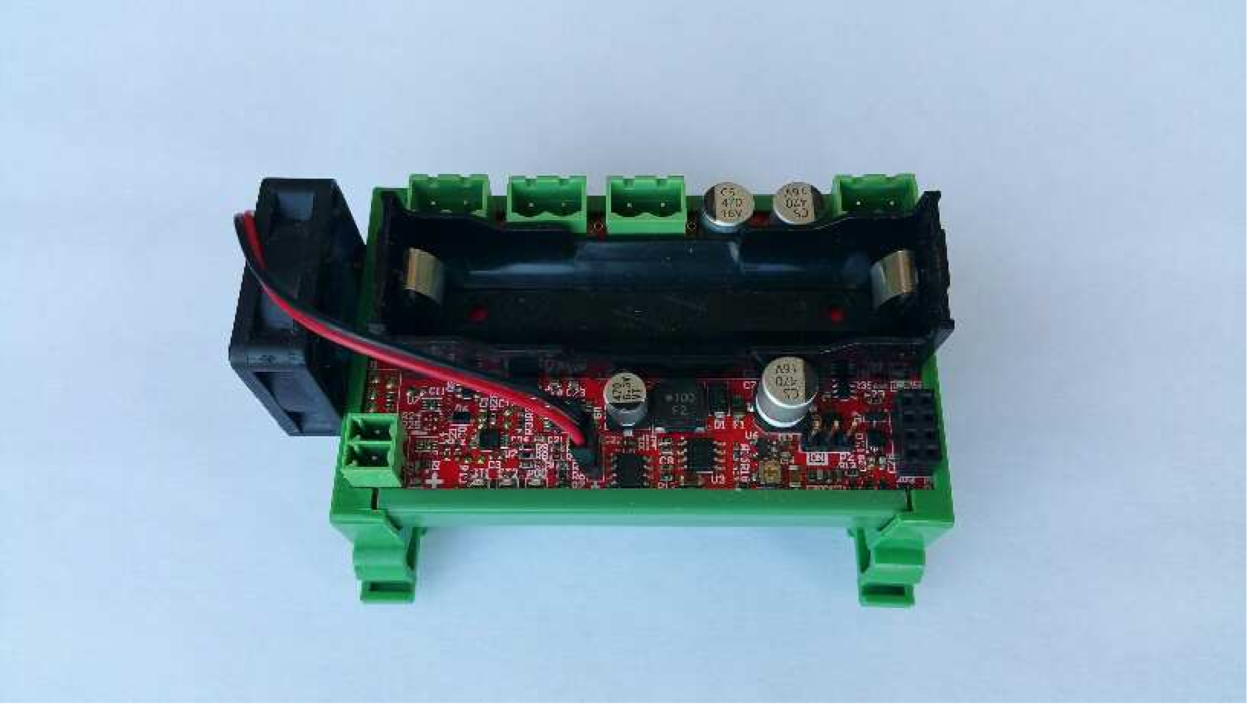
enutil Energy Inc.

# Pi18650 SMART UPS



**Description:**

The Pi18650 SMART UPS (Pi-S-U) is a Power Supply and Backup UPS for the Raspberry Pi board. This unit allows you to operate your Raspberry Pi without a power cable and can use various capacity 18650 Lithium Ion batteries. On board is one 250mA battery charging circuit for charging the battery. The Pi-S-U also includes a 4x2 100mil header for use with our custom WROOM32-DONGLE (W32-D) Wifi/BLE module for remote monitoring and CLOUD integration or another custom designed board of your liking. The W32-D can be used to provide remote reboot feature with an example provided for system lockup or other issues or procedures. Many Pi's are located in remote or hard to reach areas and the W32-D provides a simple method of rebooting your Pi without any physical interface. A low power fan provides air flow to help reduce heat when used with a 24V DC supply.

**How It Works:**

The Pi-S-U holds one single cell lithium Ion 18650 form factor battery which should have integrated battery protection circuits. Using Lithium Ion batteries without protection circuits can be very dangerous. The boost circuit maintains the voltage to the Pi at 5.1V for battery voltages of 3.7V to 4.2V. The 3-Pin jumper allows you to disable power to the Pi and Isolate the battery circuit or start the Pi. This jumper can be used with an external relay providing automatic control from circuit or system. It also includes one charging IC's which can charge up to 250mA from the Power Supply Input connector We have coded a Python script using I2C SMBUS for you to read the Battery Voltage, Mode, Humidity, Temperature and Reboot Status bit along with a shutdown script for low battery voltage or remote reboot request. Charging LEDs show the status of the charging process. The Pi-S-U can also be used with other SBC's or devices which use up to 16VDC supply which include Routers, Modems and lots of other electronic equipment. Any DC power supply, adaptor or solar panel up to 24V max can be used with the Input connector for charging and running the system. Pluggable connectors provide easy access to connect and remove wires in your system setup.

Proper shutdown is required for all computers using an operating system otherwise data or system corruption will occur reducing your system run times and performance. Using a UPS keeps the system running regardless of a power failure, brown-out or supply line interruptions and allows a quick and seamless software shutdown when needed. Using our Pi-S-U along with the W32-D can provide a routine or scheduled shutdown and wake-up by developing software using ESP-IDF or Arduino platform.

Please follow the safety precautions of your Li-Ion battery supplier and use only with li-Ion batteries containing internal protection circuitry. When purchasing your batteries, check that they have protection circuits and if not listed, contact your supplier prior to purchasing. Lithium Ion batteries provide a substantial amount of energy storage compared with other technologies but care must be taken when using, storing, disposing of and handling these type of batteries.

## Use Cases:

- Industrial Automation and Control Systems
- Remote battery operation for photography, security filming and monitoring
- Data logging for IoT/IIoT applications, Embedded systems server backup power
- Research and Development

## Technical Specifications:

| | |
|---|---|
| Charge Current: | 250mA DC |
| Operating Temperature: | Per battery specifications (-20 to 40C) |
| Charge Time: | Varies with battery capacity |
| Backup/Operating Time: | Varies with battery capacity |
| ROHS Compliant: | Yes |
| Operating Input Voltage: | 5V - 24V DC |
| UPS Mode: | Up to 1.8A for Raspberry Pi/Device |
| Battery Only Mode: | Up to 1.8A for Raspberry Pi/Device |

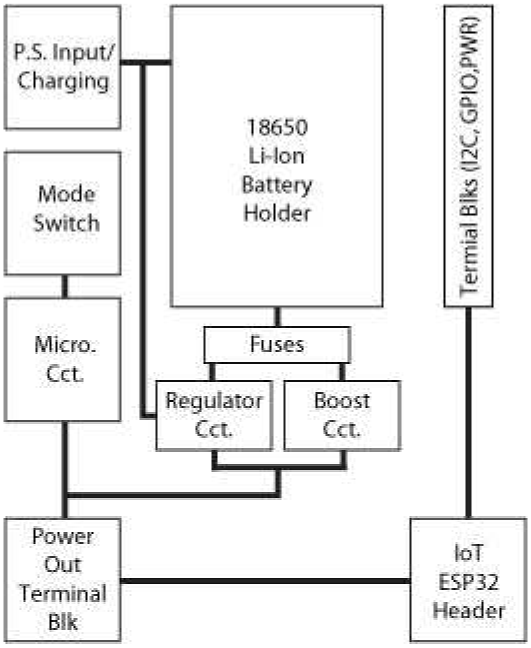
## Calculating Operating Times:

The Pi-S-U uses 18650 form factor Li Ion battery which come in various sizes of capacity. To calculate the run time on a battery, an example is provided below. The total current consumption or all attached peripherals to the Raspberry Pi/device can be measured via the jumper by the +ve battery terminal.

As an example the Raspberry Pi Zero uses approximately 87mA without and 103mA with a USB dongle plugged in. With a fully charged 3000mAh battery, the Pi would last 34.5 Hrs with nothing attached and load at 87mA (ideal conditions).

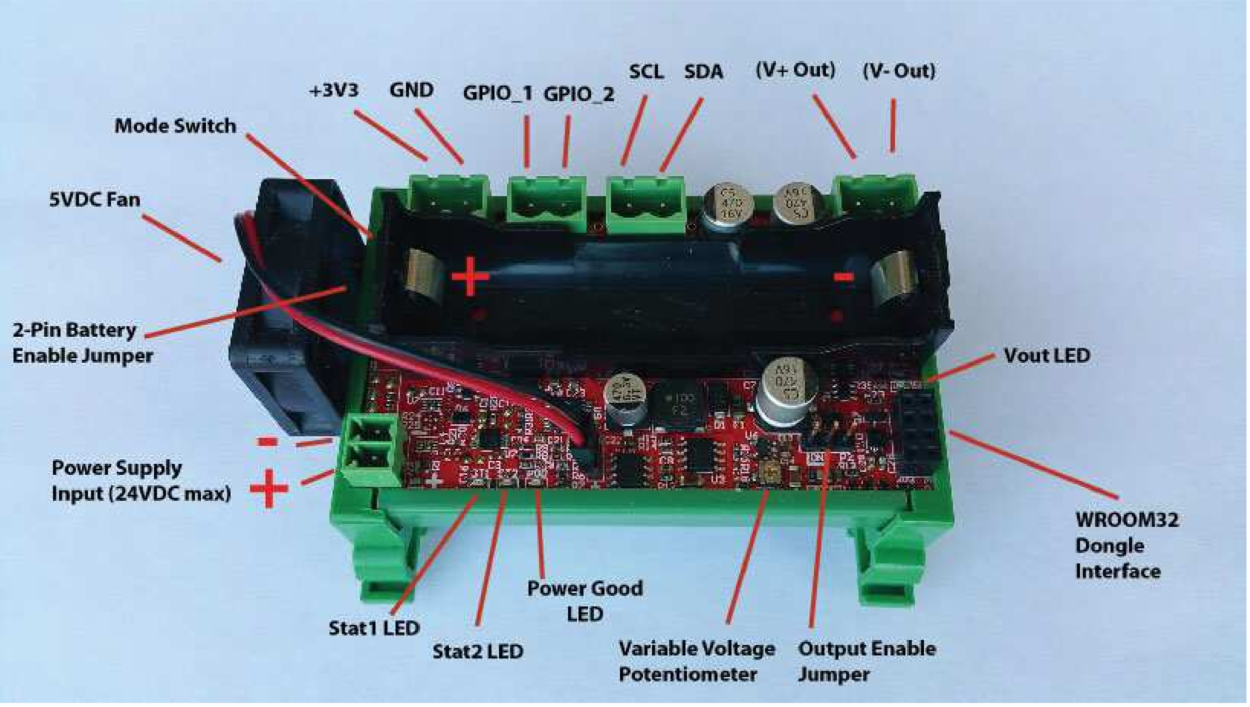
Battery Capacitry / Load = Run Time
3000mAh / 103mA = 29hrs

## Block Diagram:



## Operating Instructions:

The Pi-S-U has several jumpers, pluggable terminal blocks and switches for operation of the device seen in the image below.



The 2-Pin battery jumper near the fan location allows the user to disable all power drain from the battery for storage (Note: charging is also disabled when this jumper is removed).

**Note:** The proper polarity for inserting your 18650 battery. Some batteries are longer or shorter than others so the metal clips which contact the battery may be squeezed in slightly or pushed outward to make a snug fit with the battery. 18650 batteries are encased in a metal housing with a plastic outer wrap which can wear down with the continuous removal and insertion of the battery. To avoid this wear if the battery is removed and replaced often, please use a small flathead screwdriver and pry out the (-V) end of the battery first so the front can lift out without sliding. If the plastic outer wrap wears down you can short your battery by just removing it upwards without lifting the (-V) end first. We have integrated into our design Reverse-Polarity protection in case the user has inserted the battery the wrong way which would damage most circuits without this feature.

The MODE SWITCH located between the Fan and the (+V) end of the battery holder allows the user to switch between two modes of operation.

Mode (0): Battery mode operation in which the system continues to operate in the absence of a power supply. The system will operate off battery power up until the battery voltage reads 3.4Va t which time the shutdown timer will start and set GPIO_2 (HIGH) indicating that power will be turned off within 30 seconds.

Mode (1): UPS mode operation in which the system will initiate a power down sequence when input power supply is absent setting GPIO_2 (HIGH) and disabling power to the output within 30 seconds and restart as soon as input power supply has returned. (Default position with the switch in the upwards position towards the top pluggable connectors)

Fan (+5VDC) provides cooling when using higher power supply voltages such as 24VDC (max). Fan only runs off input power supply not battery voltage.

Charging LED's: (MCP73833 - 250mA charge current)

STAT1 (ON)

STAT2 (OFF) - Pre-Conditioning or Fast Charge Mode

STAT2 (ON) STAT1 (OFF) - Charge Complete

PWRGD (ON) - Power Is Good For Charge

Variable Voltage Potentiometer is used to adjust the output voltage to the connected Pi or device. Care must be taken to ensure that the output voltage is not higher than what the connected device can handle as this may destroy your connected Pi/device including the Pi-S-U. For Raspberry Pi operation, turn the potentiometer counter-clockwise all the way to the left until it stops which is around 4.9V and a measurement should be taken prior to connecting your device. The output voltage may be increased above 16V at which point a protection diode will kick-in and the voltage will drop, so do not increase above 16V value for proper operation.

Output Enable Jumper allows the user to disable power to the output or can be used with relays for external operation. The ON position is the left-middle pin connection and OFF right-middle pin connection as shown on the PCB.

WROOM32 DONGLE Header is used along with our custom WROOM32 dev board which provides remote reboot feature and other IoT/IIoT controls with the onboard ARM Cortex MCU.

V(out) LED provides visual indication of output power is present on the V(out) terminal blocks in the top right corner of the board.

V(out) plus and minus terminal provide power to the external Pi/Device connected.

I2C communication to the Pi/Device can be achieved using the SCL-SDA terminal block. Our example python script with the Pi shows reading info from the supervisory microcontroller.

GPIO_2 provides a (HIGH) shutdown in progress and (LOW) normal operation to the external Pi/Device which can be used to initiate a soft-shutdown of the Os to avoid corruption or data loss.

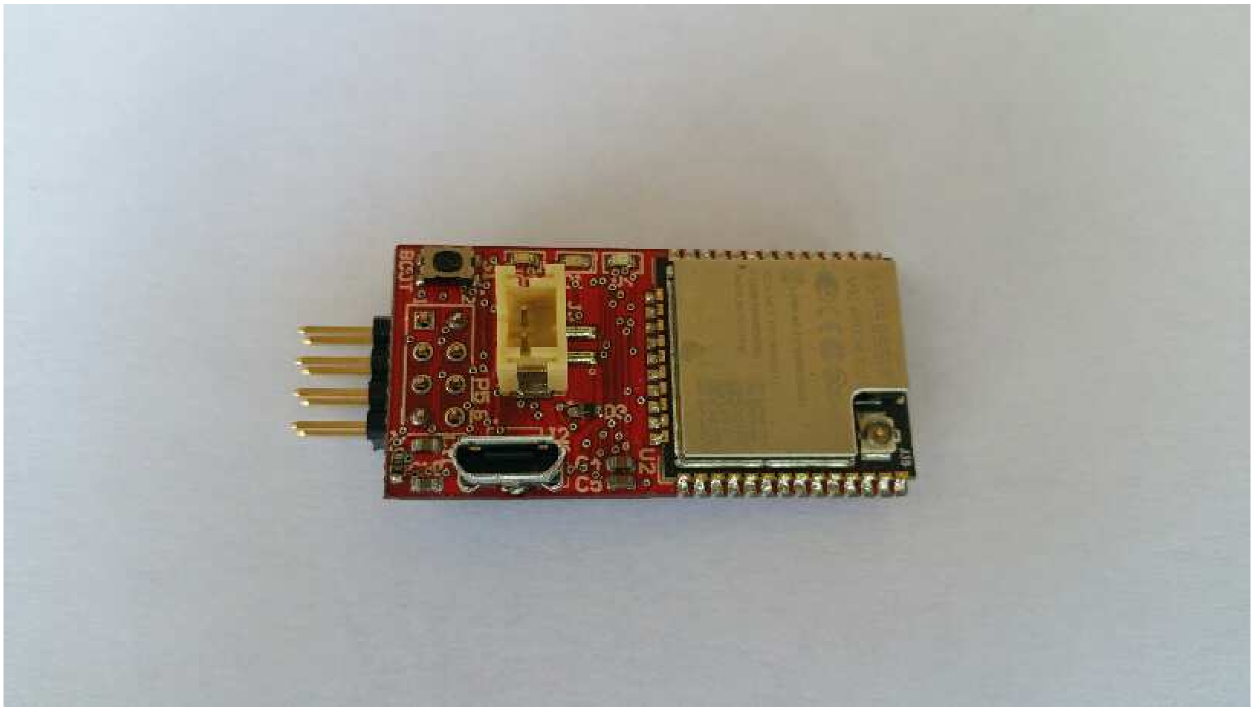
GPIO_1 is a general purpose GPIO which is connected directly to a Pin (5) on the WROOM32 header. This can be used as a digital signal between the Pi/Device and the WROOM32-DONGLE for any IoT/IIoT application.

+3V3 and GND are provided on the last terminal block and should not drain more than 200mA if used with the WROOM32-DONGLE.

On the bottom layer of the Pi-S-U, contains input circuitry to reduce the supply voltage to a safe operating level along with components to protect against ESD, voltage spikes (from relay activity and supply fluctuations),  which may be present in industrial applications.

Our custom firmware provides algorithms to filter out voltage spikes, brownouts and power losses under a specified period of time to allow smooth operation of your connected Pi/Device. A DIN Rail mountable housing allows seamless integration into control panels, wall mounting or desktop applications. The firmware also detects the Mode switch position which can be changed on the fly if needed.

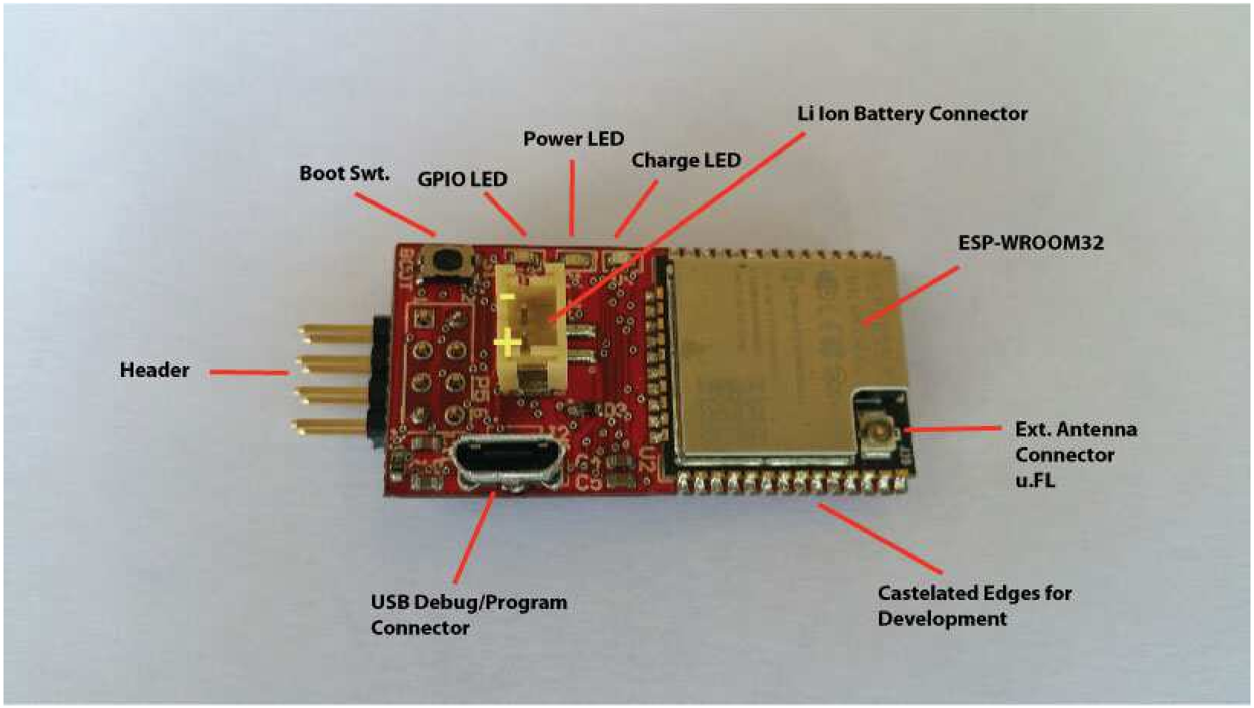
# WROOM32-DONGLE



## WROOM32-DONGLE:

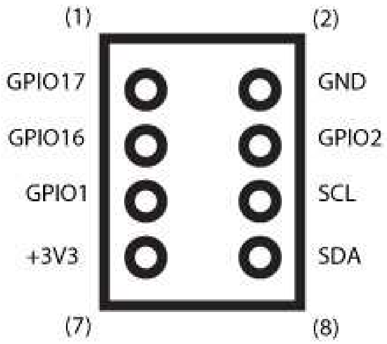
The WROOM32-DONGLE (W32-D) was designed to provide a compact IoT/IIoT interface for standalone and integrated applications with the Pi-S-U. This board houses an ESP32 dual core controller with available Wifi and BLE protocols making it an ideal component for various use cases. It can operate with a connected Li-Ion battery with GPIO and I2C communications on the header. Provisions for external antenna is available on the u.fl connector. An adaptor with u.fl to SMA type connector is required to use an external antenna with this device. Take note there are RP (Reverse Polarity) and Non RP type SMA connectors so choose the right adapter combination with your antenna.

## Operating Instructions:


Li Ion Battery Connector
Power LED
Charge LED
Boot Swt.
GPIO LED
ESP-WROOM32
Header
Ext. Antenna Connector u.FL
USB Debug/Program Connector
Castelated Edges for Development

Header 2x4 (100 mil) provides access to I2c and GPIO along with interfacing with the Pi-S-U.

WROOM32-DONGLE HEADER LAYOUT



GPIO2 used for Remote Reboot for the Pi
GPIO71 and GPIO16 Not Connected
3V3 input from Pi18650 SMART UPS or External Device

GPIO16 and 17 are not used/connected in the device. GPIO2 controls the Remote-Reboot feature of the Pi-S-U. GPIO1 is a general purpose gpio and ported to the terminal block on the Pi-S-U which can be connected to an external device. The I2C (SDA/SCL) pins are connected to the Pi-S-U when plugged in and can also be accessed via the terminal block. The 3V3 and GND pins are used to provide power to the device from the Pi-S-U when connected or can be used as an external 3V3 output ONLY when used with the USB/Li Ion Battery and not connected to the Pi-S-U which already provides power on this pin.

Boot Swt. is used to put the W32-D into programming mode upon power-up. Hold this button down prior to connecting the USB cable from PC to update and load new firmware into the Device.

GPIO LED is a general purpose LED which can be used in your applications for visual indication.

Power LED turns on when power is applied to the device.

Charge LED indicates charging process. (MCP73831 - 500mA charge current)

LED (OFF) Charge Complete

LED (ON) - Pre-Conditioning or Fast Charge Mode

Lithium Ion battery connector is used for external battery connection. This should not be used when connected to the Pi18650 SMART UPS or other devices which already provide external power.  Take care when removing the connector slowly by wiggling gently side-to-side not to damage the board with too much force on the connector.

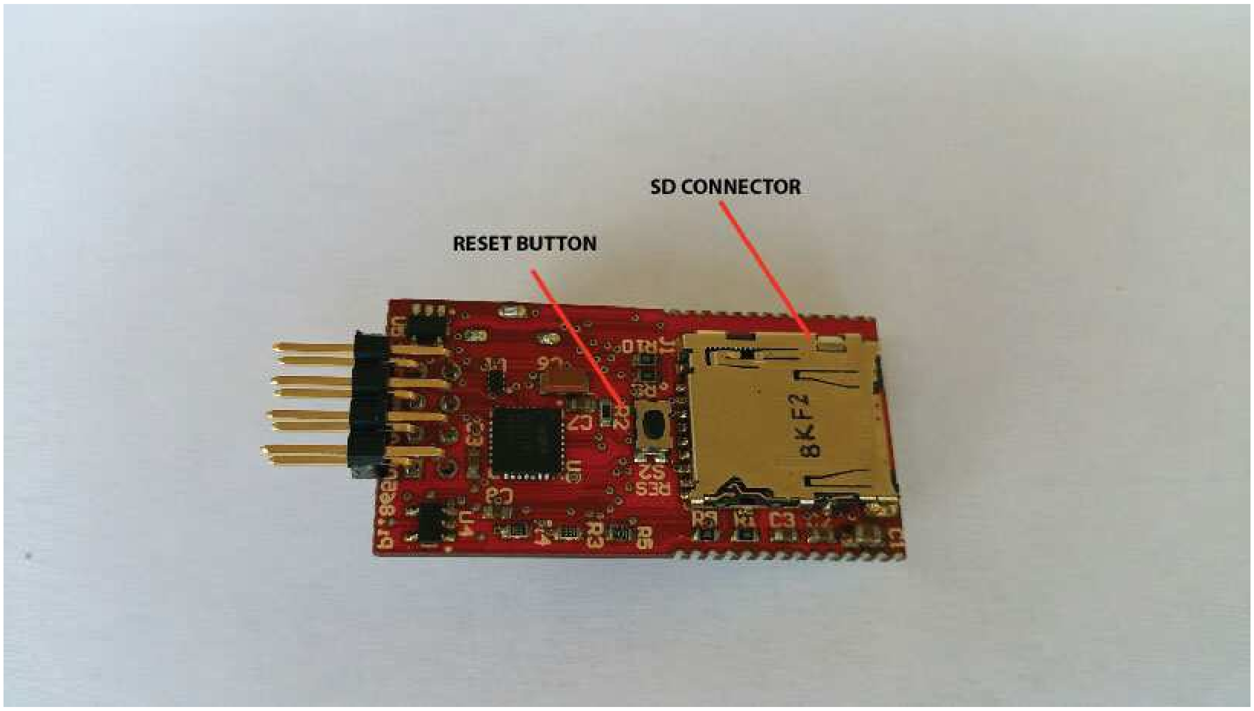
WROOM32 module based on the ESP32 dual core MCU. Developed by Espressif Systems and more information can be found on their site.

External antenna is required to be used with this device otherwise reception may be intermittent. A Wifi/BLE 2.4GHz antenna is sufficient for this purpose with a standard u.fl connector.

Castellated edges provide access to all GPIO on the device.

USB Debug/Program connector is used for updating firmware and providing power when used with a PC.

Firmware can be developed using the ESP-IDF platform, Arduino IDE (integrating ESP32 libraries) on a Windows PC, Linux or Virtual Machine running some flavour of Linux.



Reset Button is used to reboot the ESP32 module after firmware updating is complete. (located on the bottom side of the board)

SD Connector is used to hold a standard uSD Card for device storage and other applications. This can be implemented the device firmware when developing applications. (located on the bottom side of the board)

Note: The proper orientation for the WROOM32-DONGLE once inserted into the Pi18560-SMART-UPS. Make sure the pins are in line with the header when inserting prior to powering up the SMART-UPS.