Highest switch position 240 volts AC</p> <p>Select the AC voltage you are using.</p>
Load powers up but the red SYS fault LED lights and the DC LOAD LED will not come on.	AC line voltage may be too low.	<p>The load detects low incoming AC voltage (88% or less) and turns the load off for self-protection.</p> <p>Measure the AC input and correct or change the AC switch position as above.</p>
Load powers up and the “SAT” LED lights before a “Load On” is initiated.	There are one or more defective components in the load.	<p>The “SAT” LED should never come on during a load off condition.</p> <p>Send the unit in for service.</p>
Load will not “Load On” with a green LED indicator.	EN to S– jumper may be missing.	Install missing jumper.
	Bad EPO switch.	Verify EPO switch function.

Symptom	Possible Cause	Explanation/Corrective Action
Load powers up but the “SYS” and “UV” LEDs light red. The “DC Load” LED will not come on.	The under voltage switch on the rear panel is on and the voltage applied the loads input is less than 0.6 volts DC.	With the “UV” switch in the on position, the load will “Load Off” whenever the input voltage falls below 0.6 volts DC. Switch the “UV” switch to the off position.
	The voltage applied to the input of the load may be reversed and greater than 0.6 volts DC.	Correct the polarity of the load’s input DC connection.
Unit “Loads Off” by itself. The “OV” and “SYS” LEDs light red.	The voltage applied to the loads input has exceeded the voltage limit setpoint, menu item number 2.	<p>The load detects DC input voltage above its over voltage setpoint and “Loads Off” for self-protection. Measure the DC input voltage and reduce as necessary.</p> <p>Check the loads voltage limit setpoint by pressing the menu button until item 2 “Voltage Limit” appears. This voltage limit can set for zero to 105% of the voltage range selected.</p>
Unit “Loads Off” by itself with no fault lights.	The voltage applied to the loads input has exceeded the maximum voltage of the load for its present range and then reduced to within range, as with a voltage spike.	The loads voltage detection circuit is very fast and will “Load Off” when a voltage spike above it’s over voltage setpoint appears. The fault lights do not latch they are self-resetting. Measure for voltage spikes at the loads input and correct as necessary. Once the input voltage is within range, manually press the load on button to resume operation.

Symptom	Possible Cause	Explanation/Corrective Action
Load powers up, "Loads On" but will not draw current.	The "EXT PROG" button or a range button has been pressed after setting the current (CI 5 for example).	Pressing the "EXT PROG" or a range button will reset the current to zero. Repeat your required current entry.
	In the constant resistance mode, the voltage sense leads may be improperly wired.	If the voltage sense read zero applied voltage, the load will calculate infinite resistance (zero current). Units are shipped with internal voltage sense lead jumpers installed on the rear terminal strip. These can be removed and remote sense leads can be installed. Refer to the voltage sense-related sections of Chapter 1.
Unit powers up, "Loads On" "SYS" and "SAT" LEDs are yellow and will not draw current.	There is little or no DC voltage applied to the loads input.	The "SAT" LED indicates the loads inability to draw the proper set point current, due to lack of input voltage. Measure the input voltage; it must exceed the compliance voltage specification for your model.
With the unit in a "Load On" condition, the "SYS" and "SAT" LEDs are light yellow. The load is set for "CI 0" and has no input DC voltage connected to it.	The "SYS" fault LED will light whenever the "SAT" LED lights. Both these LED's under these conditions can be on or off. This is normal.	At "CI 0" the load may normally leak a small amount of current (30 milliamps for example). When the loads input voltage is zero, it can't even provide the 30ma leakage current and the "SAT" LED lights. Connect an input voltage to the load and these LEDs will turn off.

Symptom	Possible Cause	Explanation/Corrective Action
Load is set to draw a current. The current is correct but the “SYS” and “SAT” LEDs light yellow.	DC voltage applied to the load is too low.	Raise the input voltage.
	If the voltage is above the compliance voltage specification, one or more components in the power section may be defective.	Send the unit in for service.
Load draws current when it is not programmed for current.	Loads rear terminal strip has a programming (0 to 10 VDC) signal applied to “REM” (positive) and S– (return) and the “EXT PROG” button has been pressed.	The load is in the external programming mode. Press the “EXT PROG” button to clear the unit to the constant current mode.
	Peak button has been set for a current other than zero and the pulse “RUN” button has been pushed.	The load is in the pulse mode. Press the “RUN” button to clear the unit to the constant current mode.
	In the constant power mode, the voltage sense leads may be improperly wired.	If the voltage sense leads read zero applied voltage, the load will try to draw infinite current to achieve the proper power. Units are shipped with internal voltage sense lead jumpers installed on the rear terminal strip. These can be removed and remote sense leads can be installed. Refer to the voltage sense-related sections of Chapter 2.
	Loads power section may have one or more defective components.	Send the unit in for service.
Loads voltmeter reading does not match the voltage sense leads measured on the rear terminal strip.	The voltage sense leads may be improperly wired.	Units are shipped with internal voltage sense lead jumpers installed on the rear terminal strip. These can be removed and remote sense leads can be installed. Refer to the voltage sense-related sections of Chapter 2.

Symptom	Possible Cause	Explanation/Corrective Action
During normal operation the loads red “SYS” and “TEMP” light.	One or more power modules in the power tray are overheating.	Send the unit in for service.
	No cooling fans in WCL.	Check the water flow and the chiller water temperature as per manual. Check that the Water Flow Regulator Valve is wired correctly and opening. Check any water flow shutoff relays in your system.
Load is set in the constant current mode, constant power mode or the constant resistance mode, and the expected current differs from the actual current. An audible sound may also be heard.	System (includes the load, power source, metering, etc.) may be oscillating. Prolonged use of the load while the system is oscillating may cause damage to the load.	To check for oscillation, connect an oscilloscope to the “CS” (current sample) with respect to the S– on the rear terminal strip. Oscillation is usually caused by the inductance of the cabling between the DC source and the load. This cabling should be as short as possible and the positive and negative wires should be twisted, to reduce the cable inductance. Also connecting a capacitor across the loads inputs can squelch the oscillation.
Load does not communicate over the IEEE bus.	IEEE address of the load is not matched with the computer program being used to communicate.	Change the IEEE address using menu item 9 to match the computer program being used.
	IEEE interconnect cable maybe loose or defective	Tighten or replace the cable.
Load communicates commands over the IEEE bus but not queries.	The terminator in the load may not be matched to the terminator of the computer program being used.	Change the terminator in the load, “CR” (carriage return) or “CR-LF” (carriage return, line feed) using the menu item 13 to match the computer program being used.
Load does not communicate over the RS 232 bus.	Computer program used to run the RS 232 is not properly set up.	The computer program should be set to 9600 Baud N8+1 (8 Bit, 1 Stop Bit, no parity).
	RS 232 interconnect cable may be loose or defective.	Tighten or replace the cable.

Symptom	Possible Cause	Explanation/Corrective Action
System does not recognize total number of slave units in system.	All slave units not powered up (AC).	Apply AC power to all slave units.
	Slave bit identifier switch not properly set.	Check all switch positions (watch for more than one unit set at the same number).
	Bad master/slave cable.	Inspect cable for cuts and shorts. Replace if necessary.
Gross errors in current level.	Slave bit identifier switch not properly set.	Check all switch positions (watch for more than one unit set at the same number).
	Bad master/slave cable.	Inspect cable for cuts and shorts. Replace if necessary.
	Bad slave unit.	Replace faulty slave unit.

Appendix H — Specifications by Model



Features

- Highest Density Solution:
Complete 120kW System Only 60" Tall
- Constant Current, Resistance, Voltage, Power
- Master Unit - 5.25"H x 19"W x 24"D
Slave Unit - 3.5"H x 19"W x 24"D
- Modular Design Using Standard Building Blocks
- Low Water Flow (3gpm @ 10°C / 12kW)
- Range Switching for Increased Resolution and Accuracy

Series Specifications

OPERATION

Constant Current: 0 to selected full scale current
 * Prog. Accuracy: ±0.5% of selected full scale
 Regulation: ±0.5% of selected full scale
 Resolution: 1/4000 of selected full scale
Constant Resistance: Constant Resistance mode operates in Amps/Volt, IEEE units entered in ohms or A/V
 * Prog. Accuracy: ±3% of selected full scale
 Regulation: ±1% of selected full scale
 Resolution: 1/4000 of selected full scale
Constant Voltage: 0 to selected selected full scale
 * Prog. Accuracy: ±0.5% of selected full scale
 Regulation: ±0.2% of selected full scale
 Resolution: 1/4000 of selected full scale
Constant Power: 0 to full scale power
 * Prog. Accuracy: ±3% of full scale
 Regulation: ±3% of full scale
 Resolution(IEEE): 0.25% of full scale power

ANALOG MODE

Ext. Prog: 0 to 10 Volts input yields 0 to selected full scale loading in all operating modes.
 Input Impedance: 330k Ohms
 Prog. Response: Limited by internal adjustable slew rate limiter

PULSE MODE

**Frequency: 0.06Hz to 20kHz
 Accuracy: 0.1%
 Duty Cycle: 0 - 100%(IEEE),10 - 90%(Analog)
 Accuracy: 0.1%
Adjustable Slew Rate
 **Max: 0 to full scale in 50µs
 Min: 0 to full scale in 10ms

OUTPUT SIGNALS

Current Sample Output
 Scaling: 10 Volts = selected full scale
 Accuracy: ±0.5% of selected full scale
Sync Output
 Timing: Synchronous with pulse generator.
 Output: Sink with 10k pull up to +15V

PROGRAMMABLE PROTECTION

Current Limit
 Range: 0 - 105% of selected full scale
 Resolution: 0.5% of selected full scale
Voltage Limit
 Range: 0 - 105% of selected full scale
 Resolution: 0.5% of selected full scale

Power Limit

Range: 0 - 105% of full scale
 Resolution: 50 Watts
Thermal: Load disconnect at internal temperature of 70°C
Undervoltage: Load inhibited at less than 1 Volt, when enabled

IEEE-488 READBACKS

Current
 Resolution: 1/4000 of Selected Full Scale
 Accuracy(Range): ±0.5% ±1 Digit
Voltage
 Resolution: 1/4000 of Selected Full Scale
 Accuracy(Range): ±0.5% ±1Digit
Power
 Resolution: 3 Watts
 Accuracy: 0.50%

MISCELLANEOUS

AC Input: User Selectable 100VAC, 120VAC, 200VAC, 240VAC, ±10%, 48 - 62 Hz @ 350W
Ambient Temp: 0°C to 40°C

* Where applicable, stated accuracies are with respect to an externally programmed reference. Meters may be used together with calibration data for increased accuracy.
 ** Practical upper limits of pulse frequency and maximum slew rate are highly dependent on operating mode, source characteristics, and source to Dynaload wiring.

WCL488 50-1200-12000

OPERATING RANGES (FULL SCALES)

Voltage: 10 Volts, 20 Volts, 50 Volts
Current: 120 Amps, 600 Amps, 1200 Amps
Power: 12000 Watts
Short Circuit: 0.0002 Ohms max.

CONSTANT RESISTANCE RANGES

High Ohms Mode

Range	120A	600A	1200A
10V	0 - 6.0 A/V	0 - 30 A/V	0 - 60 A/V
20V	0 - 3 A/V	0 - 15 A/V	0 - 30 A/V
50V	0 - 1.2 A/V	0 - 6.0 A/V	0 - 12 A/V

Low Ohms Mode

Range	120A	600A	1200A
10V	0 - 60 A/V	0 - 300 A/V	0 - 600 A/V
20V	0 - 30 A/V	0 - 150 A/V	0 - 300 A/V
50V	0 - 12 A/V	0 - 60 A/V	0 - 120 A/V

METER RESOLUTION

	120A	600A	1200A
Ammeter:	10mA	100mA	100mA
	10V	20V	50V
Voltmeter:	10mV	100mV	100mV
Powermeter:	1 Watt up to 9,999 Watts		
(Autoranging)	10 Watts above 10,000 Watts		

MECHANICAL - MASTER UNIT

Size: 19"W x 5.25"H x 24"D
 483mm W x 133mm H x 610mm D
 Rack Mountable

MECHANICAL - SLAVE UNIT

Size: 19"W x 3.50"H x 24"D
 483mm W x 89mm H x 610mm D
 Rack Mountable

Weight: 55 lbs. / 24.95kg

INPUT CHARACTERISTICS: See below

WCL488 100-1000-12000

OPERATING RANGES (FULL SCALES)

Voltage: 10 Volts, 50 Volts, 100 Volts
Current: 100 Amps, 500 Amps, 1000 Amps
Power: 12000 Watts
Short Circuit: 0.001 Ohms max.

CONSTANT RESISTANCE RANGES

High Ohms Mode

Range	100A	500A	1000A
10V	0 - 5 A/V	0 - 25 A/V	0 - 50 A/V
50V	0 - 1 A/V	0 - 5 A/V	0 - 10 A/V
100V	0 - .5 A/V	0 - 2.5 A/V	0 - 5 A/V

Low Ohms Mode

Range	100A	500A	1000A
10V	0 - 50 A/V	0 - 250 A/V	0 - 500 A/V
50V	0 - 10 A/V	0 - 50 A/V	0 - 100 A/V
100V	0 - 5 A/V	0 - 25 A/V	0 - 50 A/V

METER RESOLUTION

	100A	500A	1000A
Ammeter:	10mA	100mA	100mA
	10V	50V	100V
Voltmeter:	10mV	100mV	100mV
Powermeter:	1 Watt up to 9,999 Watts		
(Autoranging)	10 Watts above 10,000 Watts		

MECHANICAL - MASTER UNIT

Size: 19"W x 5.25"H x 24"D
 483mm W x 133mm H x 610mm D
 Rack Mountable

MECHANICAL - SLAVE UNIT

Size: 19"W x 3.50"H x 24"D
 483mm W x 89mm H x 610mm D
 Rack Mountable

Weight: 55 lbs. / 24.95kg

INPUT CHARACTERISTICS: See below

WCL488 400-1000-12000

OPERATING RANGES (FULL SCALES)

Voltage: 20 Volts, 200 Volts, 400 Volts
Current: 100 Amps, 500 Amps, 1000 Amps
Power: 12000 Watts
Short Circuit: 0.003 Ohms max.

CONSTANT RESISTANCE RANGES

High Ohms Mode

Range	100A	500A	1000A
20V	0 - 2.5 A/V	0 - 12.5 A/V	0 - 25 A/V
200V	0 - .25 A/V	0 - 1.25 A/V	0 - 2.5 A/V
400V	0 - .125 A/V	0 - .625 A/V	0 - 1.25 A/V

Low Ohms Mode

Range	100A	500A	1000A
20V	0 - 25 A/V	0 - 125 A/V	0 - 250 A/V
200V	0 - 2.5 A/V	0 - 12.5 A/V	0 - 25 A/V
400V	0 - 1.25 A/V	0 - 6.25 A/V	0 - 12.5 A/V

METER RESOLUTION

	100A	500A	1000A
Ammeter:	10mA	100mA	100mA
	20V	200V	400V
Voltmeter:	10mV	100mV	100mV
Powermeter:	1 Watt up to 9,999 Watts		
(Autoranging)	10 Watts above 10,000 Watts		

MECHANICAL - MASTER UNIT

Size: 19"W x 5.25"H x 24"D
 483mm W x 133mm H x 610mm D
 Rack Mountable

MECHANICAL - SLAVE UNIT

Size: 19"W x 3.50"H x 24"D
 483mm W x 89mm H x 610mm D
 Rack Mountable

Weight: 55 lbs. / 24.95kg

INPUT CHARACTERISTICS: See below

Low Level Characteristics

