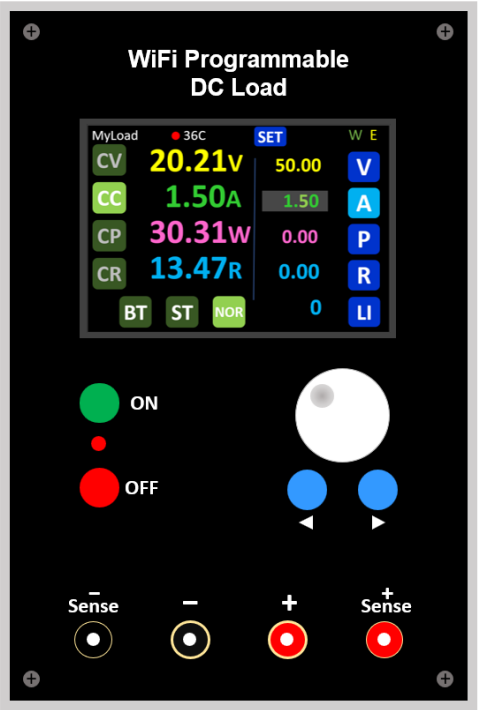
WiFi Programmable DC Load Manual

V1.1 May 2022



This manual describes the features of WiFi Programmable DC Load. It should be read in conjunction with the LCD Controller manual, where some generic features and specifications of the control interface are documented.

Key Features

- 150V and 30A maximum values within a 300W power envelope.
- Constant voltage (CV) current (CC), power (CP) and resistance (CR)modes
- Short-circuit, battery and solar cell testing
- Step test modes (square, ramp and triangle) with variable rise/fall times
- 10 mA and 10 mV resolution
- Touchscreen Control
- Data logging
- Browser and SCPI programmable over WiFi
- Remembers last five WiFi connections
- Power off settings memory
- Temperature controlled fans
- Over-voltage, over-current and reverse voltage protection
- Modular design allows expansion to higher current loads.

Repository: https://github.com/palmerr23/ESP32-DCLOAD

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Safety

Isolated remote control and monitoring via WiFi is the recommended approach for this instrument.

1. Once commissioned, do not make a non-isolated USB connection to the instrument.

- **Almost certain damage will occur if the + terminal is connected to GND and a non-isolated USB connection is also made.** This connection would create a ground loop of the full output voltage of the supply, as the ESP32's USB ground is hard wired to the – terminal of the supply.
- Differing ground potentials may also cause damage if the – terminal is connected to GND terminal unless a USB isolator is employed where a mains earth differential is present between the computer and the supply.
  Both the computer and instrument may be damaged in either case.

2. The load and DUT are NOT PROTECTED under some conditions.

- The load is capable of sinking far in excess (> 100A) of its rated current under some conditions.
- A relay provides some protection for the DUT, but the pulse current may be substantial until this happens.
- The load will sink substantial current if **reverse voltage** is applied.
  While the load is voltage and current protected (relay protected),
  the DUT may be damaged by transient currents.
- The load is protected by relay disconnection beyond its maximum input voltage (150V).
  However, damage may still occur if voltages above this value are applied.

3. The rated voltages and currents of this load are capable of substantial damage, injury or death.

- Never operate the load with the cover removed.
- Ensure that safe work practices are used when the load is used to test high voltages and/or currents.
- Ensure that the load's current setting is always less than the DUT's safe maximum
- Undertake DUT short circuit testing with the load's maximum current setting only a small amount above the DUT short circuit design value.

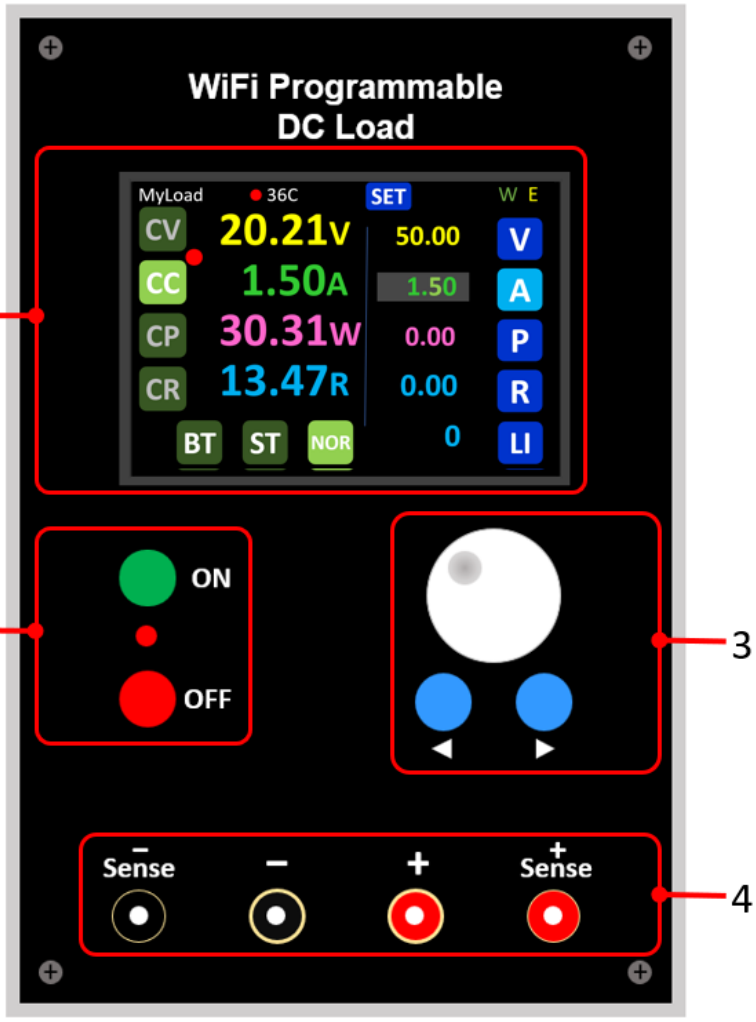
Overview

The WiFi Programmable Electronic DC Load offers high performance and flexibility. It has a user-friendly interface, and solid performance specifications, while being withing the capability of the advanced electronics amateur to construct. Its modular construction allows the constructor to select the most appropriate enclosure and panel layouts for their purposes.

Main features:

- Single channel, DC 150V/30A, total power to 300W
- 4 static modes: CV (Constant Voltage), CC (Constant Current), CP (Constant Power) or CR (Constant Resistance) .
- Dynamic (step) mode offering square, triangle and sawtooth operation in CC, CR, CP or CR modes
- Battery characterisation and testing functions
- 3.5” touch TFT, providing a flexible control interface for all settings and readings.
- Kelvin (4-wire) sensing of Device Under Test voltage.
- Built-in WiFi control via SCPI or Web interface.
- Power-off memory function

Front Panel

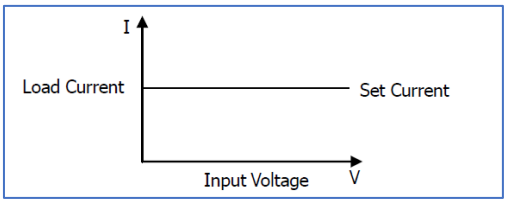


1. TFT touch control screen
2. On/Off buttons and LED indicator
3. Numeric setting controls
4. Binding posts and Kelvin sensing terminals.

Operating Modes

Constant Current (CC)

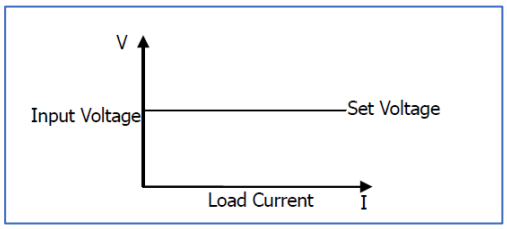
The electronic load will attempt to sink a current in equal to the set value regardless of the input voltage.



Constant Voltage (CV)

The load will attempt to sink enough current to control the input voltage to the set value.

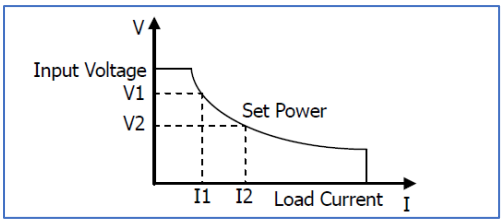
The load acts as a shunt voltage regulator when operating in CV mode.



Constant Power (CP)

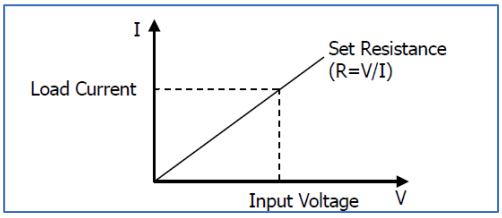
The load will attempt to sink constant power in CP mode.

The load current will change linearly proportional to the input voltage to keep sinking a constant power (P = V x I).



Constant Resistance (CR)

The load attempts to behave like a constant resistance, and changes the current linearly proportional to the input voltage.



Special Functions

Instructions for using the special function modes are provided in the General Operation section.

Battery Test (BAT)

The Battery Test function discharges a battery at a known rate until it reaches a defined voltage. At that point the load switches off.

During this process two characteristics are measured:

- Capacity — Discharge from fully charged to end voltage. Sum the power delivered over time.
- Internal Resistance (Equivalent Series Resistance) — Compare the open circuit voltage to the voltage under discharge at a known current.

The characteristics of some common battery types, and appropriate testing values, can be found at the end of this document.

Step Mode (STEP)

In Step mode, the load can be programmed to switch between two setpoints, or to generate sawtooth or triangular staircases.

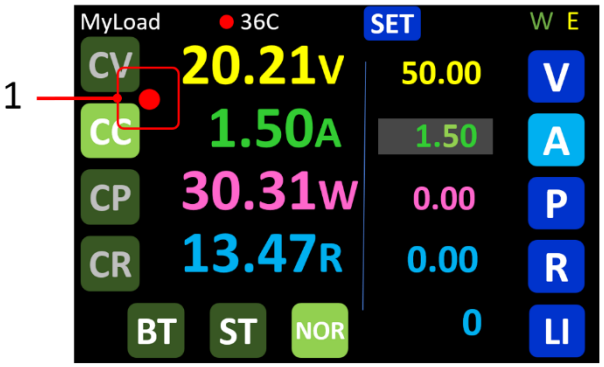
The rise and fall time for the steps is also programmable.

Safe Operating Area and Protection

The device will limit voltage and current in all operational modes and special functions so that it doesn't operate beyond its maximum voltage, current and power ratings.

When the load is on Off mode, the relay is disengaged. However, the voltage sensing circuitry is still connected in Off mode.

The SOA limiting indicator (1) lights when SOA limiting is in effect.

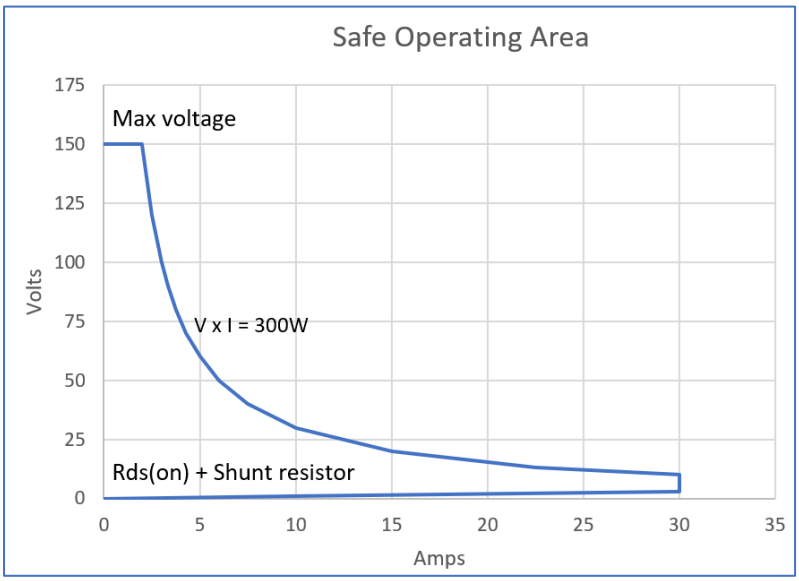


Safe Operating Area Protection

The load automatically limits its current when either the maximum power or current is exceeded.

If the applied voltage goes more than a few volts over the allowed maximum, the load will disconnect.

Limiting values are provided in the Specifications table at the end of this document.



$R_{DS(on)}$ Limits

- The load has a finite minimum resistance which is a combination of the $R_{DS(on)}$ value of the MOSFETs and the current shunt resistors. The value of the combined minimum resistance is in the Specifications table at the end of this document.

Maximum Power

- The load will reduce the current if the applied voltage and actual load current exceed the maximum power dissipation (P = V * I).
- The SOA limiting indicator will light when this condition occurs.

Overvoltage Protection

- The load will set its target current to zero and disconnect, if a voltage greater than the maximum operating voltage is detected.
  When the load is "disconnected" no current will flow, however voltage sensing is still in place.
- While the absolute maximum voltage is well-above the maximum operating voltage, damage will occur to the load if excessive voltage is applied.
- Maximum power limits also apply.

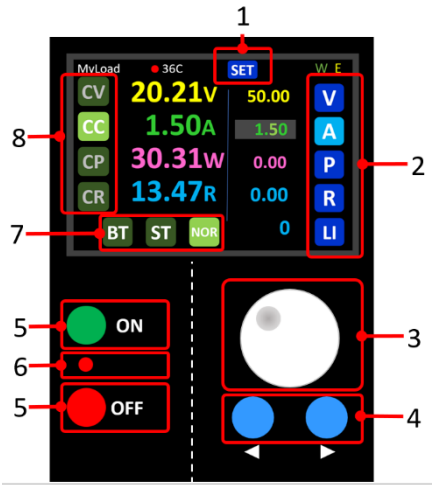
Maximum Current

- It is not possible to set the desired load current greater than the maximum operating value.
- The load will not allow the current to rise above the set value.
- Maximum power limits also apply.

Reverse Voltage and Current

- The load DOES NOT control current in the reverse direction. If a DUT is connected in a way that provides a reverse voltage, substantially unlimited current will flow until the relay disconnects.
- It is unlikely that the load will be damaged by moderate reverse voltages and currents, however the DUT may be damaged if its current limit is exceeded.

General Operation



This section describes the basic control functions and front panel operation.

There are some differences when using the web interface, which are described in the Remote Control section.

On/Off Buttons

The buttons [5] below the LCD screen connect and disconnect the load from the Device Under Test (DUT).

When the load it is disconnected from the DUT, other than the voltage measuring circuit.

The LED [6] between the On and Off buttons indicates the current state of the load, which may also be controlled remotely.

Screens and Menus

Menu items are selected using the coloured buttons on the touch screen [1, 2, 7 & 8]

For instance, on the main screen there are five buttons V, A, P, R & LI on the right-hand side, which set specific operational values. The buttons change brightness when selected to indicate their status (see *Main screen settings*, below).

On the left of the screen are buttons to select the main operating modes: CV (Constant Voltage), CC (Constant Current), CP (Constant Power) or CR (Constant Resistance).

Three special function menu buttons BT (Battery Test), ST (Step mode) and NOR (NORmal mode) are arranged across the bottom of the screen.

The SET (SETtings) button, at the centre top of the screen accesses sub-menus to control STep mode, COMmunication parameters, and CALibration functions.

Changing numeric values

Select the item with its associated on-screen button, and use the numeric setting controls [3 & 4] (rotary encoder and buttons) to alter settings. When a setting is selected its background is highlighted, as is one of the digits. The rotary encoder [3] will change the value by 1 unit of the highlighted digit per click. Clockwise rotation increases the value, anti-clockwise decreases it.

Voltage (V) setting selected and the 'units' digit being edited.

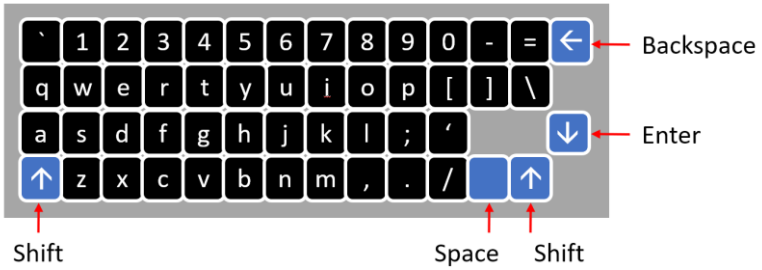
The highlighted digit is changed by the buttons [4] under the encoder (*digit buttons*). The left button will move the highlight to a more significant digit, and the right button to a less significant digit.

On/off settings

Touching a selection button for toggle controls [7] (BT, STEP and NOR) will change the value, as will rotating the encoder knob [3] or pressing the numeric setting buttons [4] (right button or clockwise rotation = On, left button or anti-clockwise rotation = Off).

Changing text values

An on-screen keyboard is displayed for test values when the associated selection button is touched. As the individual characters are small, a stylus is recommended to operate the on-screen keyboard.



When a character is touched, it is appended to the end of the string. Backspace deletes the last character typed.

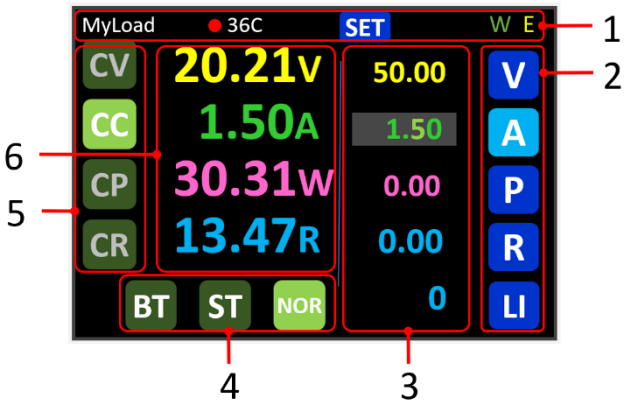
Shift buttons at the lower right and left change the case off alphabetic characters and which symbols or numbers are displayed.

The *Enter* button saves the value and returns to the menu screen.

Processing of the underpinning menu screen is suspended while the on-screen keyboard is active.

Main Screen

1. Indicators and settings menu button
2. Setting selection buttons
3. Voltage, Current, Power and Resistance value settings
4. Special function buttons
5. Operating mode selection buttons
6. Voltage, Current, Power and Resistance readings



When values are out of range, the touch screen displays "***". This most commonly occurs only for the calculated resistance reading, if the calculated value is > 999.99 Ohms (high voltage and low current).

Top row of screen

- The name assigned to the device is on the left. It can be altered in the Settings > Communications menu.
- Heatsink temperature and fan indicator (no indicator = low speed, green = medium speed, red = full speed).
- The SET button provides access to the STEP, CAL and COM menus.
- Wireless connected (W) and EEPROM save pending (E) indicators on the right.

Main screen settings

Settings are saved automatically to EEPROM approximately thirty seconds after the last value was changed. The [E] indicator is displayed when a save is pending.

Values are not saved more regularly as EEPROM has a limited (~10,000) write cycle lifetime.

Voltage, current, power and resistance target setting

Touch the **V, A P or R** button on the screen to enable the related control setting.

Use the rotary encoder and buttons, as described in *General Operation* above, to set the desired output voltage.

Note: The screen settings display updates in real time if values are changed remotely (SCPI or web interface).

Mode setting

Touch the **CV** (Constant Voltage), **CC** (Constant Current), **CP** (Constant Power) or **CR** (Constant Resistance) buttons to select the desired operating mode.

When switched On, the load will seek an operating point corresponding to the related V, A, P or R setting.

Special Functions

The **BT** (Battery Test) and **ST** (STep mode) buttons at the bottom of the screen select these functions.

Pressing a special function button starts the function sequence. The button is red while the function is operating.

When the special function is operating, it can be aborted by touching the **NOR** button, or by pressing the Off switch on the main control panel.

Setting the Operating Modes

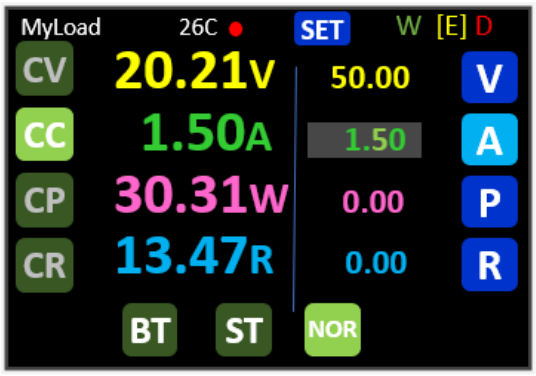
Constant Current (CC)

In CC mode, the electronic load will attempt to sink a current in equal to set value regardless of the input voltage.

The load will limit the current to within its Safe Operating Area (SOA) while in this mode.

Operation

1. Set the mode to CC and the desired current in Amps.
2. Connect the DUT and press the On button.
3. Pressing the Off switch will disconnect the load from the DUT.



Short Circuit Testing

Set the target current greater that the DUT's maximum to test its short circuit capability.

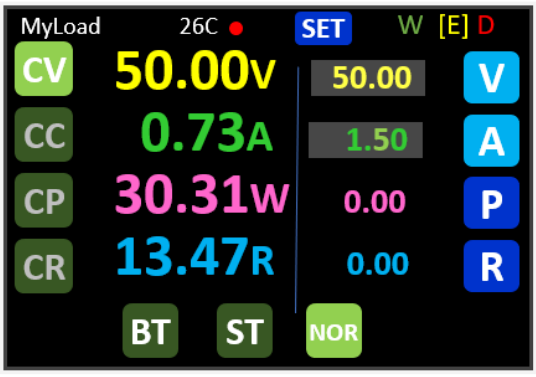
Warning: The DUT may be damaged if the maximum current value is set too high.

Constant Voltage (CV)

In CV mode, the load will attempt to sink enough current to control the input voltage to the set value. The load acts as a shunt voltage regulator when operating in CV mode.

The load will not sink more than the set current while attempting to reach the desired voltage.

The load will limit the current to within its Safe Operating Area (SOA) while in this mode.



Operation

1. Set the mode to CV and the desired target voltage.
2. Set the maximum current.
3. Connect the DUT and press the On button.
4. Pressing the Off switch will disconnect the load from the DUT.

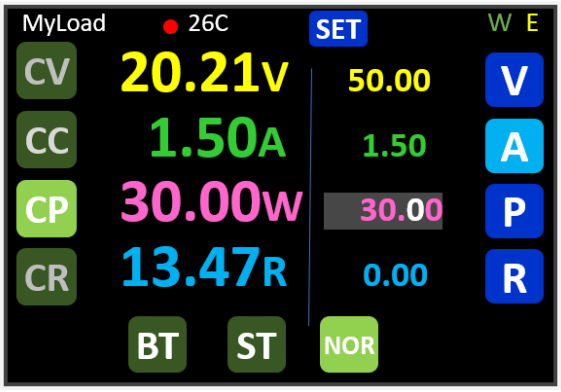
Constant Power (CP)

The load attempts to sink constant power in CP mode.

The load current will change linearly proportional to the input voltage to keep sinking a constant power (P = V x I).

The load will not sink more than the set current while attempting to reach the desired power.

The load will limit the current and voltage to within its Safe Operating Area (SOA) while in this mode.



Operation

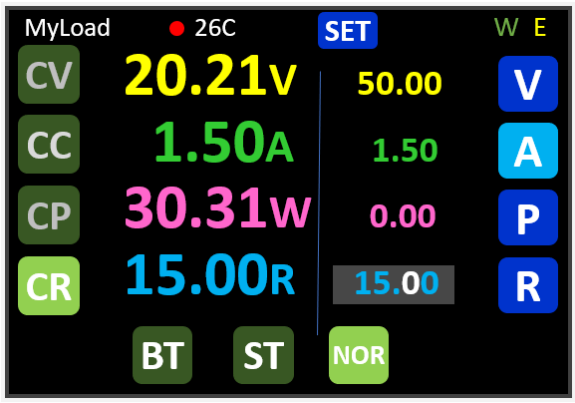
1. Set the mode to CP and the desired target power.
2. Set the maximum current.
3. Connect the DUT and press the On button.
4. Pressing the Off switch will disconnect the load from the DUT.

Constant Resistance (CR)

In CR mode, the load behaves like a constant resistance, and changes the current proportional to the input voltage.

The load will not sink more than the set current while attempting to reach the desired resistance.

The load will limit the current and voltage to within its Safe Operating Area (SOA) while in this mode.



Operation

1. Set the mode to CR and the desired load resistance.
2. Set the maximum current.
3. Connect the DUT and press the On button.
4. Pressing the Off switch will disconnect the load from the DUT.

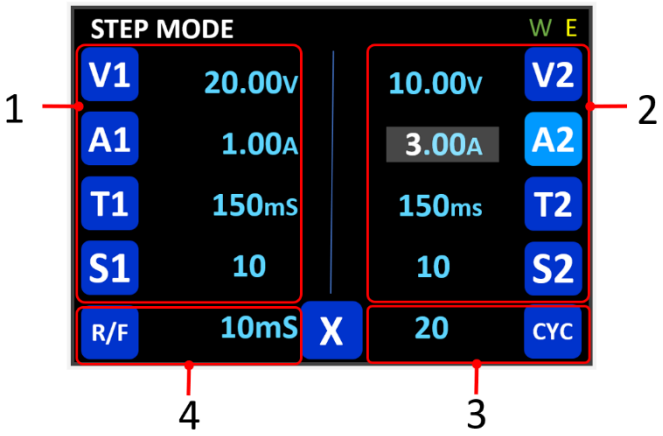
Step Mode

The Step function alternates between two setpoints and may operate in CC, CV, CR or CP mode.

It can provide a simple ‘square’ wave, alternating between the two setpoints; sawtooth or triangular staircases with a selectable number of steps.

The main screen V, A, P and R settings are disabled for Step mode, which has its own settings screen, accessed by touching the SET button on the main screen and then the STEP button on the SETTINGS menu.

1. First stage settings
   a. Voltage
   b. Current
   c. Dwell time for each step
   d. Number of steps in the staircase
   (0 = square or triangle wave)
2. Second stage settings (as for first stage)
3. Number of cycles of the S1/S1 sequence
4. Rise/Fall time between steps



Settings

The operating mode (CC, CV, CR or CP) is selected on the main screen. The mode is combined with the parameters on the STEP settings screen to determine the appropriate operating point at any given moment.

S1 and S2 parameters:

- V&A: The desired voltage (CV mode) or current (CC mode).
  For CR and CP modes, the desired value is calculated from P = V * A or R = V / A.
  Any parameter for S1 may have a higher or lower value than that of S2.
- T: The time (mS)to dwell at each step of the staircase (triangle/sawtooth) or the time at each setting (square).
  The minimum value of T is 5mS, to avoid rapid oscillation between the setpoints.
  The dwell time includes any rise/fall time value.
- S: The number of steps between the two setpoints.
  Setting both these value to 0 provides a ‘square’ wave, one zero generates a one-way staircase (sawtooth), both non-zero gives an up/down staircase (triangle) output.

CYCles: The number of iterations of the S1 / S2 sequence. Setting the value to zero causes endless repetition.

R/F: Rise and fall time (mS) between stages and steps.
The rise/fall slope is a series of 1mS steps between the two values, rather than a smooth transition.
Setting this value to zero will reduce the rise/fall times to the load’s minimum values (approx. 100uS).
The setting must be less than the dwell times (T1 and T2) for the slewing process to properly complete within each step or stage.

Note: for short rise/fall times(<100mS), particularly when the T1 or T2 parameters are also short (< 100mS), a distorted waveform may be generated, due to the ESP32 task scheduler needing to refresh the screen at regular intervals.

Operation

Step mode limits both current and voltage to the maximum for each step. Main screen modes and values are ignored while stepping.

- For voltage stepping mode operation, set A1 and A2 higher than required for the DUT.
- For current stepping mode, set V1 & V2 higher than the DUT will supply.
- Power and resistance stepping can be accommodated between two specific operating points defined by V1 & A1 and V2 & A2.

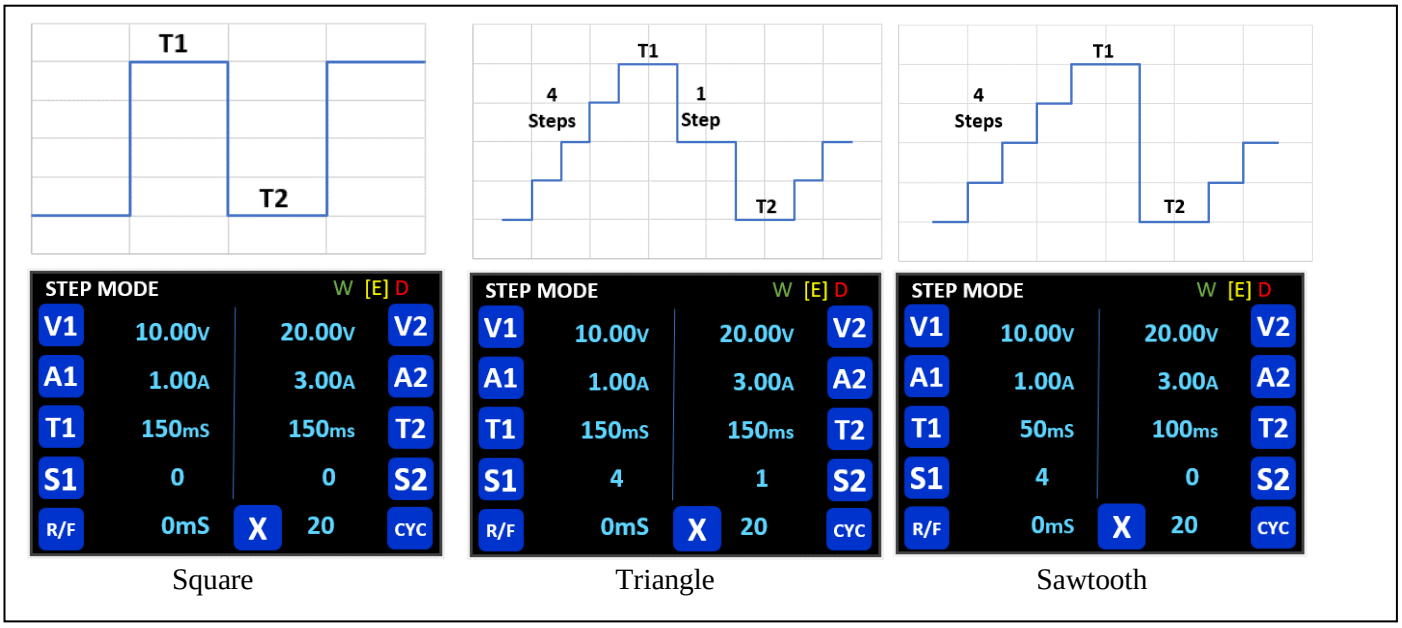
The STep button on the main screen starts the sequence. The button's colour changes to red indicate that the Step sequence is running:

The load is disconnected when the STEP sequence completes and NORmal mode is reinstated.

To stop a running STEP sequence, tap the NOR button on the main screen or press the Off switch.

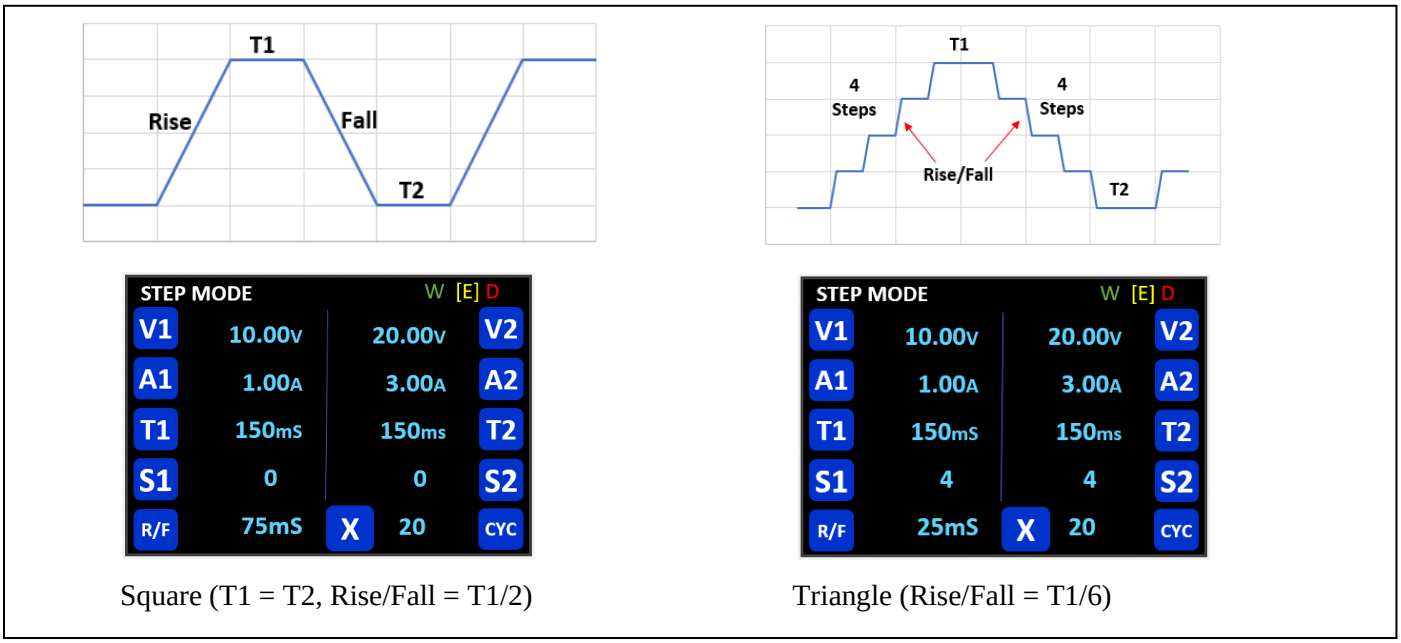
Examples

Rise/Fall = 0



Square Triangle Sawtooth

Rise/fall > 0



Square (T1 = T2, Rise/Fall = T1/2) Triangle (Rise/Fall = T1/6)

Battery Testing Mode

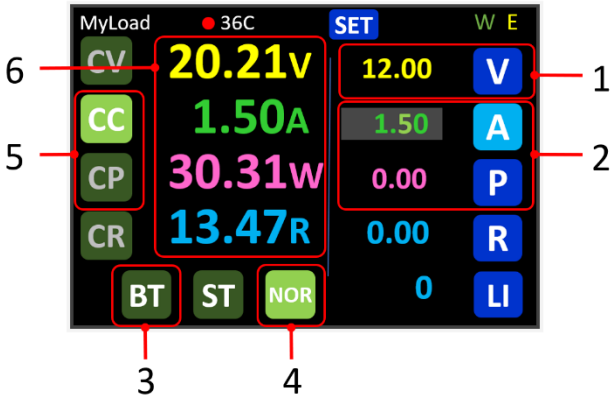
While batteries are normally tested in Constant Current mode, CP mode can also be used.

CV mode is not available for battery testing. If it is selected at the start of a test, the mode will automatically switch to Constant Current mode, and the load will change to the Off state.

Settings

1. Battery test final (end of test) voltage
2. Discharge current or power
3. Battery test start button (BT)
4. Battery test cancel button (NOR)
5. Discharge modes (CC, CP or CR only)
6. Live readings

In battery testing mode Logging is always enabled, and a log item is stored every 60 seconds when the internal resistance is measured.



Operation

1. Touch the **V** button and enter the discharged battery voltage (endpoint for the test).
2. Select the appropriate discharge mode (**CC, CR** or **CP**) and enter the desired discharge rate (Amps, Ohms or Power) on the right hand settings.
3. Ensure the output is **Off.**
4. Connect the battery.
5. Touch the **BAT** button to initiate testing. The test will continue until the battery voltage reaches the set target voltage.
   If the test immediately completes, try starting the test with the load connected (On).
6. During testing, the load will calculate the internal resistance of the battery at the beginning and end of the cycle and every 60 seconds during discharge. The discharge current is set to zero for a few seconds each time, so that the open circuit voltage can be measured.
   The battery voltage, current and power being delivered are displayed on the screen while testing proceeds.
7. The test can be aborted at any time by touching the NOR button.
   If the Off switch is used to cancel the test, the final values will not be displayed or logged.
8. Once the battery reaches the target discharge voltage, the load will change to the Off state and display the final test results – initial and final internal resistance and battery capacity (AH and mAH).

To stop a running battery test, tap the **NOR** button on the main screen. The test results, calculated to that point, will be displayed.

The **Off** switch will also cancel a test, however the final results are not displayed or logged.

At any time, until another test is started, or the load is switched to **On**, the test logs can be accessed via the web interface (see below).

The ESR and total energy (Watt-hours) discharged values are interleaved with the logged battery voltage readings, as they are calculated.

Logging

Logging is managed via the main screen Log Interval (LI) setting. The minimum time between log entries is 10mS, and the minimum increment is 10 mS.

A zero (0) value in LI sets logging:

- disabled for NOR mode.
- to SYNC mode for STEP and BAT (see below).

Log values are available via the web interface, and may be queried at any point via SCPI.

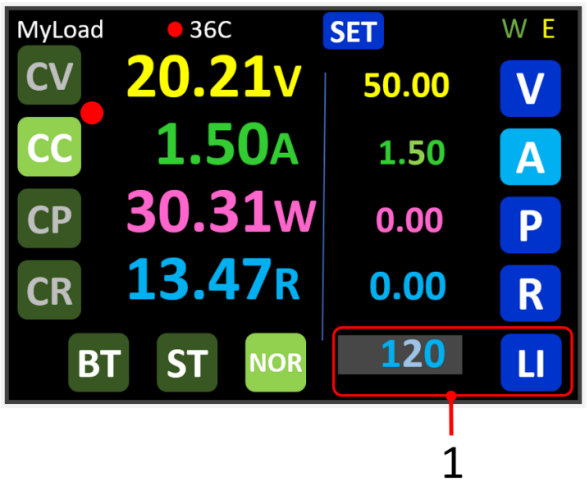
The web interface does not need to be live throughout the duration of logging.

Logging results can be called up at any time during the test process or afterward. As the data is held in RAM memory, it is cleared when the load is switched On or the next BAT or STEP operation commenced.

If the maximum number of log measurements (1000) is reached, the earliest values logged are overwritten with newer data.

Operation

1. On the main screen set the LI parameter.
   Very small values of Log Interval (<100mS) are not permitted to avoid high processor loads
   A zero setting disables logging.
2. Logging data is cleared and logging re-started when any of the following occurs.
   - The On button is pressed.
   - BT or ST modes are initiated.
3. Log data stops being collected when the output is set Off, either by pressing the Off button, or STEP or BAT mode terminating.



Log data remains available, via the web or SCPI interfaces, until the On button is pressed, or another BAT/STEP cycle is initiated.

The log data format is detailed below.

Step Mode

In step mode, logging begins when Step mode is initiated and ceases when Step mode completes or is aborted.

SYNC mode (LT = 0)	Synchronises log reading with steps and stages. Takes one reading at the end of each step or stage.
FREE mode (LT > 0)	Free-running, logs at fixed intervals, regardless of Step mode settings. Logs each LT period, regardless of step and stage state.

Battery Test Mode

In BT mode, logging begins when BT mode is initiated and ceases when the test completes or is aborted.

Every 60 seconds, discharge is paused and the open circuit voltage measured, so that the battery's internal resistance can be calculated. The open circuit voltage (OCV) and internal resistance (ESR) are logged.

SYNC mode (LT = 0)	Synchronises log reading with the regular calculation of battery internal resistance. Takes one reading at the end of each step or stage.
FREE mode (LT > 0)	Free-running, logs at fixed intervals, regardless of Step mode settings. Logs each LT period, regardless of step and stage state.

Note: In Battery test mode, the Setting line on the web interface plot includes the setting (CC, CR or CP value), the ESR and Open Circuit Voltage. The CSV log properly identifies all the different values of Setting.

Log Results

Results are available via the web interface or SCPI until the next cycle is initiated (On, BT or ST buttons pressed).

Partial results can be obtained at any point in the logging cycle by pressing the Update button on the Log tab of the web interface. Note that accessing large log datasets during a measurement sequence may cause delays to that sequence.

The data is presented as comma delimited text (CSV) with a five line heading block and column headers on row 6.

For each measurement, logging reports:

- Time of measurement is in *milliseconds* since the start of the test.
- Current reading (A)
- Voltage reading (V)
- Setting (V, A, W, R – as indicated by mode)
- Mode [CV, CC, CP, CR]
- Function [NOR, BAT, STEP]

```
DC Load Log
Project:
Date:
Operator:
Entries, 3
Time,Voltage,Current,Setting,Mode,Function
0, 12.23, 0.25, 0.25, CC, NOR
50, 10.23, 0.25, 0.25, CC, NOR
100, 12.02, 0.25, 0.25, CC, NOR
```

Battery Test Logs

In Battery test mode, the Setting line on the web interface plot includes the setting (CC, CR or CP value), the ESR and Open Circuit Voltage. The CSV log properly identifies all the different values of Setting.

- Time of measurement is in *seconds* since the start of the test.
- At the start of the test, after the load is connected (On), the battery-is-discharged voltage setting and the discharge current or power setting are logged, depending on the discharge mode selected
- Every 60 seconds, and at the end of the test, the following data is recorded
    - Equivalent series resistance (ESR_
    - Open circuit voltage (OCV)
    - Capacity in AH and mAH (CAP & CAPM)
- The values at the end of the run are recorded after the load has been disconnected.

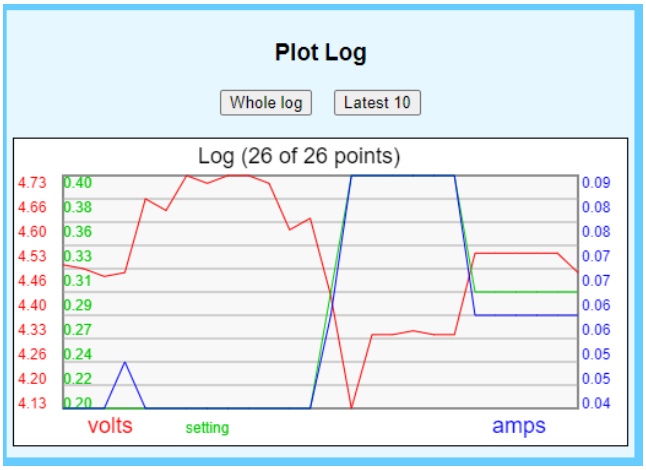
```
DC Load Log
Project:
Date:
Operator:
Entries, 26
Time,Voltage,Current,Setting,Mode,
Function
0,10.07,0.20,7.00,TERM_V,BAT
0,10.07,0.20,0.20,DIS_A,BAT
62,10.07,0.20,0.20,CC,BAT
63,10.07,0.20,10.58,ESR,BAT
63,10.07,0.20,12.23,OCV,BAT
63,10.07,0.20,0.00,CAP,BAT
63,10.07,0.20,3.42,CAPM,BAT
                ...
      NOR button pressed or
    terminal voltage reached.
70,12.23,0.00,10.52,ESR,BAT
70,12.23,0.00,10.14,CCV,BAT
70,12.23,0.00,0.01,CAP,BAT
70,12.23,0.00,9.33,CAPM,BAT
```

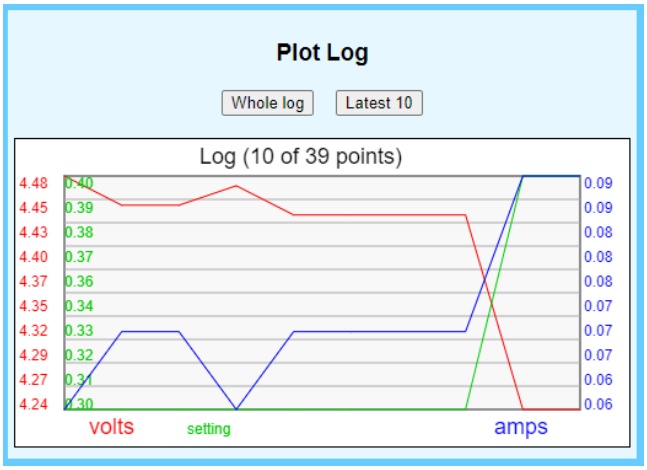
Log Data Plot

The Log screen has a plotting function so that the progress of a test can be monitored.

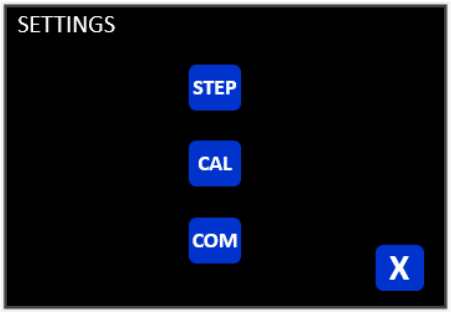
There are two display options:

- The entire log
- The last 10 readings.





Settings Menu



- The Settings menu provides access to three sub-menus:
- STEP: controlling the STEP mode settings
- CAL: voltage, current and screen calibration.
- COM: WiFi and hostname.

Note: Settings are not saved permanently until the [E] indicator at the top right of the screen has gone out (approx. 30 seconds after the last change).

Step Screen

The operation of this menu is described in the General Operation section, above.

Calibration Screen

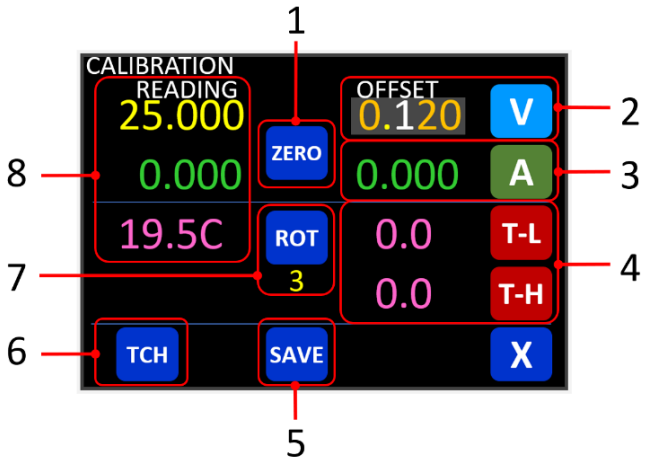
The Calibration screen provides two functions

- Calibrating voltage, current and temperature measurements
- Aligning the touch screen (sub menu)

Voltage, Current and Temperature Calibration

Calibration Screen

1	Zero current and voltage calibration button
2	Voltage offset (calibration) button and value
3	Current offset (calibration) button and value
4	Temperature low and high offset buttons and values
5	Voltage, current and temperature calibration update (Save) button
6	Touch panel calibration menu button
7	Touch screen rotate button and value
8	Live voltage, current and temperature readings



High Volts Calibration

1. Connect the Load to a voltage source (preferably higher than 50V DC).
2. Connect a voltmeter across the load.
3. Do not press the load's On switch.
4. Select CV and set the voltage to a higher value than the test voltage.
5. Navigate to the Calibration menu (SET > CAL).
6. Select the V button and set the voltage OFFSET value to the difference between the voltmeter reading and the value displayed on the left of the screen. If the displayed value is low, the required offset will be positive.
7. Press SAVE.
8. The offset is limited to +/- 5 V to avoid mishaps. If the error is beyond this limit, repeat the process until the correct value is reached.

High Amps Calibration

1. Connect the Load to a current source (preferably higher than 10A).
2. Connect an ammeter in series with the load.
3. Select CC and set the load's current to the desired test current.
4. Press the load's On switch.

5. Navigate to the Calibration menu (SET > CAL).
6. Select the A button and set the current OFFSET value to the difference between the ammeter reading and the value displayed on the left of the screen. If the displayed value is low, the required offset will be positive.
7. Press SAVE.
8. The offset is limited to +/- 2 A to avoid mishaps. If the error is beyond this limit, repeat the process until the correct value is reached.

Zero Volts and Amps Calibration

1. Disconnect the Load from any source.
2. Navigate to the Calibration menu (SET > CAL).
3. Touch the ZERO button (the voltage and current zero offsets are automatically calculated).
4. Press SAVE

Zero amps calibration is automatically performed whenever the output is off for more than a few seconds.

Temperature Calibration

A two-point calibration process is used for temperature.

- The LOW value should be close to 20°C (room temperature).
- The HIGH value should be close to the shut-off temperature (65°C).

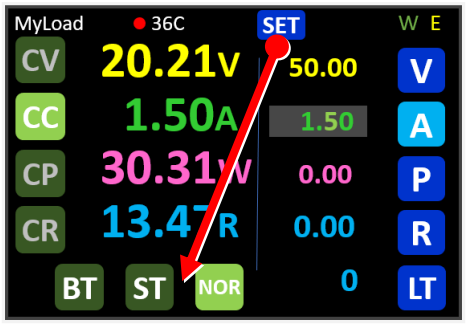
If a more convenient method is not available, equal volumes of room temperature (20°C) and boiling water will produce a temperature close enough to 60°C for our purposes.

1. Stabilise the thermistor at a suitable low temperature.
2. Input the offset into the T-L setting on the calibration menu.
3. Press SAVE.
4. Repeat the process with a suitable high temperature and the T-H button.

Each calibration setting may be saved separately, or several calibrations made while in the menu, then saved.

All calibration settings are be saved to EEPROM after the E indicator goes out (approx. 30 seconds after the last setting or calibration change).

Touch Screen Alignment



Screen Rotation

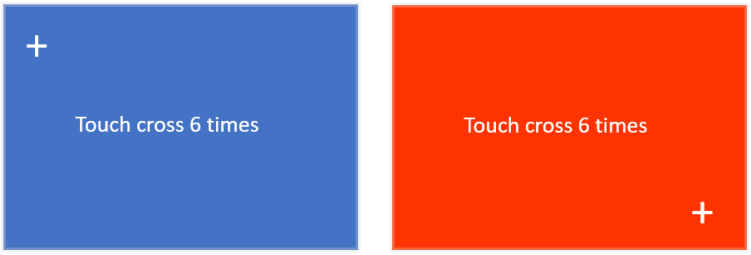
Some TFT displays have the touch panel rotated by 180 degrees. If your touch panel does not appear to be responding, tap the main screen diagonally opposite to the SET button. If the SETTINGS menu appears, tap the CAL button in the middle of the screen enter the CALIBRATION menu to rotate the touch settings.

The number under the ROT button will be 1 or 3 depending on the current touch panel rotation.

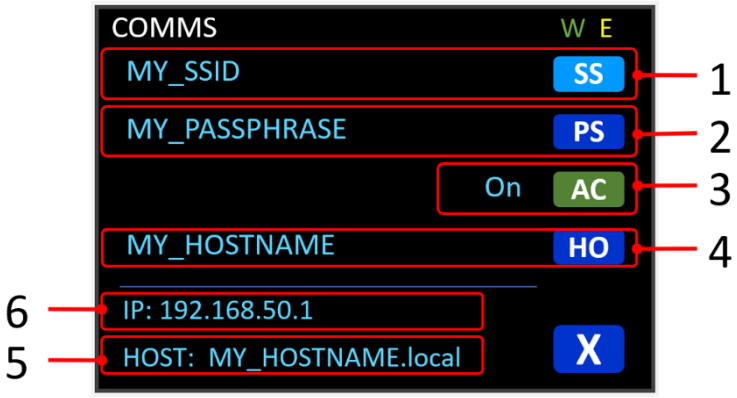
Touch screen alignment is only required if the control buttons or on-screen keyboard touch positions are offset from the display.

Touching the screen six times on the + sign at the top left corner of the blue screen, and then 5 times on the + sign at the bottom right corner of the red screen calibrates the touch screen relative to the display panel.

A stylus is recommended for this operation.



Communications Screen



1. SSID button and value
2. WiFi Passphrase button and value
3. WiFi Auto-connect button
4. Hostname (instrument name) button and value
5. IP address reading
6. Local hostname reading

The Communications screen is entered by touching the COM button on the main screen, and exited with the X button.

The load remembers the last five SSIDs entered, replacing the least-recently used if additional credentials are saved.

Changing settings

Select the appropriate blue button to change the SSID or WiFi passphrase using the on-screen keyboard, as outlined above. *Hostname* changes will not affect the Web address (HOST:) until the WiFi connection is refreshed (*AC* Off then On).

To satisfy the requirements of IEEE 802.11 value and are case-sensitive.

- SSIDs may be up to 32 characters in length. While any valid 8-bit value (e.g. special characters) is permitted, non-alphabetic and non-numeric values should be used with care.
- Passphrases must be between 8 and 32 characters long (WPA2 enforces an eight character minimum). Any legitimate 8-bit value is acceptable.

Changes to Windows 10/11 Bonjour services in 2021 mean that the load can no longer be addressed as hostname.local without Windows registry changes.

Remote Control

Web Interface

A simple web interface is provided for the supply. It is accessible from the web address indicated on the COM screen, (on the standard Port 80). Using the example above, the URLs would be:

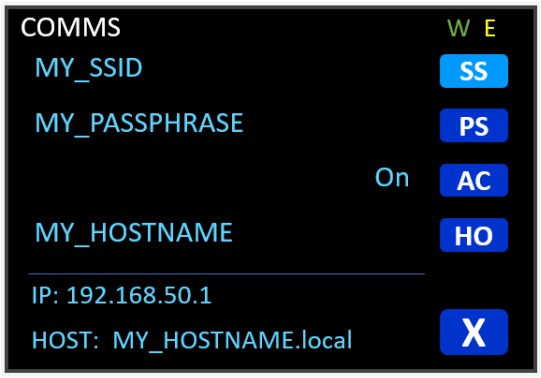
http://192.168.50.1
or
http:// MY_HOSTNAME.local (not available on some WiFi LANs / operating systems).

Accessing the web interface

The URL for the web screens is found on the SETTINGS > COMMS menu. Either the IP address can be used or the hostname*.

Communication is not encrypted.

* On some WiFi LANs the hostname mode may not work due to router or operating system configurations.

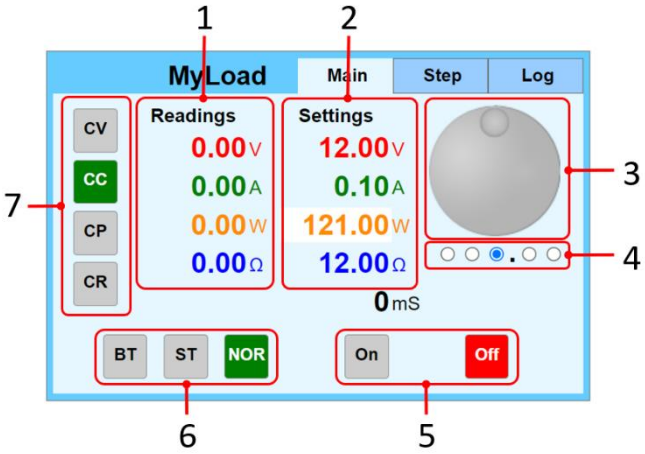


Main Tab

The main screen operates in a manner similar to the load's front panel.

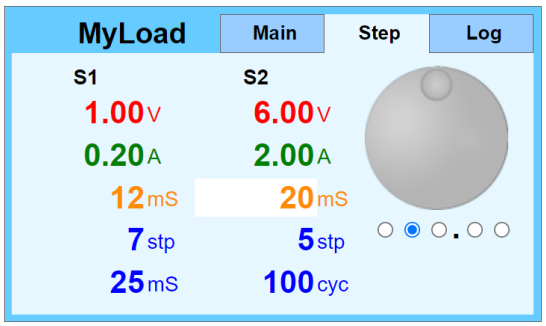
The main difference is that a Settings value [2] is clicked to enable editing.
The selected value has a white background (Watts in the diagram below).

The radio buttons [4] under the scrubber knob [3] determine which unit is changed [e.g. tens, units or decimals).
(Each unit of knob rotation will increment/decrement by one unit in the diagram below).



Step Tab

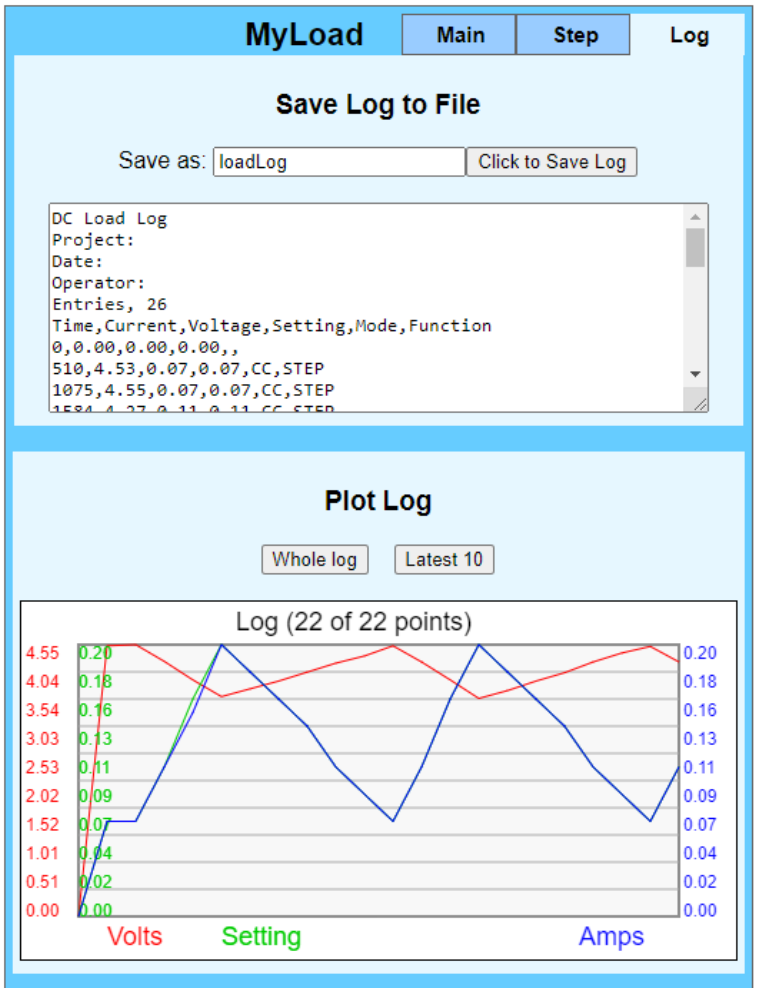
As for the Main menu, in the Step menu, the are selected for editing by clicking on the value.
(S2 dwell time is selected in the diagram below, and each unit of knob rotation will increment/decrement by ten units).



Log Tab

The Log tab has two functions:

1. To save Log data to a host computer.
2. to graphically display the current log data, mainly to ensure it is being correctly captured during a test cycle.

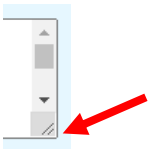


Save Log data

1. Enter a file name into the *Save as:* field.
2. Click the Save Log button.

Data will then be copied into the text box as well as saved to the host computer.

The size of the text box can be altered by dragging the bottom corner of the right-hand scroll bar



The plotting function auto-scales to the values displayed. The Setting value displayed is that indicated by the function mode (CV, CC, CR or CP).

In the diagram opposite the mode is CC (see log file listing) so the green Setting value plotted is Amps (almost identical to the blue Amps data).

TestController

Most of the inbuilt functions are controllable from the device Setup in TestController. Calibration is not supported on any of the remote-control interfaces. TestController has its own logging and charting functions.

It is best to avoid changing settings on either the touch screen or the web interface while using TestController, as values are not always updated in TestController if they are changed elsewhere.

Extensive documentation is available at
https://lygte-info.dk/project/TestControllerCommands%20UK.html

The TestController forum is at
https://www.eevblog.com/forum/testgear/program-that-can-log-from-many-multimeters/

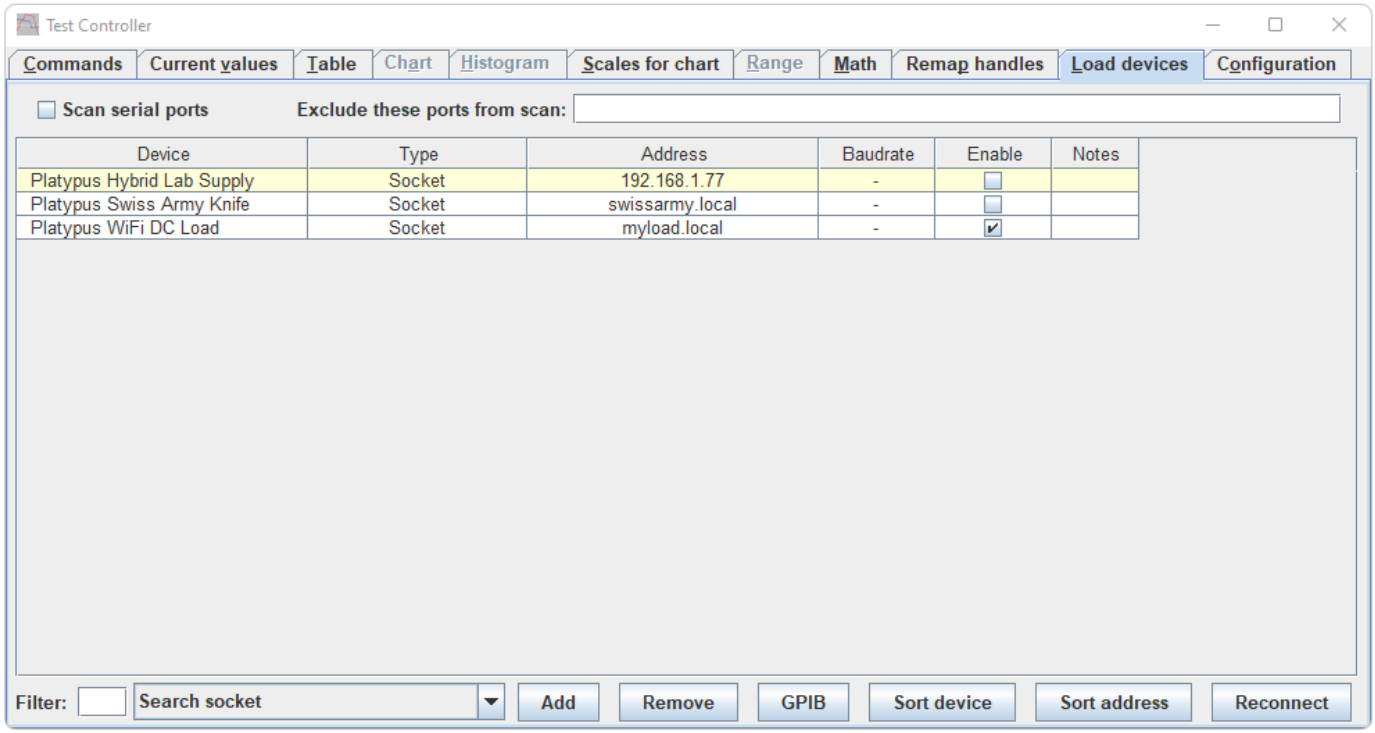
Configuration

Copy the PlatyLoad.txt device definition file downloaded from the repository into the Devices folder at the location you installed the TestController program.

Copy the PlatyLoadHelp.txt file into you Documents > TestController > Settings folder. Once loaded, as you start to type commands, the Help window below the command line will display the remaining command options.

The setup screen and help information will be available next time TestController is started.

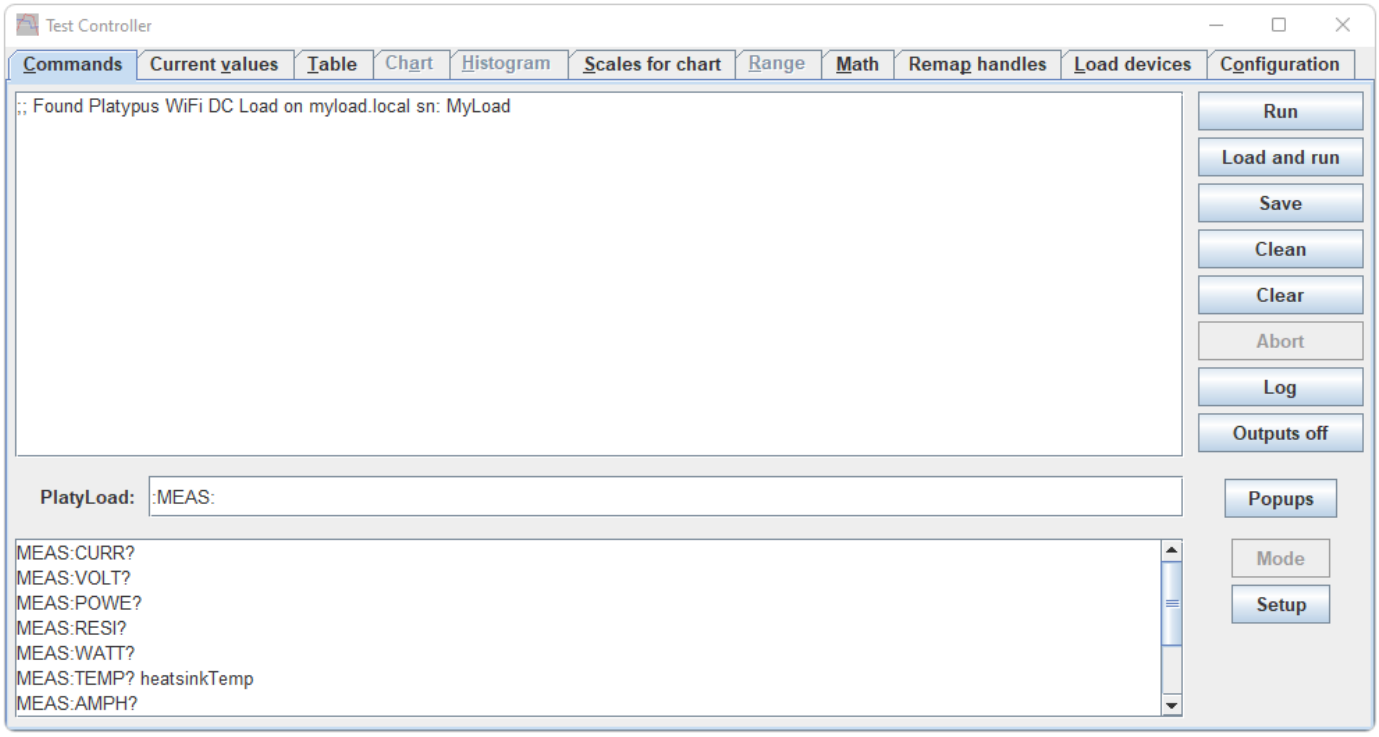
Add the device on the Load Device tab. If DHCP is being used, the DNS name of the device is a better way to identify its Address, as the device's assigned IP address may change over time.



The Load Devices tab with several devices added. The DNS name for the device or its IP address can be used. Hostnames are not case-sensitive.

Operation

All of TestController's main functions should operate once the device has been connected.

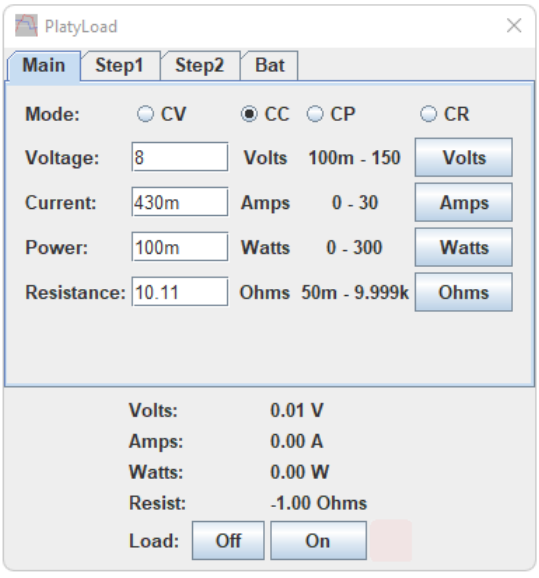


The main TestController window with the PlatyLoad device selected. There is a partially typed MEASure command in the command line, and the Help widow is displaying the remaining command options.

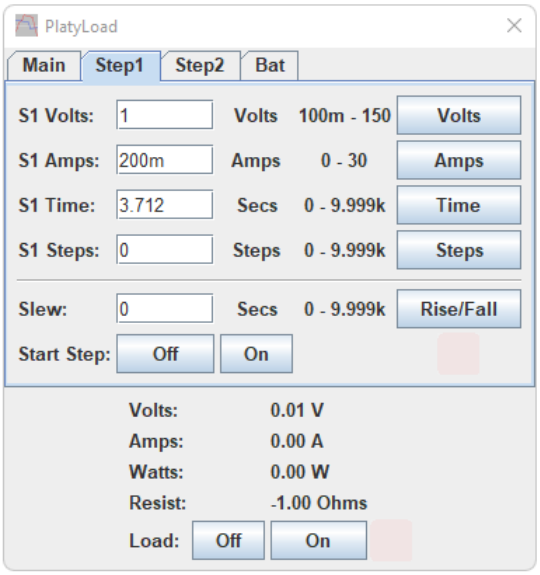
The Device Setup pop-up window

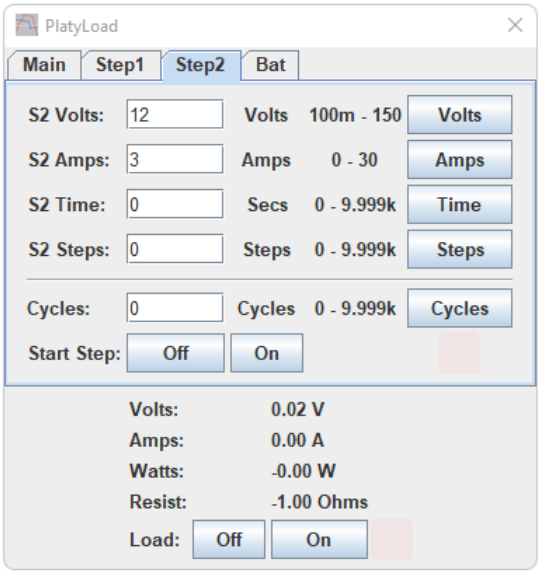
The Setup pop-up window is opened by clicking on the Setup button on the TestController Command tab, when the Load is selected (Command Line). Most Load settings can be managed from this pop-up, excluding logging and calibration.

The Load's current settings are loaded into the pop-up when it is opened. They are not updated after that, unless a value is changed using the pop-up's controls. Therefore, it is not advisable to change settings on either the touch screen or the web interface while using TestController, as the current settings may not be displayed in the pop-up window if they are changed elsewhere.

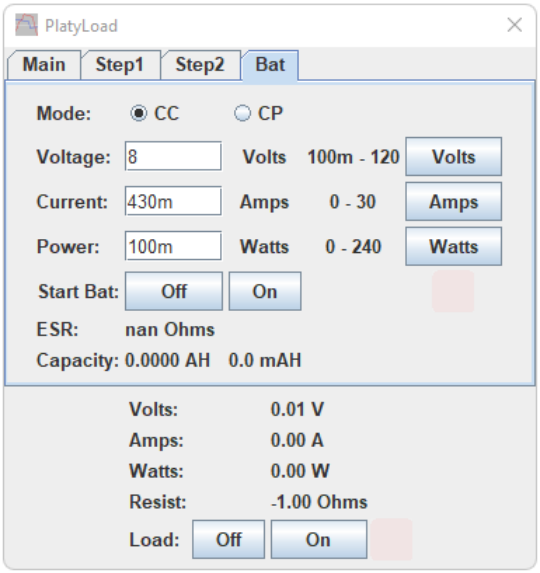


The Main device pop-up tab. Mode and control values are set in the top section and readings are displayed in the bottom panel.





The Step function screens.



The Battery testing function screen

SCPI Communication

Standard Commands for Programmable Instruments (SCPI) was developed in the early 1990's to provide a common syntax and command structure for programmable instruments from power supplies to oscilloscopes and beyond. It was designed as a master-slave protocol, with the controlling software always being master. While it was originally implemented on the GPIB bus (IEEE 488) other protocols, such as serial (including USB serial) and Telnet, are now commonly used.

The IVI Foundation, which is the successor to the non-profit SCPI Consortium, has a website with exhaustive documentation on SCPI and more recently developed, and more flexible instrument communication protocols such as VISA and VXI. https://www.ivifoundation.org/specifications/default.aspx

SCPI commands can be processed from several sources:

- A TELNET connection on Port 5025, for instance from TestController.
- A command packet from a member of the same *tracking group* as this instrument via UDP packet on Port 8888. (Messages for other tracking groups are read and discarded).

While USB Serial terminal, such as the Arduino Serial Monitor can also be used, significant care needs to be taken to avoid ground loops. (See the safety warning at the beginning of this document). It is highly recommenced that an *isolated* USB serial connection be used to avoid damage to the computer or instrument. USB Serial commands are equivalent to Telnet.

SCPI Command Format

Commands consist of case-sensitive keywords, separated by colons, and each keyword may have parameters associated with it, e.g. ":SOURce:VOLTage 350 mV" or ":MEASure:VOLTage?"

Commands ending in a question mark are queries, and the instrument should return a value or set of values to any query.

Parameters may be integers, floating point numbers or strings, depending on the command. Numeric commands may be followed by a unit, such as V, mV, A or mA.

Each command, such as "MEASure" can be issued using the full form or by using an abbreviation, which is always the part in upper case, and almost always four characters long. Thus ":MEAS:VOLT?" is equivalent to ":MEASure:VOLTage?"

Some SCPI rules for this instrument:

- Commands are case sensitive. "ABCX" is not equivalent to "aBCX"
- There *must* be one or more spaces between a command and its argument.
- There *may* be one or more spaces between an argument and its unit specifier
- String arguments are not enclosed in quotes
- No other spaces are permitted within or between commands. For instance, ":INST:NAME Fred" (no extra spaces) is legal and ": INST : NAME Fred" (extra spaces) is illegal.
- All commands must start with a '*' or a ':', and colons must be inserted between each command in a command line.
- Where unit specifiers are omitted, the natural unit (e.g. Volts, Amps) will be assumed.
- Case is significant in unit specifiers, as the SCPI interpreter recognises a wide range of the possible SI prefixes, e.g. m [milli] and M [mega].
- Floating point number should always have a numeral before a decimal point (leading zero).
- Incorrectly formatted commands will be rejected, and an error message returned, eg.
  SCPI_proc: unknown cmd [MY_BAD_CMD]
- Only one command may be issued on each command line.
- Floating point values are stored as single-precision. Thus, 7 significant figure accuracy is available, but not required.
  Value are generally returned with four decimal places, however accuracy may be limited to less decimal places. See the instrument Specifications table for value limits and accuracy.

In the detailed explanation of commands below

- Square brackets [ ] indicate the type of input required, e.g. [floating point] or [command]
- Angle brackets < > indicate the specific options available, e.g. <ON|OFF> or <CH1|CH2

SCPI Argument and Return Value Types

Data type	Description
Value	Floating point number. A A leading zero is required for values < 1.0. Actual value set may be constrained by limits embedded in the instrument.
Unit	A one or two character SI value of Amps or Volts (only V, mV, A, mA are recognised).
ON/OFF	String containing the characters {ON | OFF}. Case sensitive.
Group	Integer [1 .. 255]. Group 0 is reserved.
String	Alpha numeric, plus keyboard symbols, no spaces (ASCII 0x21 .. 0x7E). No quote marks. Case sensitive.

SCPI Command Quick Reference

Command tree			Argument	Function
*IDN?				Identify instrument
*TST?				Self-test (POST) results
:SOURCce				
	:VOLTage		<float[V]>	Set voltage
	:VOLTage?			Get set voltage
	:CURRent		<float[A]>	Set current
	:CURRent?			
	:POWEr		<float[W]>	Set power
	:POWEr?			
	:RESIstance		<float[R]>	Set resistance
	:RESIstance?			
	:LOGInterval		<unsigned integer[S]>	Set log interval
	:LOGInterval?			
	:STATe		<ON|OFF>	output on/off
	:STATe?			
:MEASure				
	:VOLTage?			Measure actual voltage
	:CURRent?			Measure actual current
	:POWEr?			Measure calculated power
	:RESIstance?			Measure calculated resistance
	:TEMP?			Measure heatsink temperature
-	~~:LOGData?~~	-	-	~~Current run log data (up to 1000 CSV entries)~~
:FUNCTION				
	:BATTery			
		:STATe	<ON|OFF>	Start/stop Battery test
		:STATe?		
		:ESR?		Last calculated ESR value
		:CAPAcity?		Last calculated total power discharged
	:STEP			
		:STATe	<ON|OFF>	Start/stop Step mode
		:STATe?		
		:ACURrent	<float[A]>	S1 current
		:ACURrent?		
		:BCURrent	<float[A]>	S2 current
		:BCURrent?		
		:AVOLtage	<float[V]>	S1 voltage
		:AVOLtage?		
		:BVOLtage	<float[V]>	S2 voltage
		:BVOLtage?		
		:ATIMe	<unsigned integer[S]>	S1 step time
		:ATIMe?		
		:BTIMe	<unsigned integer[S]>	S2 step time
		:BTIMe?		
		:ASTEps	<unsigned integer[S]>	S1 number of steps
		:ASTEps?		
		:BSTEps	<unsigned integer>	S2 number of steps
		:BSTEps?		
		:SLEW	<unsigned integer[S]>	Rise/fall time
		:SLEW?		
		:CYCLes	<unsigned integer>	Number of cycles to repeat
		:CYCLes?		
:SYSTEM				
	:ERROR?			
	:PASSword		<text> [8-63 chars]	WiFi password
	:PASSword?			
	:SSID		<text> [2-32 chars]	WiFi SSID
	:SSID?			
	:CONNect		<ON|OFF>	Auto connect to WiFi
	:CONNect?			
	:HOSTname		<text> [2-16 chars]	Network Hostname
	:HOSTname?			

SCPI Command List

*IDN? 31
MEASure 31
CURRent? 31
VOLTage? 31
POWEr? 31
RESIstance? 31
TEMPerature? 31
WAVEdata? 32
SOURce 32
MODE 32
VOLTage 32
CURRent 32
POWEr 33
RESIstance 33
LOGInterval 33
STATe 34
FUNCtion 34
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*IDN?

Command format	*IDN?
Description	Identify the instrument
Return Info	Manufacturer, product type, instrument name/serial number, software version
Typical return	Platypus,DCL01,myLoad,2

MEASure

Command format	:MEASure:[parameter]?
Description	Query the actual value (reading)

CURRent?

Command format	:MEASure:CURRent?
Description	Measure load current
Return Info	Floating point (Amps)
Typical return	3.00 (Zero if load is off)

VOLTage?

Command format	:MEASure:VOLTage?
Description	Measure voltage on the output binding posts, or 4-wire (Kelvin) terminals in
Return Info	Floating point (Volts)
Typical return	12.00

POWEr?

Command format	:MEASure:POWEr?
Description	Return calculated power (volts * amps)
Return Info	Floating point (Watts)
Typical return	28.5

RESIstance?

Command format	:MEASure: RESIstance?
Description	Return calculated load effective resistance (volts / amps).
Return Info	Floating point (Ohms)
Typical return	28.5 (-1.00 if out of calculation range)

TEMPerature?

Command format	:MEASure:TEMPerature?
Description	Query the current heatsink temperature
Example	:SOUR:TEMP?
Return Info	Floating point, in degrees C

Typical return	28.5

WAVEdata?

Command format	:MEASure:WAVEdata?
Description	Return
Return Info	Complex, see section “WAVEdata”, below
Typical return	CSV formatted data

SOURce

Command format	:SOURce:[command]
Description	Set or query operational settings, such as voltage, current, or output status

MODE

Command format	:SOURce:MODE [command]
Description	Enable CV, CC, CP or CR mode
Example	:SOUR:MODE CC

MODE?

Command format	:SOURce:MODE?
Description	Query the current mode
Return Info	Text <CV|CC|CP|CR>
Typical return	CC

VOLTage

Command format	:SOURce:VOLTage [float] [unit]
Description	CV Mode: Set the desired voltage for when the output is ON BAT function: Set the Battery Test fully-discharged trigger voltage.
Example	Each of these commands will set the target voltage to 2.50V :SOUR:VOLT 2.50V :SOUR:VOLT 2500 mV :SOUR:VOLT 2.50

VOLTage?

Command format	:SOURce:VOLTage?
Description	Query the current target voltage setting
Return Info	Floating point, in Volts.
Typical return	12.00

CURRent

Command format	:SOURce:CURRent [float] [unit]
Description	All Modes and functions: Set the maximum current that the load will sink when On

Example	Each of these commands will set the target limit current to 2.50A :SOUR:CURR 2.50A :SOUR:CURR 2500 mA :SOUR:CURR 2.50

CURRent?

Command format	:SOURce:CURRent?
Description	Query the target current limit setting
Return Info	Floating point, in Amps
Typical return	2.00

POWEr

Command format	:SOURce:POWEr [float] [unit]
Description	All Modes and functions: Set the maximum power that the load will sink when On
Example	Each of these commands will set the target limit current to 2.50 Watts :SOUR:POWE 2.50 W :SOUR:POWE 2500 mW :SOUR:POWE 2.50

POWEr?

Command format	:SOURce:POWEr?
Description	Query the target power limit setting
Return Info	Floating point, in Watts
Typical return	2.00

RESIstance

Command format	:SOURce:RESIstance [float] [unit]
Description	CR mode: Set the target resistance for the load will sink when On
Example	Each of these commands will set the target resistance to 2.50 Ohms :SOUR:RESI 2.50 R :SOUR:RESI 2500 mR :SOUR:RESI 2.50

RESIstance?

Command format	:SOURce:RESIstance?
Description	Query the target resistance setting
Return Info	Floating point, in Ohms
Typical return	2.00

LOGInterval

Command format	:SOURce:LOGInterval [float] [unit]
Description	Set the time between logged measurements
Example	Each of these commands will set the log interval to 2.50 Seconds :SOUR:LOGI 2.50 S :SOUR:LOGI 2500 mS :SOUR:LOGI 2.50

LOGInterval?

Command format	:SOURce:LOGInterval?
Description	Query the time between logged measurements setting
Return Info	Floating point, in Seconds
Typical return	2.00

STATe

Command format	:SOURce:STATe <ON|OFF>
Description	Turn the output on or off
Example	:SOURce:STATe ON :SOURce:STATe OFF

STATe?

Command format	:SOURce: STATe?
Description	Query the current status of the output
Return Info	Text <ON|OFF>
Typical return	ON

FUNCtion

Command format	:FUNCtion:[command]
Description	Set or query Battery Test or Step Mode variables

BATTery

Command format	:FUNCtion:BATTery:[command]
Description	Set or query Battery Test variables

STATe

Command format	:FUNCtion:BATTery:STATe [command]
Description	Start or stop the Battery test function.
Example	:FUNCtion:BATTery:STATe ON

STATe?

Command format	:FUNCtion:BATTery:STATe?
Description	Returns Battery Test function status.
Typical return	ON

ESR?

Command format	:FUNCtion:BATTery:ESR?
Description	Return the latest ESR calculation
Return Info	Floating point, in Ohms
Typical return	8.5

CAPAcity?

Command format	:FUNCtion:BATTery:CAPAcity?
Description	Return the latest battery capacity calculation
Return Info	Floating point, in Amp-Hours
Typical return	1.5

STEP

Command format	:FUNCtion:STEP:[command]
Description	Set or query STEP mode variables

STATe

Command format	:FUNCtion:STEP:STATe [command]
Description	Start or stop the STEP mode function.
Example	:FUNCtion:STEP:STATe ON

STATe?

Command format	:FUNCtion:STEP:STATe?
Description	Returns STEP mode function status.
Typical return	ON

ACURrent or BCURrent

Command format	:FUNCtion:STEP:ACURrent [command] or :FUNCtion: STEP:BCURrent [command]
Description	STEP Mode: Set the S1 or S2 target current
Example	:FUNCtion:STEP:ACUR 5

ACURrent? or BCURrent?

Command format	:FUNCtion:STEP:ACURrent? or :FUNCtion:STEP:BCURrent?
Description	Returns STEP mode S1 or S2 target current setting (Amps).
Typical return	4.8

AVOLtage or BVOLtage

Command format	:FUNCtion0 STEP:AVOLtage [command] or :FUNCtion: STEP:BVOLtage [command]
Description	STEP Mode: Set the S1 or S2 target voltage
Example	:FUNCtion:STEP:AVOLT 15

ACURrent? or BCURrent?

Command format	FUNCtion:STEP:AVOLtage? or :FUNCtion: STEP:BVOLtage?
Description	Returns STEP mode S1 or S2 target voltage setting (Volts).
Typical return	12

ATIMe or BTIMe

Command format	:FUNCtion:STEP:ATIMe [command] or :FUNCtion: STEP:BTIMe [command]

Description	STEP Mode: Set the S1 or S2 dwell time. (**milliSeconds**)
Example	:FUNCtion:STEP:ATIME 0.15

ATIMe? or BTIMe?

Command format	:FUNCtion:STEP:ATIMe [command] or :FUNCtion: STEP:BTIMe [command]
Description	Returns STEP mode S1 or S2 dwell time. (**milliSeconds**)
Typical return	1.5

ASTEps or BSTEps

Command format	:FUNCtion:STEP:ASTEps [command] or :FUNCtion: STEP:BSTEps [command]
Description	STEP Mode: Set the number of steps for the S1 or S2 staircase.
Example	:FUNCtion:STEP:ATIME 3

ATIMe? or BTIMe?

Command format	:FUNCtion:STEP:ASTEps? or :FUNCtion: STEP:BSTEps?
Description	Returns the number of steps for the S1 or S2 staircase
Typical return	3

ACYCles or BCYCles

Command format	:FUNCtion:STEP:ACYCles [command] or :FUNCtion: STEP:BCYCles [command]
Description	STEP Mode: Set the number of complete S1 / S2 cycles before Step mode exits.
Example	:FUNCtion:STEP:ATIME 3

ACYCles? or BCYCles?

Command format	:FUNCtion:STEP:ACYCles? or :FUNCtion: STEP:BCYCles?
Description	Returns the number of complete S1 / S2 cycles before Step mode exits
Typical return	3

SLEW

Command format	:FUNCtion:STEP:SLEW [command]
Description	STEP Mode: Set the rise / fall time of each step. (**milliSeconds**)
Example	:FUNCtion:STEP: SLEW 0.015

SLEW?

Command format	:FUNCtion:STEP:SLEW?
Description	Returns the rise / fall time of each step. (**milliSeconds**)
Typical return	1.5

SYSTem

Command format	:SYSTem:[command]
Description	Set or query system variables such as hostname and WiFi credentials

ERROR?

Command format	:SYSTem:ERROR?
Description	Return all the error messages currently queued and reset the queue.
Example	:SYST:ERROR?
Typical return	-200,"Command error; Invalid set voltage 3690.00"

SSID

Command format	:SYSTem:SSID [string]
Description	Set the SSID of a preferred WiFi LAN The SSID must be 8 – 32 characters in length to conform with the 802.11 specification.
Example	:SYST:SSID MyHomeWiFi

SSID?

Command format	:SYSTem:SSID?
Description	Returns the SSID of the connected WiFi LAN
Typical return	MyHomeWiFi

PASSphrase

Command format	:SYSTem:PASSphrase [string]
Description	Set the passphrase for the last entered SSID. The argument string is case sensitive. The passphrase must be 8 – 32 characters in length to conform with the 802.11 specification.
Example	:SYST:PASS MYpAssWord23

PASSphrase?

This command is not implemented, as it poses a security vulnerability for the WiFi network.

Command format	:SYSTem:PASSphrase?
Description	Returns a descriptive message.
Typical return	WiFi password can only be SET remotely.

CONNect

Command format	:SYSTem:CONNect <ON|OFF>
Description	Set the instrument to Autoconnect to the WiFi network. Turning this setting OFF effectively disables WiFi
Example	:SYST:AUTO ON

CONNect?

Command format	:SYSTem:CONNect?
Description	Return the autoconnect status
Typical return	0 (OFF) or 1 (ON)

HOSTname

Command format	:SYSTem:HOSTname [string]
Description	This command sets both the name displayed on the web interface and the hostname component of its URL. The argument string should not be enclosed in quotes. The URL generated is not case sensitive and will be of the form hostname.local The unit may be addressed name as well as its IP address. *The hostname will not change until the WiFi server is re-initialised.* Restart, or follow this command with :SYST:AUTO OFF then :SYST:AUTO ON to change the web interface URL.
Example	:SYSTem:HOSTname myLoad mDNS will respond to ICMP (ping, DNS) requests to MYLoad.local or myload.local as URLs are case insensitive.

HOSTname?

Command format	:SYSTem:HOSTname?
Description	Return the hostname (same as Instrument name)
Typical return	myLoad

SCPI Packet Structure

SCPI commands are sent as ASCII text and the command string is NULL terminated in the packet.

Transport (UDP/IP) Headers

Item	Type	Content	
IP Header	20 bytes	Source & Destination Address, Protocol	
UDP Header	8 bytes		
Bytes		**Content**	Location
2		Source Port (optional IPV4, IPV6)	0-1
2		Destination Port	2-3
2		Length	4-5
2		Checksum (optional for IPV4)	6-7

SCPI packet (follows UDP/IP headers)

Bytes		Content	Location
4	char	'SCPI'	0-3
4	uint32_t	Pkt sequence number (0, other than for logging)	4-7
2	uint16_t	Message length (max 1024 bytes - to avoid jumbo packets)	8-9
1	int8_t	Tracking group (-1 is universal, e.g. all eStop)	10
16	char	Sender name or ID?	11-26
Up to 1024	char	Content (Always ASCII. SCPI commands and responses. CSV for logging).	27-1050
1051	**Total**	**SCPI packet**	

Design Overview

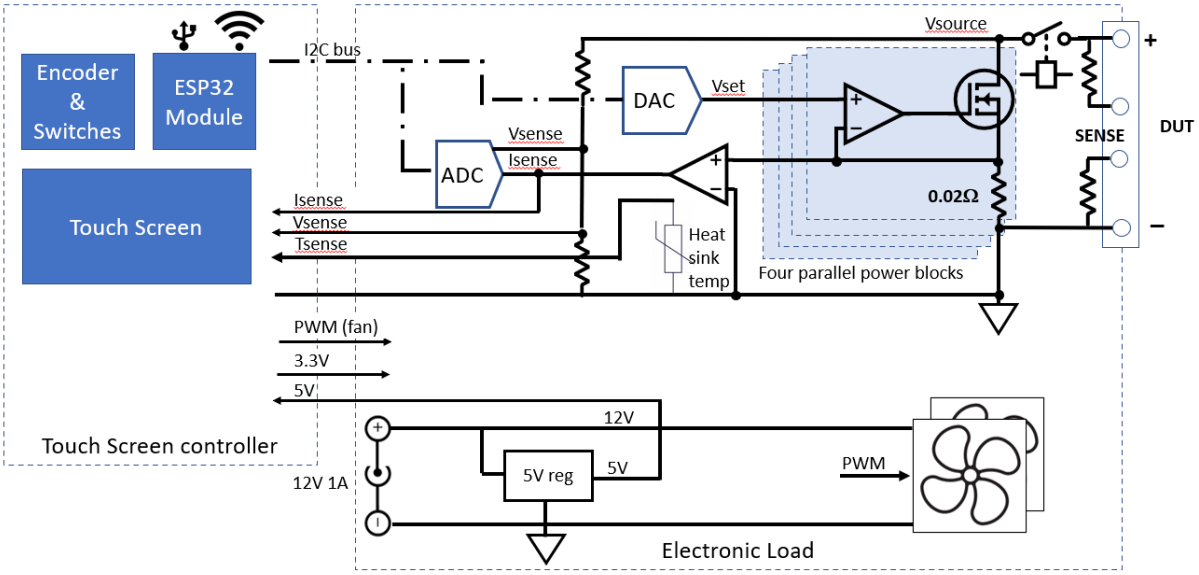

Fig.2. a simplified block diagram showing the major features of the load. Four identical op amp / MOSFET power blocks are controlled by a DAC. Input voltage and current are measued by an ADC. A relay can disconnect the load. The ESP32 module handles communications and control functions.

At the core of the design (Fig.2) are four power blocks, each with a MOSFET, a shunt resistor and some control circuitry. A control voltage, Vset, is provided to the power blocks by a shared DAC.

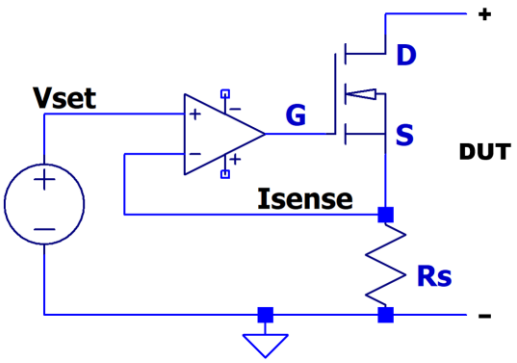

Fig.3. Basic constant current load circuit. The MOSFET drain current is reasonably proportional to its gate voltage, once the gate threshold voltage has been reached.

The voltages at the load's input and across Rs are measured by an ADC. The microcontroller iterates Vset until the desired operating conditions are reached.

One of the MOSFET's case temperatures is read by a thermistor and fed to an ESP32 ADC channel. This value controls both the fan speed, via a PWM signal from the ESP32, and over-temperature shutdown.

Power comes from a 12V plug pack which directly powers the fans and op amps. It is switched down to 5V to power the ESP32 controller and several load components. 3.3V is fed back from the controller to power the DAC and ADC. The general arrangement is the same as for the Hybrid Lab Supply project (SC May-June 2021).

To simplify mounting of the MOSFETs on the CPU coolers and arranging them inside the enclosure, one pair of MOSFETS and their cooler have been separated onto a separate daughter board. Power supply and control signals connect to the main load PCB via a short ribbon cable.

Schematic

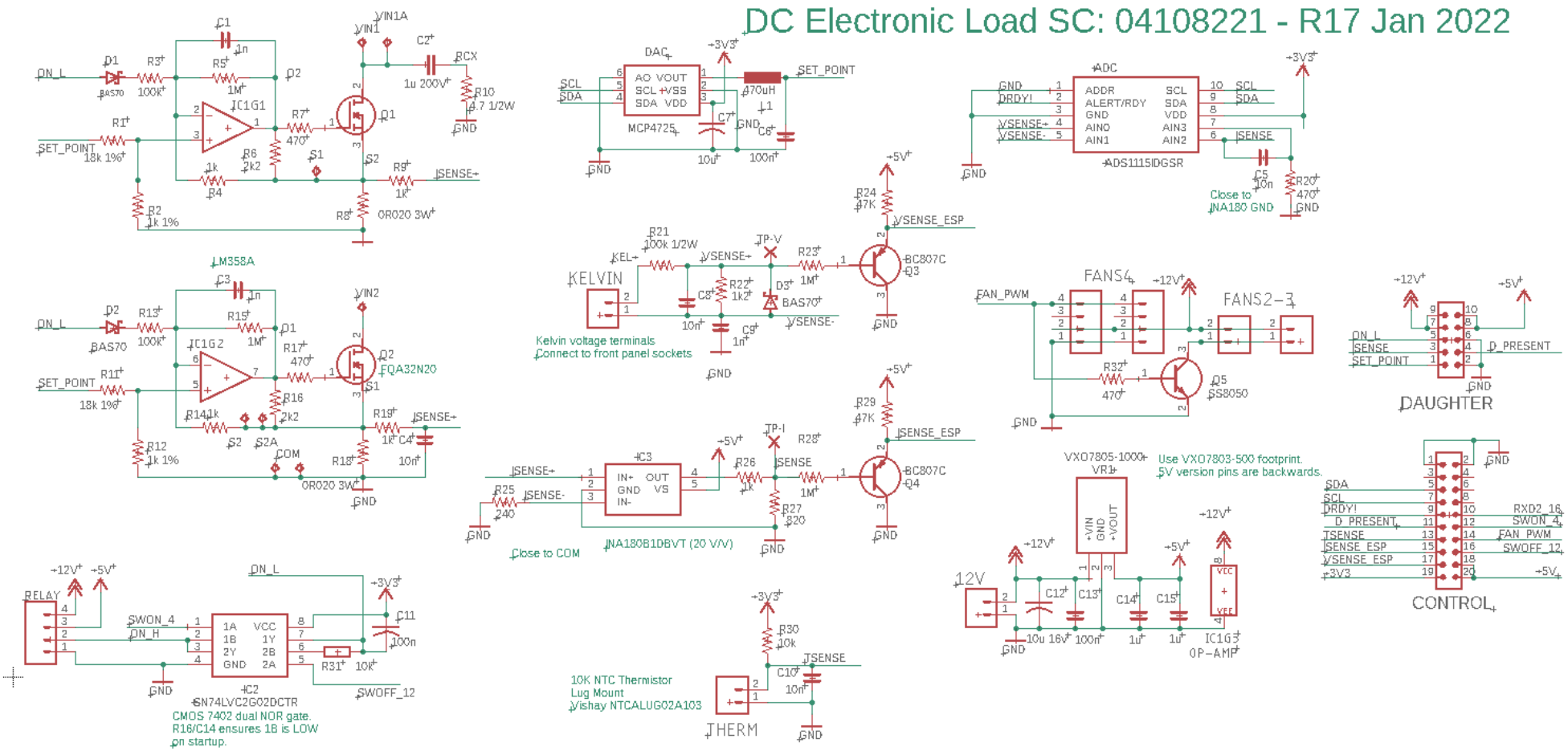

Fig.15 the main load board includes two power modules, based around IC1, Q1 and Q2; control and monitoring components including the ADC, DAC, IC3, Q3, Q4 and the thermistor TH1. The DAC sets the output current of Q1 & Q2. The input voltage and voltage across the shunt resistors R8 & R12 are amplified by IC2 and measured by the ADC. Current monitor IC2 controls the on/off functions of the MOSFETs and relay. A PWM signal to Q5 sets the fan speed.

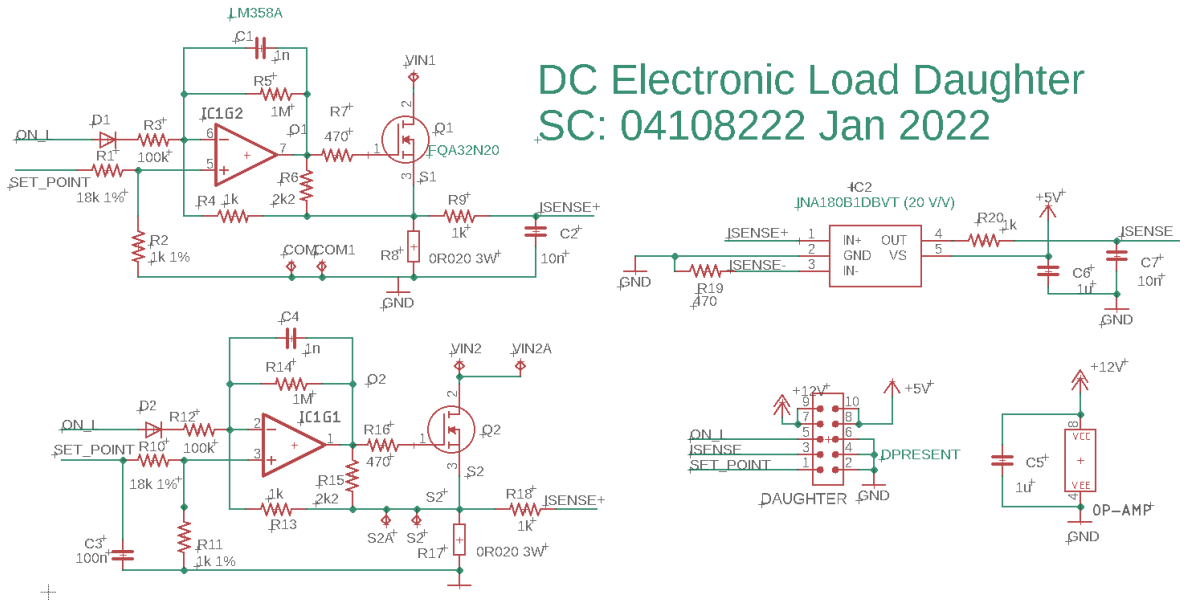

Fig.16 the daughter board comprises two power modules and a current monitor IC, identical to those on the main board. Control and sensing are transmitted to the main board via the daughter connector.

Control header pins

ESP32 IO pins are not 5V tolerant. Only 0 – 3.3V signals should be connected to inputs.

GPIO outputs have a 12mA maximum current rating.

Header Pin	ESP32 Function	GPIO		Header Pin	Function	GPIO
1	GND			2	GND	
3				4		
5	SDA	21		6		
7	SCL	22		8		
9	DRDY!	2		10		
11	D_PRESENT			12	SW_ON	4
13	TSENSE			14	FAN_PWM	26
15	ISENSE			16	SW_OFF	12
17	VSENSE			18	+5V (Supply)	
19	+3.3V (Return from ESP32)			20	+5V (Supply)	

A Bill of Materials and construction details are included in the associated Silicon Chip article published in 2022.

Specifications

Item	Value
Load power dissipation	300W
Minimum resistance	0.025 ohms (design)
Input Voltage	Operating: 0 – 150V Absolute maximum: 200V Resolution: 6mV above 100mV Linearity < 1% (above 150mV) when calibrated
Input current	Software limited to max rated dissipation (see Safe Operating Area and Protection) 30A max @ 3 - 10V 2A @ 150V 10A @ 1 V (min resistance) 2A at 200mV (min resistance) Absolute maximum: +/-35A (relay disconnect) Resolution: Set: 7mA Read: 1.5mA 0.2% measurement linearity when calibrated (> 200mA) Warning: Load will sink substantial current if reverse voltage is applied before disconnection (< 100ms).
Constant Current Mode	Set: 10mA – 30A Line regulation < 0.2% (>100mV & 20mA) Rise time (0.1-4A) < 200 uS Limited to max dissipation – see SOA curve
Constant Voltage mode	50mV min Accuracy < 2% above 1V
Constant Power Mode	0.1W to 300W 1V to 150V input Accuracy < 2% above 1W
Constant Resistance Mode	0.2Ω to 999.99Ω Accuracy < 2% below 100Ω and above 100mA & 1V
Step Mode	CC, CV, CP, CR modes T_{HIGH}, T_{LOW} 5 mS – 32767 S Rise/Fall: zero setting: < as per CC mode non-zero setting: 1 – 32767 mS Limited to max dissipation – see SOA curve

Battery Test Mode	CC, CP and CR modes supported
Electronic Protection	Relay current disconnect time < 100mS Voltage reading remains connected to DUT terminals. Current 30A (soft limiting) 35A (disconnects) Power 300W (soft limiting) Voltage 155V (disconnects) Reverse Voltage < -0.1V (disconnects) MOSFET case temp. 65ºC (disconnects)
DC input	12VDC 1.5A double insulated.
Dimensions	270mm x 210mm x 140mm
Weight	2 kg

Communication and remote control

Command processing time	
Average time for control change or response after a single command is issued	< 30mS A single waiting command processed every 20mS.
SCPI commands	
Units accepted	Volts and millivolts [V | mV]. No unit specified is equivalent to Volts. Amps and milliamps [A | mA]. No unit specified is equivalent to Amps. Ohms Watts Seconds [S | mS]. No unit specified is equivalent to Seconds.
Remote control connections	

WiFi	802.11 b/g/n/e/i Auto-connect to the SSID/passphrase combinations provided on the COM menu. The five most recently used WiFi credentials are stored, and each is tried until a successful connection is made. Where connection to any of the stored WiFi LANs fails, a local WiFi network is created: SSID: ESPINST PW: ESPPW99X The IP address range provisioned on ESPINST, using DHCP, is 192.168.50.X DHCP IP addresses are used or provisioned in all modes. **The current IP address is available on the COM menu screen.** DNS name is hostname.local (each instrument implements an mDNS responder) (see SCPI command :INST:NAME and COM menu) *Windows computers no longer recognise the hostname.local format.* WPS is not supported.
Telnet	Port: 5025 SCPI commands accepted and results returned. Functionality has been tested with the open source software TestController Studio, and an instrument definition file for this software is included in the project's downloads.
Web (HTTP)	A web interface allows most settings can be altered and most actions initiated. Calibration and Communication settings are not available via the web interface. Port: 80 http://IPaddress **The page is and not secured or encrypted.**
UDP (packet)	SCPI commands may also be received using UDP packets, although this mechanism is primarily designed for inter-instrument communication. Port: 8888 IP address or hostname as above. Packet specifications are outlined in the *SCPI Packet Structure* section.
Isolated USB Serial	**Damage may occur if a non-isolated USB connection is used.** Baud rate: 115,200 SCPI commands accepted and results returned.

Troubleshooting

Symptom	Likely cause	Remediation
Touch panel not responding.	Touch panel is rotated 180° from LCD.	See the *Touch Calibration* section.
Touch not centred on buttons.	Touch panel out of register with LCD.	See the *Touch Calibration* section.
Voltage or current screen reading incorrect.	Calibration not completed.	See the *Voltage* and *Current Calibration* sections.
Instruments in a tracking group not tracking.	Voltage &/or Current tracking mode not enabled	See the *Tracking Screen* section.
Can't access instrument (Web page or Telnet) remotely.	Wifi not connected. Instrument has joined the ESPINST WiFi network, rather than the WiFi LAN.	See *Communication Screen* and *Specifications – WiFi* sections.
Can't access web interface using hostname.	Duplicate hostname. On some WiFi LANs the hostname mode may not work due to router or operating system configurations.	Use the IP address found in the COMMs console menu.

Battery Testing Data

The information below is offered as a guide only. Specifications for individual batteries should be obtained from the manufacturer.

Battery type	Standard discharge test current*	Nominal cell voltage	End of discharge cell voltage	Information from
Sealed Lead Acid	Constant current (10 hour rate* = 0.1C)	2.1V	1.75V	Megger. Battery Testing Guide
LiPO	Constant current (2 hour rate* = 0.5C)	3.6V	3.0V	https://www.lipoly-battery.com/lipoly-battery-performance-standards/
LiFePO4	Constant current (2 hour rate* = 0.5C)	3.2V	2.5V	https://en.wikipedia.org/wiki/Lithium_iron_phosphate_battery
NiCd	Constant current (10 hour rate* = 0.1C)	1.2V	1.10V	SBS. NiCad Battery Capacity Testing Procedure
NiMH	Constant current (10 hour rate* = 0.1C)	1.2V	1.0V	https://m.greenway-battery.com/news/NiMH-Battery-Voltage--Checking-And-Voltage-Range-964.html

* A common value. Some batteries are rated at a higher or lower discharge rate.
The 10-hour discharge rate (amps) is the amp hour capacity of the battery divided by 10.

Sealed Lead Acid Battery Characteristics

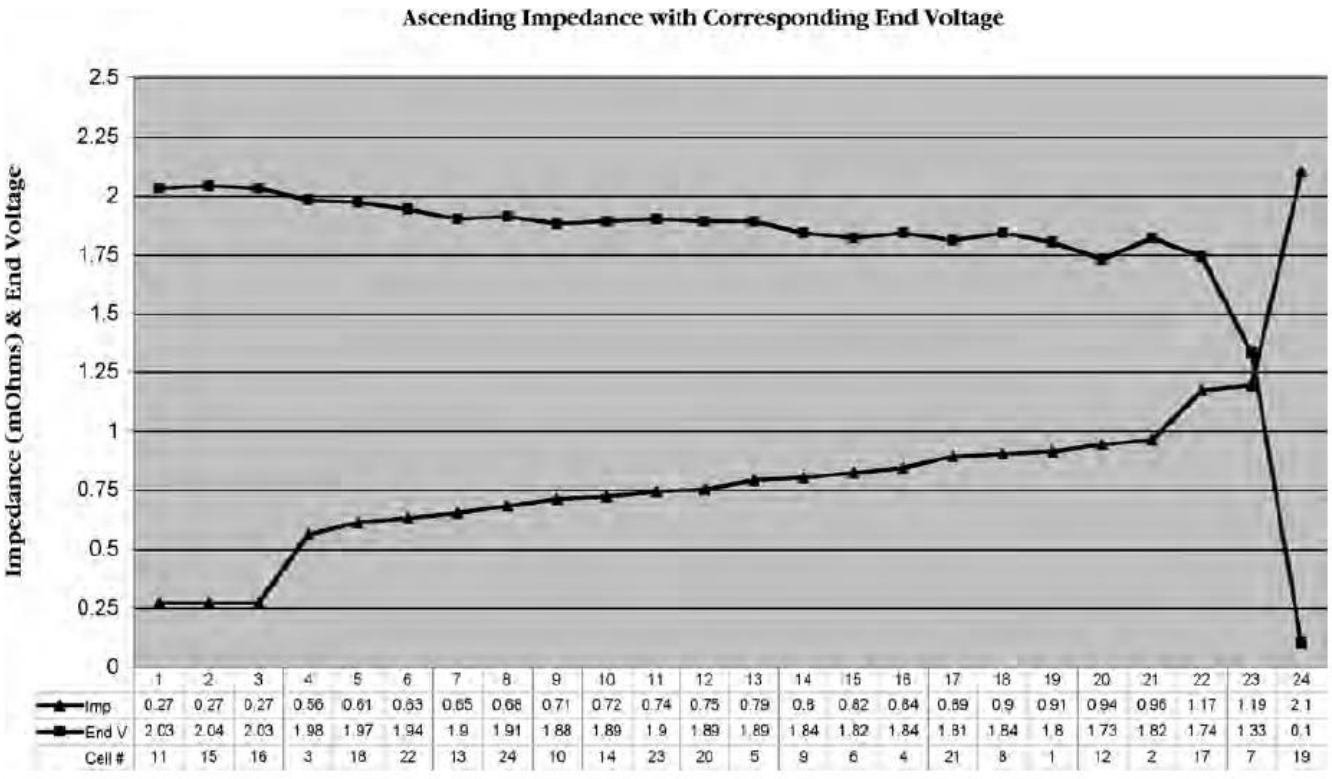

Figure 5 Ascending impedance with corresponding end voltage

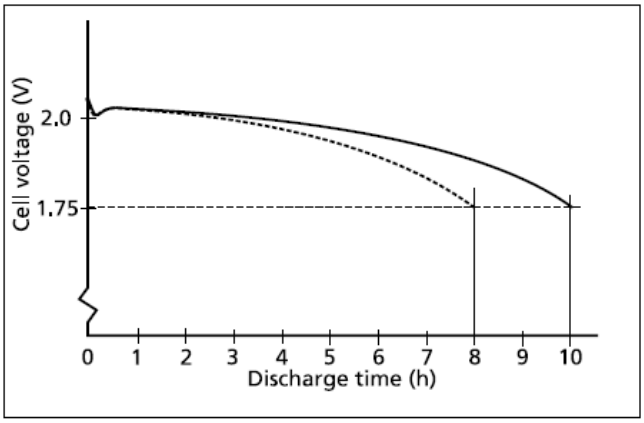

Figure 3 If the battery reaches the end of discharge at 80% (8 h) or before of the specified 10 h it is shall be replaced.

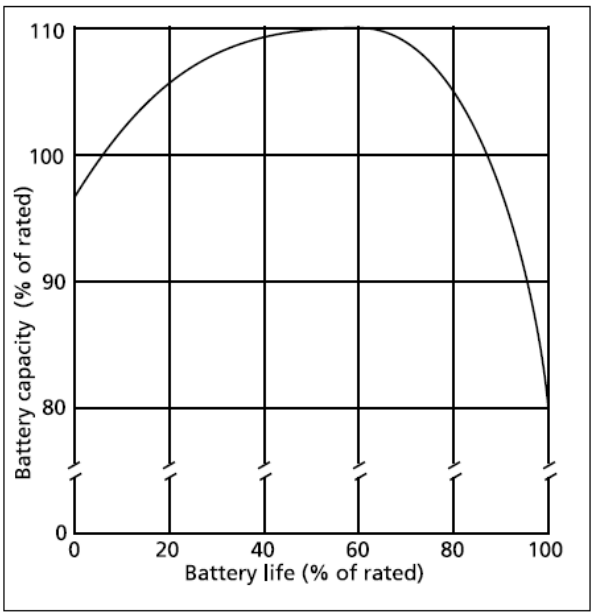

Figure 4 Replacement of battery is recommended when the capacity is 80% of rated.

Diagrams are from the Megger Battery Testing Guide:
https://megger.com/products/archive/proactiv/technical/battery-testing-guide