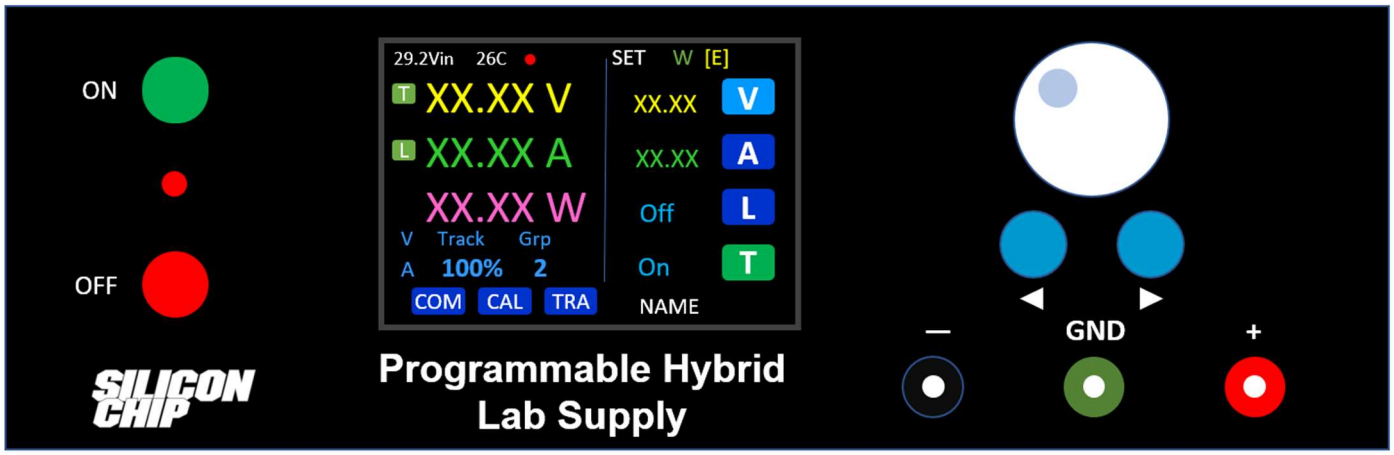
Programmable
Hybrid Lab Supply
Manual



This manual describes the features of Programmable Hybrid Lab Supply. 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

- Hybrid architecture with SMPS pre-regulation and linear final regulation for high efficiency and performance.
- 26V maximum voltage. 24V @ 3.5A, 16V @ 5A.
- Setting resolution 10mV and 10mA.
- Control resolution better than 1mV and 1mA
- Excellent line and load regulation.
- Soft Start parallels real world PSU performance when output is switched on, avoiding ‘crash’ starts.
- Remote monitoring and control via WiFi.
- Multiple units can coordinate to deliver flexible stacking and tracking options.
- HTTP, Telnet and isolated USB serial control supported using universal SCPI commands.
- Compact, lightweight and low heat dissipation.
- Universal AC input (100-240 VAC, 50-60 Hz).

Contents

Safety

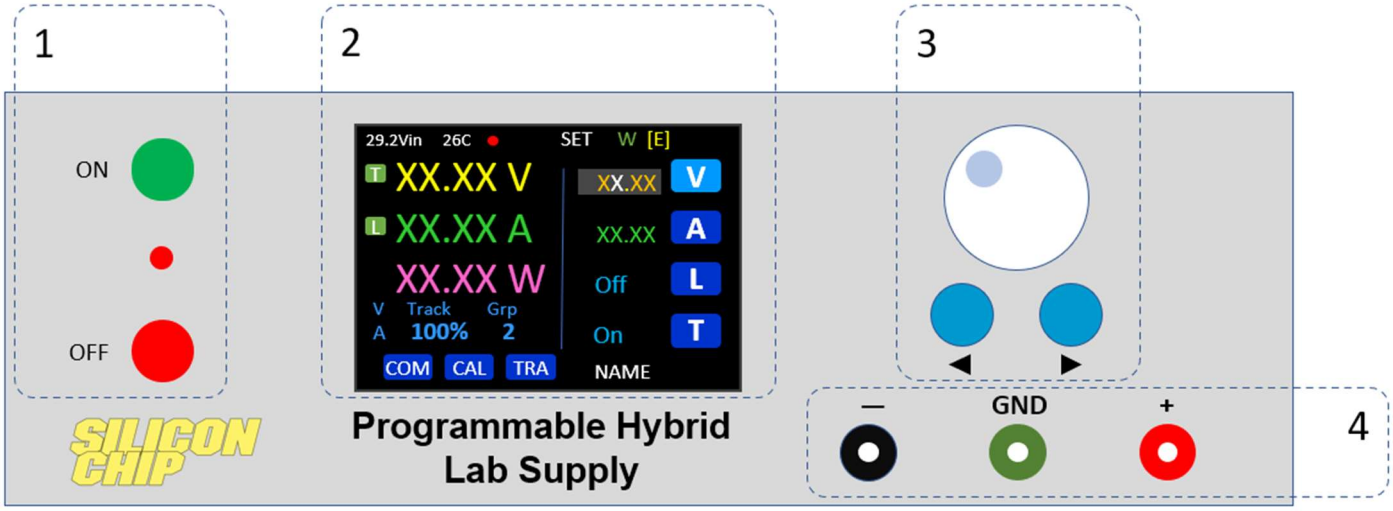
Isolated remote control and monitoring via WiFi is the recommended approach for this instrument.

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.

Units connected in parallel must always have the same output voltage set.

2. **Multiple supplies connected in parallel must ALWAYS have voltage tracking enabled (VOL = On), and be in the same enabled (T = On) tracking group (Grp = same).**
   Damage to one or more supplies may otherwise occur.

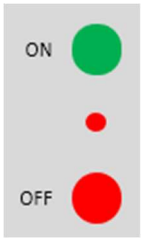
Front Panel



1 On/Off buttons and LED indicator
2 Control touch screen
3 Numeric setting controls
4 Output binding posts

General Operation

On/Off Buttons

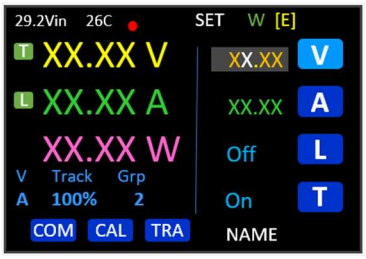


The buttons to the left of the LCD screen turn the output On and Off.

The LED indicates the current state of the output, which may also be controlled remotely.

Screens and Menus

Menu items are selected using the dark blue buttons on the touch screen.



For instance, on the main screen there are four buttons V, A, L & T on the right-hand side, which set specific operational values. The buttons change colour when selected or to indicate their status (see *Main screen settings*, below).

Three smaller sub-menu buttons COM (communication), CAL (calibration) & TRA (tracking) are arranged across the bottom left of the screen.

Changing numeric values

Select the item with its associated on-screen button, and use the numeric setting controls (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 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 'tens' digit being edited.

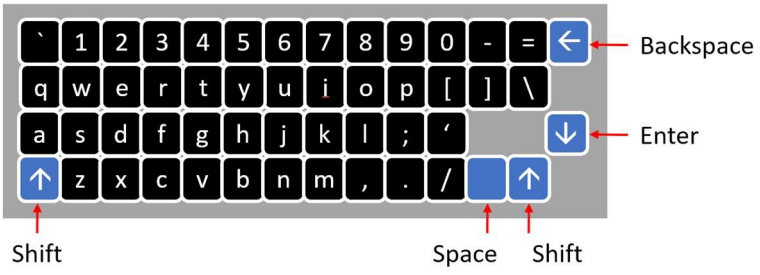
The highlighted digit is changed with the buttons under the encoder (*digit buttons*). The left button will move the highlight to a more significant digit, and the right button to a less significant digit.

On/off settings

Touching a selection button for on/off controls will change the value, as will rotating the encoder knob or pressing the numeric setting buttons (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.



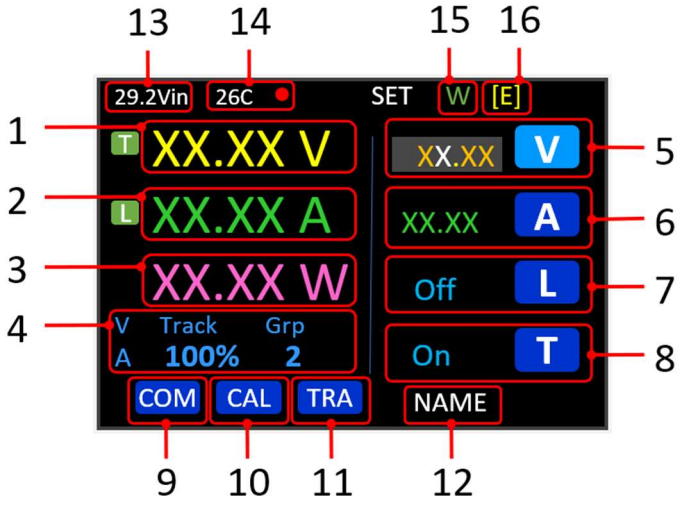
When a character is touched, it is appended to the end of the string. Backspace deletes the last character typed.

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. Output voltage reading
2. Output current reading
3. Output power reading
4. Tracking voltage reduction value and group ID (only visible when Tracking is enabled)
5. Output voltage setting button and value
6. Output current setting button and value
7. Current limit enable button
8. Tracking enable button
9. Communication menu button
10. Calibration menu button
11. Tracking menu button
12. Instrument name
13. Input voltage reading
14. Heatsink temperature
15. WiFi connection indicator (visible on all screens)
16. Save values to EEPROM pending indicator (visible on all screens)

Main screen settings

Settings are saved automatically to EEPROM 60 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 save cycle lifetime (> 10,000).

Voltage

Touch the *V* button on the screen to enable voltage control setting.

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

Output voltage will be displayed as 0.00 until the output is turned on. The actual output voltage may be reduced if current limiting is active (*L* button), or group tracking is enabled (*T* button).

Current

Set the desired output current limit with the *A* button on the screen.

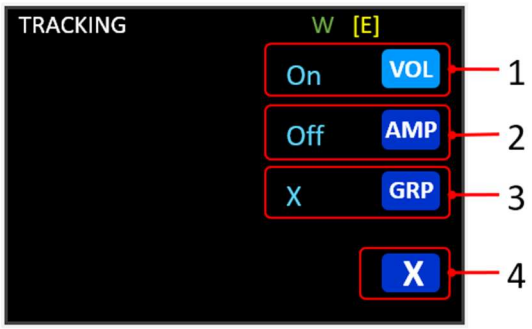
Current Limiting

Current limiting may be turned On or Off by touching the *L* button. The rotary encoder and buttons will also change this setting, as described in *General Operation* above.

Tracking

Tracking functions may be enabled or disabled by touching the *T* button. Once selected, the rotary controls and digit buttons alter the value, as for current limiting. Specific tracking functions are enabled on the TRA(tracking) sub-menu (below).

Tracking Screen



1. Voltage tracking mode indicator and button
2. Voltage tracking mode indicator and button
3. Tracking Group
4. Menu exit button

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

Basic (VOL and AMP both Off). When Tracking is enabled on the main menu, *all* units will reduce their output voltage if *any* of the group current limits. The entire group will reduce its output voltage by the same proportion as the member of the group which is limiting by the greatest amount.

Voltage (VOL). The voltage set on any of the group's controllers affects all units in the group. 'V' is displayed on the main screen next to the 'T' button when this mode is set set and tracking is active.
This mode must *always* be enabled when supplies are connected in parallel.

Current (AMP). The current set on simplest mode, where the current limiting function on any instrument reduces the Voltage of all members of the tracking group by the same proportion. 'A' is displayed on the main screen next to the 'T' button when this mode is set and tracking is active.

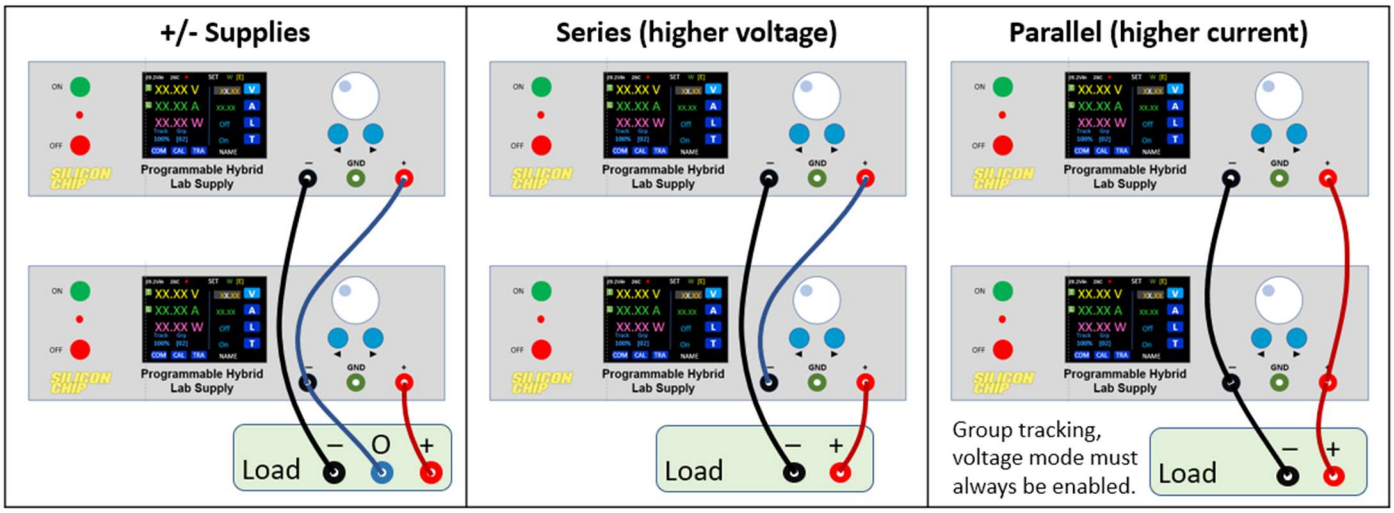
Current and **Voltage** tracking modes can be independently enabled.
Both modes are commonly engaged when providing +/- power supplies, where the commoned terminals are connected to the 0V rail of the circuit being powered.

In **any** of the tracking modes:

- The **On** and **Off** buttons on any controller will control all units in the tracking group, even if none of the current or voltage tracking modes, above, are enabled.
- **Short circuit or overvoltage protection** triggering on any active member of a tracking group will cause all other active units to disconnect their outputs.

Combining Multiple Supplies

Floating outputs on the power supply allows flexible configuration of multiple units. Units may be connected in series (higher output voltage) and parallel (higher current), as well as the common +/- supply arrangement.



While it is possible to operate most modes, other than parallel, with independent controls, tracking can be enabled to allow simultaneous voltage reduction on current limiting, or common control of all supplies in a group from any of the group's control screens.

Multiple instrument groups may be configured. Only instruments in the same tracking group will respond to commands from another unit.

All units in the group will enter the same mode, whenever it is changed on *any* member of the group, as mode changes are broadcast to the group as they are set.

If group tracking is enabled, current limiting on one unit will be mirrored (if *L* & *T* are both On) on the other units, reducing the output voltage by the same *proportion* as the limiting supply. This provides predictable behaviour where the voltages are not equal (e.g. +12V, -5V).

+/- Supplies

Several units may be connected together to provide +/- supplies. Depending on the group tracking mode selected, voltage and current limits may be controlled together, or separately (see below).

Series

To increase the available output voltage, units may be connected in series.

If voltage tracking is enabled and the maximum voltage outputs of both units are not the same, two conditions may occur.

- If the unit with the *higher* maximum voltage is used to control both units, the lower voltage unit will not exceed its maximum voltage setting. The actual setting will be displayed on the lower voltage unit.
- If the unit with the *lower* maximum voltage is used to control both units, the higher voltage unit will not be able to be set beyond the limit of the lower voltage unit.

Current limiting in one unit will cause the other unit to reduce its output voltage proportionately, even if its set current limit has not been reached.

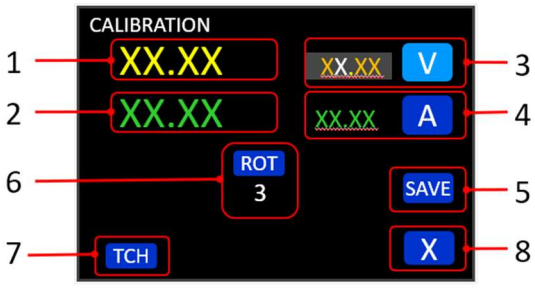
Parallel

Several units may be connected in parallel to increase the available current. **Use this mode with great care.**

For this mode, *voltage* tracking MUST be enabled, as different output voltage settings will cause unpredictable results.

Warning: Multiple supplies connected in parallel must ALWAYS have voltage tracking enabled (VOL = On), and be in the same enabled (T = On) tracking group (Grp = same).
Damage to one or more units may otherwise occur.

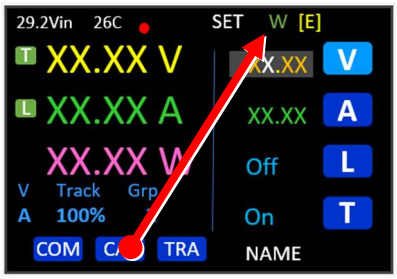
Calibration Screen



1 Voltage reading
2 Current reading
3 Voltage offset (calibration) button and value
4 Current offset (calibration) button and value
5 Voltage and current offset update (save) button
6 Touch screen rotate button and value
7 Touch panel calibration menu button
8 Menu exit button

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

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 CAL button. If the Calibration menu appears, tap the ROT button in the middle of the screen to rotate the touch settings.

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

Voltage calibration

- Set the output voltage to a value close to 25V.
- Disconnect any load and attach a voltmeter to the binding posts. Do no connect anything to the Earth (green) post.
- Turn on the output and select voltage calibration.
- Using the numeric value controls, enter the *difference* between the voltmeter reading and the value displayed on the left of screen. If the external voltmeter is higher, the value entered will be positive.
- Touch the SAVE button to save the result. This will also exit the Calibration menu.
- Wait for the [E] indicator to extinguish before turning the instrument off, so that the new calibration value is permanently stored in EEPROM.

Current calibration

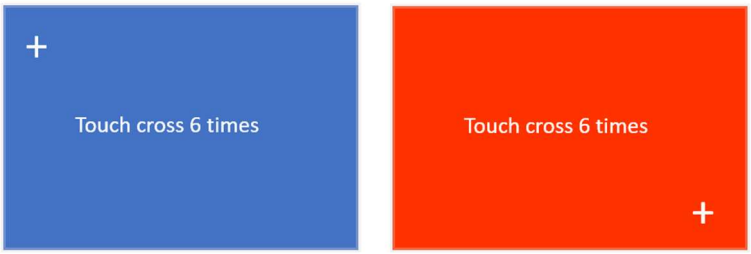
- Connect a load (a 1 ohm 10W resistor is ideal) and ammeter in series between the + and – terminals. Do no connect anything to the Earth (green) post.
- On the main screen, set the output voltage so that the current will be more than 1 Amp (more than 3 Amps is preferred).
- The output may be turned off and on during the following operation, if desired.
- Enter the Calibration screen and select current calibration.
- Using the numeric value controls, enter the difference between the ammeter reading and the value displayed on the screen. If the external ammeter is higher, the value entered will be positive.
- Touch the SAVE button to save the result. This will also exit the Calibration menu.
- Wait for the [E] indicator to extinguish before turning the instrument off, so that the new calibration value is permanently stored in EEPROM.

Touch calibration

Touch calibration 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.

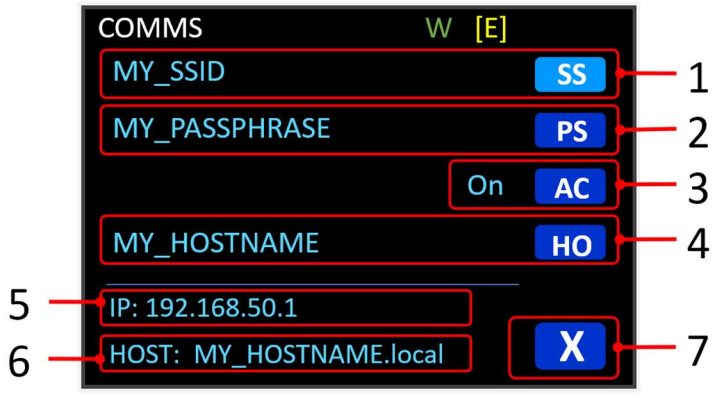
A stylus is recommended for this operation.



Communications Screen

1	SSID button and value
2	WiFi Passphrase button and value
3	Autoconnect button
4	Hostname (instrument name) button and value
5	IP address reading
6	DNS hostname reading
7	Menu exit button

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



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.

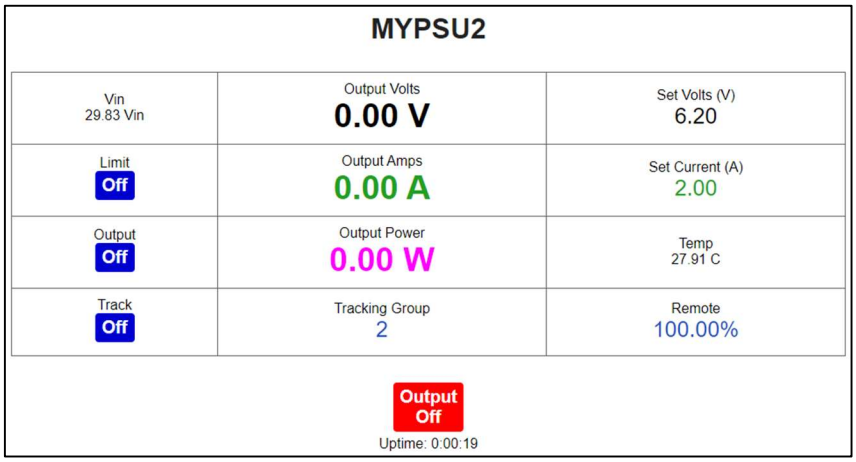
- SSIDs may be up to 32 characters in length. While any valid 8-bit value (e.g. special characters) is permitted, non-alphabetic and non-numeric values should be used with care.
- Passphrases must be between 8 and 32 characters long (WPA2 enforces an eight character minimum). Any legitimate 8-bit value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

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



Functionality is limited to monitoring values and settings, as the interface is not password protected, and there is a 'big red button' that will disconnect the output.

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 EEZ Studio.
  Note: When issued via Telnet or Serial USB, tracking commands are only re-broadcast to the entire group when the appropriate tracking mode is enabled (TRAC:VOLT, TRAC:CURR).
  TRAC:ESTO is rebroadcast to the group when tracking (*T*) is enabled on the connected unit.
- 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. ":SET: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
- 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.
Channel	Integer [0 .. 255]
String	Alpha numeric, plus keyboard symbols, no spaces (ASCII 0x21 .. 0x7E). No quote marks. Case sensitive.

SCPI Command List

*IDN?

Command format	*IDN?
Description	Identify the instrument
Return Info	Manufacturer, product type, series No., software version, hardware version
Typical return	

MEASure

Command format	:MEASure:[parameter]?
Description	Query the actual value of a parameter for the current Channel

CURRent?

Command format	:MEASure:CURRent?
Description	Measure output current
Return Info	Floating point
Typical return	3.00

Voltage?

Command format	:MEASure:VOLTage?
Description	Measure voltage on the output binding posts
Return Info	Floating point Zero if output is OFF
Typical return	12.00

IVOLtage?

Command format	:MEASure:IVOLtage?
Description	Measure input voltage (from AC-DC converter)
Return Info	Floating point
Typical return	28.5

INSTrument

Command format	:INSTrument:[command]
Description	Set or query a setting of the instrument

CHANnel

Command format	:INSTrument:CHANnel CH<1|2>
Description	Set which channel subsequent SOURCE commands will modify *This command has no effect in a single channel instrument.*
Example	:INST:CHAN CH1

ESTOp

Command format	:INSTrument ESTOp
Description	Turn all outputs OFF for *this instrument* (and take whatever additional local action has been specified). *This is the command executed when the 'big red button' on the web monitoring interface is clicked.*
Example	:INST:ESTO

SOURce

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

VOLTage

Command format	:SOURce:VOLTage [float] [unit]
Description	Set the desired output voltage for when the output is ON
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	Set the current limit target
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	Measure the target current limit setting
Return Info	Floating point, in Amps
Typical return	2.00

OUTPut

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

Example	:SOURce:OUTPut ON :SOURce:OUTPut OFF

OUTPut?

Command format	:SOURce:OUTPut ?
Description	Query the current status of the output
Return Info	Floating point, in Volts.
Typical return	12.00

PROTection

Command format	:SOURce:PROTection <ON|OFFt>
Description	Enable/disable current limiting.
Example	:SOURce:PROT ON

PROTection?

Command format	:SOURce:PROTection?
Description	Query the current limiting setting
Example	:SOUR:PROT?
Return Info	Integer 0 for OFF, 1 for ON.
Typical return	1

TEMPerature?

Command format	:SOURce:TEMPerature?
Description	Query the current heatsink temperature
Example	:SOUR:TEMP?
Return Info	Floating point, in degrees C
Typical return	28.5

TRACk

A description of tracking modes in is the section *Combining Multiple Supplies*, above.

Note: When issued via Telnet or Serial USB, tracking commands are only re-broadcast to the entire group only when the appropriate tracking mode is enabled (TRAC:VOLT, TRAC:CURR, :TRAC:REDU).
TRAC:ESTO is always rebroadcast to the group, when tracking is enabled on the connected unit.

Command format	:TRACk:[command]
Description	Set or query values related to tracking between channels or instruments When Tracking is ON, this instrument will transmit and respond to certain commands addressed to the group (depending on the VENAble and CENAble settings).

GROUp

Command format	:TRACk:GROUp [integer]

Description	Set the tracking group number. Acceptable numbers are [1 .. 255]. Group 0 is reserved.
Example	:TRACk:GROU 2

GROUp?

Command format	:TRACk:GROUp?
Description	Query the current tracking group number for this instrument
Typical return	2

ENABle

Command format	:TRACk:ENABle <ON|OFF>
Description	Enable or disable tracking for this instrument.
Example	:TRACK: ENAB ON

ENABle?

Command format	:TRACk:ENABle?
Description	Query the current tracking status number for this instrument.
Typical return	ON

VENAble

Command format	:TRACk:VENAble <ON|OFF>
Description	Enable or disable Voltage tracking. When On, altering the Voltage setting on any of the units will change the setting on any members of the group with this setting enabled (see :TRACk:VOLTage).
Example	:TRACk:VENAble ON

VENAble?

Command format	:TRACk:VENAble?
Description	Query the voltage tracking setting for this instrument.
Typical return	ON

VOLTage

Command format	:TRACk:VOLTage [float]
Description	Set Voltage for this group. When enabled (VENAble = On and TRACk = On), change the Voltage setting on any members of the group with this Voltage tracking enabled. *When issued via Telnet or Serial USB. the command is rebroadcast to the wider group when the appropriate tracking mode is enabled, locally.*
Example	:TRAC:VOLT 12

The setting is queried with the :SOURce:VOLTage? command.

CENAble

Command format	:TRACk:CENAble <ON|OFF>

Description	Enable or disable Current tracking. When On, altering the Current setting on any of the units will change the setting on any members of the group with this setting enabled.
Example	:TRAC: CENA ON

CENAble?

Command format	:TRACk:CENAble?
Description	Query the current tracking for this instrument.
Typical return	ON

CURRent

Command format	:TRACk:CURRent[float]
Description	Set Current limit for this group. When enabled (CENAble = On and TRACk = On), change the Current limit setting on any members of the group with this Voltage tracking enabled. *When issued via Telnet or Serial USB. the command is rebroadcast to the wider group when the appropriate tracking mode is enabled, locally.*
Example	:TRAC:CURR 3.5

The setting is queried with the :SOURce:CURRent? command

REDUce

Command format	:TRACk:REDUce [float]
Description	When tracking is enabled (TRACk = On), reduce the output voltage of each unit in the group to locally set Voltage value * the argument of this command. *When issued via Telnet or Serial USB. the command is rebroadcast to the wider group when the appropriate tracking mode is enabled, locally.*
Example	:TRAC:REDU 0.75 Each unit in the current tracking group should reduce its output voltage to 80.0% of its locally set value. If unit XX: has an output voltage setting of 12V, its output voltage will be reduced to 12V * 0.75 = 9V

REDUce?

Command format	:TRACk:REDUce?
Description	Query the current level of group voltage reduction for this unit.
Typical return	0.80 (Indicating that the output voltage is reduced to 80% of the local setting.)

ESTOp

Command format	:TRACk:ESTOp
Description	Turn output OFF for all members of the group (and take whatever additional local action has been specified). *When issued via Telnet or SerialUSB, this message will be rebroadcast to all members of the current tracking group, regardless of Tracking settings.*
Example	:TRAC:ESTO

SYSTem

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

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 is not available remotely

AUTOconnect

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

AUTOconnect?

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

HOSTname

Command format	:SYSTem:HOSTname [string]

Description	This is command will have the same result as setting the instrument using :INSTrument:NAME mDNS will respond to ICMP (ping, DNS) requests to hostname.local allowing the host to be addressed by this name as well as the 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 MYPSU mDNS will respond to ICMP (ping, DNS) requests to MYPSU.local or mypsu.local (case insensitive)

HOSTname?

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

SCPI Packet Structure

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

Transport (UDP/IP) Headers

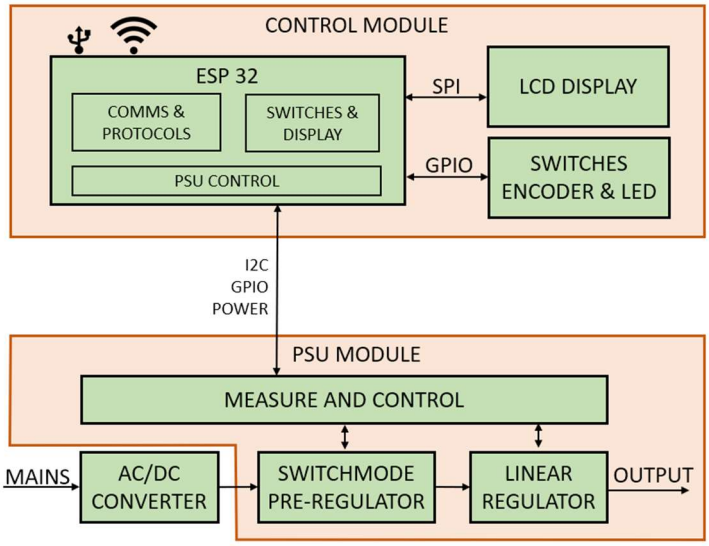
Item	**Type**	**Content**	
IP Header	20 bytes	Source & Destination Address, Protocol	
UDP Header	8 bytes		
Bytes		**Content**	**Location**
2		Source Port (optional IPV4, IPV6)	0-1
2		Destination Port	2-3
2		Length	4-5
2		Checksum (optional for IPV4)	6-7

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 cmds and responses. CSV for logging).	27-1050
1051	**Total**	**SCPI packet**	

Design Overview

The basic design to the power is shown in the block diagram. AC power is converted to 28-30V DC using a commercial 100W switch mode module. This has been chosen, in preference to a traditional transformer design, to reduce size, cost, and weight.



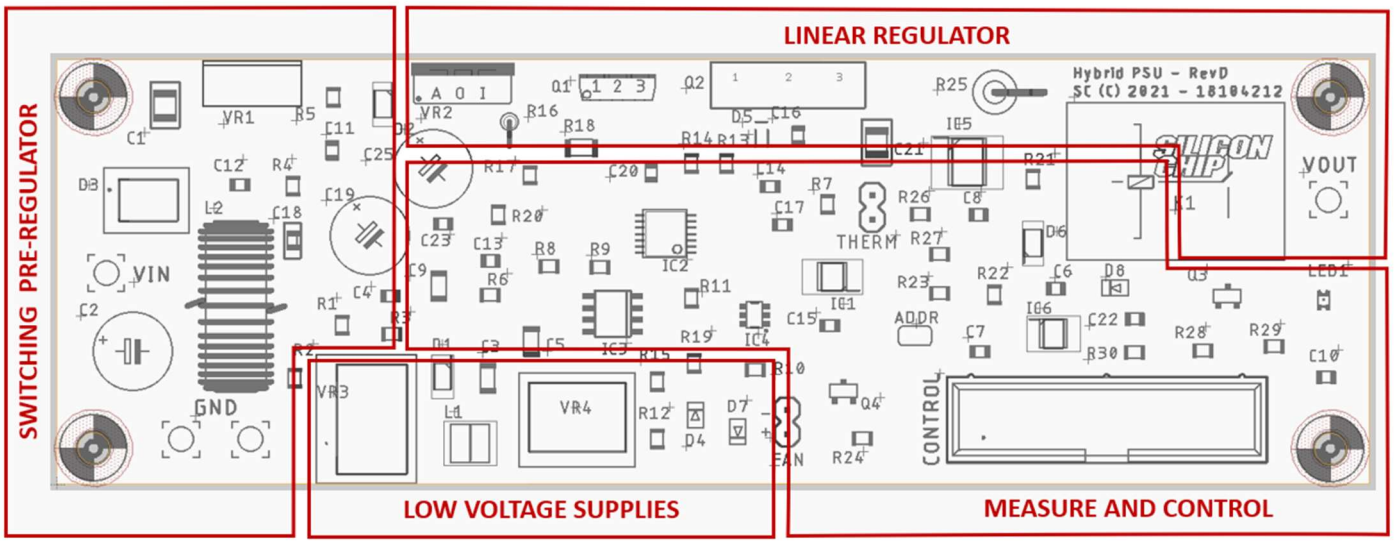
Programmable supply block diagram

Next, a LM2679-based DC-DC buck pre-regulator reduces the DC voltage to 3.6V more than the required output. Finally, a current-boosted linear regulator, based on an LM317, brings the voltage down to the correct output value.

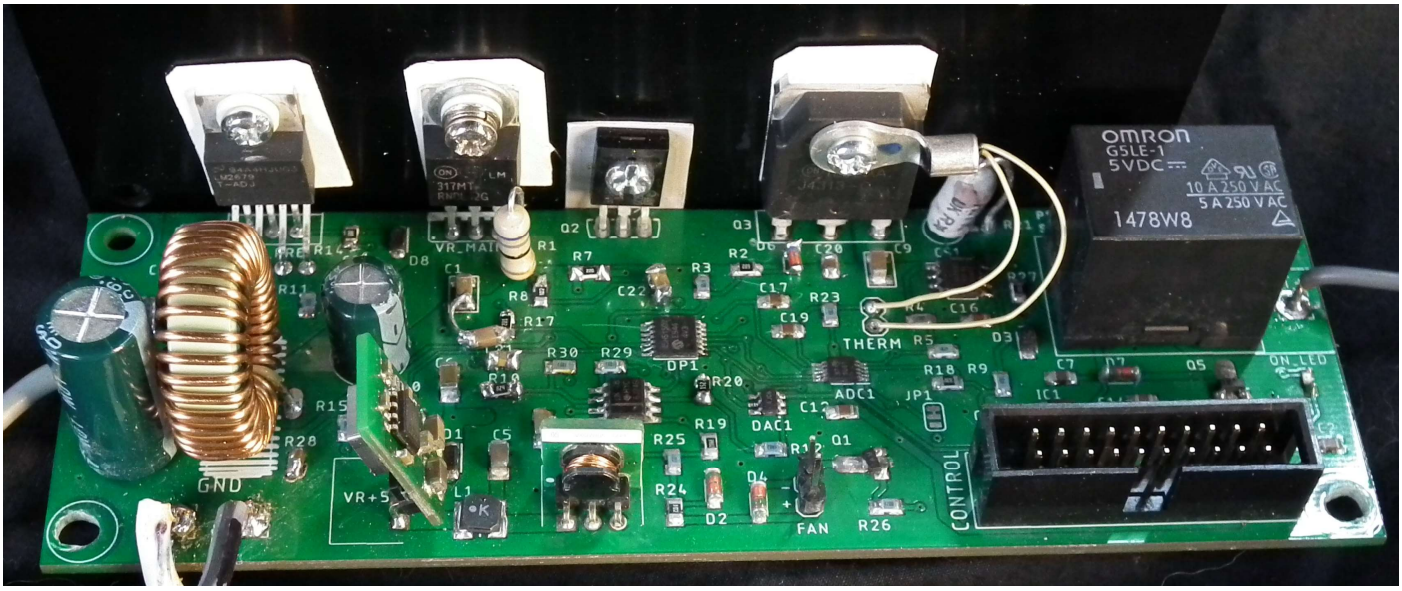
Output current is converted to voltage using an INA282 high-side current to voltage converter measuring the voltage drop across an 0.01 ohm shunt resistor. The output voltage and current, along with the input voltage and heatsink temperature, are then measured using a 16-bit ADC. DRDY! signals a complete ADC conversion.

The LM317's coarse output voltage is controlled by a voltage divider consisting of R20 and the digital pot, IC3, and trimmed using the DAC's output and opamp IC3A.

All digital control functions use the I2C bus, and the ADDR jumper allows two modules to share a single controller, by altering one bit of each device's I2C address.

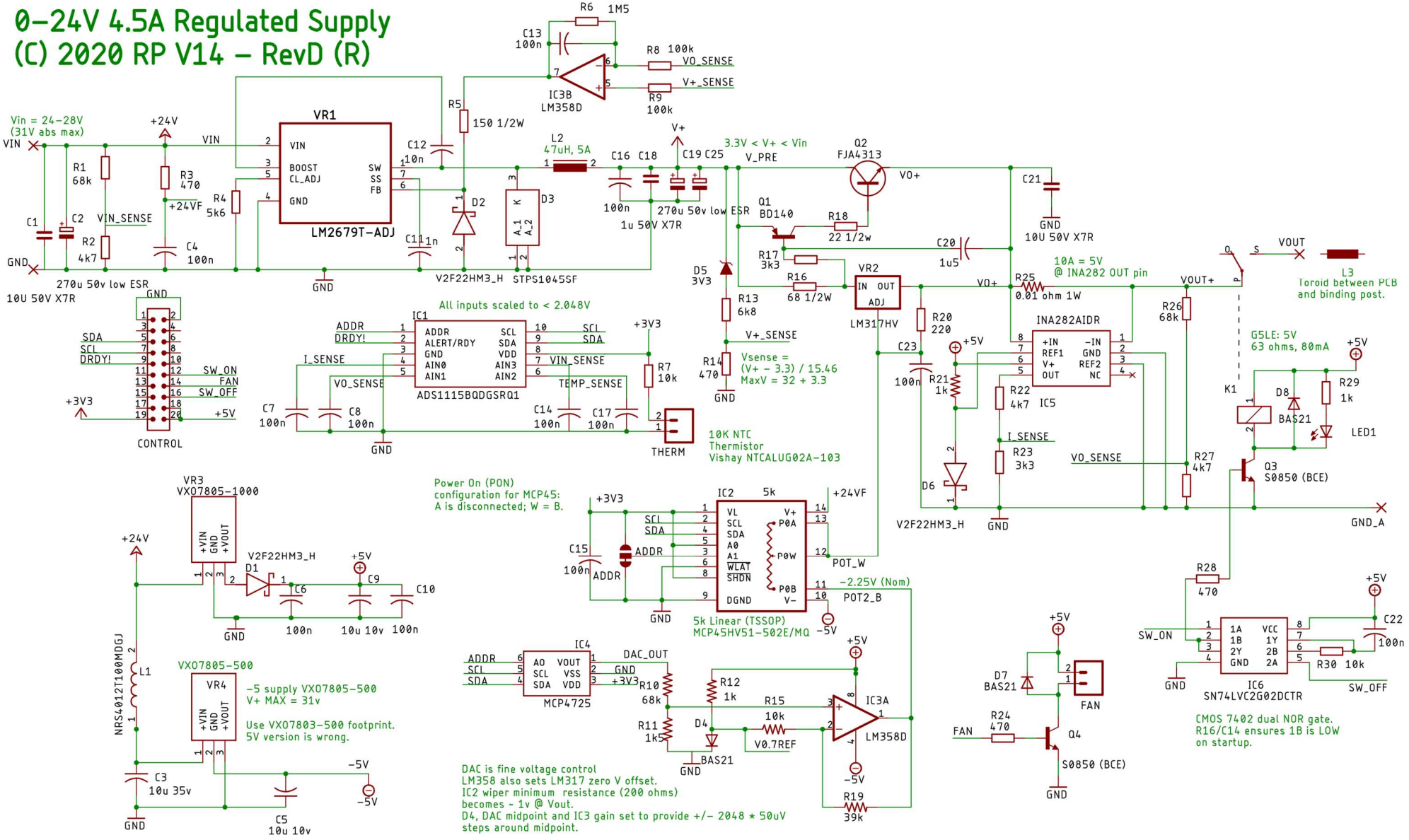


PCB layout (Rev D)



Prototype (Rev C)

Schematic


0–24V 4.5A Regulated Supply
(C) 2020 RP V14 – RevD (R)
Vin = 24–28V
(31V abs max)
VR1
LM2679T-ADJ
VIN
BOOST
CL_ADJ
GND
SW
SS
FB
R1 68k
R2 4k7
R3 470
R4 5k6
R5 150 1/2W
C1
C2 270u 50v low ESR
10U 50V X7R
C4 100n
C11 1n
C12 10n
D2 V2F22HM3_H
D3 STPS1045SF
L2 47uH, 5A
C16 100n
C18 1u 50V X7R
C19 C25 270u 50v low ESR
V_PRE
3.3V < V+ < Vin
IC3B LM358D
R6 1M5
C13 100n
R8 100k
R9 100k
VO_SENSE
V+_SENSE
Q2 FJA4313
Q1 BD140
R18 22 1/2w
R17 3k3
R16 68 1/2W
D5 3V3
R13 6k8
R14 470
Vsense =
(V+ – 3.3) / 15.46
MaxV = 32 + 3.3
VR2
LM317HV
IN OUT ADJ
C20 1u5
C21 10U 50V X7R
10A = 5V
@ INA282 OUT pin
R25 0.01 ohm 1W
INA282AIDR
IC5
R20 220
R21 1k
R22 4k7
R23 3k7
R26 68k
R27 4k7
D6 V2F22HM3_H
L3
Toroid between PCB
and binding post.
K1
G5LE: 5V
63 ohms, 80mA
D8 BAS21
LED1
R29 1k
Q3 S0850 (BCE)
GND_A
All inputs scaled to < 2.048V
IC1
ADS1115BQDGSRQ1
ADDR
ALERT/RDY
AIN0
AIN1
AIN3
AIN2
SCL
SDA
DRDY!
I_SENSE
VIN_SENSE
TEMP_SENSE
R7 10k
C7 100n
C8 100n
C14 100n
C17 100n
THERM
10K NTC
Thermistor
Vishay NTCALUG02A-103
CONTROL
SW_ON
FAN
SW_OFF
+5V
+3V3
VR3
VX07805-1000
+VIN GND +VOUT
D1 V2F22HM3_H
C6 100n
C9 10u 10v
C10 100n
L1 NRS4012T100MDGJ
VX07805-500
VR4
C3 10u 35v
C5 10u 10v
-5 supply VX07805-500
V+ MAX = 31v
Use VX07805-500 footprint.
5V version is wrong.
Power On (PON)
configuration for MCP45:
A is disconnected; W = B.
IC2 5k
MCP45HV51-502E/MQ
5k Linear (TSSOP)
C15 100n
POT_W
POT2_B
-2.25V (Nom)
IC4
MCP4725
DAC_OUT
R10 68k
R11 1k5
R12 1k
R15 10k
D4 BAS21
V0.7REF
IC3A LM358D
R19 39k
DAC is fine voltage control
LM358 also sets LM317 zero V offset.
IC2 wiper minimum resistance (200 ohms)
becomes ~ 1v @ Vout.
D4, DAC midpoint and IC3 gain set to provide +/– 2048 * 50uV
steps around midpoint.
D7 BAS21
FAN
R24 470
Q4 S0850 (BCE)
R28 470
R30 10k
IC6
SN74LVC2G02DCTR
C22 100n
CMOS 7402 dual NOR gate.
R16/C14 ensures 1B is LOW
on startup.

Control header pins

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

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				12	SW_ON	4
13				14	FAN	26
15				16	SW_OFF	12
17				18	+5V (Supply)	
19	+3.3V (Return from ESP32)			20	+5V (Supply)	

A Bill of Materials is included in the associated Silicon Chip article (2021).

Specifications

Power supply

Output ratings (see also SOA diagram: Fig X)	
Low range: 10mV – 16V	5A
High range: 16V – 26V	5A @16V tapering to 3.5A @ 24V further reducing to 250mA @26V SOA limiting is always enabled.
Programming accuracy	
Voltage	10mV
Current	10mV
Control accuracy	
Voltage	Better than +/- 5mV when calibrated. No change under load, unless SOA or current limiting is active. On-screen calibration of maximum voltage.
Current	Better than +/- 5mA when calibrated On-screen calibration of maximum current. Zero point is recalibrated when output is OFF for greater than 1 second.
Ripple and noise (no terminal grounded) 20Hz – 20MHz	
Voltage	37mV RMS at full load
Load regulation (change in load current at fixed voltage, measured at front panel binding posts)	
Voltage	No measurable change once output has stabilised
Transient response	< 5uS recovery to within 5% of rated voltage (0 – 0.5 A step change with rise time of < 100uS) Full recovery to programmed voltage (within SOA limits) within 5mS. With load rise times of less than 50uS switching transients of up to 3V may occur at load changes greater than 2A. Transients at lower and higher currents are proportional to this value.
Line regulation (change in voltage under constant resistance load, measured at front panel binding posts)	

Settling time after reaching nominal target voltage	< 50mS Rise time is intentionally limited to 100V/sec. (0-26V in 260mS) 40V/mS (no load). Shorter fall times under load. The time constant can be calculated using 10uF and the actual load resistance.
Transient response	Overshoot < 1V Undershoot < 300mV
Readback resolution (SCPI)	
Voltage	1mV
Current	1 mA

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.
Remote control connections	
WiFi	802.11 b/g/n/e/i Auto-connect to the SSID/passphrase combinations provided on the COM menu. WPS is not supported. Where connection to a local WiFi LAN fails, connection is attempted to SSID: ESPINST PW: ESPPW99X If this also fails, a local WiFi network is created with the SSID ESPINST The IP address range provisioned on ESPINST, using DHCP, will be 192.168.50.X DHCP IP address provision in all modes. The current IP address available on the COM menu page DNS name is hostname.local (each instrument implements an mDNS responder) (see SCPI command :INST:NAME and COM menu)

Telnet	Port: 5025 SCPI commands accepted and results returned. Functionality has been tested with the open source software EEZ Studio, and a bare instrument definition for this software is included in the project's downloads.
Web (HTTP)	A simple web interface is provided which displays the current settings and readings. **The page is and not secured or encrypted.** The output can be turned off from the web page, but no other settings can be affected. Page refresh rate: 5 seconds Port: 80 http:// hostname.local or http://IPaddress
UDP (packet)	SCPI commands may also be received using UDP packets, although this mechanism is primarily designed for inter-instrument communication when tracking is enabled. Only commands issued by members of the same *tracking group* are processed. Other messages are discarded. 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

Physical and electrical

Electrical	
AC input	100 – 240V 2.1A max < 120W at full load, after start-up.
Physical	
Dimensions	253 x 190 x 82mm
Weight	1.5kG

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. Duplicate hostname.	See *Communication Screen* and *Specifications – WiFi* sections.