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MCL488 Series Electronic Loads

Operation & Programming Manual

TDI-Dynaload® Division

Document Number 403606 — Revision A

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TDI-Dynaload Division
36A Newburgh Road
Hackettstown, NJ 07840
Telephone: (908) 850-5088
Facsimile: (908) 850-0679

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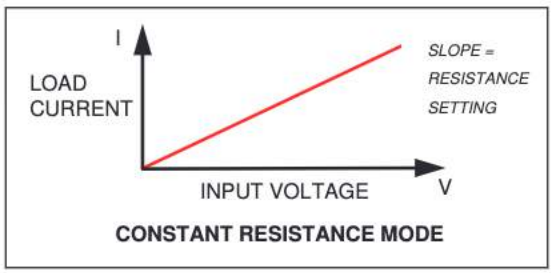
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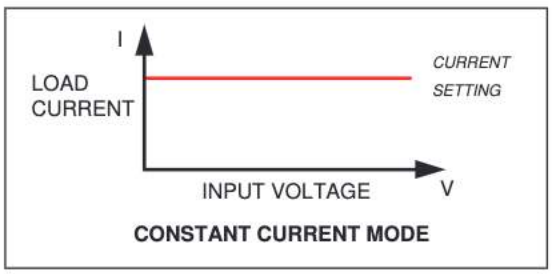
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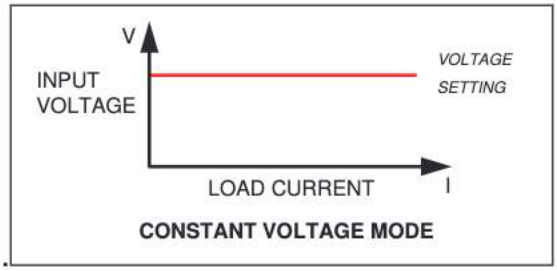
INTRODUCTION

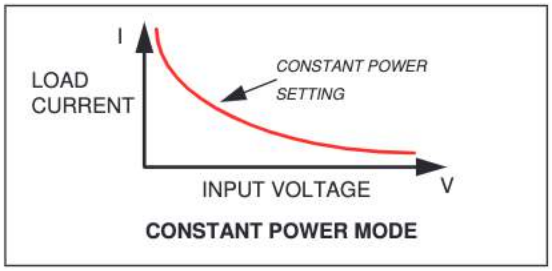
The Dynaload is a precision instrument which simulates DC loads to test power supplies, generators, servo systems, batteries and similar DC sources.

The MCL488 series provides up to ten load channels housed in a single chassis. Each load channel is fully independent, operating in one of four modes: Constant Current, Constant Resistance, Constant Voltage and Constant Power. Complete control of any channel is available through the full feature front panel, IEEE-488 bus or optional RS232 interface. A 0-10V analog programming input is also available for each channel in all of the four modes of operation. The connections for IEEE-488 and analog programming are located at the rear of the unit. The four modes of operation are outlined below:









CONSTANT CURRENT

The Dynaload will sink the set current regardless of the input voltage.

CONSTANT RESISTANCE

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

CONSTANT VOLTAGE

The Dynaload will sink the current required to maintain the voltage of the source connected to it.

CONSTANT POWER

The Dynaload will sink the current required at its present input voltage to maintain the desired power level.

PROTECTION CIRCUITS

CURRENT LIMIT:

Each load channel is protected from drawing excessive current beyond its rating. The factory set point is 65 Amps. This is not a user settable function and serves to protect the load module only. This limit acts as an absolute barrier and will not permit the current to increase beyond the setpoint. An alarm warning is illuminated on the front panel if the limit is achieved.

POWER LIMIT:

Each load channel is protected against operation at power levels beyond its rating. The power level is factory set at 365 Watts. This is not a user settable function and serves to protect the load module only. This limit acts as an absolute barrier and will not permit the product of volts and amps to exceed the setpoint. In the event that power limit is achieved but the input voltage continues to increase, the load will respond by decreasing the current in order to limit the total power being dissipated. An alarm warning is illuminated on the front panel if the limit is achieved.

OVERVOLTAGE:

Each load channel is protected from operating at input voltages greater than its rating. The overvoltage threshold is set at approximately 105% of the module voltage rating. In the event that excessive voltage is detected, the load channel will disconnect from the source. The load will not reconnect until the input voltage is below the overvoltage threshold. This is considered a major fault as the load is no longer connected to the source and all current flow has stopped. An alarm is illuminated on the front panel if the voltage limit is achieved.

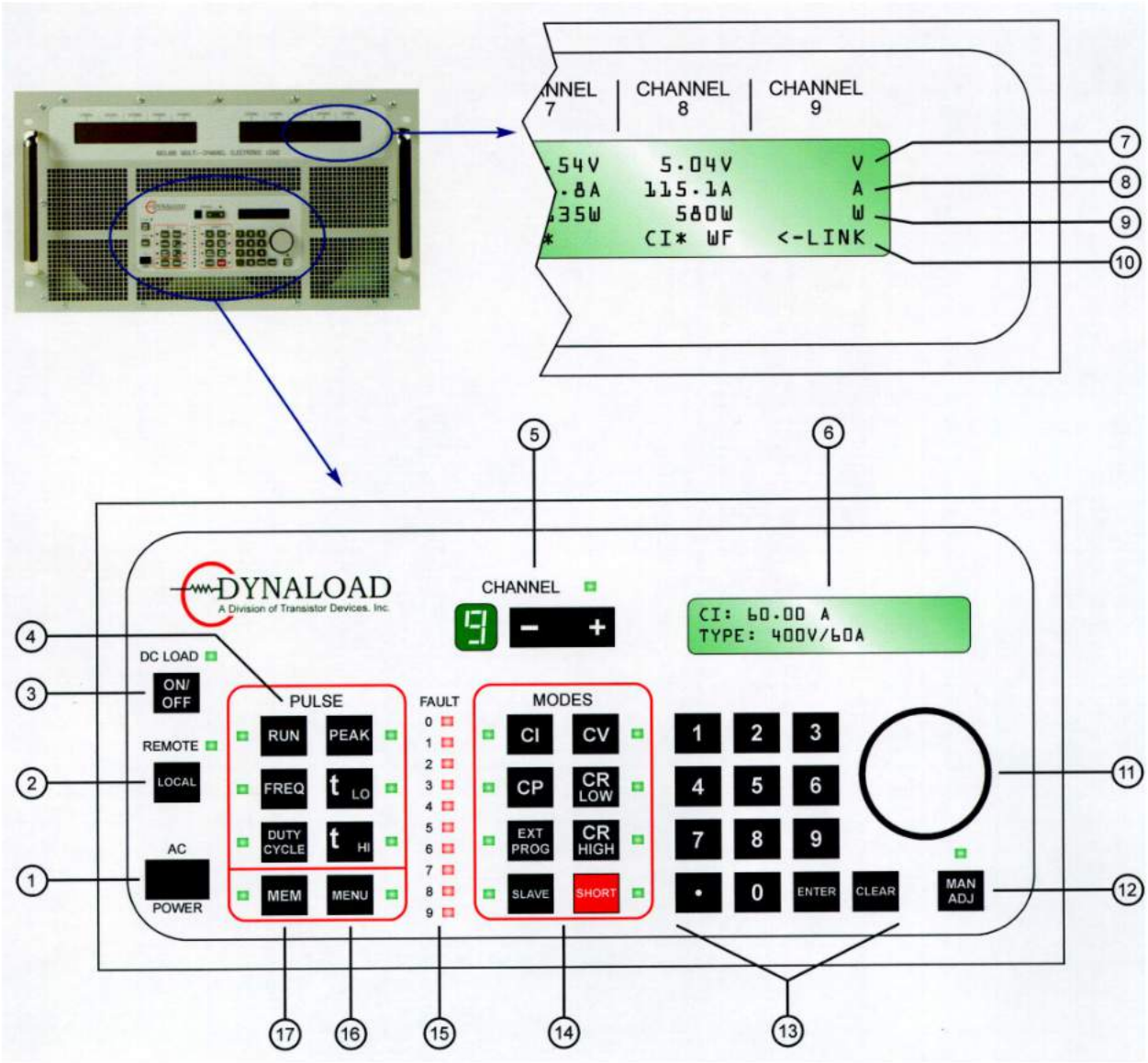
REVERSE POLARITY:

In the event that the unit is connected to a source with reverse polarity, the undervoltage detect circuit will engage and the unit will disable the DC ON function. An undervoltage alarm is illuminated on the front panel display.

UNDERVOLTAGE LOCKOUT:

To protect against high current and power surges, there is an undervoltage lockout. This keeps the load inhibited until there is about .45 volts or greater on the input studs.

FRONT PANEL OPERATION



1. AC Power
2. Local Select
3. DC On
4. Flexible And Comprehensive Pulse Generation
   - RUN: Pulse Mode on / off
   - PEAK: Sets Peak Amplitude of Pulse
   - FREQ: Sets Frequency of Pulse
   - DUTY CYCLE: Sets Duty Cycle of Pulse
   - t_{LO}: Sets Duration of the Low Portion of Pulse
   - t_{HI}: Sets Duration of the High Portion of Pulse
5. Channel Select and Indicator
6. 2 Row by 16 Column Backlit Alpha-Numeric Display
7. Channel Voltmeter
8. Channel Ammeter
9. Channel Watt meter
10. Channel Status Monitor
11. Manual Adjust Knob
12. Manual Adjust Enable
13. Keypad For Numerical Entry
14. Mode Select
    - CI: Constant Current Mode Select
    - CV: Constant Voltage Mode Select
    - CP: Constant Power Mode Select
    - CRLOW: Constant Resistance (Low Ohm) Mode Select
    - CRHIGH: Constant Resistance (High Ohm) Mode Select
    - EXT PROG: Remote Programming Mode Select
    - SLAVE: Slave Mode Select - Links Channels in Parallel
    - SHORT: Short Circuit (Momentary Action)
15. Fault and Warning Status Indicators
    - Yellow: Warning
    - Red: Fault
16. Menu Select
17. Preset (Up to 10 Configurations)

ELECTRICAL CONNECTIONS

TERMINAL IDENTIFICATION

E-, E+ are the power input studs for connection to the power source. These are the large studs on the rear of the unit.

CAUTION - **Only the power source-to-load connections are to be made to these studs.**

THE TERMINAL BLOCK

SENSE- (S-) and SENSE+ (S+) - are the voltage sense terminals.

E - AND E + - are connected internally to the power input studs. They are to be used only as a convenient connection point for the sense terminals when sensing the voltage locally. These terminals must not be used for load current.

Link - Analog output used by master to control slaves when multiple channels are linked.

PGM - AND PGM + Analog programming input - accepts 0 to 10 Volts to achieve 0 to full scale loading in any mode. PGM (-) must not be more than ±200VDC from E(-).

CS - this terminal is provided for the 0 to 10 Volt current sample output signal.

THE "IEEE-488" CONNECTOR (RS232 OPTIONAL)

This is utilized for computer control

AC INPUT

This connection provides the Dynaload with its' operating power and its safety ground.

E+ AND E- WIRING TIPS

- Use short 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). This will reduce self-inductance.
- Whenever possible, use low inductance coaxial power cables.
- Use lugs to secure the E+, E- cables to the studs.
- Connect only the power source to load cables to the E+ & E- studs; all other connections must be made via the terminal block.

EFFECTS OF CABLE LENGTH

CURRENT OSCILLATION

The Dynaload regulation loop is designed to operate at a maximum response time of 10∝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 may occur. It is always recommended to monitor the current sample output to verify that the load is operating without high frequency current oscillation. If this situation occurs refer to the section on effects of cable inductance on pulse loading for recommended solutions on page 23.

LINE LOSS

If the Dynaload is not configured for remote voltage sensing, the voltage display and voltage readback will indicate the voltage present at the input terminals. This number will be effected by the current level. Wire is a resistor, and will drop 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. You can use Ohm's law (E = I x R) to calculate the line losses for your particular application.

S-, S+ WIRING TIPS

S- and S+ (Sense- and Sense+) are used to sense the load voltage. They may be connected at the back of the Dynaload, or remotely, at the source. In any single or multiple load system, the sense leads should be connected to the source at **one and only one point**.

CAUTION **- Damaging current loops could result from multiple connections from source to sense**

The Dynaload is supplied with (2) metal jumpers between the S-, E- terminals and between the S+, E+ terminals on the terminal block. These are to facilitate voltage sense wiring when sensing locally at the load terminals.

The S-, S+ external sense leads can be connected any where 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.

The S+ voltage must be greater than or equal to the E+ voltage, and the S- voltage must be less than or equal to the E- voltage. This is the case with normal wiring practices.

LINK

This is an analog control signal which is generated by a master module for use when controlling slave channels. This signal is wired to each slave channel's PGM+ terminal. (The slaves' PGM- terminals are wired to the master's E- terminal).

PGM+

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. The signal source should be referenced to PGM-. The maximum voltage permitted from PGM+ to PGM - is 10 Volts.

PGM-

This is the signal return for the remote control input. The maximum voltage permitted from PGM- to E- is ±200V. When linking channels, the Slave's PGM- is connected to the Master's E-.

CS

0-10V signal representing 0-full scale current. Connect an oscilloscope or other external instruments to this terminal as external monitoring devices. This signal is referenced to E-.

AC Input Wiring Tips

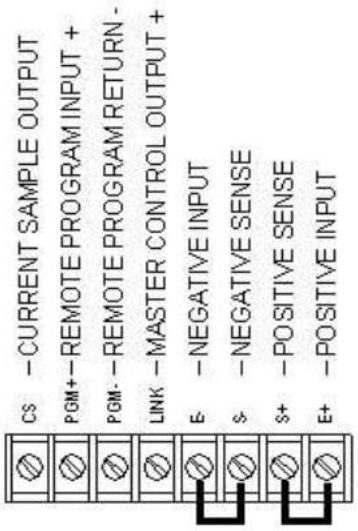
- The standard U.S. 3-prong cord is provided with your Dynaload.
- The voltage selector switch is located above the 3-prong AC connector.

SAFETY WARNING: **Make sure that the appropriate voltage is selected before applying power to the Dynaload.**

SAFETY 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.**

- Connect the AC cord first to your Dynaload then to the utility outlet.
- Fuse replacement 3AG (3 mp, 250 volt, slow blow)

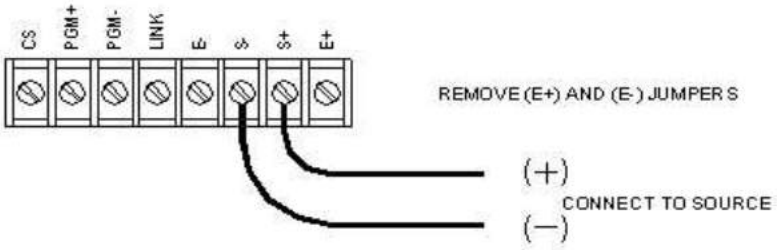
TERMINAL BLOCK CONNECTIONS



FOR LOCAL VOLTAGE SENSING, CONNECT (S+) TO (E+) AND CONNECT (S-) TO (E-) FACTORY INSTALLED JUMPERS ARE PROVIDED.

NOTE:
THE POSITIVE AND NEGATIVE INPUTS ARE PROVIDED ON THE TERMINAL BLOCK FOR EASE OF CONNECTION. DO NOT CONNECT THESE INPUTS TO YOUR TEST SOURCE AT ANY TIME. DAMAGE TO THE UNIT MAY RESULT.

REMOTE VOLTAGE SENSE



FOR IMPROVED VOLTAGE READBACK, USE THE REMOTE VOLTAGE SENSING CAPABILITIES.

1. REMOVE THE JUMPERS FROM (E+) TO (S+) AND (E-) TO (S-).
2. CONNECT THE (S+) TERMINAL TO THE POSITIVE OUTPUT ON THE TEST SOURCE.
3. CONNECT THE (S-) TERMINAL TO THE NEGATIVE OUTPUT ON THE TEST SOURCE.

OPERATING INSTRUCTIONS

The following procedure is recommended for connecting the Dynaload:

1. AC switch should be turned off.

2. Connect DC source(s) to E+ and E- stud(s).

3. If external analog programming is to be used, connect signal source(s). Connect link signals for paralleled modules. If IEEE-488 or RS232 (optional) is to be used, connect the cable.

4. Connect AC power.

5. Turn on AC power; meters should come on and fans should run.

6. For manual operation: select the appropriate channel and mode via the front panel.

7. Press the DC-ON button or send the DC-ON command over the bus. This will close the relays and connect the source to the power dissipating circuitry.

8. Enter a value and press enter. If analog programming is desired, press the EXT PROG button. For computer controlled operation, begin sending the appropriate commands (see IEEE-488 section for command listing). The load should now be drawing the set current value.

CONSTANT CURRENT MODE

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 a 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.

NOTE: 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 when simulating short circuit protection and recovery of most power supplies, unless otherwise specified by the manufacturer.

CONSTANT RESISTANCE MODE

The constant resistance mode regulates the load current in direct proportion to the load voltage. There are two different resistance ranges available (HIGH and LOW) to accommodate a variety

of requirements. The actual available ranges are outlined in the specification section of this manual.

NOTE: The resistance may be entered in Ohms or Amps/Volt (1/R). This option is selected for front panel operation through the menus. For automated control, either the AVx or the CRx commands are used.

CV - Constant Voltage 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 will lead to an unstable condition.

CP - Constant Power 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.

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

Local Control

The local button on the front panel will allow the user to resume front panel control of the load when operating with the IEEE488 bus. Pressing this button will enable all the front panel controls and the unit will ignore all IEEE commands. 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.

Remote Programming

The MCL series is analog programmable in all four modes of operation. The loading is directly proportional to the 0-10 volt programming input. For example: If the constant current mode is selected on an MCL488 400-60-350, a programming voltage of 5 volts is required to program the load to 30A. 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 100µs for a 0 to full scale transition, but is adjustable from the front panel by the menus, or through the IEEE-488 bus.

Short Circuit Button

Pressing the short button drives the power section into a saturated (short circuit) state. This feature is disabled from the factory and can be activated through the IEEE-488 bus.

NOTE: To use the short circuit feature, the undervoltage protection must be disabled through the front panel menu, or with the UV OFF command.

CAUTION! **The short circuit button is used only on power sources having inherent current limit capability.**

CAUTION! **The short circuit button must not be used if the power source is capable of delivering a current greater than the maximum current rating.**

MANUAL ADJUST

The round knob above the MAN ADJ key is utilized 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 can be set through the menu.

SLAVE MODE

Multiple MCL load channels may be used in parallel for greater current and power capacity. In linked channel systems, one channel is used as the master. It is operated in the same manner as if it were being used individually. The remaining channels are put into slave mode by either pressing the SLAVE button on the front panel or sending the channel the SLAVE ON command. Once linked, each slave will conduct current proportionately to the master load's current. (Refer to page 25 for details).

MEM - MEMORY RECALL LOCATIONS

The configuration of the load may be stored in 10 settable memory locations labeled 0 thru 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: MEM- Memory Location Zero is reserved for power-up state.

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.

The menu features are as follows:

1. SR – Slew Rate limit
2. IE - IEEE bus address
3. KR – Knob Resolution for load level
4. KR – Knob Resolution for time
5. KR – Knob Resolution for frequency
6. LP – Lock Front Panel
7. PC – Change Password for front panel lock
8. AR – enter resistive load level as Ohms or amps/volt
9. TR – IEEE bus Terminator – CR or CR+LF
10. PN – Number of Pulses – 0 for continuous
11. MS – Memory Set
12. SE – Short Enable
13. PA – Pulse Amplitude entry mode – ABSOLUTE or DELTA
14. UV – UnderVoltage lockout
15. PT – Pulse Train
16. SC – System-wide DC on/off Control
17. SF – Scale Factor – pulse timing scaled down by this factor
18. Firmware version number

SLEW RATE ADJUST

The slew rate adjustment is utilized to compensate for long load input cables which could cause oscillation or overshoot in the load due to high inductance on the loads input. The slew rate setting is set at the factory for 100µs for a 0 to selected full scale transition. Minimum slew rate is 10 microseconds; Maximum is 40,000 microseconds, 40 milliseconds (SS) 10 milliseconds, and .4 sec. When prompted, press ENTER to select the function, enter the numeric value in microseconds, then press ENTER.

IEEE ADDRESS SETTING

The IEEE488 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.

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 which 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.

KNOB RESOLUTION FOR TIME

The resolution for the rotary knob can be set for increased or decreased resolution. The minimum resolution for time is .001A and the maximum is 1.00A. It is up to the user to decide an appropriate set point. This function is active when using the T(hi) and T(lo) keys to set a pulse function. This is inactive if using the frequency button for pulse loading.

KNOB RESOLUTION FOR FREQUENCY

The resolution for the rotary knob can be set when operating in the frequency set mode. The minimum frequency increment is .001 and the maximum is 1.00A. It is up to the users discretion to set an appropriate resolution. This function is active when using the FREQ key on the front panel. This function is inactive if using the T(hi) and T(lo) functions.

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.
The factory default is 1234.

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 (7). The factory default is 1234.

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.

TERMINATOR

When operating using the IEEE488 control input the user must select the line terminator. You must choose either CR (carriage return) or CR/LF (carriage return/line).

NUMBER OF PULSES

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

MEMORY SET

The Dynaload has the provision for memory presets. When a memory location is selected, the load will remember 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 thru 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 (0) is executed.

NOTE: The memory set locations are channel specific.
There are 10 memory locations per channel. If the user sets a memory location for channel 1, it will have no effect on any other channel. Each channel must have the memory locations programmed individually.

SHORT ENABLE

In some applications, such as battery testing, the short circuit feature could be detrimental to the unit under test. As a protection the short circuit function can be "Locked" to prevent use of this function.

PULSE AMPLITUDE, ABSOLUTE OR DELTA

The pulse function will allow the user to operate in either Absolute or Delta for pulse level setting. The Absolute mode will accept the level set with reference to a zero current baseline. The Delta mode will assert the current level relative to the last entered baseline current. Refer to the pulse loading section of this manual for more details.

UNDERVOLTAGE LOCKOUT

To protect against high current and power surges, there is an undervoltage lockout. This keeps the load inhibited until there is about .45 volts or greater on the input studs. If your application requires operation with less than .45 volts input, the undervoltage lockout may be over-ridden through the front panel menu or UV OFF command. Otherwise, it is strongly recommended that the UV protection be left on. To use the short circuit feature, the undervoltage lockout must be disabled. This lockout feature is provided to prevent high current surges in the event that the load is pre-programmed to a level and an instantaneous voltage is applied. (i.e.: external relay closure.)

PULSE TRAIN

The internal Pulse generator can operate in both two level and three level modes. The user must select a "0" for operation in two level pulsing or select "1" to operate in three level pulse mode. Refer to the pulse loading section of this manual for more details.

SYSTEM WIDE DC ON/OFF CONTROL

This function will allow the user to control the DC ON/OFF function of all channels simultaneously. By choosing the "ON" selection a single push of the DC ON/OFF button will engage or disengage all the load channels. This is also controlled by IEEE488 commands. Selecting the "OFF" position defines all load channels as individuals and each channel would need to be set for an ON or OFF state.

SCALE FACTOR

The pulse function has the ability to be enhanced by applying a scale factor. This will extend the minimum operating frequency range by the number entered. Refer to the pulse loading section of this manual for more detail.

FAULT INDICATORS

Red is alarm or major fault. (Channel will shut down)

UV - Undervoltage - DC ON will not function until voltage is present. (over ride is provided through menu or UV command)

OV - Overvoltage - Channel will disconnect from source

OT – Overtemperature - Channel will shut down

Yellow is a warning or minor fault. (Channel may continue to operate, but may be out of regulation.)

OC - Overcurrent - Unit has reached the maximum current.

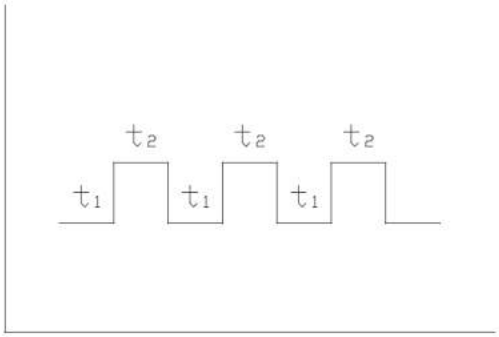
OP - Overpower- Unit has reached the power limit.

SAT - Saturation - Saturation condition whereby one or more of the electronic power components are completely turned-on. This may be due to insufficient source voltage or inadequate wiring. This may also indicate electronic component failure.

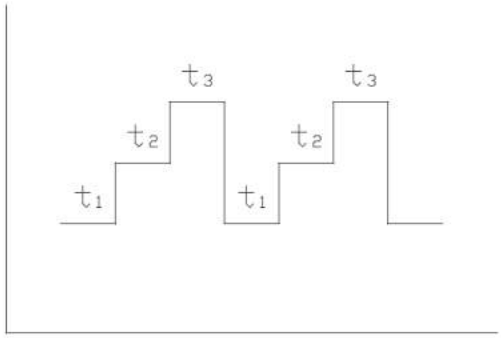
PULSE LOADING

Pulse loading is available in all four modes of operation. The examples below depict Constant Current mode, but are applicable to all modes.

Pulse loading may be set for two load levels or three levels. To enable or disable three level pulsing, use the front panel menu or the TP [ON/OFF] command.

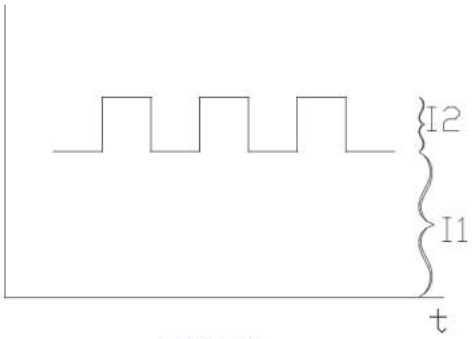


TWO LEVEL PULSING

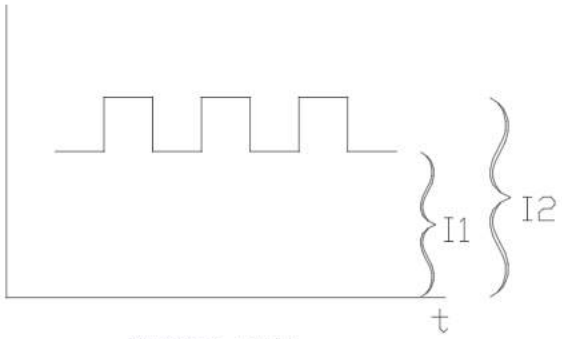


THREE LEVEL PULSING

The amplitude of the load levels may be entered in two different ways: DELTA mode, which specifies the amount of change relative to the previous load level, or ABSOLUTE mode, which specifies the absolute level relative to zero. To select DELTA or ABSOLUTE mode, use the front panel menu or use the PAx command. Delta is the factory default setting.



DELTA



ABSOLUTE

The pulse timing may be entered as frequency and duty cycle, or as time duration. Entering a frequency will change the pulse duration, but will not change the duty cycle. Entering a duty cycle will also change the pulse duration, but will not affect the frequency. Setting any time duration directly will affect both frequency and duty cycle.

The pulse generator may be configured to shut off after a predetermined number of pulses. This is set through the front panel menu, or with the SW or WF commands.

The frequency and duty cycle limits are a result of the minimum and maximum limits of pulse duration. The factory default condition limits the minimum pulse duration to 10∝S, maximum duration of 16,777,215 ∝S, with a resolution of 1 ∝S. To achieve longer duration pulses, a scale factor may be used which slows the timing characteristics per the following equations:

Resolution = scale factor (∝S)

Minimum duration = scale factor (∝S), or 10∝S, whichever is longer

Maximum duration = 16,777,215 X scale factor (∝S)

The scale factor may be from 1 to 255.

Follow the following steps when operating in pulse mode:

MANUAL OPERATION

1. Use the Channel select key to select the desired channel.

NOTE: The number keypad may be used directly after the channel select button is pressed to jump directly to the desired channel.

2. Use the CI, CP, CV or CR button to set the baseline current, power, voltage, or resistance respectively.

3. Use the FREQ button to set the frequency

4. Use the DUTY CYCLE button to set the duty cycle. For applications which require the period to be set, the t_{hi} and t_{low} functions should be used. The t_{hi} function will set the time that the pulse remains at the peak setting. The t_{low} function will set the time that the pulse remains at the baseline setting.

5. Use the PEAK button to set the amplitude of the pulse.

6. If necessary, use the menu button to set the slew rate.

7. Use the RUN button to initiate pulse loading.

IEEE-488 PROGRAMMING

1. Use the CH command to select the desired channel.

2. Use the appropriate command to set the baseline current, power, voltage, or resistance.

3. Use the FREQ Command to set the frequency.

4. Use the DU command to set the duty cycle. For applications which require the period to be set, the T1 and T2 commands should be used. The T1 Command will set the time that the pulse remains at the baseline setting. The T2 command will set the time that the pulse remains at the peak setting.

5. Use the appropriate command to set the amplitude of the pulse.

6. If necessary, use the SR command to set the slew rate.

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

7. Use the SW command to initiate pulse loading.

For more information on pulse loading with the IEEE-488 commands, please see the section on Language Elements.

It is recommended to monitor the current sample output with an oscilloscope to observe the actual current amplitude and waveform. If overshoot or ringing occurs, slowing the slew rate will often correct the problem.

If waveforms other than square waves are required, this can be accomplished by programming the loads using an external analog program source. (See remote programming).

NOTE: In constant voltage mode the load is increased by lowering the voltage. Therefore, in constant voltage pulse mode, the baseline voltage is usually higher than the peak setting.

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 wave form distortion will occur. This is because the power devices are driven into saturation in an attempt to reach the programmed current which cannot occur 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. 1 microhenry = 2.4 feet of wire (total).
2. 50A @ 50 microseconds rise time = 1 volt drop

   with 1 microhenry.
3. The inductive drop cannot exceed the difference between the source voltage and

   the minimum compliance.

For example: To test a 10V source with a 100A pulse, and assuming a 3 volt minimum compliance, the maximum cable length would be:

E Max drop = 7V

$$E = L \frac{di}{dt} \qquad 7V = L \frac{100A}{50 \propto s}$$

L = 3.5 microhenries maximum

Maximum cable length = 8.4 feet total
or 4.2 feet per cable from source to Dynaload.

If the distance from the load to the source must be greater than this, there are several methods to

increase it. One way is to use several insulated conductors. This cuts the inductance in half if 4 are used instead of 2 or by one-third if 6 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. 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. By the formula:

$$E = \frac{I \quad T}{C}$$

The capacitor required would be 900 microfarads.

TRANSCONDUCTANCE

There exists a little known characteristic of power MOSFET'S 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 is 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 which 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.

LINKING MODULES

The MCL488 load modules can be linked in order to operate at higher current and power levels. The loads which are "linked" will operate as a single load with all current and voltage readbacks reflecting the total current and power of the group. Any number of channels can be linked, and there are no restrictions to the number of linked groups
within a chassis.

NOTE: The link feature cannot be extended beyond one chassis.

Figure 1. shows the proper wiring required to link load channels. The example shows the wiring in order to link channels 0, 1, and 2 to operate as a single channel. Channel 0 would be the control module while channels 1 and 2 would respond to commands sent by channel 0.

NOTE: The "master" or controlling module must be the lowest channel number within the group. Failure to follow this requirement will result in erroneous operation.

The wiring for linked load channels is a “hard” connection and will not provide for “on the fly” changes in the link configuration. When a system is wired for linked operation it is possible to separate linked channels and operate them as individual channels. The external wiring will have no effect on the operation of a single channel if it is "unlinked"
from a master channel.

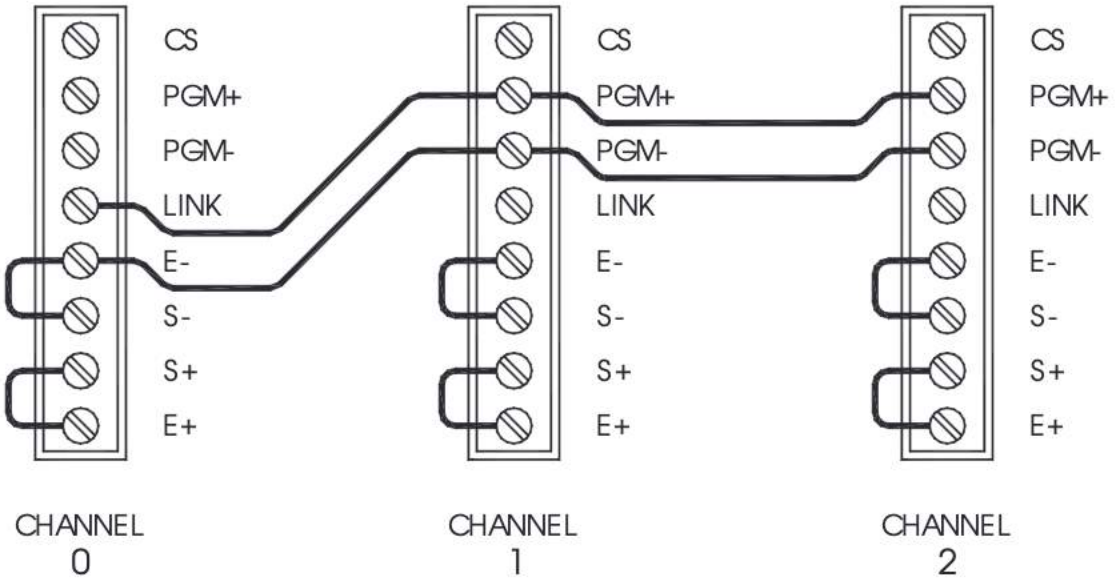


FIGURE 1

LOCATION, AIRFLOW, MAINTENANCE

The following figures show the dimensions of your Dynaload. The MCL488 is designed with rack mounting ears for installation in a 19" rack enclosure. In addition to the rack mounting ears, the use of slides or shelf type supports is required. To facilitate this, the MCL488 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 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.

The internal fans cool 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'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℃ and with derated power dissipation capability up to 50℃.

OPERATOR SAFETY INSTRUCTIONS

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 which the load is connected to. 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.

WARNING

Be sure all AC and DC power for both the load, the test source, and any peripheral equipment is OFF prior to making any connections to the load.

Be sure the proper AC input range is selected before attaching the line cord.

Be sure the load selected is properly rated for the voltage and current generated by the DC source.

Be sure all connections are correct and secure, and that all safety covers are inplace 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.

SAFETY SYMBOLS

SYMBOLS	DEFINITIONS	PUBLICATION
	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

IEEE-488 PROGRAMMING INTRODUCTION

The purpose of this section is to enable you to use IEEE-488 commands to operate your programmable Dynaload. This section assumes that your MCL488 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 the operating section of this manual first, especially the SAFETY SUMMARY, before proceeding.

IEEE-488 BUS SUBSETS

The programmable Dynaload has the IEEE-488 bus subset capabilities indicated below.

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. All program settings are reset to the values stored in location 0 with the load relay disconnected.
Device Trigger	DTO	No capability.

DATA SEPARATORS

It is not necessary to separate numerical data from the previous command by any character. 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 either a carriage return and a line feed or as a carriage return only by following the IEEE-488 bus configuration procedure in the operating manual.

NUMERICAL DATA FORMATS

The programmable Dynaload accepts the numerical data formats listed below. These are described in more detail in IEEE standard 488.2 "standard digital interface for programmable instruments".

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 MCL488 receives and transmits quantities are fixed. They are listed in the table below.

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.

ITEM	MEANING	UNIT	FORMAT
FQ	Square wave frequency	hertz	Hz
DU	Square wave duty cycle	percent	%
CI	Constant current setpoint	amperes	amps
CV	Constant voltage setpoint	volts	volts
CP	Constant power setpoint	watts	watts
CRL	Constant Resistance setpoint (lowΩ)	ohms	ohms
CRH	Constant Resistance setpoint (high Ω)	ohms	ohms
AVL	Constant Resistance setpoint (low A/V)	amps/volt	amps/volt
AVH	Constant Resistance setpoint (high A/V)	amps/volt	amps/volt
I1	First current value	amperes	amp
I2	Second current value	amperes	amp
I3	Third current value	amperes	amp
V1	First voltage value	volts	volts
V2	Second voltage value	volts	volts
V3	Third voltage value	volts	volts
P1	First power value	watts	watts
P2	Second power value	watts	watts
P3	Third power value	watts	watts
R1	First resistance value (ohms mode)	ohms	ohms
R2	Second resistance value (ohms mode)	ohms	ohms
R3	Third resistance value (ohms mode)	ohms	ohms
A1	First resistance value (A/V mode)	amps/volt	amps/volt
A2	Second resistance value (A/V mode)	amps/volt	amps/volt
A3	Third resistance value (A/V mode)	amps/volt	amps/volt
T1	First Duration	microseconds	µS
T2	Second Duration	microseconds	µS
T3	Third Duration	microseconds	µS
S1	Slew Rate (rise time)	microseconds	µS
S2	Slew Rate (fall time)	microseconds	µS
SR	Slew Rate	microseconds	µS

POWER ON DEFAULTS

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

PARAMETER	SETTING
Mode	Constant current
Relay	Open
Short	Off
Text	On
External modulation	OFF
Pulse amplitude entry mode	DELTA
FQ - Square wave frequency	1KHz
DU - Square wave duty cycle	50%
CI - Constant current setpoint	0
CV - Constant voltage setpoint	Vmax
CP - Constant power setpoint	0
CR - Constant resistance setpoint	∞
I1 - First current value	0
I2 - Second current value	0
V1 - First voltage value	Vmax
V2 - Second voltage value	Vmax
P1 - First power value	0
P2 - Second power value	0
R1 - First resistance value	∞
R2 - Second resistance value	∞
T1 - First duration	500 microseconds
T2 - Second duration	500 microseconds
SF – Scale Factor	1
SR - Slew rate	100µs (0-FS)

COMMANDS

The basis of the MCL488 syntax is the instrument control command. Each command sends an instruction to the Dynaload. A query command requests information from the Dynaload.

Each element of the load syntax command 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. All commands must be spelled correctly or else an “unrecognized command error” will occur.

For instance:

CI 10

This places the load in it’s Constant Current Mode set at 10 amps

LOAD ON

This connects the load to the source.

QUERIES

Commands followed by "?" are queries. When received by the MCL488 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 a request for the present value of programmed parameters or status.

Many of the syntax 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.

For instance:

CI?

This requests the present value of the Constant Current program.

LOAD?

This requests the state of the load’s input relay.

COMMAND CHAINING

The MCL supports a limited form of command chaining. This can streamline commanding by

allowing multiple commands to be sent in a single command line. Commands can be chained by inserting a semi-colon (;) or colon (:) as a separator. This allows for faster commanding and reduces the per command overhead. Limitations to command chaining are as follows:

The total length of the command string (including separator characters and spaces) needs to be less than 72 characters.

Only a single inquiry is allowed in a command chain and it must be the last in the sequence. Otherwise the returned data may be lost.

Examples:

CH4;SLAVE ON;CH3;FQ 1250;DU 35;I1 2;I2 80;SW;LOAD ON

This command line slaves channel 4 to 3 and configures them to run at 1250Hz, 35% duty cycle pulsing with a base current of 2A and peak of 80A then turns the load on. (spaces are only shown for clarity and can be left out to reduce character count if needed)

CH2;STA?

This command line selects channel 2 and queries the status of that channel.

CH4;STA?;CON? *Invalid Command!*

This is invalid because it contains two queries.

CH4;STA?;LOAD OFF *Invalid Command!*

This is invalid because the single query is not the last in the chain.

CH0;LOAD OFF;CH2;LOAD OFF;CH3;LOAD OFF

This command line turns off the load on channels 0, 2 and 3.

SYNTAX

Note: Characters may be either upper or lower case. Spaces and Items in brackets,"[ ]" are optional.

LOAD OPERATING MODES

CI x	Enter constant current mode with current set to x amps
CV x	Enter constant voltage mode with voltage set to x volts
CRL/CRH x	Enter constant resistance value to x ohms
AVH/AVL x	Enter constant resistance vale in amps/volt
CP x	Enter constant power mode with power set to x watts
XM ON	Enable external modulation

PULSE PARAMETERS

Constant Current Pulse Mode

I1 x	Set the first current value to x amps (same as CI)
I2 x	Set the second current value to x amps
I3 x	Set the third current value to x amps

Constant Voltage Pulse Mode

VI x	Set the first voltage value to x volts (same as CV)
V2 x	Set the second voltage value to x volts
V3 x	Set the third voltage value to x volts

Constant Resistance Pulse Mode

R1,AV1 x	Set the first resistance value to x ohms(R1), amps/volt (AV1)
R2,AV2 x	Set the second resistance value to x ohms(R2), amps/volt (AV2)
R3,AV3 x	Set the third resistance value to x ohms(R3), amps/volt (AV3)

Constant Power Pulse Mode

P1 x	Set the first power value to x watts
P2 x	Set the second power value to x watts
P3 x	Set the third power value to x watts

Square Wave Setup(all modes)

FQ x	Set the frequency of the wave to x Hz
DU, D2, D3 x	Set the duty cycle to x %
T1	Set the duration of the low portion of the pulse
T2	Set the duration of the second portion of the pulse
T3	Set the duration of the third portion of the pulse
SW or WF [x]	Turn on square waves. Optional number is number of pulses
SR, S1, S2	Set slew rate limit (S1 & S2 are included for compatibility)

RELAY CONTROL

LOAD ON	Close the load connect relay
LOAD OFF	Open the load connect relay

MISCELLANEOUS

CH x	Selects channel x as the active channel.
SHORT ON	Enter the loads electronic short circuit mode
SHORT OFF	Leave the loads electronic short circuit mode
RST	Reset the load to its power on condition
*RST	Reset to power on defaults
SDN x	Program the Protective Shutdown Mask (OV and OT shutdown bits are always set)
LAT x	Program the Latched Fault Mask
SBE x	Program the summary bit enable mask
SRQ x	Program the SRQ enable mask
LOCK ON	Disable the front panel
LOCK OFF	Enable the front panel
TEXT ON	Long Response: Query response will consist of numerical data and/or text.
TEXT OFF	Short Response: Query response will consist of numerical data only.
UV ON	Enables the undervoltage detect circuit.
UV OFF	Disables the undervoltage detect circuit

READBACKS

I?	Read the current through the load
P?	Read the power dissipating in the load
V?	Read the voltage across the load

MULTI-CHANNEL COMMANDS

ALL I?	Read the currents for all modules
ALL P?	Read the power dissipations for all modules
ALL V?	Read the Voltages across all modules
PS ON	Execute the SW or WF command to all modules
PS OFF	Execute the SW OFF command for all modules
SYS ON	Enables all module control for LOAD and UV commands
SYS OFF	Disables all module control for LOAD and UV commands

QUERIES

CI?	Read the programmed current
CV?	Read the programmed voltage
CP?	Read the programmed power
CR?	Read the programmed resistance(ohms)
AV?	Read the Programmed resistance(amps/volt)
FQ?	Read the square wave frequency
DU?,D2?	Read the square wave duty cycle (second pulse level)
D3?	Read the square wave duty cycle (third pulse level)
T1?	Read the T1 time value
T2?	Read the T2 time value
T3?	Read the T3 time value
SR?	Read the slew rate
S1?	Read the slew rate
S2?	Read the slew rate
I1?	Read the I1 current level
I2?	Read the I2 current level
I3?	Read the I3 current level
V1?	Read the V1 voltage level
V2?	Read the V2 voltage level
V3?	Read the V3 voltage level
R1?	Read the R1 resistance level (ohms)
R2?	Read the R2 resistance level (ohms)
R3?	Read the R3 resistance level (ohms)
AV1?	Read the AV1 resistance level (amps/volt)
AV2?	Read the AV2 resistance level (amps/volt)
AV3?	Read the AV3 resistance level (amps/volt)
P1?	Read the P1 power level
P2?	Read the P2 power level
P3?	Read the P3 power level
STA?	Report the system status messages
CON?	Report the condition messages
ERR?	Report the system command error messages
MODE?	Report the loads operating mode
SDN?	Report the loads Protective Shutdown Mask
LAT?	Report the loads Fault Latch Mask
SBE?	Report the summary bit enable mask
SRQ?	Report the state of the SRQ flag
TEXT?	Report the response mode
LOCK?	Report the front panel lock state
LOAD?	Report the state of the load connect relay
SHORT?	Report the state of the short circuit
RNG?	Report the current and voltage range
ID?	Read the load ID (Current, Voltage, Power)
VER?	Read the loads firmware version
*IDN?	Read the loads model number

LANGUAGE ELEMENTS

This section is an alphabetical listing that gives the syntax and required parameters for all elements in the programmable load's syntax. The syntax functions and forms are generic for all MCL488 module ratings.

The following section provide the information below for each command:

DESCRIPTION:	Indicates the type of command and provides a brief explanation of its function.
SYNTAX:	Provides the proper form and numerical subset of the element in question. **Spaces are ignored**.
EXAMPLE:	Gives an example of command usage.
QUERY SYNTAX:	Provides the proper form to turn the command into a query.
RETURNED PARAMETERS:	Indicates the response formats to the query form of the command both in the TEXT ON and TEXT OFF modes.

READBACKS

I?

DESCRIPTION: Query used to read back the current through the currently selected channel

SYNTAX: I?

RETURNED PARAMETERS:
TEXT ON: <NR2> amps
TEXT OFF: <NR2>

P?

DESCRIPTION: Query used to read back the power dissipation in the currently selected channel

SYNTAX: P?

RETURNED PARAMETERS:
TEXT ON: <NR2> watts
TEXT OFF: <NR2>

V?

DESCRIPTION: Query used to read back the voltage across the currently selected channel

SYNTAX: V?

RETURNED PARAMETERS:
TEXT ON: <NR2> volts
TEXT OFF: <NR2>

AV1

DESCRIPTION: LOAD COMMAND used to set the base resistance to the specified amps/volt value. **NOTE:** AVL or AVH must have been previously set.

SYNTAX: AV1 <NR2>

EXAMPLE: AV1 2
The resistance level AV1 is set to 2 amps/volt

QUERY SYNTAX: AV1?

RETURNED PARAMETERS: TEXT ON: <NR2> amps/v
TEXT OFF: <NR2>

AV2

DESCRIPTION: LOAD COMMAND Used to set the amplitude of the peak loading in constant resistance pulse mode. The value specified is added to the base value. **NOTE:** AVL or AVH must have been previously set.

SYNTAX: AV2 <NR2>

EXAMPLE: AV2 4
The resistance level AV2 is set to 4 amps/volt

QUERY SYNTAX: AV2?

RETURNED PARAMETERS: TEXT ON: <NR2> amps/volt
TEXT OFF: <NR2>

AV3

DESCRIPTION: LOAD COMMAND Used to set the amplitude of the peak loading in constant resistance pulse mode. The value specified is added to the base value. **NOTE:** AVL or AVH must have been previously set.

SYNTAX: AV3 <NR2>

EXAMPLE: AV3 4
The resistance level AV3 is set to 4 amps/volt

QUERY SYNTAX: AV3?

RETURNED PARAMETERS: TEXT ON: <NR2> amps/volt
TEXT OFF: <NR2>

AVH

DESCRIPTION: MODE COMMAND that places the programmable load in its constant resistance high amps/volt mode at the value specified.

SYNTAX: AVH <NR2>

EXAMPLE: AVH 5
This command places the load in its constant resistance mode at an input resistance of 5 amps/volt.

QUERY SYNTAX: AV?

RETURNED PARAMETERS: TEXT ON: <NR2> amps/v
TEXT OFF: <NR2>

AVL

DESCRIPTION: MODE COMMAND that places the programmable load in its constant resistance low amps/volt mode at the value specified.

SYNTAX: AVL <NR2>

EXAMPLE: AVL 0.5
This command places the load in its constant resistance mode at an input resistance of 0.5 amps/volt.

QUERY SYNTAX: AV?

RETURNED PARAMETERS: TEXT ON : <NR2> amps/v
TEXT OFF : <NR2>

CH

DESCRIPTION: LOAD COMMAND used to set active channel.

SYNTAX: CH <NR1>

EXAMPLE: CH 4
The active channel is set to #4

QUERY SYNTAX: CH?

RETURNED PARAMETERS: TEXT ON: <NR1>
TEXT OFF: <NR1>

CI

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant current mode at the value specified.
SYNTAX:	CI <NR2>
EXAMPLE:	CI 10.5 This command places the load in its constant current mode, set to regulate 10.5 amperes.
QUERY SYNTAX:	CI?
RETURNED PARAMETERS:	TEXT ON: <NR2> AMPS TEXT OFF: <NR2>

CP

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant power mode at the value specified.
SYNTAX:	CP <NR2>
EXAMPLE:	CP 20.0 This command places the load in its constant power mode, set to regulate 20 watts.
QUERY SYNTAX:	CP?
RETURNED PARAMETERS:	TEXT ON : <NR2> watts TEXT OFF : <NR2>

CRH

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant resistance high ohms mode at the value specified.
SYNTAX:	CRH <NR2>
EXAMPLE:	CRH 100 This command places the load in its constant resistance mode, at an input resistance of 100 ohms.
QUERY SYNTAX:	CRH?
RETURNED PARAMETERS:	TEXT ON : <NR2> ohms TEXT OFF : <NR2>

CRL

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant resistance low ohms mode at the value specified.
SYNTAX:	CRL <NR2>
EXAMPLE:	CRL 1 This command places the load in its constant resistance mode, at an input resistance of 1 ohm.
QUERY SYNTAX:	CRL?
RETURNED PARAMETERS:	TEXT ON : <NR2> ohms TEXT OFF : <NR2>

CV

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant voltage mode at the value specified.
SYNTAX:	CV <NR2>
EXAMPLE:	CV 100.0 This command places the load in its constant voltage mode, set to regulate 100 volts,
QUERY SYNTAX:	CV?
RETURNED PARAMETERS:	TEXT ON : <NR2> volts TEXT OFF : <NR2>

DU

DESCRIPTION:	LOAD COMMAND used to set the duty cycle of a waveform.
SYNTAX:	DU <NR2>
EXAMPLE:	DU 40 This command establishes the duty cycle in Pulse Mode. It is the percent of the total period for which level I2 P2, R2 or V2 is in effect. In this example, that is 40% of the total period.
QUERY SYNTAX:	DU?
RETURNED PARAMETERS:	TEXT ON: <NR2> % TEXT OFF: <NR2>

D2

DESCRIPTION: LOAD COMMAND used to set the duty cycle of a waveform. Same as DU.

SYNTAX: D2 <NR2>

EXAMPLE: D2 40
This command establishes the duty cycle in Pulse Mode. It is the percent of the total period for which level I2 P2, R2 or V2 is in effect, In this example that is 40% of the total period.

QUERY SYNTAX: D2?

RETURNED PARAMETERS: TEXT ON: <NR2> %
TEXT OFF: <NR2>

D3

DESCRIPTION: LOAD COMMAND used to set the duty cycle of the third pulse level of a waveform in three pulse mode.

SYNTAX: D3 <NR2>

EXAMPLE: D3 40
This command establishes the duty cycle in Pulse Mode. It is the percent of the total period for which level I3 P3, R3 or V3 is in effect. In this example, that is 40% of the total period.

QUERY SYNTAX: D3?

RETURNED PARAMETERS: TEXT ON: <NR2> %
TEXT OFF: <NR2>

FQ

DESCRIPTION:	LOAD COMMAND used to set the frequency of a waveform.
SYNTAX:	FQ <NR2>
EXAMPLE:	FQ 1000 This command establishes the frequency in the pulse mode of operation at 1000 Hertz.
QUERY SYNTAX:	FQ?
RETURNED PARAMETERS:	TEXT ON: <NR2> Hz TEXT OFF: <NR2>

I1

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant current mode at the value specified. In pulse mode, this is the base current setting.
SYNTAX:	I1 <NR2>
EXAMPLE:	I1 10.5 load is set in constant current mode at 10.5 amperes.
QUERY SYNTAX:	I1?
RETURNED PARAMETERS:	TEXT ON: <NR2> amps TEXT OFF: <NR2>

I2

DESCRIPTION:	LOAD COMMAND used to set the peak current in pulse mode. **NOTE:** In DELTA mode, the I2 current is summed on top of the I1 current. For Example: If I1=10 amps and I2=50 amps, the actual pulse is between 10 amps and 60 amps.
SYNTAX:	I2 <NR2>
EXAMPLE:	I2 25.3 The current level I2 is set to 25.3 amperes
QUERY SYNTAX:	I2?
RETURNED PARAMETERS:	TEXT ON: <NR2> amps TEXT OFF: <NR2>

I3

DESCRIPTION:	LOAD COMMAND used to set the third peak current in three level pulse mode. **NOTE:** In DELTA mode, the I3 current is summed on top of the I1 & I2 current. For Example: If I1=10 amps, I2=10 amps, and I3 = 20 amps, the actual pulse is from 10 amps to 20 amps to 40 amps.
SYNTAX:	I3 <NR2>
EXAMPLE:	I3 25.3 The current level I3 is set to 25.3 amperes
QUERY SYNTAX:	I3?
RETURNED PARAMETERS:	TEXT ON: <NR2> amps TEXT OFF: <NR2>

LAT

DESCRIPTION: LOAD CONTROL COMMAND that sets the indicated bits in the latched fault mask. When a bit is set in the latched fault mask, an abnormal condition in the load condition register will be latched until read by the computer.

SYNTAX: LAT <NR1>

EXAMPLE: Each of the bits in the latched fault mask register have a decimal weight as indicated in the table below. The weights of the bits to be set are added to form the decimal number that accompanies the command. Any bit whose weight is not added in is cleared with the exceptions of bits 5 & 6, which are always set. If a bit is cleared its corresponding abnormal condition will not be latched,

BIT	LATCHES CONDITION	WEIGHT	NOTE
7	UV	128	
6	OV	64	Always Set
5	OT	32	Always Set
4	GPIB ERROR	16	
3	OC	8	
2	OP	4	
1	SAT	2	
0	PWR	1	

The command LAT 33 will set bits 0 and 5, causing any PWR alarms, OT alarms, or OV alarms to be latched.

RELATED QUERY: LAT?

RETURNED PARAMETERS: TEXT ON: A Comma Delimited ASCII string whose components correspond to the set bits.

TEXT OFF: <NR1>.
Where the number is the sum of the weights of the set bits.

LOAD OFF

DESCRIPTION:	LOAD CONTROL COMMAND that opens the loads power handling contactor, isolating the E+ input studs from the power dissipating circuitry.
SYNTAX:	LOAD OFF
RELATED QUERY:	LOAD?
RESPONSE PARAMETERS:	TEXT ON: LOAD OFF TEXT OFF: 0

LOAD ON

DESCRIPTION:	LOAD CONTROL CONMAND that closes the load's power handling contactor. The contactor connects the E+ input studs to the internal power dissipating circuitry.
SYNTAX:	LOAD ON
RELATED QUERY:	LOAD?
RESPONSE PARAMETERS:	TEXT ON: LOAD ON TEXT OFF: 1

LOCK OFF

DESCRIPTION:	LOAD CONTROL COMMAND that enables the local control keypad.
SYNTAX:	LOCK OFF
RELATED QUERY:	LOCK?
RESPONSE PARAMETERS:	TEXT ON: LOCK OFF TEXT OFF: 0

LOCK ON

DESCRIPTION:	LOAD CONTROL COMMAND that locks out the front panel.
SYNTAX:	LOCK ON
RELATED QUERY:	LOCK?
RESPONSE PARAMETERS:	TEXT ON: LOCK ON TEXT OFF: 1

MR

DESCRIPTION:	LOAD COMMAND recalls the setup stored in location “x”
SYNTAX:	MR <NR2>
EXAMPLE:	MR 3 Recalls the setup stored in memory location 3.
QUERY SYNTAX:	NONE
RETURNED PARAMETERS:	NONE

MS

DESCRIPTION:	LOAD COMMAND stores the current setup in location “x”
SYNTAX:	MS <NR2>
EXAMPLE:	MS 3 Stores current setup in memory location 3.
QUERY SYNTAX:	NONE
RETURNED PARAMETERS:	NONE

P1

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant power mode at the value specified. In pulse mode, this is the base power setting.
SYNTAX:	P1 <NR2>
EXAMPLE:	P1 253 The power level P1 is set to 253 watts
QUERY SYNTAX:	P1?
RETURNED PARAMETERS:	TEXT ON: <NR2> watts TEXT OFF: <NR2>

P2

DESCRIPTION:	LOAD COMMAND used to set the peak power in pulse mode. **NOTE:** In DELTA mode, the P2 power is summed on top of the P1 power. For Example: If P1=100 watts and P2=150 watts, the actual pulse is between 100 watts and 250 watts.
SYNTAX:	P2 <NR2>
EXAMPLE:	P2 25 The power level P2 is set to 25 watts
QUERY SYNTAX:	P2?
RETURNED PARAMETERS:	TEXT ON: <NR2> watts TEXT OFF: <NR2>

P3

DESCRIPTION: LOAD COMMAND used to set the peak power in pulse mode. **NOTE:** In DELTA mode, the P3 power is summed on top of the P1 and P2 power. For Example: If P1=100 watts, P2=150 watts, and P3 = 50 watts, the actual pulse is from 100 watts to 250 watts to 300 watts.

SYNTAX: P3 <NR2>

EXAMPLE: P3 25
The power level P3 is set to 25 watts

QUERY SYNTAX: P3?

RETURNED PARAMETERS: TEXT ON: <NR2> watts
TEXT OFF: <NR2>

PAA

DESCRIPTION: LOAD CONTROL COMMAND used to select ABSOLUTE method of setting the pulse amplitude. In ABSOLUTE mode, the value entered is the actual load. In contrast, in DELTA mode, the value entered is the amount of load pulsed in addition to the base level.

SYNTAX: PAA

QUERY SYNTAX: PA?

RETURNED PARAMETERS: TEXT ON: ABS
TEXT OFF: 0

PAD

DESCRIPTION: LOAD CONTROL COMMAND used to select DELTA method of setting the pulse amplitude. In DELTA mode, the value entered is the amount of load pulsed in addition to the base level. In contrast, in ABSOLUTE mode, the value entered is the actual load.

SYNTAX: PAD

QUERY SYNTAX: PA?

RETURNED PARAMETERS: TEXT ON: DLT
TEXT OFF: 1

PS ON

DESCRIPTION: LOAD CONTROL COMMAND used to execute the SW or WF command to all modules simultaneously.

SYNTAX: PS ON

QUERY SYNTAX: PS?

RETURNED PARAMETERS:
TEXT ON: PS ON
TEXT OFF: <NR2>

PS OFF

DESCRIPTION: LOAD CONTROL COMMAND used to execute the SW OFF command to all modules simultaneously.

SYNTAX: PS OFF

QUERY SYNTAX: PS?

RETURNED PARAMETERS:
TEXT ON: PS OFF
TEXT OFF: <NR2>

R1

DESCRIPTION: LOAD COMMAND used to set the base resistance to the specified value. **NOTE:** CRL or CRH must have been previously specified to set the mode.

SYNTAX: R1 <NR2>

EXAMPLE: R1 25
The resistance level R1 is set to 25 ohms

QUERY SYNTAX: R1?

RETURNED PARAMETERS:
TEXT ON: <NR2> ohms
TEXT OFF: <NR2>

R2

DESCRIPTION: LOAD COMMAND Used to set the amplitude of the peak loading in constant resistance pulse mode. In DELTA mode, the resistance will be added in parallel to the base resistance. **NOTE:** CRL or CRH must have been previously specified to set the mode.

SYNTAX: R2 <NR2>

EXAMPLE: R2 25
The resistance level R2 is set to 25 ohms

QUERY SYNTAX: R2?

RETURNED PARAMETERS: TEXT ON: <NR2> ohms
TEXT OFF: <NR2>

R3

DESCRIPTION: LOAD COMMAND Used to set the amplitude of the third peak loading in constant resistance pulse mode. In Delta mode, the resistance will be added in parallel to the base resistance and R2. **NOTE:** CRL or CRH must have been previously specified to set the mode.

SYNTAX: R3 <NR2>

EXAMPLE: R2 25
The resistance level R2 is set to 25 ohms

QUERY SYNTAX: R3?

RETURNED PARAMETERS: TEXT ON: <NR2> ohms
TEXT OFF: <NR2>

REC

DESCRIPTION:	LOAD COMMAND recalls the setup stored in location “x”. Identical to MR command.
SYNTAX:	REC <NR2>
EXAMPLE:	REC 3 Recalls the setup stored in memory location 3.
QUERY SYNTAX:	NONE
RETURNED PARAMETERS:	NONE

RST

DESCRIPTION:	LOAD CONTROL COMMAND that returns the programmable load to its power on reset condition (as set in memory location zero) with the load contactor off (LOAD OFF).
SYNTAX:	RST
RELATED QUERY:	None
RESPONSE PARAMETERS:	TEXT ON: None TEXT OFF: None

S1

DESCRIPTION:	LOAD COMMAND used to set the slew rate limit in all modes, including remote programming. The value specified is the number of microseconds it will take to slew from zero to full scale. Command is identical to S2 and SR.
SYNTAX:	S1 <NR2>
EXAMPLE:	S1 10 Sets the slew rate to 10µS.
QUERY SYNTAX:	S1?
RETURNED PARAMETERS:	TEXT ON: <NR2> ∝S TEXT OFF: <NR2>

S2

DESCRIPTION:	LOAD COMMAND used to set the slew rate limit in all modes, including remote programming. The value specified is the number of microseconds it will take to slew from zero to full scale. Command is identical to S1 and SR.
SYNTAX:	S2 <NR2>
EXAMPLE:	S2 10 Sets the slew rate to 10µS.
QUERY SYNTAX:	S2?
RETURNED PARAMETERS:	TEXT ON: <NR2> µS TEXT OFF: <NR2>

SBE

DESCRIPTION: LOAD CONTROL COMMAND that sets the indicated bits in the summary bit enable register mask. When a bit is set in the summary bit enable register, an abnormal condition in the load condition register will be passed through to the status register.

SYNTAX: SBE <NR1>

EXAMPLE: Each of the bits in the summary bit enable register have a decimal weight as indicated in the table below. The weights of the bits to be set are added to form the decimal number that accompanies the command. Any bit whose weight is not added in is cleared. If a bit is cleared its corresponding abnormal condition will not be passed through to status.

BIT	PASSES THROUGH	WEIGHT
7	UV	128
6	OV	64
5	OT	32
4	GPIB ERROR	16
3	OC	8
2	OP	4
1	SAT	2
0	PWR	1

The command LAT 33, will set bits 0 and 5 causing any PWR alarm and OT alarm to be passed to status.

RELATED QUERY: SBE?

RETURNED PARAMETERS: TEXT ON: A comma delimited ASCII string whose components correspond to the set bits.

TEXT OFF: <NR1>.
Where the number is the sum of the weights of the set bits.

SDN

DESCRIPTION: LOAD CONTROL COMMAND that sets the indicated bits in the shutdown mask. When a bit is set in the shutdown mask, an abnormal condition in the status register will shut the load down.

SYNTAX: SDN <NR1>

EXAMPLE: Each of the bits in the shutdown mask register have a decimal weight as indicated in the table below. The weights of the bits to be set are added to form the decimal number that accompanies the command. Any bit whose weight is not added in is cleared. If a bit is cleared its corresponding status condition will not cause a shutdown.

BIT	LATCHES CONDITION	WEIGHT
7	UV	128
6	OV	64
5	OT	32
4	GPIB ERROR	16
3	OC	8
2	OP	4
1	SAT	2
0	PWR	1

The command SDN 33, will set bits 0 and 5 causing any PWR alarm or OT alarm to shut down the unit.

RELATED QUERY: SDN?

RETURNED PARAMETERS: TEXT ON: A comma delimited ASCII string whose components correspond to the set bits.

TEXT OFF: <NR1>.
Where the number is the sum of the weights of the set bits.

SRQ

DESCRIPTION: LOAD CONTROL COMMAND that sets the indicated bits in the IEEE-488 bus SRQ mask, When a bit is set in the SRQ mask, an abnormal condition in the status register will cause a service request.

SYNTAX: SRQ <NR1>

EXAMPLE: Each of the bits in the SRQ mask register have a decimal weight as indicated in the table below. The weights of the bits to be set are added to form the decimal number that accompanies the command. Any bit whose weight is not added in is cleared. If a bit is cleared its corresponding status condition will not cause an IEEE-488 bus service request.

BIT	LATCHES CONDITION	WEIGHT
7	Config	128
6	Change in Status	64
5	Single Shot Complete	32
4	Command Error	16
3	Minor Fault	8
2	Major Fault	4
1	System Minor	2
0	System Major	1

The command SRQ 35 will set bits 0, 1, and 5 causing an SRQ if there is a system major alarm, a system minor alarm or when a pulse burst finishes.

RELATED QUERY: SRQ?

RETURNED PARAMETERS: TEXT ON: An ASCII string whose components correspond to the set bits. These elements are separated by commas.

TEXT OFF: <NR1>.
Where the number is the sum of the weights of the set bits.

SF

DESCRIPTION:	MODE CONTROL COMMAND used to alter the timing characteristics of the pulse generator by pre-scaling the timing clock. When long duration pulsing is required, setting the scale factor (SF) greater than 1 will increase the maximum duration by that factor. **NOTE:** Pulse resolution is decreased by the factor, and the minimum pulse duration is increased by the factor. The maximum scale factor allowed is 255.
SYNTAX:	SF <NR1>
EXAMPLE:	SF 20 Sets the scale factor to 20. Pulse duration may be as long as 268 S, timing resolution is 20µS, and the shortest pulse allowed is 20 µS.
QUERY SYNTAX:	SF?
RETURNED PARAMETERS:	TEXT ON: <NR1> TEXT OFF: <NR1>

SHORT OFF

DESCRIPTION:	LOAD CONTROL COMMAND that removes the load from its “SHORT ON” forced saturation condition. The load returns to its previous mode and state.
SYNTAX:	SHORT OFF
QUERY SYNTAX:	Short?
RESPONSE PARAMETERS:	TEXT ON: SHORT OFF TEXT OFF: 0

SHORT ON

DESCRIPTION: LOAD CONTROL COMMAND that forces the load to a saturated condition presenting the lowest possible electronic impedance to the source under test.

NOTE: Unit under test must have a current limit less than the current rating of the load. The undervoltage lockout must be disabled.

SYNTAX: SHORT ON

RELATED QUERY: SHORT?

RESPONSE PARAMETERS: TEXT ON: SHORT ON
TEXT OFF: 1

SLAVE OFF

DESCRIPTION: MODE CONTROL COMMAND used to turn slave mode off and return to constant current mode with zero input current.

SYNTAX: SLAVE OFF

EXAMPLE: SLAVE OFF
Sets channel in constant current mode .

QUERY SYNTAX: NONE

RETURNED PARAMETERS: NONE

SLAVE ON

DESCRIPTION: MODE CONTROL COMMAND used to set the selected channel in slave mode.

SYNTAX: SLAVE ON

EXAMPLE: SLAVE ON
Sets the selected channel in slave mode.

QUERY SYNTAX: NONE

RETURNED PARAMETERS: NONE

SR

DESCRIPTION:	MODE CONTROL COMMAND used to set the slew rate limits. Slew time for a full scale transition is set to the value specified.
SYNTAX:	SR <NR2>
EXAMPLE:	SR 200 Sets the maximum rise or fall time to 200µS for a 0 - full scale transition.
QUERY SYNTAX:	SR?
RETURNED PARAMETERS:	TEXT ON: <NR2> µS TEXT OFF: <NR2>

SW

DESCRIPTION:	LOAD COMMAND used to initiate pulse operation in all modes. When entered without the optional number, the square waver start and run continuously. When entered with a number, the indicated number of pulses are generated. Note that the number zero (0) is treated the same as omitting the number. **NOTE:** After the specified number of pulses are complete, the load continues to operate at the base value. SW OFF stops pulsing.
SYNTAX:	SW <NR1>
EXAMPLE:	SW 7 Enters pulse mode, generates 7 pulses, then exits pulse mode
QUERY SYNTAX:	None
RETURNED PARAMETERS:	None

SYS OFF

DESCRIPTION:	LOAD COMMAND which causes LOAD OFF and LOAD ON commands to affect only the currently selected channel.

SYNTAX:	SYS OFF
QUERY SYNTAX:	SYS?
RETURNED PARAMETERS:	TEXT ON: OFF TEXT OFF: 0

SYS ON

DESCRIPTION:	LOAD COMMAND which causes LOAD OFF and LOAD ON commands to affect all channels simultaneously.
SYNTAX:	SYS ON
QUERY SYNTAX:	SYS?
RETURNED PARAMETERS:	TEXT ON: ON TEXT OFF: 1

T1

DESCRIPTION:	LOAD COMMAND which establishes time duration in pulse mode. T1 is the time in µS that the base loading is active.
SYNTAX:	T1 <NR1>
EXAMPLE:	T1 1000 Sets base loading duration to 1000 microseconds.
QUERY SYNTAX:	T1?
RETURNED PARAMETERS:	TEXT ON: <NR1> µS TEXT OFF: <NR1>

T2

DESCRIPTION: LOAD COMMAND which establishes time duration in pulse mode. T2 is the time that the second load level is active.

SYNTAX: T2 <NR1>

EXAMPLE: T2 1000
Sets second peak loading duration to 1000 µS

QUERY SYNTAX: T2?

RETURNED PARAMETERS: TEXT ON: <NR1> µS
TEXT OFF: <NR1>

T3

DESCRIPTION: LOAD COMMAND which establishes time duration in three pulse mode. T3 is the time that the third load level is active.

SYNTAX: T3 <NR1>

EXAMPLE: T3 1000
Sets third peak loading duration to 1000 µS

QUERY SYNTAX: T3?

RETURNED PARAMETERS: TEXT ON: <NR1> µS
TEXT OFF: <NR1>

TEXT OFF

DESCRIPTION: LOAD CONTROL COMMAND that returns all the responses from the load in the form of decimal numbers.

SYNTAX: TEXT OFF

RELATED QUERY: NONE

RETURNED PARAMETERS: TEXT ON: None
TEXT OFF: None

TEXT ON

DESCRIPTION: LOAD CONTROL COMMAND that returns all the responses from the load in the form of text strings, and/or values.

SYNTAX: TEXT ON

RELATED QUERY: NONE

RETURNED PARAMETERS: TEXT ON: None
TEXT OFF: None

TP OFF

DESCRIPTION: LOAD COMMAND which disables three level pulsing, returning load to normal square wave mode.

SYNTAX: TP OFF

QUERY SYNTAX: TP?

RETURNED PARAMETERS: TEXT ON: OFF
TEXT OFF: 0

TP ON

DESCRIPTION: LOAD COMMAND which enables three level pulsing.

SYNTAX: TP ON

QUERY SYNTAX: TP?

RETURNED PARAMETERS: TEXT ON: ON
TEXT OFF: 1

UV OFF

DESCRIPTION: LOAD COMMAND which disables the input undervoltage protection.

SYNTAX:	UV OFF
QUERY SYNTAX:	UV?
RETURNED PARAMETERS:	TEXT ON: OFF TEXT OFF: 0

UV ON

DESCRIPTION:	LOAD COMMAND enables the input undervoltage protection. When active, the load will remain inhibited until there is approximately 1 volt present at the input studs.
SYNTAX:	UV ON UV OFF
QUERY SYNTAX:	UV?
RETURNED PARAMETERS:	TEXT ON: ON TEXT OFF: 1

UVP

DESCRIPTION:	LOAD COMMAND which sets a programmable undervoltage shutdown. UVP monitors the readback voltage. When the voltage falls below the setpoint, the channel performs a LOAD OFF. This is unrelated to the UV command.
SYNTAX:	UVP <NR2>
EXAMPLE:	UVP 8 Sets undervoltage shutdown point to 8 volts. May be used to protect battery from over discharge.
QUERY SYNTAX:	UVP?

RETURNED PARAMETERS:	TEXT ON: <NR2> volts TEXT OFF: <NR2>

V1

DESCRIPTION:	MODE COMMAND that places the programmable load in its constant voltage mode at the value specified. In pulse mode, this is the base voltage. **NOTE:** When pulsing in constant voltage mode, higher voltage corresponds to less load. Therefore, V1 is a higher value than V2.
SYNTAX:	V1 <NR2>
EXAMPLE:	V1 25 The voltage level V1 is set to 25 volts
QUERY SYNTAX:	V1?
RETURNED PARAMETERS:	TEXT ON: <NR2> volts TEXT OFF: <NR2>

V2

DESCRIPTION:	LOAD COMMAND used to set the amplitude of the second load level in the constant voltage mode. In DELTA mode, V2 is the amplitude of the voltage drop from the baseline (V1) level.
SYNTAX:	V2 <NR2>
EXAMPLE:	V2 5.3 The voltage level V2 is set to 5.3 volts. Assuming

the example under V1 above, in DELTA mode, the voltage levels pulse from 25 volts to 19.7 volts. In ABSOLUTE mode, the voltage levels pulse from 25 volts to 5.3 volts.

QUERY SYNTAX: V2?

RETURNED PARAMETERS: TEXT ON: <NR2> volts
TEXT OFF: <NR2>

V3

DESCRIPTION: LOAD COMMAND used to set the amplitude of the third pulse in the constant voltage mode. In DELTA mode, V3 is the amplitude of the voltage drop from the second pulse (V2) level.

SYNTAX: V3 <NR2>

EXAMPLE: V3 4
The voltage level V3 is set to 4 volts. Assuming the example under V1 and V2 above. In DELTA mode, the voltage levels pulse from 25 volts to 19.7 volts to 15.7 volts. In ABSOLUTE mode, the voltage levels pulse from 25 volts to 5.3 volts to 4 volts.

QUERY SYNTAX: V3?

RETURNED PARAMETERS: TEXT ON: <NR2> volts
TEXT OFF: <NR2>

WF

DESCRIPTION: LOAD COMMAND used to initiate pulse operation in all modes. When entered without the optional number, the square waves start and run continuously. When entered with a number, the indicated number of pulses are generated. Note that the number zero (0) is treated the same as

omitting the number. **NOTE:** After the specified number of pulses are complete, the load continues to operate at the base value. WF OFF stops pulsing.

SYNTAX: WF <NR1>

EXAMPLE: WF 7
Enters pulse mode, generates 7 pulses, then exits pulse mode

QUERY SYNTAX: None

RETURNED PARAMETERS: None

XM

DESCRIPTION: LOAD COMMAND used in all modes to enable remote analog programming.

SYNTAX: XM ON
XM OFF

EXAMPLE: XM
The load will now begin to respond to the control signal at its external modulation input. A zero to ten volt input signal programs the load from zero to full scale selected current, resistance, and power. In constant voltage mode, zero to ten volts corresponds to full scale to zero volts

QUERY SYNTAX: None

RETURNED PARAMETERS: TEXT ON: None
TEXT OFF: None

*RST

DESCRIPTION: LOAD CONTROL COMMAND that returns the programmable load to its default power on factory settings.

SYNTAX: *RST

RELATED QUERRY: None

RETURNED PARAMETERS: TEXT ON: None
TEXT OFF: None

STATUS & ERROR REPORTING

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 which 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.

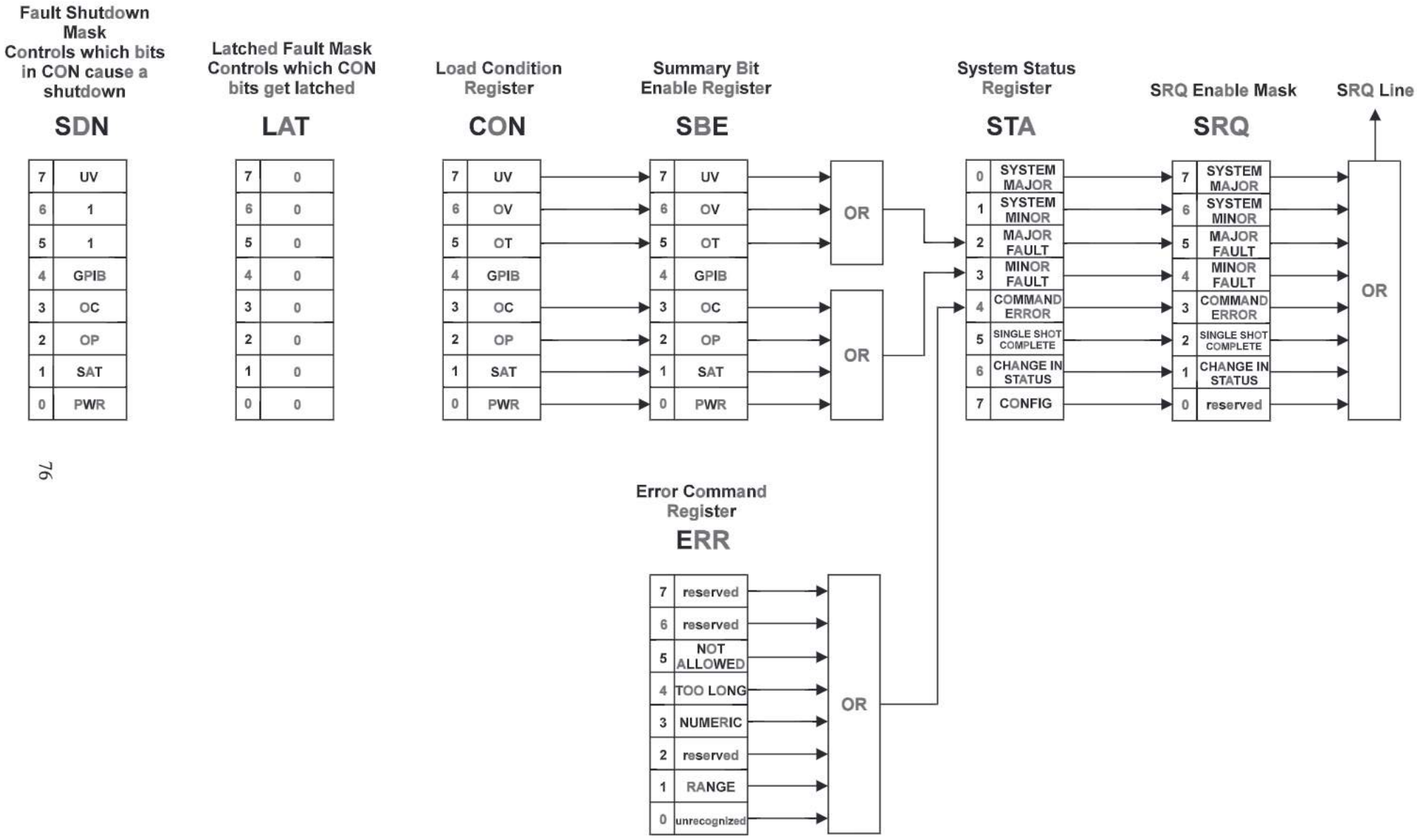
CONDITION, LATCH, SHUTDOWN AND SUMMARY BIT ENABLE REGISTER

BIT	MNEMONIC	INTERPRETATION
7	UV	Indicates an under voltage condition
6	OV	Indicates an over voltage condition
5	OT	Indicates an over temperature condition
4	GPIB ERROR	Indicates a GPIB bus error
3	OC	Indicates current limit condition
2	OP	Indicates a power limit condition
1	SAT	Indicates a load or module saturation condition
0	PWR	Indicates AC power fault

ERROR REGISTER

BIT	MNEMONIC	INTERPRETATION
7	Reserved	Reserved for future use.
6	Reserved	Reserved for future use.
5	Not allowed	The received command is not permitted in the loads present state. For example, a LOAD ON in the presence of a Hardware Failure.
4	Too long	The program line length exceeds

		the loads input buffer.
3	Numeric	A number has been received that can not be interpreted for example, 3.14A2 instead of 3.14.
2	Reserved	Reserved for future use
1	Range	A numerical value either too low or too high has been received.
0	Unrecognized	A command has been received that is not in the loads syntax.



Load Status Logic

ALL I?

DESCRIPTION: Query used to read back the currents through all channels. This returns a comma-delimited string of 10 values. Each value is the current in Amps. The first value is for CH0 and the last being CH9. Channels configured as a slave or not installed will return a 0.0. Current reading for the master includes slave currents.

SYNTAX: ALL I?

RETURNED PARAMETERS:
TEXT ON: <NR2>,<NR2>, ……..<NR2>
TEXT OFF: <NR2>,<NR2>, ……..<NR2>

ALL P?

DESCRIPTION: Query used to read back the power dissipation in all channels. This returns a comma-delimited string of 10 values. Each value is the power in Watts. The first value is for CH0 with the last being CH9. Channels configured as a slave or not installed will return a 0.0. Power reading for the master includes slave power.

SYNTAX: ALL P?

RETURNED PARAMETERS:
TEXT ON: <NR2>,<NR2>, ……..<NR2>
TEXT OFF: <NR2>,<NR2>, ……..<NR2>

ALL V?

DESCRIPTION: Query used to read back the voltage across all channels. This returns a comma-delimited string of 10 values. Each value is the Voltage in Volts. The first value is for CH0 with the last being CH9. Channels not installed will return a 0.0.

SYNTAX: ALL V?

RETURNED PARAMETERS:
TEXT ON: <NR2>,<NR2>, ……..<NR2>
TEXT OFF: <NR2>,<NR2>, ……..<NR2>

CON?

DESCRIPTION: A LOAD STATUS QUERY that reports the contents of the load's condition register.

SYNTAX: CON?

RESPONSE PARAMETERS: TEXT ON: an ASCII string corresponding to each of the bits that are set in the register (see table). The individual responses are separated by commas.

TEXT OFF: <NR1>
Where <NR1> is the sum of the bit weights of each bit that is set.

BIT	MEANING	WEIGHT
7	UV	128
6	OV	64
5	OT	32
4	GPIB ERROR	16
3	OC	8
2	OP	4
1	SAT	2
0	PWR	1

ERR?

DESCRIPTION: A LOAD STATUS QUERY that reports the contents of the load's command error register.

SYNTAX: ERR?

RESPONSE PARAMETERS: TEXT ON: an ASCII string corresponding to each of the bits are set in the register (see table). The individual responses are separated by commas.

TEXT OFF: <NR1>
Where <NR1> is the sum of the bit weights of each bit that is set.

BIT	MEANING	WEIGHT
7	Reserved	128
6	Reserved	64
5	Not Allowed	32
4	Too Long	16
3	Numeric	8
2	Reserved	4
1	Range	2
0	Unrecognized	1

ID?

DESCRIPTION: A LOAD STATUS QUERY that reports the loads full scale ratings.

SYNTAX: ID?

RETURNED PARAMETERS: TEXT ON: MCL488-<NR2> -<NR2>-<NR2>, where the numbers are the full scale voltage, current, power ratings.

TEXT OFF :<NR2>, <NR2>, <NR2|> Where the numbers are the full scale voltage, current, power ratings in that order.

MODE?

DESCRIPTION: A LOAD STATUS QUERY that reports the loads operating mode.

SYNTAX: MODE?

RESPONSE PARAMETERS: TEXT ON: an ASCII string corresponding to each of the bits that are set in the register (see table). The individual responses are separated by commas

TEXT OFF: <NR1>
Where <NR1> is the sum of the bit weights of each bit that is set.

BIT	MEANING	WEIGHT
None	Constant Current	0
0	Constant Voltage	1
1	Constant Power	2
2	Constant Resistance Low (ohms)	4
3	Constant Resistance High (ohms)	8
4	Constant Resistance Low (A/V)	16
5	Constant Resistance High (A/V)	32
6	Slave Mode	64
7	External Modulation	128
8	Pulse Run	256

STA?

DESCRIPTION: A LOAD STATUS QUERY that reports the contents of the status (serial poll) register.

SYNTAX: STA?

RESPONSE PARAMETERS: TEXT ON: an ASCII string corresponding to each of the bits are set in the register (see table). The individual responses are separated by commas.

TEXT OFF: <NR1>
Where <NR1> is the sum of the bit weights of each bit that is set.

BIT	MEANING	WEIGHT
7	Config	128
6	Change in Status	64
5	Single Shot Complete	32
4	Command Error	16
3	Minor Fault	8
2	Major Fault	4
1	System Minor	2
0	System Major	1

VER?

DESCRIPTION: LOAD STATUS QUERY that reports the loads software version.

SYNTAX: VER?

RETURNED PARAMETERS: TEXT ON : VER: <NR2>
TEXT OFF: <NR2>

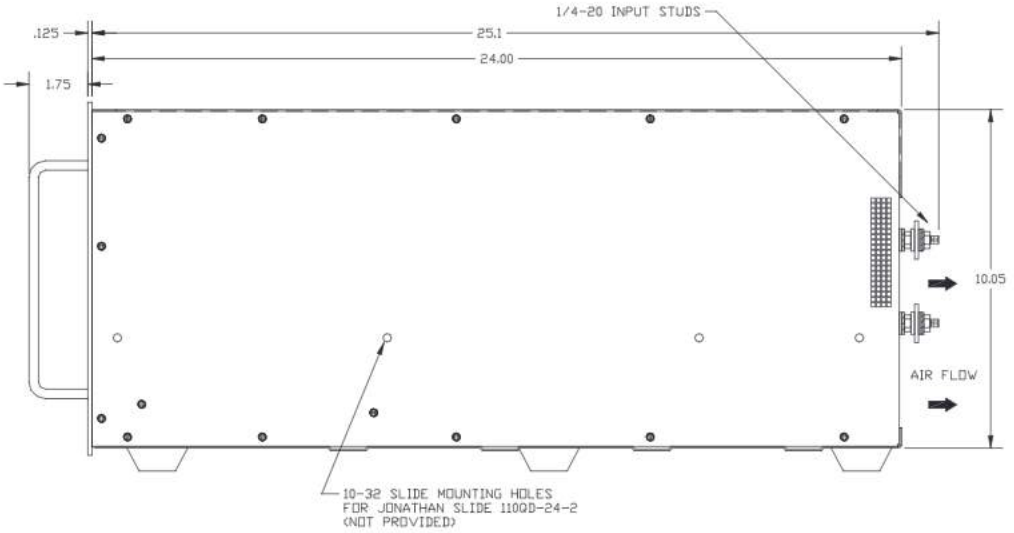
*IDN?

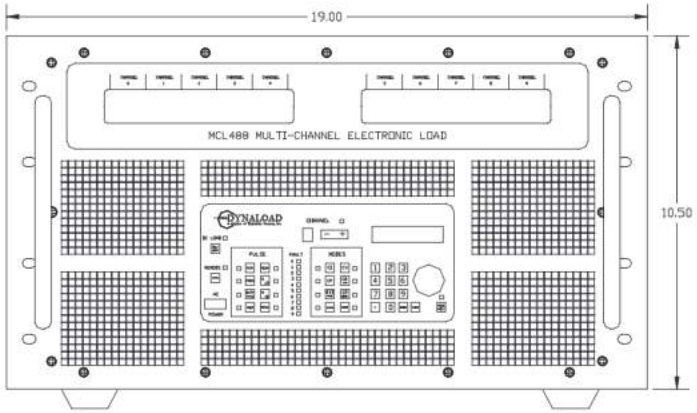
DESCRIPTION: A LOAD QUERY that reports unit type and firmware version.

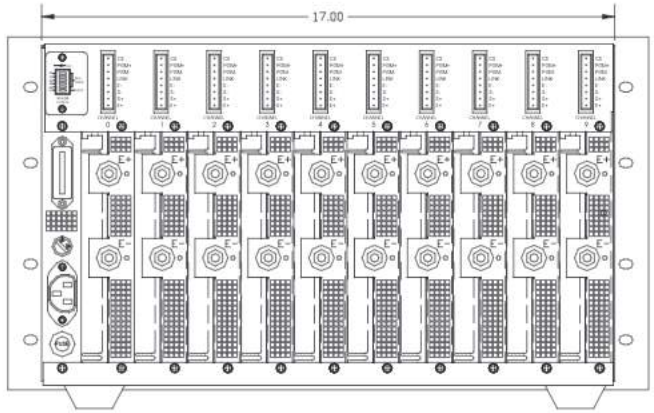
SYNTAX: *IDN?

RETURNED PARAMETERS: Dynaload, MCL488, Version XXX

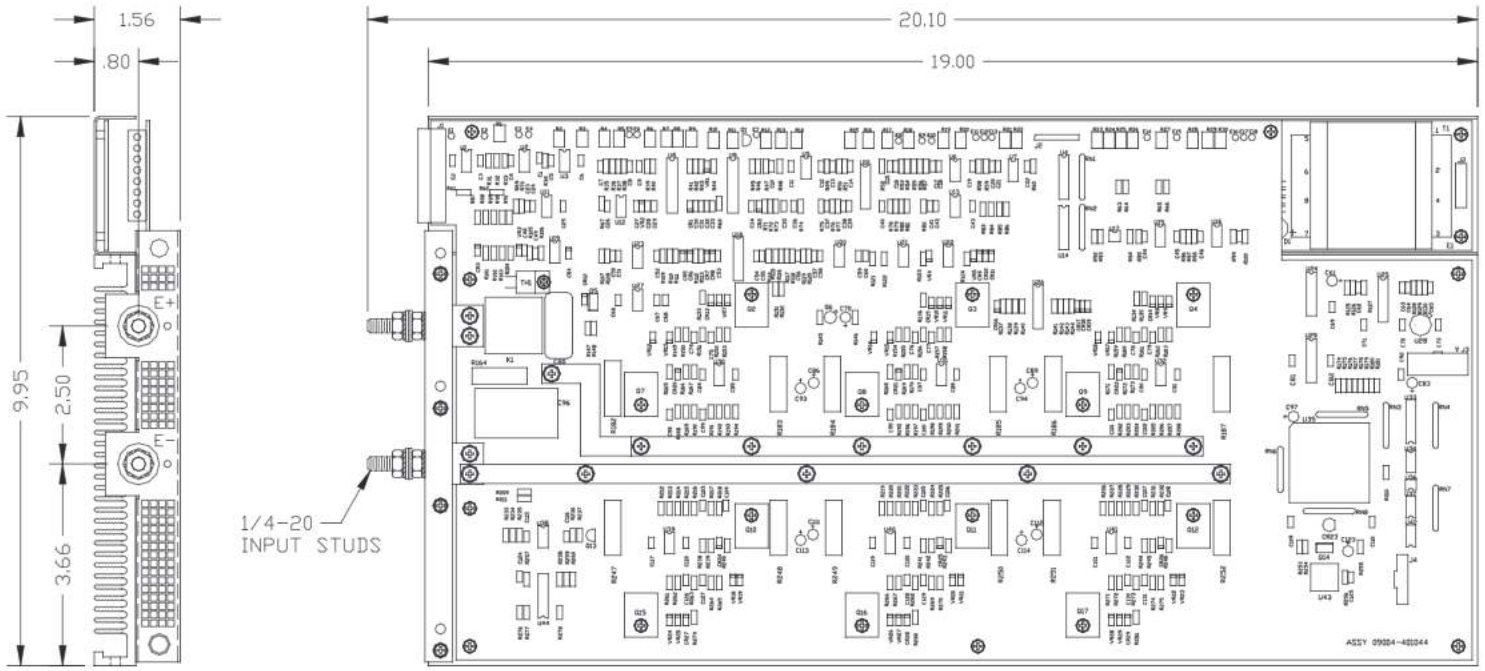
Appendix A







MCL488 CHASSIS OUTLINE



MCL MODULE OUTLINE

Appendix B

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