The Afterburner

USER MANUAL V3.5.2

A Bluetooth / Wi-Fi enabled controller for Chinese Diesel Heaters

Congratulations on your acquisition of the Afterburner.
This device allows you unprecedented remote controllability of your compatible Chinese diesel heater, and detailed examination of the run time conditions.

Contents

DISCLAIMER

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No responsibility will be taken for any damages caused by operating the Afterburner with your diesel heater system.

Introduction

The Afterburner only works with compatible digitally controlled Chinese Diesel air heaters.
Not all heaters are digitally controlled.

It is not compatible with Webasto or Eberspaecher heaters.
It is not compatible with any water (hydronic) heaters.

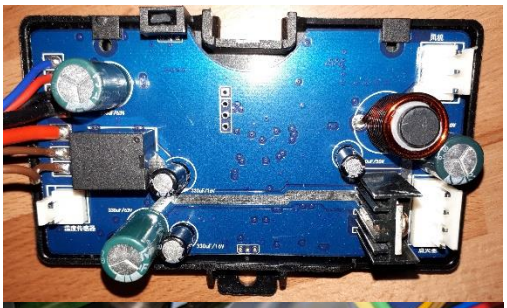
Primarily, there must be only 3 wires to the controller.
Typically being red, black, and blue.
These ultimately terminate in either a triangular or round waterproof connector.

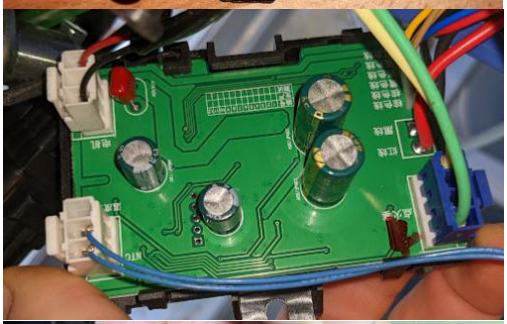
The only brand that IS 100% known to be compatible is the Lavaner Pro, or Lavaner Standard.

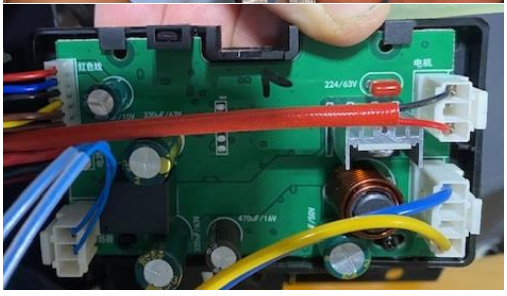
ECU must be compatible.

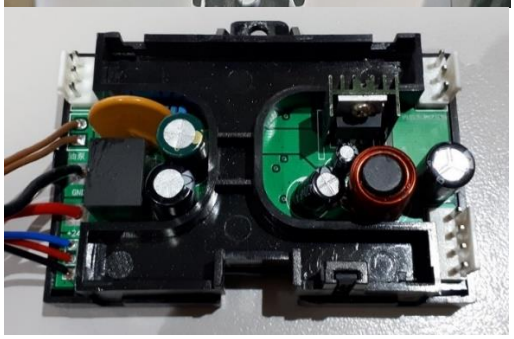
The crucial component is the ECU mounted within the heater which determines the digital data protocol that is used, and this must be compatible with the data protocol the Afterburner uses.
Not all Chinese heaters use the same data protocol, despite plugs possibly being the same.

The following images are of ECUs known to support the correct data protocol.
If yours looks like any of the following, then your heater is compatible and will work with the Afterburner controller.
Those with a large inductor (coil) provide better glow plug control.









Controller connectors

The controller connectors will terminate in either a triangular or round waterproof connector.

The triangular connector is found in both compatible and incompatible units.

It is an extremely poor discriminator to use.

The round connector so far has only been found on compatible ECU systems.

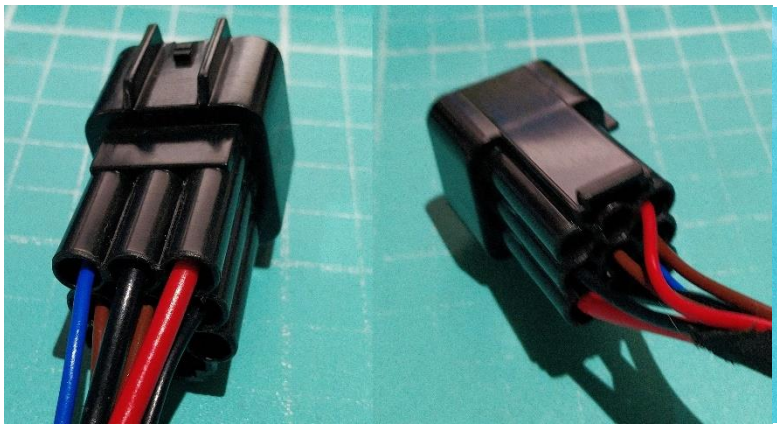
This is a likely indicator of a good ECU being present.

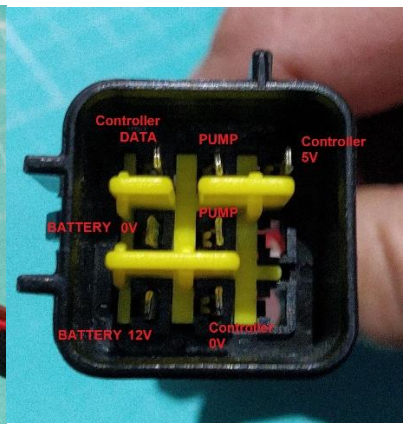
× **Any other connector style likely indicates incompatibility.**

eg

ECU Plug

The ECU plug shown be of this style, and wired as shown:





OEM Controllers

Relying upon an image of the controller alone is fraught with peril.
Frequently you will find their internal electronics may be incompatible with the supported ECUs.

You simply cannot look at a controller and be 100% certain it is compatible.
You can however be definitely certain that some controllers are NOT compatible.

You can interact with a powered controller to gauge likely compatibility.

Generally red digits when lit up is a good start, but not always
Go hunting for the protected heater tuning menu, typically requiring a “1688” password to gain entry. Incompatible controllers do not expose a tuning method.

Aqua blue digit controllers are definite no go systems, an ECU replacement would definitely be required.

These controllers have tended to be compatible

These controllers should be treated with caution

These controller bodies have sadly been known to have been manipulated to hold the later incompatible ECU system's required electronics, and as such must be treated carefully when observed in a listing.

Inspection of the ECU is strongly recommended.

These units are definitely associated with incompatible ECUs





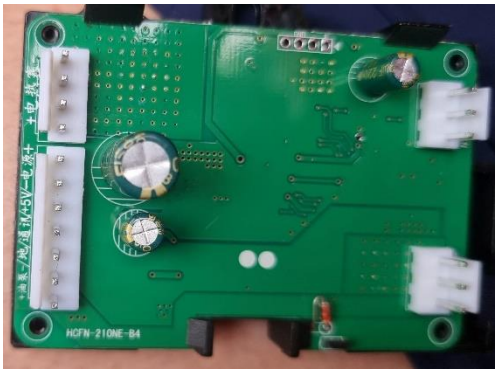


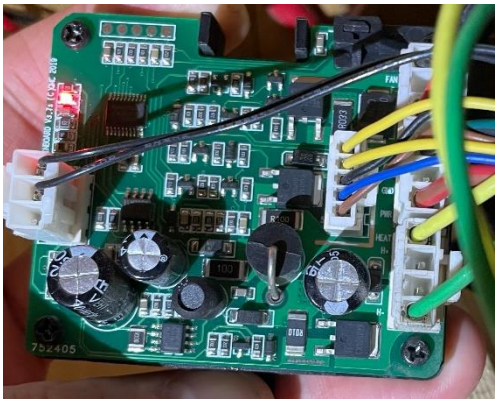


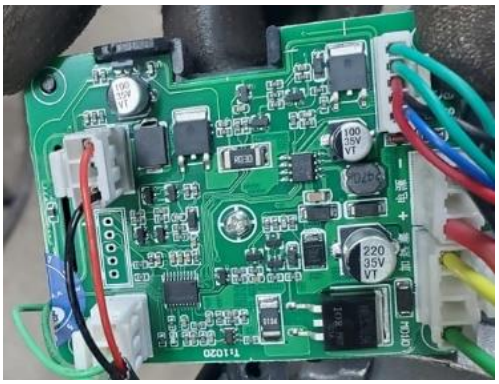


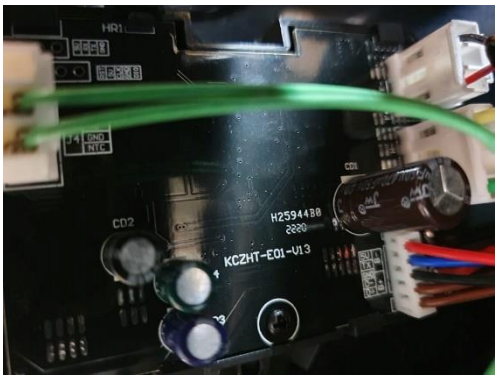
- × **Show a 3 bladed fan on the LCD**
- × **Aqua blue digits**
- × **Has speaker holes**
- × **Beeps**
- × **Talks**
- × **Has no ---- tuning menu capability**
- × **More than 3 wires**
- × **Latest Maxpeedingrods / HCalory Bluetooth heater**

These ECUs are definitely NOT compatible









Any MANY MORE.

- × **Any ECU marked with STM32**
- × **Any ECU marked with CCFN**
- × **HCalory / Maxpeedingrods Bluetooth heater.**

Operational checks

The following tests will help identify the likelihood of system compatibility:

Probably good	Maybe good	Definitely bad
• Manipulation of the settings button reveals the ---- PIN entry mode, where you can typically enter 1688 and gain access to the tuning parameters. • Display operates as a clock upon power up, starting at 00:00. • ECU has a large inductor coil present.	• LCD shows red digits. • Voltage is reported in 0.1V steps. • Controller has a triangular connection plug • Controller has 3 wires • Controller uses a round connection plug.	• LCD shows aqua blue digits. • Always starts at H3 power level. • Can only choose H1-H5 power levels. • Controller beeps. • Controller speaks. • Has no timer function. • Controller connection is neither round nor triangular. • Controller has more than 3 wires. • Heater supports Bluetooth

The ultimate proof is ALWAYS the ECU located within the heater body!

General Overview

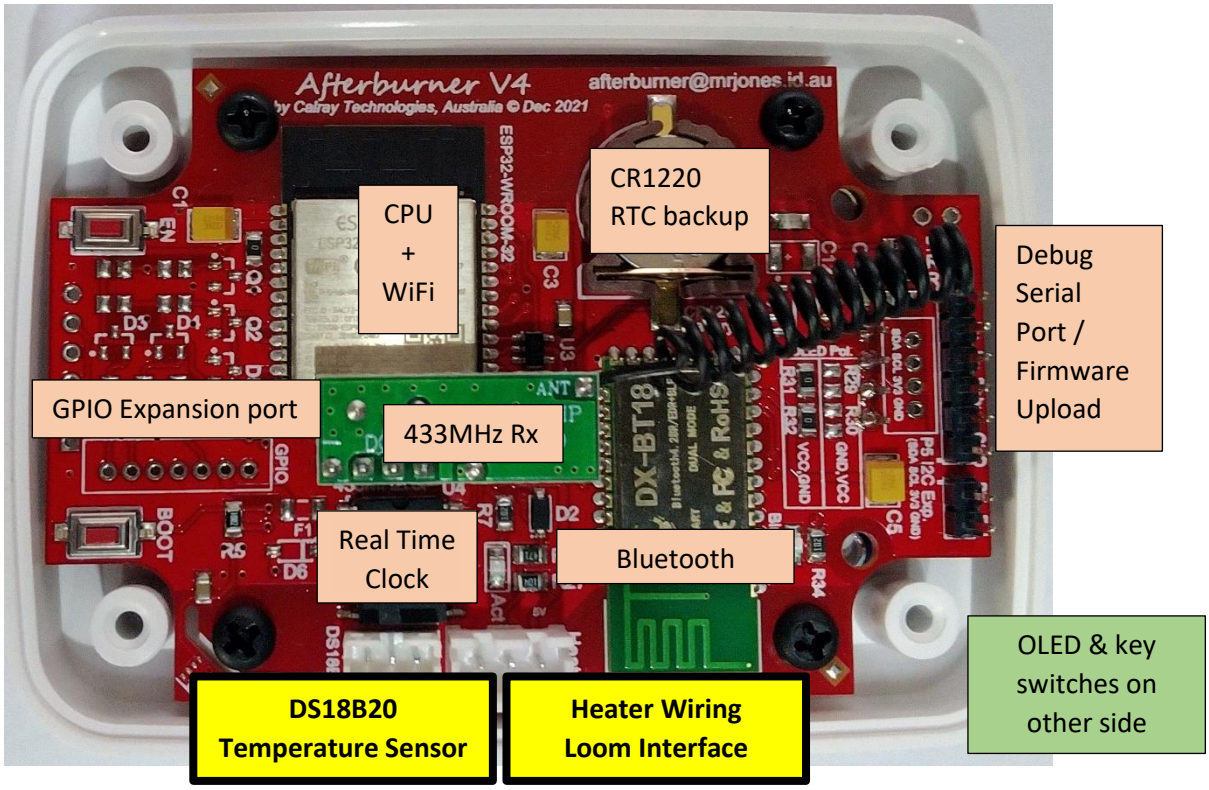
Compatibility

The Afterburner entirely replaces the controller supplied with a (compatible) Chinese diesel heater.

Compatibility is determined by the ECU within the heater.
The ECU must support the appropriate data protocol, otherwise the Afterburner cannot control the heater unit.

It is not required to have the OEM controller, but it can be initially useful for importing any prior tuning adjustments that may have been made in the past.

System connections



The Afterburner has two primary connections to the outside world:

- Heater communications
  3-pin JST XH (2.5mm pitch)
- Temperature Sensor
  3-pin JST PH (2.0mm pitch)

Units with GPIO also have a 7-pin connection header to enable connections to the Digital I/O and Analogue input.
7-pin JST PH (2.0mm pitch)

Heater Wiring Loom interface

The smaller triangular male connection plugs into the existing heater wiring loom in place of the OEM controller.

The larger female connector is only needed for initial installation to learn the tuning settings from the previous controller.
This process is not essential.

The Afterburner termination is a 3-way JST-XH (2.54mm pitch) connector.

Temperature sensor

An encapsulated DS18B20 is used as the temperature sensor.

This discrete unit can be mounted wherever desired away from the Afterburner.

The Afterburner termination is a 3-way JST-PH (2mm pitch) connector.

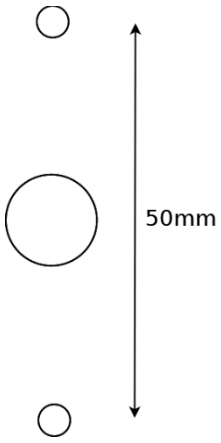
It is not recommended to install this sensor within the case as heat radiated from the ESP32 will distort the temperature readings.

GPIO Interface

If the GPIO option was ordered, a lead with 7 pin JST PH is provided.
The ends are simple wires as it is expected the user will implement their own hardware to complete the function required,
i.e. it is not predictable how this will ultimately be used.

Physical mounting

The Afterburner enclosure is held together with four #1 Phillips head screws, from the rear of the enclosure.



The rear of the enclosure is machined with a central opening to pass the connecting leads though, along with a pair of 50mm spaced keyholes.

The intention is cabling can be neatly concealed and use the keyhole shaped holes to slip onto a pair of screws driven to a suitable depth to hold the unit firmly on a wall.

Initial Usage

OEM tuning importing

The supplied controller adapter lead is double-headed, hosting both a male and a female connector of the same type as your existing wiring loom uses.
The female portion is only intended to initially obtain the existing heater tuning settings being advertised by the OEM controller. This can be safely removed if preferred.

The Afterburner connection is always the 3-pin JST XH connection.

It is not possible to otherwise extract the tuning settings from the ECU itself.

The OEM controller should only be connected during this initial importing process.
The Afterburner is not able to control the heater whilst an OEM controller is also present.

Initial power up

When powered up, the Afterburner presents a splash screen, along with the version number of the installed firmware.
A series of brief messages will appear as the Afterburner attempts to connect to a wifi network, defaulting to providing its own access point if a network is not yet defined.

A common fault is the splash screen is repeatedly shown, and the system fails to boot.

Invariably this is due to a poor electrical contact on one of the 3 connectors between the ECU and the Afterburner:

- Main ECU plug
- Wiring harness 3 pin plug
- Final JST XH connection to the Afterburner

There is a significant increase in current draw when the wifi radio system is enabled, and this can induce enough of a voltage drop (due to poor contact resistance) to trip the Afterburner's low voltage brownout detector, resetting the ESP32 processor.

Re-seating the connectors usually solves this issue.

After the initial boot sequence, the root menu is shown.
By default, this is the "Basic Control" menu. You can optionally change this to be the "Detailed Control", or "Clock" menu: *User Settings, Home Menu Actions: "stop" configuration.*

The Basic or Detailed menus allow fundamental control of the heater:

- Start / Stop
- Demand adjustment (temperature or fixed Hz demand)
- Operation mode (thermostat, or constant fixed power)

Menu System

The Afterburner is highly configurable, and most configuration is achievable via the inbuilt menu system.

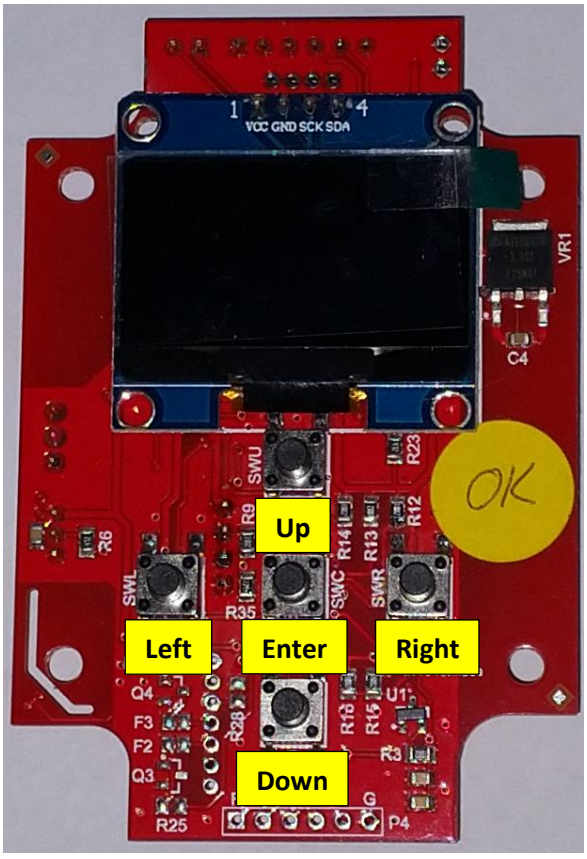
Notable exceptions being configuration items that requires textual entry (e.g. wifi STA credentials, MQTT configuration) and some optional advanced modes that are only accessible via the Debug Menu system via telnet, serial or the web content.

Wifi can be configured via a web browser connection, using the special /wifi URL.
The "Debug and Logging" area of the web content also enables access to the Debug Menus.

User interface

The physical user interface is on the nominal rear of the PCB, hosting a 1.3" 128 x 64 OLED display, and a 5-button keypad arrangement.

If you do remove the PCB from the case, be especially careful of the lower corners of the OLED display.
The glass is extremely thin and conductive strips pass through the area.
Breakage may well lead to entire lines not illuminating on the display.



The keypad buttons are referred to in the menu descriptions as **LEFT**, **RIGHT**, **UP**, **DOWN** & **CENTRE**.

The OLED display can present numerous menus used to monitor/control the heater, or alter settings such as fuel mixture, timers etc.

Landscape orientation

If you prefer a landscape orientation of the PCB, and are prepared to create your own housing, it is possible to orientate the PCB horizontally and physically rotate the OLED module so it lies to the left or right of the keypad.

A Debug Menu system option allows you to alter the function of the switches according to the PCB's orientation. (Screen above, to left, or to right of the keypad).

You can also optionally attach external pushbuttons to the lower series of holes, which are in parallel with the tactile switches soldered to the PCB.

Menu Navigation

The menu system is arranged in "loops":

- Root menus
- User Settings
- System Settings
- Comms Settings
- Tuning settings

When in navigation mode, which is generally the lowest visible line on the screen when configurable items are available, pressing **LEFT** or **RIGHT** will move sideways through the menus in the current loop.

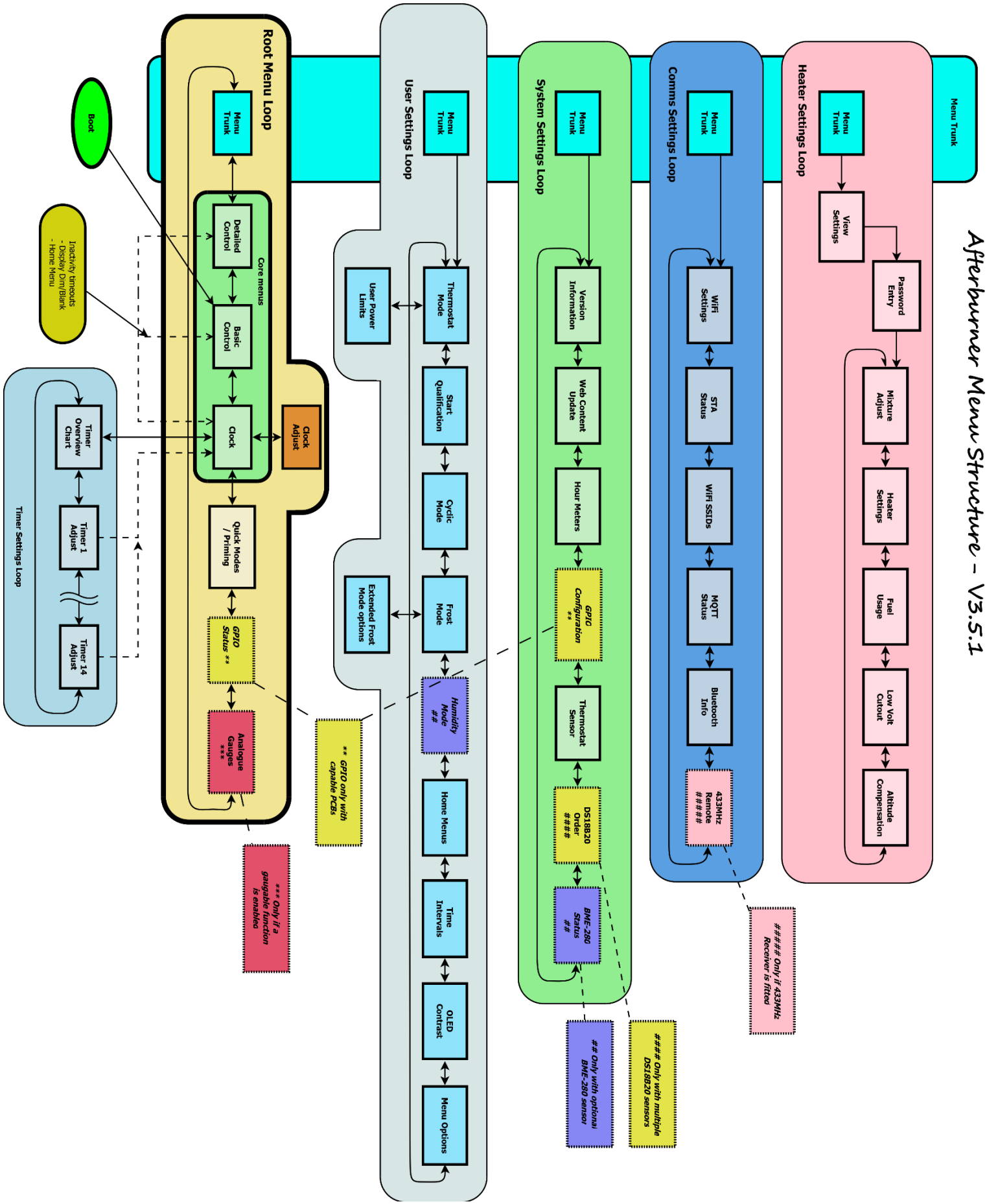
Menu Trunk

A special ***Menu Trunk*** is accessible from the ***Root menu loop***, allowing you to branch to the other menu loops.
Here you can move **UP** or **DOWN**, then enter the selected loop by moving **LEFT** or **RIGHT**.

If you press **CENTRE** whilst in navigation mode on a menu within a loop other than the root menus, you will be returned to the ***Menu Trunk***.

If you are in the ***Menu Trunk***, but not on the "Root Menu" selection, pressing **CENTRE** will move the selection down to the lowest "Root Menu" position.
When on the "Root Menu" position, pressing **CENTRE** will then return you to the default home menu.

You can also simply navigate to the next / previous menu in the Root Menus using **LEFT** or **RIGHT** when on the bottommost "Root Menu" selection.


Afterburner Menu Structure - V3.5.1
Menu Trunk
Heater Settings Loop
Menu Trunk
View Settings
Password Entry
Mixture Adjust
Heater Settings
Fuel Usage
Low Volt Cutout
Altitude Compensation
Comms Settings Loop
Menu Trunk
WiFi Settings
STA Status
WiFi SSIDs
MQTT Status
Bluetooth Info
433MHz Remote #####
System Settings Loop
Menu Trunk
Version Information
Web Content Update
Hour Meters
GPIO Configuration **
Thermostat Sensor
DS18B20 Order ####
BME-280 Status ##
User Settings Loop
Menu Trunk
Thermostat Mode
Start Qualification
Cyclic Mode
Frost Mode
Humidity Mode ##
Home Menus
Time Intervals
OLED Contrast
Menu Options
User Power Limits
Extended Frost Mode options
Root Menu Loop
Menu Trunk
Core menus
Detailed Control
Basic Control
Clock
Quick Modes / Priming
GPIO Status **
Analogue Gauges ***
Clock Adjust
Boot
Inactivity timeouts
- Display Dim/Blank
- Home Menu
Timer Settings Loop
Timer Overview Chart
Timer 1 Adjust
Timer 14 Adjust
** GPIO only with capable PCBs
*** Only if a gaugable function is enabled
Only with optional BME-280 sensor
Only with multiple DS18B20 sensors
Only if 433MHz Receiver is fitted

Configuration menus

Configuration menus allow you to adjust the settings used by the Afterburner.

Pressing **UP** from the initial navigation (bottom) line will enter the menu, and the first adjustable item will be selected.
Typically using **LEFT** or **RIGHT** will alter the selected field's value.
Using **UP** or **DOWN** will select an alternate editable field.
In some menus these roles are reversed, e.g. the ***Set Clock*** menu.

Scrollable menus

Some menus have more lines than are visible at any one time.
These menus will host a scroll bar to the right-hand side of the display, and the upper or lower arrow element will flash if more items exist in that direction.
The thumb portion shows the relative location of items to the entire range of possible lines.

Saving changed values

If any value has been altered from the saved configuration, a notification icon will begin flashing at the top right of the display.
This indicates that you are yet to commit the changes to NVS (Non-Volatile Storage).

You must be on an editable field when pressing CENTRE to initiate the save action.

CENTRE press:

UP press:

Cancelling changes

When within the editable fields, moving **DOWN** past the last available option will return to the bottommost navigation line / mode.

Pressing **CENTRE** when on the bottommost navigation line will not save any changed settings and will return you to the ***Menu Trunk***.

You can also simply navigate sideways to the next / previous menu in the current menu loop using **LEFT** or **RIGHT** when in this navigation position.

Note:
You cannot return to the ***Menu Trunk*** when not in the ***Root menu loop*** using **LEFT** or **RIGHT**.
You can only do so by pressing **CENTRE** when on the bottommost navigation line.

Status (informational) menus

Status menus contain information only, you cannot edit any of the information presented.

These are notified by the presence of a flashing "info" icon at top left of the display.

General Operation

Starting or stopping the heater

To start or stop the heater, view either the ***Detailed Control***, ***Basic Control***, or ***Clock*** menu.

Detailed Control

Basic Control

Clock

HOLD the **CENTRE** keypad button for ~1 second.

A ***Heater Start*** popup menu appears for 6 seconds allowing further user input:

- Immediately apply action (start or stop)
- Delay action
- Ignore the action request (abort)

If no user input occurs, the default "Immediately" action will occur.

Delayed Start (or Stop)

If the 2nd line is selected (using **DOWN**), you can then move to the **RIGHT** and adjust the delay until the start (or stop) will occur *(using **UP** / **DOWN**)*.
The increment size is in steps of 5 minutes, and the last chosen value is remembered for next instance.

When a delay has been chosen and is active, the time remaining is then shown at lower right on the ***Basic Control*** menu, prefixed with either a start ▶ or stop ■ icon.

Special options:

Bobil mode (start option)

This option only appears on the start pop up if the Bobil Manager capability has been enabled via the Debug Menus.

1. Heat air only.
2. Heat water, then continue running once water is heater (diverting to air heating).
3. Heat water, then stop once water is heated.

Recalculate altitude tune (stop option)

This option only appears in the stop menu (i.e. when heater is running) when Automatic Altitude Correction is enabled.
Automatic altitude requires a BME280 pressure sensor to be attached to the system.

Altitude compensation is usually only recalculated when the heater is initially started.
Using this option allows the automatic tuning to be recalculated if the heater has been running and the altitude has changed significantly e.g. in a motorhome, on the move.

Adjusting Demand

When viewing either the ***Detailed Control*** or ***Basic Control*** menu, pressing the **UP**/**DOWN** keypad buttons begins to allow the current demand to be adjusted via the ***Adjust Demand*** popup.

The initial key press does not change the demand but does present the ***Adjust Demand*** popup menu for a few seconds, showing the current setting.

Now if you press **UP**/**DOWN** again, the value will be changed and become the new demand.
When adjusting, holding **UP**/**DOWN** will auto repeat, allowing faster adjustment.

The ***Adjust Demand*** popup automatically times out after a few seconds, returning to the prior control menu.

Mode Selection (Thermostat/Fixed Hz, Celsius/Fahrenheit, Keylock)

When viewing either the ***Detailed Control*** or ***Basic Control*** menu, **HOLDING** the **UP**/**DOWN** keypad buttons presents a ***Select Mode*** popup menu.

Here you can:

- Switch between Fixed Hz, or Thermostat operation.
- Switch between Celsius or Fahrenheit presentation of temperature.
- Invoke a basic key lock mode to prevent accidental presses affecting operation

Simply use **UP**/**DOWN** to select the item of interest, then use **LEFT**/**RIGHT** to toggle the setting.

Note: The active changeable selection is circled, the active state of the unselected item is shown with a white (inverse text) background.

Screen Unlock

If the key lock mode is selected, the screen will be blanked, other than a roaming “Locked” annotation drifting about the screen.

The process to unlock is self-evident.
When you press any button, you are then prompted to **hold both LEFT and RIGHT** simultaneously to unlock the keypad.

The intent is not security, but to prevent accidental keypresses being mistaken as actual requests.

Thermostats and Fixed Hz

The Afterburner's great strength is the flexibility of available options for controlling the heater's power per the user's desires.

*Setup menus for **Thermostat Mode**, **Cyclic Mode**, and **Frost Mode** are within the **User Settings menu loop** of the unit.*
Full descriptions of the setup menus can be found in the Menu System descriptions of this manual.

An overview of the thermostat modes is provided here.

Fundamental heater output control

There are 2 major modes of operation:

- Fixed Hz
- Thermostat

Fixed Hz

Fixed Hz is simply a fixed power demand.
The heater will always run at this power unless altered by the user.
The specified Hz is how fast the fuel pump delivers fuel to the heater, the fan speed varies in proportion.

Thermostat modes

The Afterburner offers 4 Inbuilt Thermostat Modes.
It can also support an external dry contact thermostat via a GPIO input, though such control is disconnected from the Afterburner's defined setpoint (other than Cyclic Mode suspension):

- Standard
- Dead-band
- Linear Hz
- Stop / Start
- An external dry contact thermostat can be used *(only if GPIO capability is available)*

User Power Limits - Limited heater power

By default, when operating under thermostatic control heater power requests are bounded by the maximum and minimum tuning endpoints.

The user can optionally define ***User Power Limits***, within these tuning bounds, limiting the actual heater power requested.

Additional control modes

Cyclic Mode

A supervisor mode, called Cyclic Mode can be enabled and is effective in any operation mode whilst the heater is running.
Cyclic Mode allows the heater to be automatically stopped (suspended) if the thermostat action is not able to constrain the desired setpoint.
Likewise if operating in Fixed Hz mode, and the nominal thermostat setpoint is similarly exceeded, the heater is shutdown (suspended).

When the ambient temperature later falls below the restart threshold, the suspended heater is restarted.

Caution

Starting and stopping the heater causes the glow plug to be cycled during both shutdown and restart phases.
Consideration should be given to the potentially higher electrical energy load required when using a battery powered system if you expect the transition thresholds to be frequently encountered.

As a rule of thumb, a stop/start cycle consumes ~1Ah of battery capacity.

It usually takes 5 minutes for a heater to reach normal running condition, and a further 3 minutes or so to shut down.
Also note that the heater's ECU will deny restart attempts whilst completing the shutdown procedure.

Frost Mode

Automatically starting the heater when falling below a low temperature threshold is available via Frost Mode.

Thermostat Mode Descriptions

Standard Thermostat mode

This mode mimics the standard thermostat algorithm ordinarily built into the heater ECU.

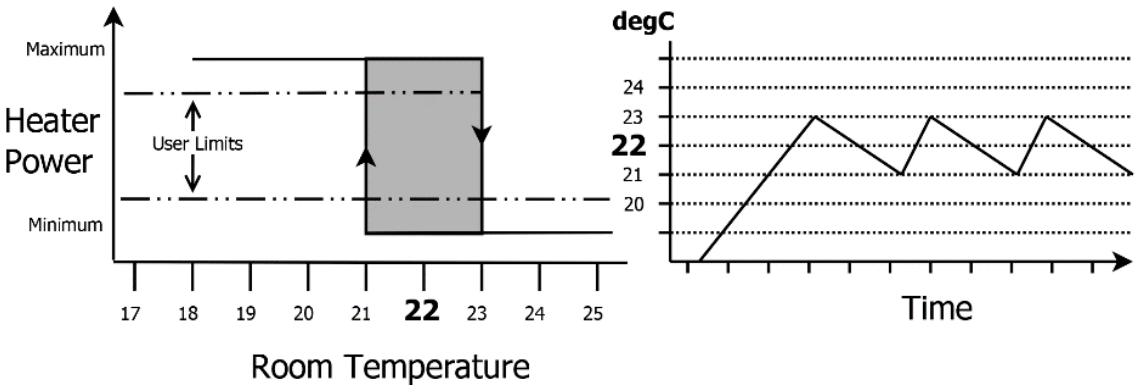
Starting from cold, the heater will run at the maximum power limit until the ambient temperature exceeds the desired setpoint by 1°C.

Once this threshold is crossed, the heater then runs at the minimum power limit.

Later, when the ambient temperature drops 1°C below the desired setpoint, the heater once again runs at the maximum power limit.

i.e. a 2°C hysteresis exists about the setpoint.
This is shown in *italic text* on the menu as this cannot be altered

Standard thermostat mode graphic, demonstrating power transitions about a 22°C setpoint:



Dead-band mode - adjustable hysteresis

Dead-band mode is much the same as standard mode but allows the user to define the hysteresis about the desired thermostat setpoint.

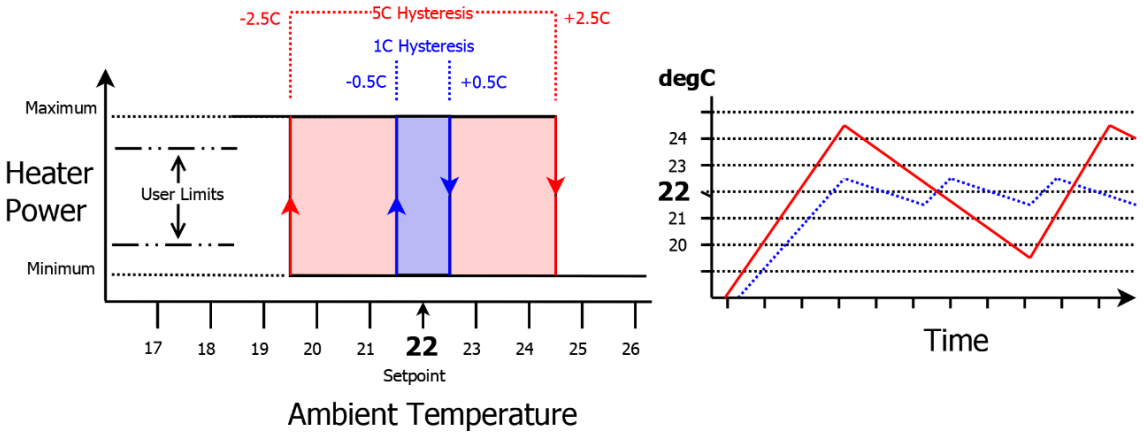
The hysteresis is configurable via the 2nd field's value.

Assuming the ambient temperature started below the setpoint, the heater will run at full power until the temperature is raised ½ of the hysteresis over the desired setpoint.

The heater then runs at minimum power until the ambient temperature falls ½ of the hysteresis below the defined setpoint, then returns to maximum power.

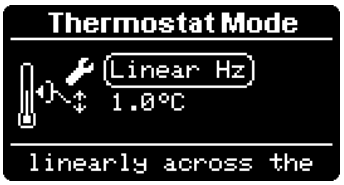
Thereby the hysteresis of the ECU's thermostat can be controlled over a wider or narrower range. A dead-band hysteresis of 2°C is functionally equivalent to the standard thermostat function.

Dead-band thermostat mode graphic:



Linear Hz

Linear Hz mode is more akin to cruise control in a vehicle.
As the thermostat setpoint is neared, the heater power is gradually tapered resulting in smoother temperature control.



If the ambient temperature is below the bounds of the hysteresis about the setpoint, the maximum power limit is requested.

If the ambient temperature is above the hysteresis bounds, the minimum power limit is requested.

Within the hysteresis, the heater power is linearly adjusted between the maximum and minimum limits, according to the present deviation from the desired setpoint.

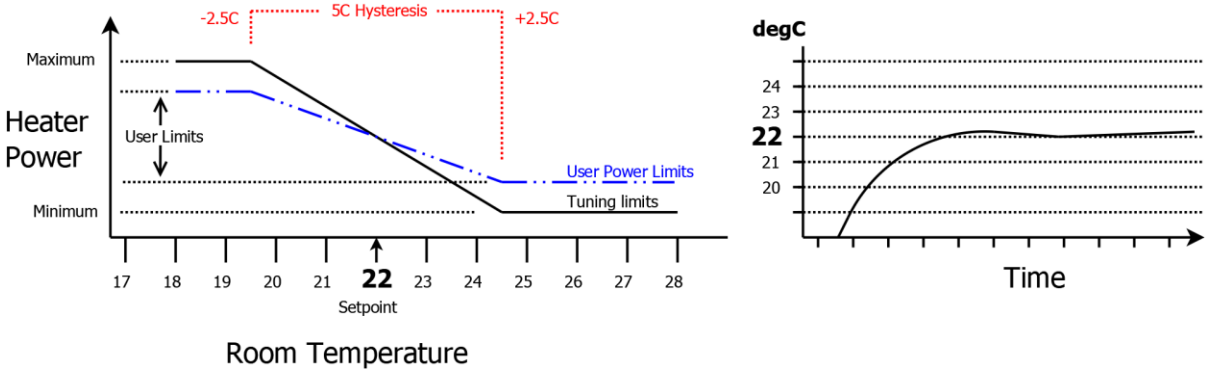
Accordingly, the ambient temperature is automatically maintained within a narrower band than high / low running achieves.

The hysteresis is configurable as the 2nd field's value.

As the heater power is gradually tapered, the initial arrival at the setpoint will be more exponential. Note that the exact average temperature may be slightly above or below the desired setpoint but should remain relatively steady.

The hysteresis width is effectively a "gain" term, determining how quickly adjustments to heater power occur.
A smaller hysteresis increases gain, and you may find the system excessively hunts about the set point. Accuracy though will be higher.

Linear Hz thermostat mode graphic:



Stop / Start Thermostat Mode

Stop / Start thermostat mode operates by running the heater at the full power limit until the desired setpoint is reached.

The heater is then instructed to shut down.

e.g.: Desired setpoint is 22°C,
The heater will be shut down @ 22°C.

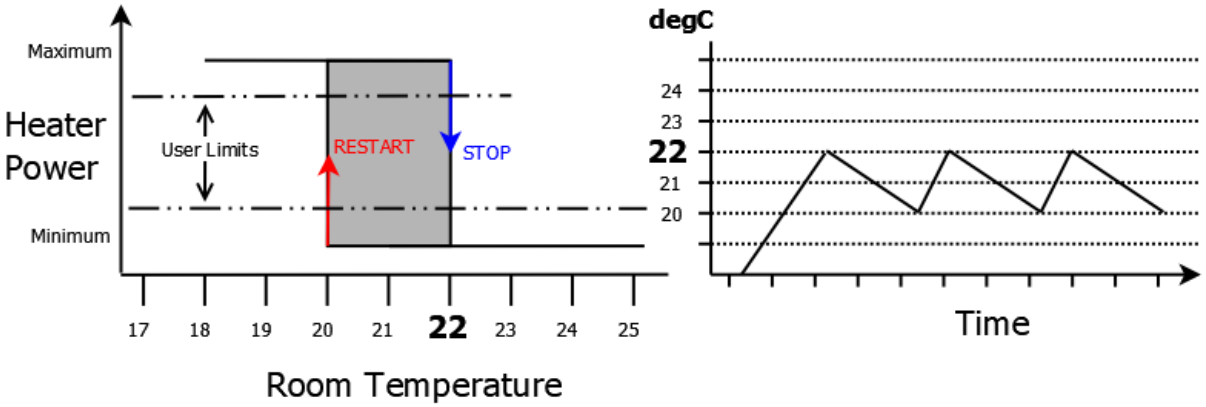
Once shut down, the Afterburner considers the heater to be in the special "suspended" state as it was asked to stop by action of the thermostat.

As it is suspended, it will later instruct the heater to start when the ambient temperature falls back below the desired setpoint, less hysteresis. e.g. 20°C.

Graphic demonstrating Stop / Start mode

e.g.:

Desired setting is 22°C, Hysteresis is defined as 2°C.
Heater will be asked to restart @ 20°C.



Caution

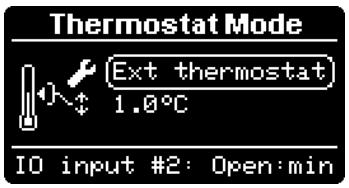
Starting and stopping the heater causes the glow plug to be cycled during both shutdown and restart phases.
Consideration should be given to the potentially higher electrical energy load required when using a battery powered system if you expect the transition thresholds to be frequently encountered.

As a rule of thumb, a stop/start cycle consumes ~1Ah of battery capacity.

It usually takes 5 minutes for a heater to reach normal running condition, and a further 3 minutes or so to shut down.
Also note that the heater's ECU will deny restart attempts whilst completing the shutdown procedure.

External Thermostat Mode *(requires GPIO input)*

A thermostat typically used for domestic heating that provides a “dry contact closure” calling for heat demand can be attached to an Afterburner GPIO input.



Before you can select External Thermostat mode in the Thermostat Mode menu, you MUST first enable the External Thermostat mode in the GPIO Configuration menu for a digital input.

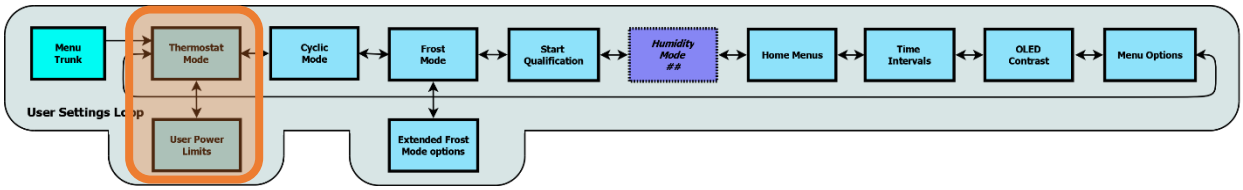
Maximum and minimum power demands are commanded according to the thermostat’s contact being closed or open respectively.

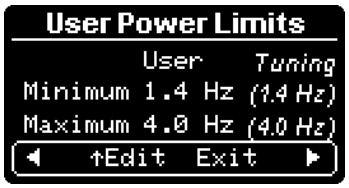
If the heater is stopped, the initial contact closure will also make the heater start.
Subsequent opening and closings of the thermostat contact will cause the heater to run at minimum and maximum power respectively.

An associated option exists in the GPIO configuration to shut down the heater when the contact remains open longer than a specified time interval, otherwise a manual shutdown of the Afterburner is required.

Cyclic Mode will still supervise this mode.
It will still shut down the heater if the sensed ambient temperature should get too warm, relative to the Afterburner’s setpoint.
Note that the Afterburner has no idea what the external thermostat is set to.

User Power Limits *(Sub branch from Thermostat Mode menu)*

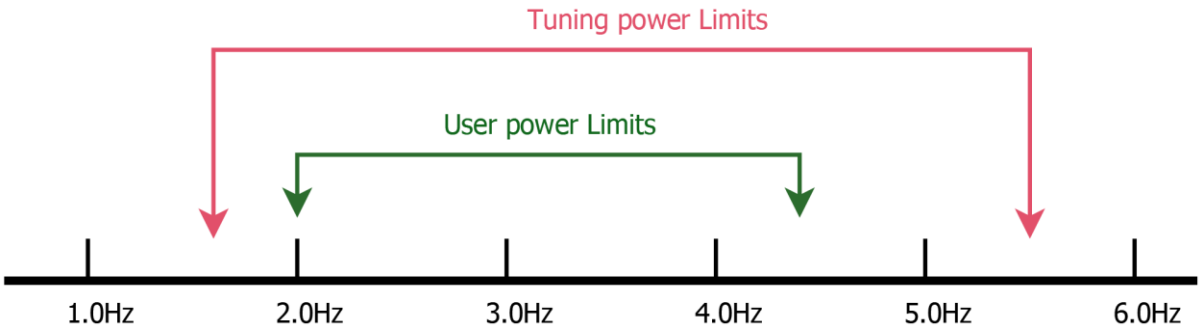




Conventionally, the maximum and minimum power levels of the heater are as defined by the ***Heater Tuning*** settings.

The Afterburner directly commands heater power for any thermostat mode.
It is therefore possible to constrain the final requested power demands within narrower bounds than the tuning limits specify.

The ***User Power Limits*** menu allows the maximum and minimum allowed pump rates to be brought inwards within the bounds of the tuning limits.
The heater's ECU automatically adjusts the fan speed in sympathy to maintain the correct air / fuel mixture ratio (just as it would do when using Fixed Hz mode).



Cyclic Mode

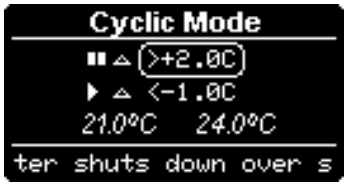
Cyclic Mode operates irrespective of the chosen thermostat mode, including Fixed Hz mode.

Cyclic Mode is a supervisor mode that can be used to shut the heater down when the ambient temperature rises too far over the desired setpoint, later restarting when the ambient temperature falls below a restart threshold.

These thresholds are always defined relative to the current thermostat set point.
If running in Fixed Hz mode, the last set thermostat set point remains the reference for Cyclic Mode.

The italic values presented on the display are the absolute temperature thresholds, **determined by using the present thermostat setpoint**.

Stop Threshold



The stop threshold is relative to the current desired setpoint.

It is the 1st field on the setup menu, preceded by the "pause delta" icons *(delta meaning a relative value to the setpoint).*

The bounds of cyclic stop are 1.5°C to +10°C *(3°F to 20°F, remember these are relative values).*
When reduced below the minimum limit, Cyclic Mode is disabled.

Restart Threshold

The restart threshold is relative to the current desired setpoint.

It is the 2nd field on the setup menu, preceded by the "play delta" icons *(delta meaning a relative value to the setpoint).*

The bounds of cyclic restart are -20.0°C to +1.0°C *(-40°F to +2°F, remember these are relative values).*

Suspended State

When stopped due to exceeding the cyclic stop threshold, the Afterburner considers the heater is "Suspended" as opposed to "Stopped", passing through the logically reported "Suspending" & "Suspend Cooling" phases.

Whilst "Suspended", the Afterburner is continually monitoring the ambient temperature.
It if falls back below the restart threshold, the heater is once again started.

e.g.:
- The Cyclic stop threshold is set to +1.5°C
  The Cyclic restart threshold is set to -1°C.
  The desired setpoint is 22°C.
- If the ambient temperature rises over 23.5°C, the heater is requested to stop.
  The Afterburner considers the heater as suspended.
- When ambient falls below 21°C the heater is restarted.

Frost Mode

Frost mode allows the heater to automatically start if the ambient temperature falls below a defined minimum value.

IMPORTANT:
When enabled, Frost Mode will always engage if the start condition is met, irrespective of whether you have already turned off the heater.
Ensure the heating ducts remain free of obstructions when left unattended.

Cancelling Frost Mode and stopping the heater

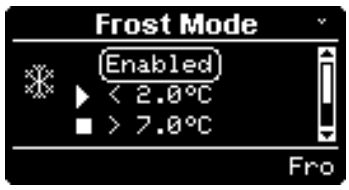
When Frost Mode is active, a frost icon will be displayed on the header of the usual heater control menus.

This alters the behaviour if a user desires the heater to stop. The initial long press of the **CENTRE** button will cancel frost mode but leave the heater running.

As frost mode is now cancelled, the frost icon disappears.

A 2nd long press of the **CENTRE** button will then initiate the heater stop, presenting the usual ***Heater Stop*** popup menu.
The same logic of a double stop sequence applies when using a 433MHz UHF key fob.

Enabling Frost Mode



Frost mode uses a distinct on/off flag.
Previously, disabling frost mode required the start temperature to be reduced to 0.
Disabling Frost mode now preserves the start temperature.

Start temperature

The upper value defines the Frost Mode start temperature.
If the ambient temperature falls below this value, the heater will be requested to start.

To disable Frost Mode, change the Enabled configuration to Disabled.

Frost Mode fundamental operating modes.

Frost Mode can be defined to operate in 1 of 3 distinct modes:

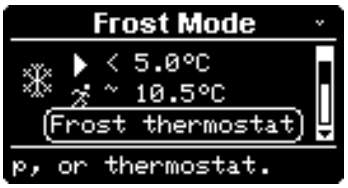
1. Start/Stop: Start, then Stop.
2. Frost Thermostat: Start, then run in thermostat mode, seeking the specific setpoint defined for Frost Mode.
3. User Thermostat: Start, then run in thermostat mode, seeking the setpoint defined for the usual system thermostat.

Start Stop frost mode

Once triggered, the heater will run until the ambient temperature reaches the value on the 2nd line.
The heater will then be commanded to stop.

eg: start @ 8.0°C, stop @ 13.0°C.

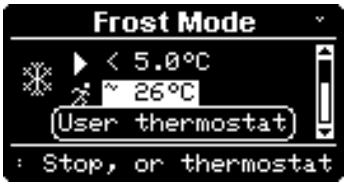
Frost thermostat mode



Once triggered, the heater will run under thermostat control, the setpoint being the value defined on the lower line. *eg: 10.5°C.*

The heater will continue to run unless the user subsequently stops it.

User thermostat mode



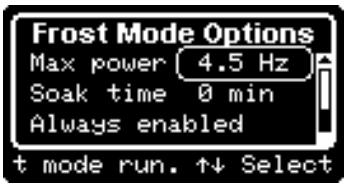
Once triggered, the heater runs under thermostat control, the setpoint being the last used system thermostat setting.
The lower line shows the current value of the system thermostat on a white background. It cannot be altered here.

The heater will continue to run unless the user subsequently stops it.

Extended Frost Mode settings

To access the extended Frost Mode settings, hold the **DOWN** key for at least 1 second anywhere on the basic ***Frost Mode*** menu.
A down arrow animation is present at the top right to indicate the extended options exist.

To leave the extended settings and return to the basic menu, press the **CENTRE** key.
BEWARE: The changed settings are not yet saved, but a "should save" warning icon appears at top right of the *Frost Mode* menu.
You will need to press the **CENTRE** key once again to invoke the setting storage.



The extended Frost Mode options are:

1. Maximum heater power.
2. Soak Time.
3. A conditional start time interval.
4. Which temperature sensor to use.

Maximum heater power

This is a variation of the User Power limits that can be defined as part of the thermostat settings.
In this instance, it is the maximum power asked of the heater when it is started by Frost Mode.
The maximum possible value is as defined by the heater tuning's maximum pump rate.

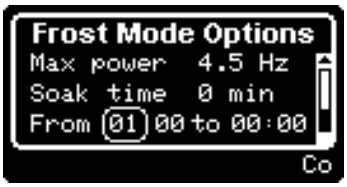
Soak Time

Soak time defines the length of time the heater will remain running once the required frost mode target is reached.
This alters the fundamental Frost Mode operating modes as follows:

1. **Start / Stop** mode.
   Once the stop temperature is reached; instead of stopping immediately, the heater will continue to run for this interval of time, then is commanded to stop.
2. **Frost Thermostat** *or* **User Thermostat** modes.
   Instead of perpetually continuing to run when the target is reached, the heater will be commanded to stop after this time interval elapses when reaching the setpoint.

Conditional Start Time Interval

Frost mode can be defined to only be armed when within a bracketed time interval.



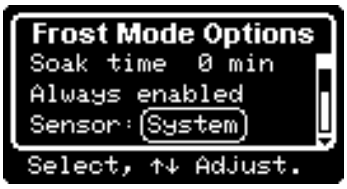
If "Always Enabled" is shown, press **LEFT** or **RIGHT** to allow setting of a time bracket.
When the start and end times differ, the conditional time interval is active.

To always arm Frost mode, simply make the start time match the end time then wait a couple of seconds. It will then revert to "Always enabled".

The time interval begins at the left hand HH:MM time, then ceases at the right hand HH:MM time.

Return to the "From" selection using **LEFT.** You can then *once again navigate to the other fields using* ***UP***/***DOWN****.*

Temperature Sensor selection



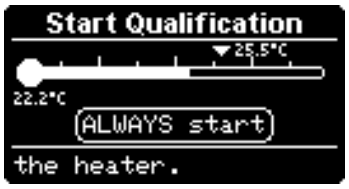
If you have more than one temperature sensor, you may desire to use a different sensor than the normal thermostat sensor to trip frost mode.

You can select this on the last line.

Start Qualification *(User Settings menu loop)*

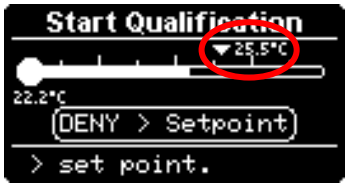
Start Qualification determines how the Afterburner reacts when a start request is received, and the ambient temperature is already over the desired thermostat set point.

Always Start



The heater will be started irrespective of the current ambient temperature.

Deny if over setpoint

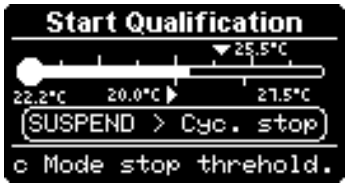


If the ambient temperature is already over the desired setpoint, any start requests will be denied.

The setpoint is shown with a flashing downwards pointing triangle above the thermometer gauge to show this is the value that will be used for the start qualification.

Suspend immediately if over the Cyclic stop threshold

This choice only functions as described if Cyclic Mode is enabled.
If not enabled, the behaviour will be as per Start Deny.
In this instance, CYCLIC IS OFF will flash below the temperature gauge.



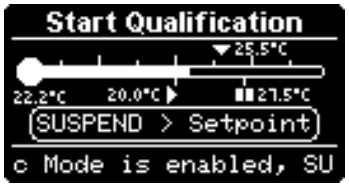
If the ambient temperature is already over the Cyclic Mode stop threshold the heater remains stopped but the Afterburner will consider the heater has been suspended.

This means that when the ambient temperature later falls below the Cyclic Mode start threshold the heater will be started.

Suspend immediately if over the Desired Setpoint

This choice only functions as described if Cyclic Mode is enabled.

If not enabled, the behaviour will be as per Start Deny.
In this instance, CYCLIC IS OFF will flash below the temperature gauge.



If the ambient temperature is already over the desired setpoint the heater remains stopped but the Afterburner will consider the heater has been suspended.

This means that when the ambient temperature later falls below the Cyclic Mode start threshold the heater will be started.

Temperature Sensors

The usual temperature sensor used by the Afterburner is a DS18B20 electronic "one-wire" sensor on a 1m lead.

The Afterburner firmware allows up to three DS18B20 sensors to be connected in parallel.
Extra sensors can simply provide extra temperature monitoring or enable special GPIO capabilities.

If a BME280 sensor is added to the system, the temperature of that device can also be reported.
Note however that when it is fitted directly to the Afterburner's PCB it does tend to read high due to heat dissipation from the ESP32 processor module.
The main reason for the BME280 is to record air pressure, optionally adjusting tuning for altitude.

Remote temperature reading

A 3rd party system can regularly publish a temperature to the Afterburner.
Such a reading will then become the sensor value used for the thermostat function.

Sending the JSON message **`{"TempRemote":X}`** via websocket, telnet, serial, MQTT or Bluetooth allows this function to operate. *(X being a Celsius reading)*
MQTT connections can also publish topicprefix/cmd/TempRemote, with a Celsius payload.

The remote reading must be updated regularly.
It will timeout after 30 seconds, failing back to the usual hardwired sensor.

When receiving a remote value, the reading is tagged with a special "**Rmt**" flag on the system's ***Basic Control*** *menu* display.

Multiple sensors

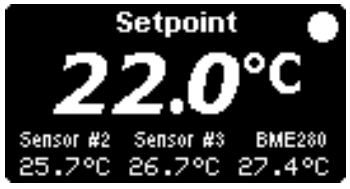
If more than one sensor is attached, the system needs to be told which sensor to use for thermostat functions.

The in-use thermostat sensor will always be shown as the current ambient temperature.
*If this is via "TempRemote", a **Rmt** tag will appear along with the reading in the **Basic Control** menu.*

The extra sensors are normally not visible on the standard control menus.

You can view them when in the ***Basic Control*** menu:
Press the **CENTRE** key, the current setpoint will be shown (large italic text), along with the extra sensor readings.
The next sensor in the priority chain will be named "Sensor #2", then "Sensor#3" & "Sensor #4".
If the sensors have been named, these are shown instead.
The sensor readings are only shown if they are physically present.
Sensor #1 of course is the large value normally shown on the display.

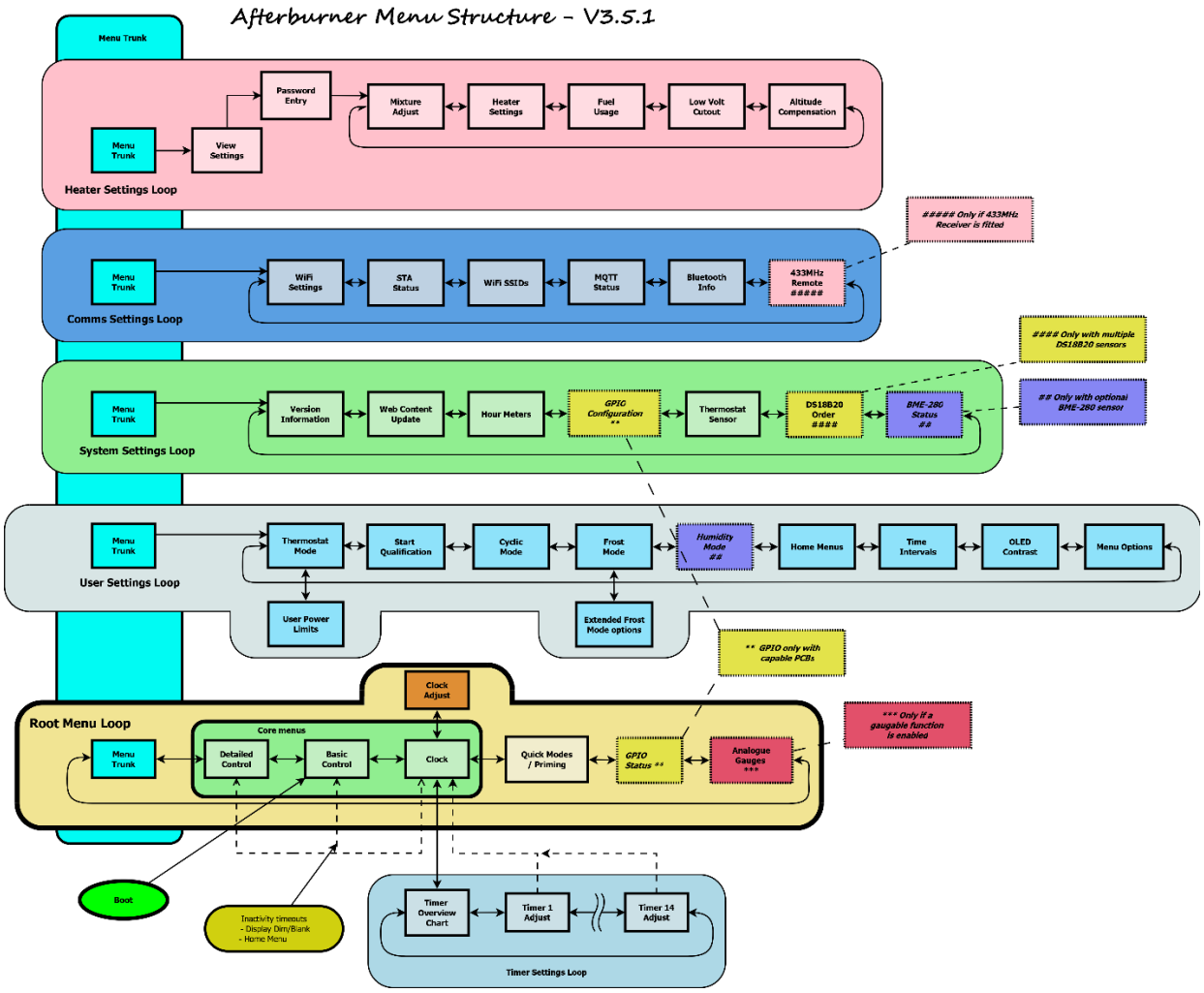
CENTRE press:



Menu System

OLED Menu Structure

The general topology of the menu structure is as follows:



The menu structure revolves around the concept of “menu loops” and a “Menu Trunk” to shift between these menu loops.

The menu loops are the horizontal looped menus in the summary diagram above, and the menu trunk is the vertical cyan zone.

The menu loops are named:

- Root menu
- User Settings
- System Settings
- Comms Settings
- Heater Tuning

Menu Navigation

Each menu in the ***Root menu loop***, and other menu loops, can be navigated to by using the **LEFT** or **RIGHT** keys when on the base selection of each menu (default location upon each menu's entry).

The ***Menu Trunk*** screen is a special menu that allows navigation away from the ***Root menu loop*** into the other menu loops.

The ***Clock*** menu screen has its own associated menu loop.
Pressing **DOWN** from the ***Clock*** menu will shift control to the ***Timer Settings loop***.
The initial screen of that loop is an overview of timers presently set on the system.
Pressing **LEFT**/**RIGHT** allows the available timers within that loop to be selected and edited.

Applying settings

If you change any settings, they need to be saved.
This does not happen automatically.
The need to save is alerted to by a flashing "save settings" icon at top right (typically).

This is generally achieved by pressing the **CENTRE** keypad button when not on the base navigation line, then pressing the **UP** button to confirm the save:

Press **CENTRE**

Press **UP**

Aborting changes

Use **DOWN** to return to the menu's base navigation line and then move away to another menu.
OR
Leave the system alone and it will time out due to inactivity *(default is 1 minute)*.
Control returns to the ***Root Menu*** and no changes will be saved.

Inactivity timeouts

Home Menu

If the keypad has been left idle for a minute, the menu selection is returned to the one of the core root menus (circled in green on the *Root Menu Loop*) (***Detailed Control***, ***Basic Control***, *or* ***Clock***).
The home menu timeout behaviour & period can be altered within the ***User Settings menu loop – Home Menu Actions*** & ***Time Intervals*** *menus*.

Display dimming or blanking

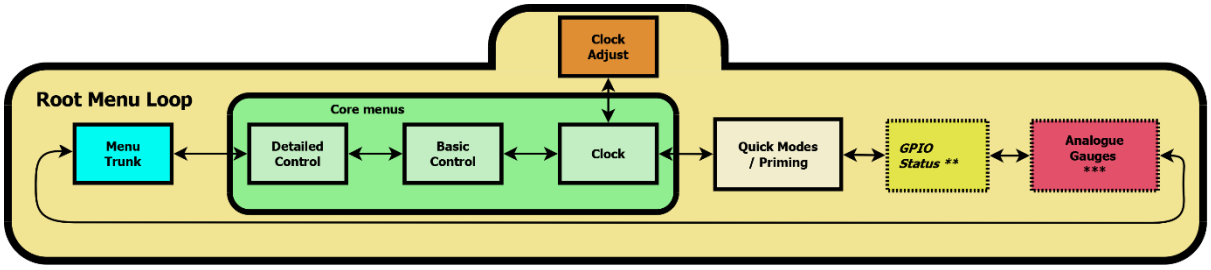
If the keypad has been left idle for a minute, the display is dimmed.
The **Display Timeout** can instead blank the display, and the period to do so is set within the ***User Settings menu loop***.

Important:
If the display has blanked, the initial press of any button is not passed onto the user interface.
If the screen is dimmed, the initial press IS passed onto the user interface.
Any keypress does restore the display to normal brightness.

Menu loops brief description

Root menu

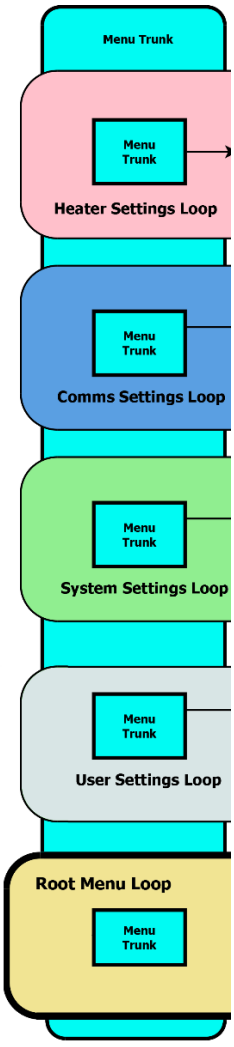
The unit always boots into one of the green boxed ***Core menus***, within the ***Root menu loop***; being either: ***Detailed Control***, ***Basic Control*** or ***Clock***.



If any other menu is left to timeout, attention will return to the user defined option chosen as the timeout menu within these core menus. The default menu is the ***Basic Control*** menu.

Menu Trunk

The ***Menu Trunk*** allows navigation to other menu loops.
It is only accessible from the ***Root menu loop***, the other loops stay within themselves once entered, not re-exposing the trunk via **LEFT**/**RIGHT**.



Heater Tuning

The ***Heater Tuning loop*** holds menus the heater's tuning and related aspects of the actual heater control.
eg: Max/Min tuning endpoints, ECU settings, Fuel usage, Low voltage cutout, Altitude compensation, etc.

Comms Settings

The ***Comms Settings loop*** holds menus associated with the various communications methods.
eg: Wifi, Bluetooth, basic MQTT setup, UHF remote (if fitted).

System Settings

The ***System Settings loop*** holds system setup specific menu items
eg: Version Information and updates, run times, temperature sensor usage, GPIO setup, etc.

User Settings

The ***User Settings loop*** holds typical configurations that a normal user would like to alter.
eg: Thermostat modes, set up of Cyclic Mode, Frost Mode, etc.

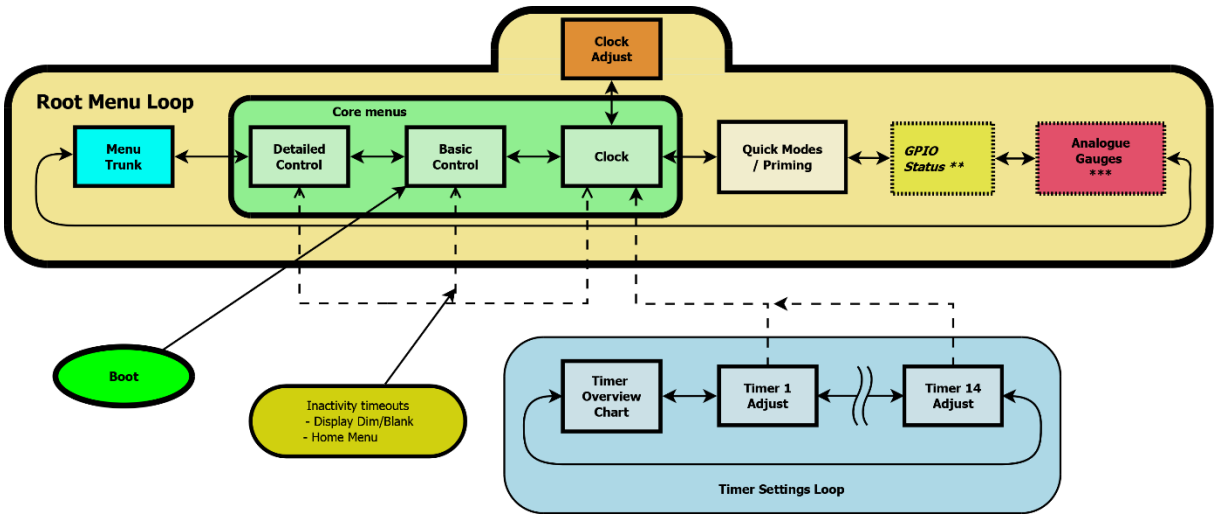
Sub menus

Some setup menus may have an associated sub menu that temporarily branches away from the menu loop.
Typically these are accessed by **holding** the **DOWN** button, a down arrow animation on the screen will show when this is possible.

Timers

A special ***Timers loop*** branches from the ***Clock*** menu.
It is used to obtain an overview of and change the timers.

Root Menu Loop

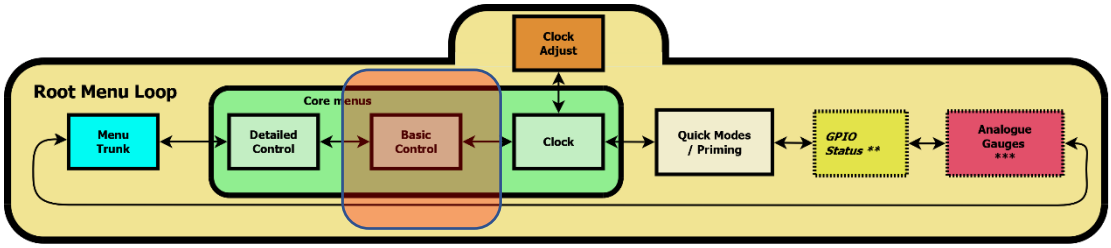


The initial user Interaction with the heater system occurs via the “home” menus available in the ***Root menu loop***.

These are the menus shown in the green area above.
The primary menus used to start and stop the heater, change demand and mode are the ***Basic Control*** and ***Detailed Control*** menus.

The Afterburner always boots into the ***Root menu loop*** and by default selects the ***Basic Control*** menu.
This is pointed out by the bright green bubble at lower left of the menu diagram.

Basic Control menu *(Root menu loop)*



This menu is the default initial menu presented upon powering up the controller, and the default timeout menu if the menu selection has branched away from the other core root menus.

The menu selected upon timeout, heater start, or heater stop can be redefined by the user in the ***User Settings menu loop***.

The ***Basic Control*** menu allows fundamental operation of the heater to take place:

- Heater On/Off
- Thermostat or Fixed power operation modes
- Temperature or Fixed Power demand adjustment
- Celsius or Fahrenheit display
- Basic status and fault monitoring
- User mode GPIO output manipulation

Quick Info

Heater On / Off

The heater can be set to run, or stop, by holding down the **CENTRE** keypad button for around 1 second.

Demand Adjustment

Press **UP** or **DOWN** to change the current demand.

Starting the heater

If the heater is off, hold the **CENTRE** keypad button for ~1 second.
A popup menu will appear, providing options:

- Start immediately.
- Start after a time delay.
- Ignore, stay off.

If left alone, the popup menu will timeout in a few seconds.
By default, the heater will start.

Delayed start

Move **DOWN** to the 2nd selection of the popup, press **RIGHT**.
You can delay the start to happen sometime later.

Use **UP**/**DOWN** to change the delay by 5-minute increments.

After accepting a delayed start, the ***Basic Control*** menu will show the remaining time until start in the bottom right corner:

Cancelling a delayed start

If a time delay is shown on the ***Basic Control*** menu, a long press of **CENTRE** instead provides options to start immediately, **cancel** the delayed start, or ignore:

Startup messaging

Once the heater start command is accepted, a series of popups will appear, and finally the ***Basic Control*** menu will return:

Other changes to ECU state as they occur will also briefly appear as popup messages.
eg Igniting, Ignited etc.

"On" Status

When the heater system has been requested to run, "ON" is shown at the lower left of the screen.
This status remains "ON" when the heater has been turned off due to a Cyclic Mode overheat

shutdown of the heater, indicating the heater is expected to run when temperature falls low enough.

Immediate failure to start

Possibly the initial heater start will immediately fail.
An error message will be brought up accordingly.

Typical failure to start causes being:

- Ambient temperature is already higher than the desired thermostat setting.
- The battery voltage is lower than the Low Voltage Cutout setting.
- The accumulated fuel usage suggests the fuel tank is nearly empty.

Stopping the heater

If the heater is on, hold the **CENTRE** keypad button for ~1 second.
A popup menu will appear, providing options:

- Stop immediately.
- Stop after a time delay.
- Ignore, keep running.

If left alone, the popup menu times out in a few seconds.
By default, the heater will begin the shutdown sequence.

Delayed Stop

Move **DOWN** to the 2nd selection of the start pop up, press **RIGHT**.
You can delay the stop to happen sometime later.

Use **UP**/**DOWN** to change the delay by 5-minute increments.

After accepting a delayed stop, the ***Basic Control*** menu will then show the time remaining until stop in the bottom right corner:

Cancelling a delayed stop

If a time delay is being shown on the ***Basic Control*** menu, a long press of **CENTRE** will instead provide options to stop immediately, **cancel** the delayed stop, or ignore:

Temperature or Fixed Hz adjustment

The desired thermostat temperature, or fixed power setting, can be altered by briefly pressing **UP** or **DOWN** to initiate the process of changing the setting.

A popup screen is shown, titled ***Adjust Demand***.

The first **UP** or **DOWN** press does not alter the current setting, which is the initial value shown on the popup menu:

When the ***Adjust Demand*** popup is shown:
Pressing **UP** or **DOWN** will alter the setting.
Holding **UP** or **DOWN** allows a rapid change to the setting.

The current setting can also be observed by briefly pressing the **CENTRE** button.
A popup menu titled ***Setpoint*** appears instead.

Any additional temperature sensors are also shown on this popup screen.
eg: a BME280 here.

Thermostat / Fixed Hz - °C / °F selection - Keypad lock

Holding **DOWN** or **UP** will present a ***Select Mode*** popup menu that allows the toggling of Thermostat & Fixed Hz modes, presentation of temperature in °C or °F, or a keypad lock function

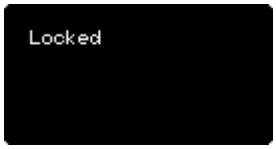
The active mode will be highlighted with a white background or surrounded by the selection loop.

Use **LEFT** / **RIGHT** to select the alternate setting of each mode.
Use **UP** / **DOWN** to move between the mode options.

Keypad Lock

A 3rd option exists which is “Keypad lock”.
This is not intended as a security measure, but a way to prevent accidental button activation, requiring an unlock key pattern to regain access to the keypad.

If the keypad lock is activated, a “Locked” message moves about the screen.
If any key is pressed whilst “Locked” is shown, the required unlock key stroke is shown on the display, being holding **LEFT** and **RIGHT** simultaneously.



Keypad lock can be configured to engage upon timeout via the “User Settings” menus.

Fault reporting

Should a fault be detected by the heater, an error message will be presented near the bottom of the screen.

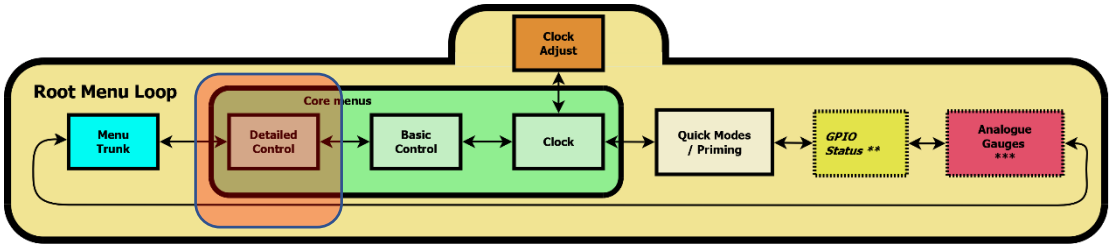
The line will alternate between the error code, and a brief text description.

GPIO output manipulation

You can manipulate either GPIO output, when they are set to “User mode”, by holding the **LEFT** or **RIGHT** keys down for 1 second.

“Ventilation mode” is also considered as a user mode.

Detailed Control menu *(Root menu loop)*



The ***Detailed Control*** menu allows the operation of the heater to be monitored in closer detail. Here the actual pump speed, fan RPM, heat exchanger temperature and glow plug activity can be observed.

Temperature or Fixed Hz adjustment

The desired thermostat temperature, or fixed power setting, can be altered by briefly pressing **UP** or **DOWN** to initiate the process of changing the setting.

A popup screen is shown, titled ***Adjust Demand***.

The first **UP** or **DOWN** press does not alter the current setting, which is the initial value shown on the popup menu:

When the ***Adjust Demand*** popup is shown:
Pressing **UP** or **DOWN** will alter the setting.
Holding **UP** or **DOWN** allows a rapid change to the setting.

When off, the current setting can be observed by briefly pressing the **CENTRE** button.
A target icon appears to the lower left of the display, and the current setting is printed beneath the icon.
This will be either the fixed Hz demand, or thermostat set point.

Once started, the desired setting is always reported beneath the "target" icon as °C, °F or Hz, depending upon thermostat or fixed demand modes.

When in thermostat mode, the desired target value is placed as a small triangle to the left of the measured ambient "temperature bulb" on the left-hand side of the screen.
Small half markers may appear to the right of the bulb to illustrate the Cyclic Mode zone.
The actual temperature is shown below the bulb, the height of the “mercury” likewise changes.

Fan Speed

The fan speed, as measured by the ECU in RPM, is reported beneath the animated rotating fan icon.
Pressing **CENTRE** will briefly change this to become the fan’s voltage.

Current Pump Rate

The actual pump rate as reported by the ECU is shown beneath the animated dripping fuel icon.

Glow Plug Power

During ECU phases where the glow plug is active, the current power applied to the glow plug is presented beneath a glow plug icon

Fuel usage

When the glow plug is not active, accumulated fuel usage since the last fuel gauge reset is shown beneath the fuel bowser icon.

Heater Body Temperature

The current heater body temperature is shown at the right edge of the display, only when the heater is running.

Heater On / Off

Starting the heater

If the heater is off, hold the **CENTRE** keypad button for ~1 second.
A popup menu will appear, providing options:

- Start immediately.
- Start after a time delay.
- Ignore, stay off.

If left alone, the popup menu will timeout in a few seconds.
By default, the heater will start.

Delayed start

Move **DOWN** to the 2nd selection of the popup, press **RIGHT**.
You can delay the start to happen sometime later.

Use **UP** / **DOWN** to change the delay by 5-minute increments.

There is no indication on the ***Detailed Control*** menu that a delayed start is active.

Cancelling a delayed start

If a delayed start is active, a long press of **CENTRE** instead provides options to start immediately, **cancel** the delayed start, or ignore:

Failure to immediately start

It is possible the heater will not start, and a message will be brought up accordingly.
Typical causes being:

- Ambient temperature is already higher than the desired thermostat setting.
- The battery voltage is lower than the Low Voltage Cutout setting.
- The accumulated fuel usage suggests the fuel tank is nearly empty.

Startup Monitoring

If started, the fan icon will appear and begin spinning, along with the RPM measured by the ECU.
The power applied to the glow plug will steadily rise.

It takes about a minute for the glow plug to receive full power, at which point the pump then starts.
The Pump being active is indicated by an animated fuel droplet, along with the actual pump rate:

The pump starts at a slow speed and steadily rises, along with fan speed to get the heater ignited.
Ignition tends to be sensed by the heater's ECU once the temperature of the heat exchanger has risen by about 5-10°C.
The heat exchanger temperature is reported by the right-hand side "thermometer bulb", the measurement value is shown below.

Once the body temperature rises above 65°C, the glow plug is shut down, all the while the fuel pump and fan speeds are progressively increased until at full speed.
The heater's ECU runs in this state for several minutes getting the internals nice and hot.

The consumed fuel icon replaces the glow plug icon:

After running at full speed for a while, the heater ECU transitions to the running state, and now obeys the desired setting being either a thermostat setting, or a fixed heat demand.
This occurs about 5 minutes after the initial start was demanded:

Thermostat / Fixed Hz - °C / °F selection - Keypad lock

Holding **DOWN** or **UP** will present a ***Select Mode*** popup menu that allows the toggling of Thermostat & Fixed Hz modes, presentation of temperature in °C or °F, or a keypad lock function

The active mode will be highlighted with a white background or surrounded by the selection loop.

Use **LEFT** / **RIGHT** to select the alternate setting of each mode.
Use **UP** / **DOWN** to move between the mode options.

Keypad Lock

A 3rd option exists which is “Keypad lock”.
This is not intended as a security measure, but a way to prevent accidental button activation, requiring an unlock key pattern.

If the keypad lock is activated, a “Locked” message moves about the screen.
If any key is pressed whilst “Locked” is shown, the required unlock key stroke is shown on the display, being holding **LEFT** and **RIGHT** simultaneously.

Keypad lock can be configured to engage upon timeout via the “User Settings” menus.

The changed operating mode is reflected in the units reported below the target icon.
°C or °F for thermostat, Hz for fixed demand.

If Cyclic Mode is enabled, markers will still appear to the right of the ambient temperature thermometer to indicate the start and stop thresholds when running in Fixed Hz mode.
These markers will persist even when in Fixed mode as Cyclic Mode is always active if enabled and the heater is running, the basis being the temperature last set when in a thermostat mode.

Stopping the heater

If the heater is on, hold the **CENTRE** keypad button for ~1 second.
A popup menu will appear, providing options:

- Stop immediately.
- Stop after a time delay.
- Ignore, keep running.

If left alone, the popup menu times out in a few seconds.
By default, the heater will begin the shutdown sequence.

Delayed Stop

Move **DOWN** to the 2nd selection of the start pop up, press **RIGHT**.
You can delay the stop to happen sometime later.

Use **UP** / **DOWN** to change the delay by 5-minute increments.

There is no indication on the ***Detailed Control*** menu that a delayed stop is active.

Cancelling a delayed stop

If delayed stop is active, a long press of **CENTRE** will instead provide options to stop immediately, **cancel** the delayed stop, or ignore:

Stop sequence

The status will then change to Stopping:

The pump speed is quickly lowered and eventually shut off.
The glow plug is re-powered to assist in clearing the heat exchanger and glow plug gauze of unburnt fuel.

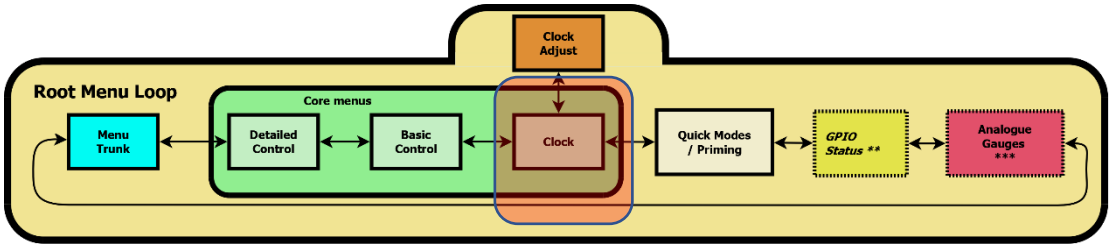
About a minute later power is removed from the glow plug and the heater transitions to cooldown mode.
Only the fan is now running:

It stays in cooldown mode until the heat exchanger is observed to have dropped below 55°C, at which point it then returns to the initial “Stopped/Ready” state.

GPIO output manipulation

You can toggle the state of GPIO outputs configured to “user mode” by holding the **LEFT** or **RIGHT** keys down for 1 second.
LEFT hold toggles digital output #1,
RIGHT hold toggles digital output #2.

Clock menu *(Root menu loop)*



The ***Clock*** menu presents the current time and date, as maintained by the Real Time Clock (RTC). This time is non-volatile, time is maintained by a CR1220 lithium coin cell if the main power is off.

This menu is essentially passive, just showing the time, but from here the clock can be set, or timers defined by pressing the **UP** or **DOWN** keypad buttons respectively.

The heater can be started or stopped by holding the **CENTRE** button longer than 1 second.
You can toggle the state of GPIO outputs configured to "user mode" by holding the **LEFT** or **RIGHT** keys down for 1 second.
LEFT hold toggles digital output #1,
RIGHT hold toggles digital output #2.

Setting the time

Press the **UP** keypad button from the ***Clock*** menu.
NOTE: access to the time setting feature is only available when set to Standard menu mode.

Control branches from the ***Root menu loop*** and the ***Set Clock*** menu is presented.

Pressing **CENTRE** will return to the ***Root menu loop's Clock*** menu.
Press **UP** again to enter clock setting mode.

Set the date

The "Date" field will be surrounded by a loop.

To procced and change the date, press **RIGHT** to select the field desired.
The day (number) field is first selected, and enlarged to show that is the selected value.
Likewise for month and year.

Use **UP** / **DOWN** to adjust the date values.

Set the time

To change the time, move back to the left, then press **UP** to select the "Time" line.

In a similar manner, press **RIGHT** to select each value to adjust.
The hour field is first selected, and enlarged to show that is the selected value.
Likewise for minute and second.

Use **UP** / **DOWN** to adjust the time values.

Clock format

Time can be shown in 12- or 24-hour format.
Select the last field on the "Time" line.
For 12-hour format, select AM or PM as appropriate.

Use **UP** / **DOWN** to adjust the format.

Applying the new Time and Date

To apply the new time/date setting, press **CENTER** whenever the "Exit" field is not selected (bottom of screen).

Pressing the **CENTRE** button will upload the new settings into the RTC chip.
Note that the time settings are maintained during power down by the CR1220 lithium battery.

Returning to parent menu (Clock)

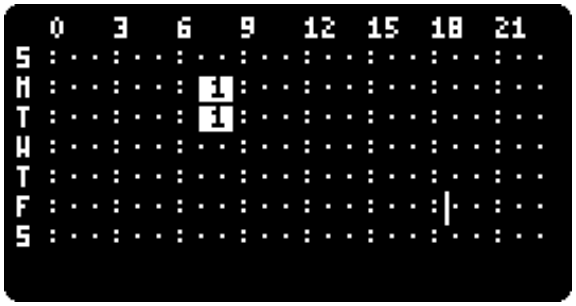
To return to the ***Root menu loop's Clock*** menu, we must not be in edit mode. i.e. "Exit" will be selected at the bottom of the screen.

Press the **CENTRE** or **DOWN** keypad buttons to return the ***Root menu loop's Clock*** menu.

Timers *(via Clock menu)*

Pressing the **DOWN** keypad button from the ***Root menu loop's Clock*** menu will enter the ***Set Timer menu loop***.
NOTE: access to the timer setting feature is only available when set to Standard menu mode.

The initial menu in the ***Set Timer menu loop*** is a graphic chart showing the coverage for the entire week of any timers that are enabled:



In this example, Timer 1 is enabled for Monday and Tuesday, starting around 07:00, stopping around 08:30.
The background bar being solid indicates this timer repeats.
The numeric within the bar shows which timer definition applies.

The current time / day is shown with a flashing vertical bar.

There are 14 timers available, each with their own menu screen.
They can be navigated to by pressing the **LEFT** or **RIGHT** keypad buttons when the selection loop is upon the bottom navigation line.

Selecting and setting fields

After navigating to a timer, a screen something like the following will appear.
The actual timer being identified in the ***Set Timer*** header.

To return to the ***Root menu loop's Clock*** menu, press the **CENTRE** button.
To start editing the timer, press the **DOWN** button.

Each timer parameter lives on its own line in the menu.
The menu scrolls vertically when you bump past the top or bottom visible selection, when in the left-hand side "Trunk" items.

Timer Mode

A timer can be defined as:

- Period (Interval) timer i.e. start and stop the heater at the defined times.
- Stop timer – stop the heater at the designated time.
- Start timer – start the heater at the designated time.
- Set Demand – heater operation is not altered, but the desired demand (Temperature or Fixed Hz) is set as the current setpoint.

- Move **RIGHT** to select the edit field.
- **UP** or **DOWN** keys to alter the mode.
- Move **LEFT** or **RIGHT** to return to the trunk.

Timer Start Time

- **The trunk position is skipped over if in Stop timer mode.**
- Move **RIGHT** to select the hour or minute edit fields.
- **UP** or **DOWN** keys to alter the values.
  Note these buttons will auto repeat.
- Move **LEFT** or **RIGHT** to return to the trunk.

Timer Stop Time

- **The trunk position is skipped over if in Start timer mode.**
- Move **RIGHT** to select the hour or minute edit fields.
- **UP** or **DOWN** keys to alter the values.
  Note these buttons will auto repeat.
- Move **LEFT** or **RIGHT** to return to the trunk.

Timer Days

Determines the days that the timer is active.

- Move **RIGHT** to select the edit field.
- **UP** or **DOWN** to simply enable or disable the timer.
  - **Every day**: Timer is in repeat mode.
  - **Next**: Timer is in Once mode (repeat off).
  - **Disabled**: Timer will not run.

Individual day selection

Besides a simple Enable / Disable of the timer, it is also possible to instead select which days of the week the timer applies to.

When the edit field is selected **HOLD** the **RIGHT** button.

The display will change to a set of days of the week.
These can then be navigated to using **LEFT**/**RIGHT** then toggled on/off by using **UP**/**DOWN.**

The day is enabled when highlighted with a white background.
Here only Monday and Tuesday are active.

To return to the overall "day" setting, accept by pressing **CENTRE.**

When back in the "primary" selection mode, the loop circles all days of the week, the selected days being in inverse text.

BEWARE:
Pressing **UP** or **DOWN** when in "primary" mode will cancel the individual days of the week and return to standard enable/disabled mode.
BE CAREFUL!

Timer Repeat

Determines if timer repeats or is only used once.

- Move **RIGHT** to select the edit field.
- **UP** or **DOWN** to toggle repeat mode on/off.

Timer Target Demand

- Move **RIGHT** to select the edit field.
- **UP** or **DOWN** to toggle repeat mode on/off.
  - Usual thermostat setpoint
  - Specific temperature
  - Specific Fixed Hz (constant power)

If the Timer Mode has been set as "Set Demand", the heater's running state will not be changed, but the desired demand (setpoint) will be installed. Thus, it is possible to create a variable temperature profile throughout the day, irrespective of whether the heater has been started or not.

GPIO function

A GPIO output can be made to activate whilst the timer is active.
The GPIO output must be configured for “User” mode.

- Move **RIGHT** to select the edit field.
- **UP** or **DOWN** to select the GPIO operation mode.
  - No effect
  - GPIO output #1
  - GPIO output #2

An active GPIO output allows continuity to ground for any external circuit attached to the GPIO output pin.

The GPIO function for the chosen output must be defined as User mode for this function to operate.

Saving the timer

If any parameter has been changed, the “should save” warning icon will be flashing at top right.

When anything other than the specific days entry is selected, press the **CENTRE** key to save the timer’s settings.
There is no abort function (i.e. no intermediate save confirmation appears).

Before the Afterburner accepts the new timer settings, a check is made against all other timers that may have already been enabled.

Overlapped timers are not supported.

If the proposed time and day settings conflict with another timer, the proposed timer is forcibly disabled, and a notification appears about which timer it conflicted with.

Irrespective of the timer being accepted, the remaining settings are always stored to non-volatile memory.
The timer may however end up being disabled due to a conflict.

If no conflict occurs the following message appears:

Returning to Root Menu loop *(Clock menu)*

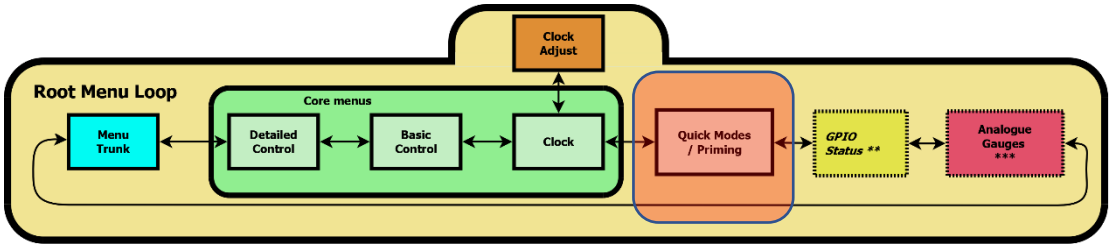
When the title is selected, press the **CENTRE** key to return to the ***Root menu's Clock*** menu.
*Note: If the keypad left is idle for minute, the **Root menu's Clock** menu will be activated.*
*This is default timeout behaviour as the **Clock** menu was the core root menu from where we branched.*

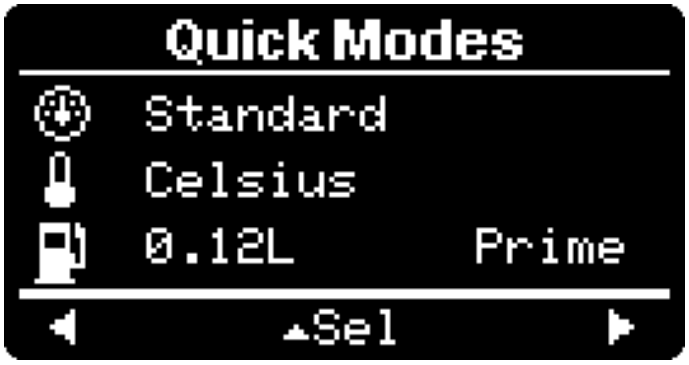
Scheduled timer reporting

The core root menus (***Detailed Control***, ***Basic Control***, ***Clock***) will show at the top of the screen the time of the next scheduled timer:

- The next timer is scheduled to start at 7:00AM
- If the timer is set to repeat, the timer icon gains an arrow at the lower left of the icon, as shown here.

Quick Modes menu *(Root menu loop)*





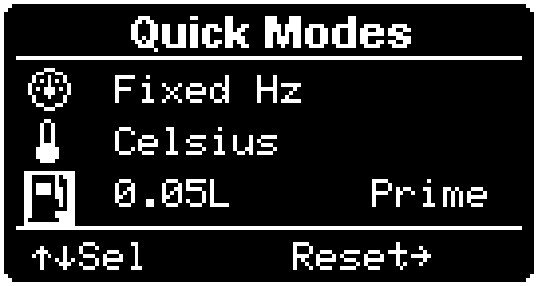
The ***Quick Modes*** menu allows:

- Thermostat / Fixed Hz mode to be toggled.
- Temperature to be reported as Celsius or Fahrenheit.
  - Internally, the Afterburner always use metric calculations.
  - Remote data interfaces are always published as metric values.
- Fuel pump to be primed.
- Fuel usage to be reset.

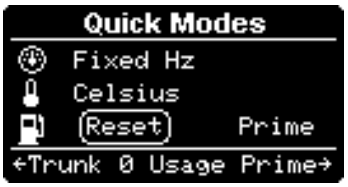
Initially enter the left-hand trunk by pressing **UP**.

- **UP** / **DOWN** to select the mode.
- **RIGHT** selects the available mode's setting.

Fuel functions



Fuel Usage Reset



Press **CENTRE** to reset fuel usage:

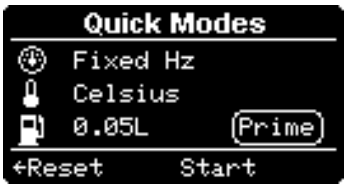
Pump Priming

Fuel pump priming should only be used when the fuel pump is known to be drained of fuel.

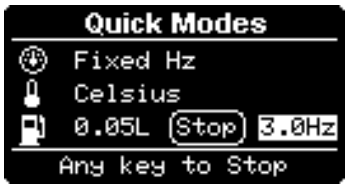
Habitually using priming prior to starting invariably leads to an over-fuelled heater, and difficult starts.
It is always better to start with less fuel than excess fuel.

Pump priming is always disabled by default and can only be enabled if the heater is **not already running**.

- Move **RIGHT** to select the Prime field.
- Press **CENTRE** to begin priming.



Press **CENTRE** to begin priming.

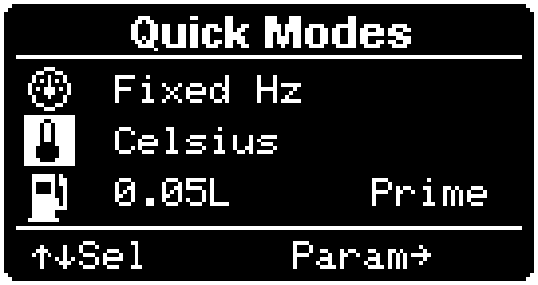


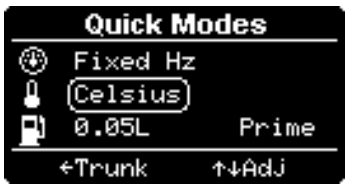
Press **any** button to stop priming.

The fuel pump will be automatically stopped after 1 minute.

Celsius or Fahrenheit reporting

Select whether temperature should be viewed as degrees Celsius or degrees Fahrenheit:



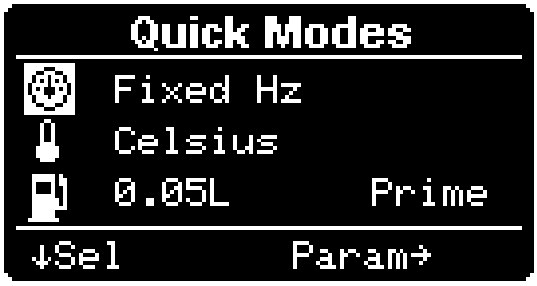


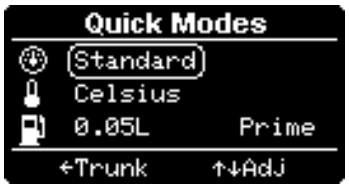
The Afterburner always uses metric values internally, and likewise publishes temperature values in Celsius to remote interfaces.
The web page and Android app are told which unit the Afterburner is set to and convert the Celsius values to Fahrenheit themselves.

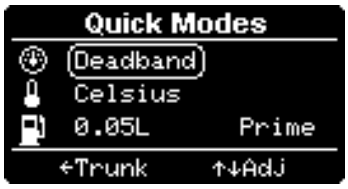
Thermostat / Fixed Hz selection

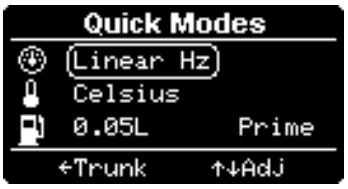
This option allows the Thermostat Mode or Fixed Hz heater mode to be chosen.

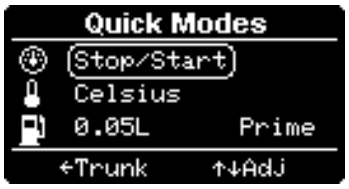
Unlike the simpler Thermostat / Fixed Hz toggle provided from the ***Detailed*** or ***Basic Control*** menus, this menu lets you to select the actual ***Thermostat Mode*** to use, without using the full menu provided in the ***User Settings menu loop***.

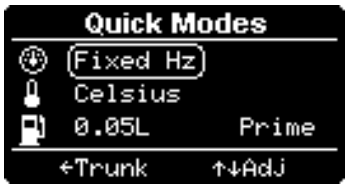




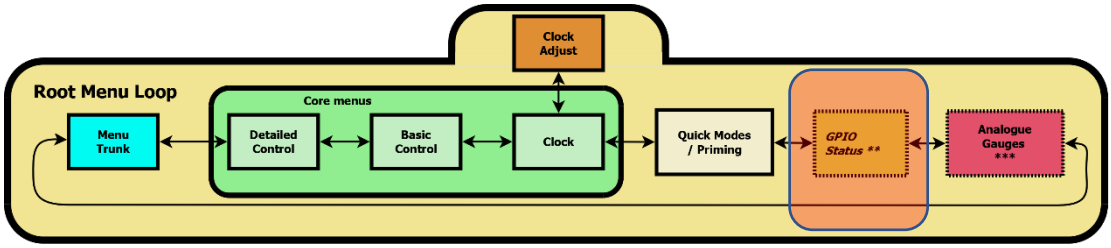


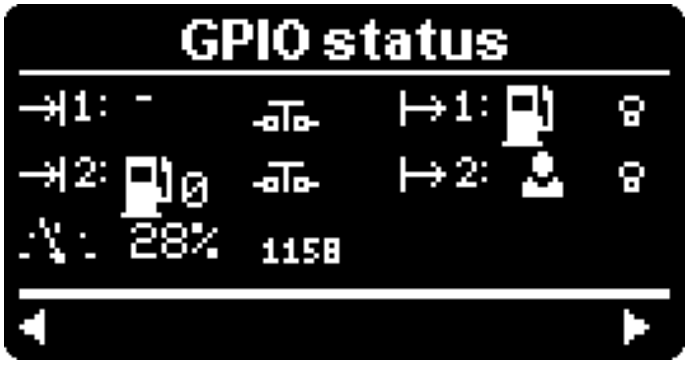






GPIO Status menu *(Root menu loop)*





The ***GPIO status*** menu allows the current signal states of the GPIO port to be visualised.

This menu only appears if GPIO hardware has been installed to the Afterburner PCB.

Digital Inputs

The 2 digital inputs are represented by the incoming arrow icons to the top left of the screen.

Depending upon how the GPIO inputs have been configured, the icons presented adjacent to the inputs will be one of the following:

-	Disabled	Changes at the input are ignored
▶	Start	A momentary closure will start the heater, a long closure will stop.
■	Stop	A momentary closure will stop the heater.
▶■	Start / Stop	Alternate momentary closures will start or stop the heater.
	Run	The heater will run whilst the input remains closed.
δT	External Thermostat	The heater will cycle high/low power according closed/open.
	Fuel Usage Reset	The fuel usage counter will be reset upon a 1 second hold.
MAX	Maximum Power	Heater runs at maximum power when closed. Reverts to original state when open – may be stopped or resume.
Σ	Pulse Counter	Accumulates pulses from something like a water flow meter.
	Permit	Heater is only allowed to run if the input is active
	Inhibit	Heater is prevented from running if the input is active.
	Timed Run	Heater starts then runs for a period when the input is made active.

The switch icon shows the state of the digital input:

	The input is open circuit.

	The input is closed to ground.

Digital Outputs

The 2 digital outputs are represented by the outgoing arrow icons to the top right of the screen.

-	Disabled	The output remains inactive.
	LED Status	An attached LED will dynamically indicate the heater run state.
	User	The output is controlled by user command.
	Temperature threshold	The output is active according to the defined absolute temperature threshold.
ΔT>	Thermostat over	The output is active if the temperature over the thermostat setting by the defined value.
ΔT<	Thermostat under	The output is active if the temperature below the thermostat setting by the defined value.
?	Heater On status	The output is active whenever the heater is not in the standby/stopped condition.
	Fuel Alarm	Off, OK; Flash, Warning; Solid, Empty
Vent	Ventilation	PWM output to allow running of fan only

The state of the output is reflected by the 'bulb' icon:

	The output is inactive
	The output is active

Analogue input

The input voltage applied to the Analogue input is presented as a percentage between 0.0V and 3.3V.

Presently the analogue value is purely for user visualisation.

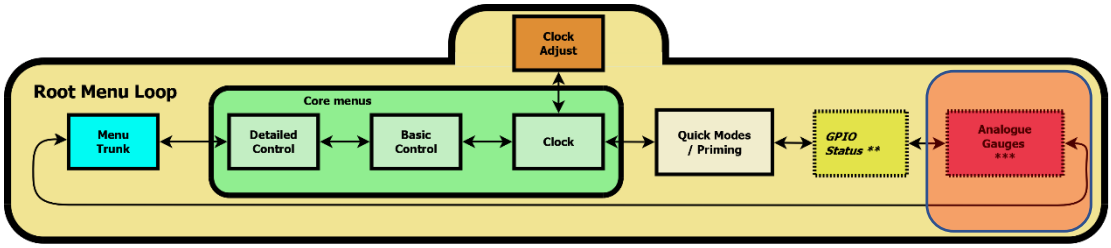
User interaction

If a digital output has been defined as User Controlled, the current state can be toggled by holding down the **LEFT** or **RIGHT** keys:

The **LEFT** key toggles digital output #1

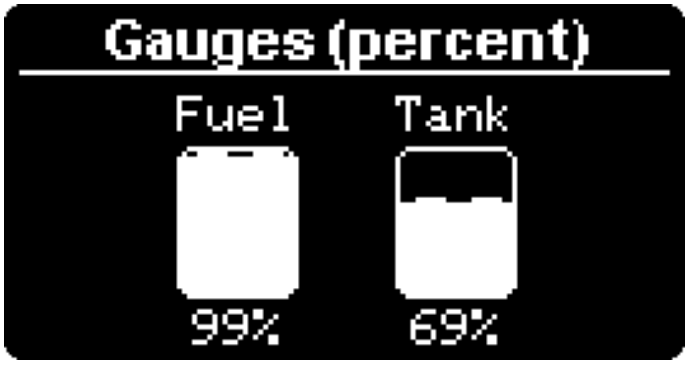
The **RIGHT** key toggles digital output #2

Gauges Menu *(Root menu loop)*



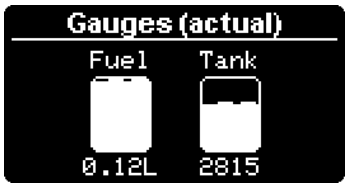
This menu will only appear when at least one of the following is enabled:

- GPIO analogue input.
- Maximum Fuel usage.
- Pulse Volume GPIO input.



Gauge native measurement

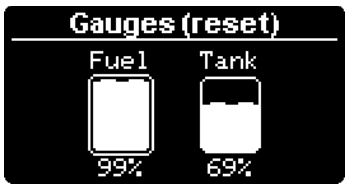
The raw value behind the gauge reading is presented when **DOWN** is pressed from the default view.



Gauge reset

Gauges can be reset when **UP** is pressed from the default view.

The entity surrounded by the flashing selection loop will be reset when you press **CENTRE**, then confirm by pressing **UP**.

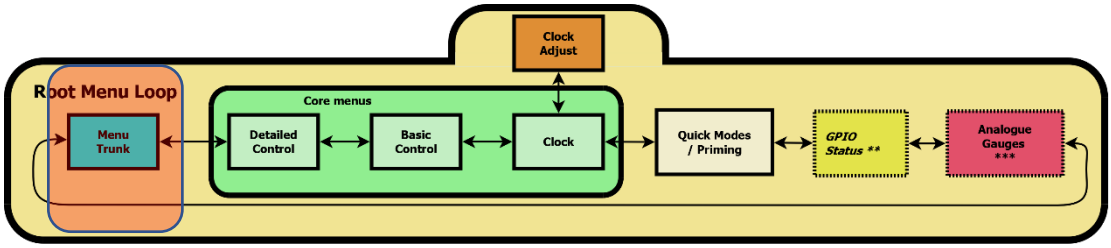


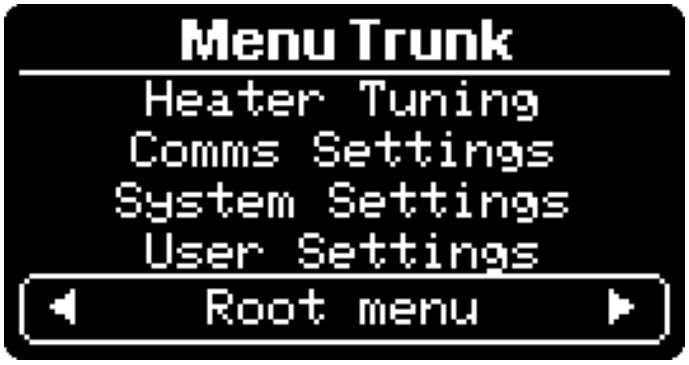
Fuel vs Tank

Fuel implies the estiamted fuel usage, derived by the Afterburner integrating the pump frequency since last being reset.
Tank is the analogue input, when set in Fuel Sender mode.

Note that the Analogue input cannot be reset. The external voltage determines the reading.

Menu Trunk *(Root menu loop)*





The menu trunk allows navigation into the other major menu loops, away from the ***Root menu loop***.

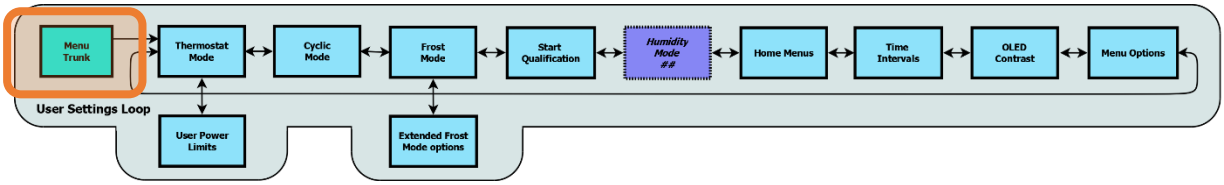
Use **UP**/**DOWN** to select a new menu loop.

Navigate into the selected menu loop using **LEFT**/**RIGHT**.

Jump to the “Root Menu” selection by pressing **CENTRE** when not on the bottom line.

Pressing **CENTRE** when already on the “Root Menu” selection will jump to the user specified default timeout menu.
If the default has not been specified, the ***Basic Control*** menu will be selected.

User Settings Menu loop



The ***User Settings menu loop*** is accessed via the ***Menu Trunk*** of the ***Root menu loop***.

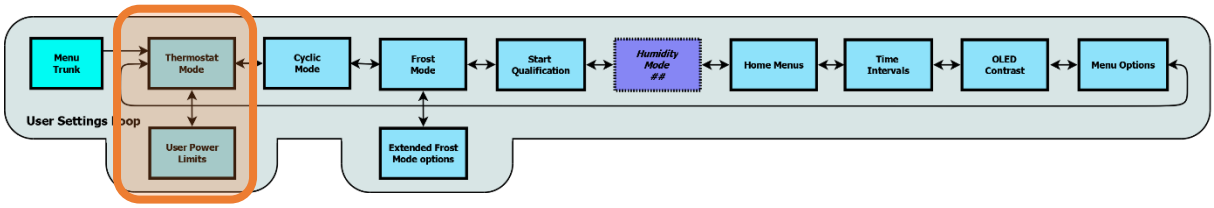
When in the ***Menu Trunk***, use **UP**/**DOWN** to navigate to "User Settings" line, then press **LEFT**/**RIGHT** to enter the ***User Settings menu loop***.

Once you have entered the ***User Settings menu loop***, you can only return to the ***Menu Trunk*** by pressing **CENTRE** when any of the loop's menus have the bottom-most navigation line selected.

As the name implies this menu loop holds settings that are predominantly user options, not so much heater system settings.

Thermostat Mode *(User Settings menu loop)*

The ***Thermostat Mode*** menu is always the first shown when departing from the ***Menu Trunk*** into the ***User Settings menu loop***.



Press **UP** to enter edit mode and select a setting to change.

- **LEFT**/**RIGHT** adjust the selected setting.
- **UP**/**DOWN** select another setting.
- **CENTRE** to accept and save the settings.

The available options are indicated by the graphic icons:

Thermostat algorithm selection *(Standard, Dead-band, Linear Hz, Stop/Start, External)*

Thermostat hysteresis *(0.2°C – 10°C range)*

Abort by pressing **DOWN** until the navigation line is re-selected, then press the **CENTRE** key, or move to another menu.

To set and save the settings, the **CENTRE** key must be pressed whilst one of the settings is selected. You must then confirm the changes by pressing the **UP** key.
STORING will then appear as the settings are saved to non-volatile memory:

Press **CENTRE**

Press **UP**

Thermostat Modes

The Afterburner offers 4 Inbuilt Thermostat Modes and can optionally support an external thermostat via a GPIO input:

- Inbuilt
  - Standard
  - Dead-band
  - Linear Hz
  - Stop / Start
- External
  - An external dry contact thermostat can be used
    (only if GPIO capability is available)

Cyclic Mode

A special supervisor mode (Cyclic Mode) can operate atop any thermostat mode, even Fixed Hz mode.
Cyclic Mode shuts the heater down if the temperature keeps on increasing despite being at minimum power.

Cyclic Mode is defined in its own menu in the ***User Settings menu loop***.

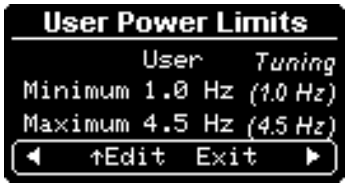
If the ambient temperature is already above the desired temperature, attempts to start the heater may also be ignored according to the Start Qualification setting.
This setting is yet another menu in the *User Settings menu loop*.

User Power Limits

Traditionally the maximum and minimum power limits of a heater under thermostat control are set by the maximum and minimum tuning limits.

User power limits allow the maximum thermostat power to be lowered, or minimum thermostat power increased, **without changing the tuning endpoints**.

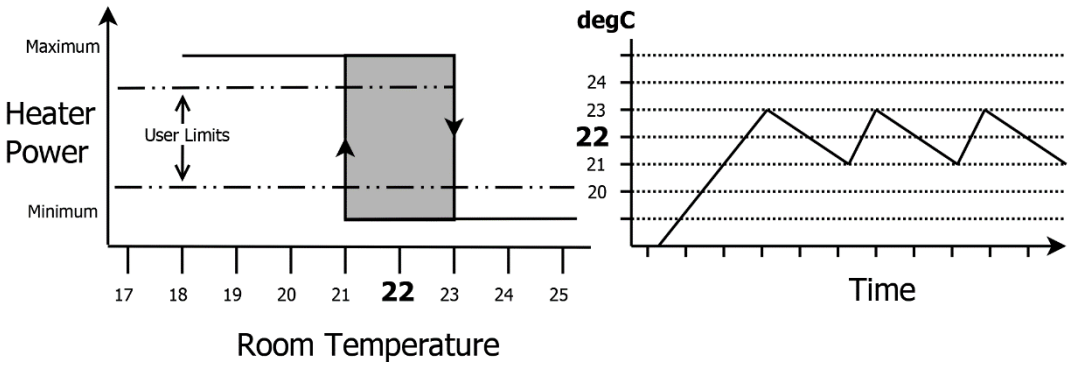
The limits are adjustable by pressing **DOWN** from the Thermostat Mode menu:



You cannot lower the minimum user limit power lower than the tuning minimum.
You cannot raise the maximum user power higher than the tuning maximum.
You cannot set the difference between maximum and minimum less than 5 power steps apart.

Note that each power step's actual increment in Hz is determined by the span of minimum to maximum pump speed (tuning), spread over 28 demand steps.
The in-use rate also gets rounded to the nearest 0.1Hz.

Standard Thermostat mode



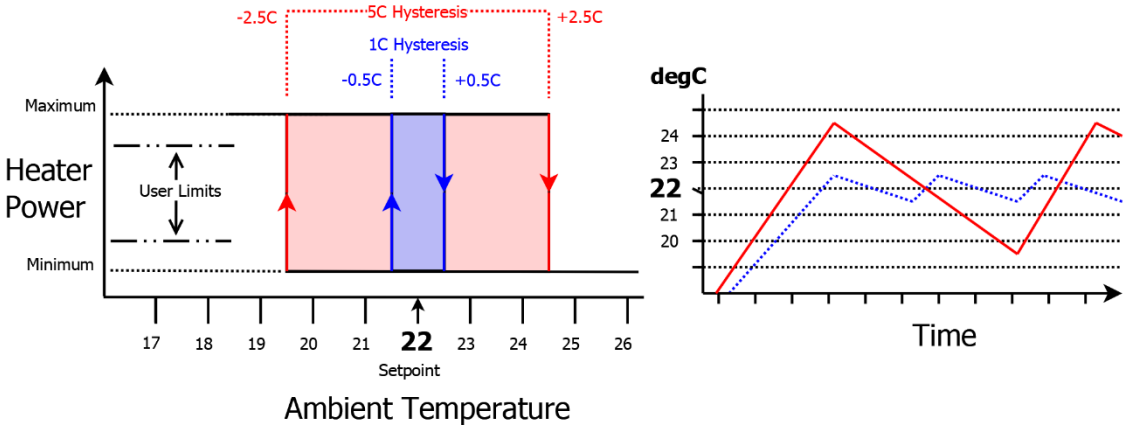
Standard thermostat mode graphic, demonstrating power demand transitions about a 22°C setpoint.

The standard thermostat mimics the algorithm built into the heater ECU.

Starting from cold, the heater will run at the maximum user power limit until the ambient temperature exceeds the user defined setpoint by 1°C.
Once this threshold is crossed, the heater then changes to run at the minimum user power limit.
Later, when the ambient temperature later drops 1°C below the setpoint, the heater once again switches to run at the maximum user power limit.

i.e. a 2°C hysteresis.

Dead-band mode - variable hysteresis



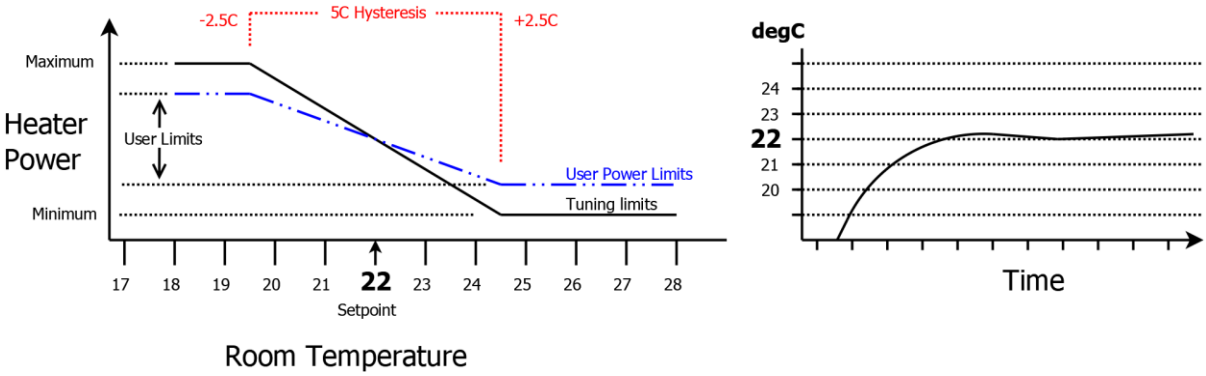
Dead-band thermostat mode graphic, demonstrating the variable hysteresis width.

Dead-band mode operates the same as standard mode but allows the user to define the hysteresis width about the thermostat setpoint.

Assuming ambient started below the setpoint, the heater will run at full power until it rises ½ the hysteresis value over the setpoint.
The heater then is switched to minimum power until the ambient temperature falls ½ the hysteresis value below the setpoint, then returning to maximum power.

Thereby the dead-band, or hysteresis of the ECU's thermostat can be controlled over a wider or narrower range.
Using a dead-band hysteresis of 2°C is functionally equivalent to the standard thermostat function.

Linear Hz



Linear Hz thermostat mode graphic, demonstrating the variable heater power across the hysteresis width.

Linear Hz mode is more akin to cruise control in a vehicle.
As the thermostat setpoint is neared, the heater power is gradually reduced resulting in smoother temperature control.

If the ambient temperature is below the bounds of the user defined hysteresis about the setpoint, the maximum user power limit is requested by the Afterburner.
If the ambient temperature is above the hysteresis bounds, the minimum user power limit is requested.
Within the hysteresis span, the fuel rate demand is linearly adjusted between the maximum and minimum user limits, according to the deviation from the setpoint.

Accordingly, the ambient temperature is automatically maintained within a narrow band.
As the fuel rate is gradually tapered, the initial arrival at the setpoint will be more exponential.
Note that the exact average temperature may be slightly above or below the desired setpoint but should remain relatively steady.

Stop / Start Thermostat Mode

Stop / Start thermostat mode operates by running the heater at full power until the desired setpoint is exceeded. Then the heater is then instructed to shut down.
e.g.:

Desired setting is 22°C.
Heater will be shut down @ >22°C.

Once shut down, the Afterburner considers the heater to be in the special "suspended" state as it was asked to stop by action of the thermostat.
This means it will later instruct the heater to start when the ambient temperature falls back below the desired setpoint - hysteresis.
e.g.:

Desired setting is 22°C, hysteresis is defined as 1°C.
Heater will be asked to restart @ <21°C.

Caution

The glow plug is cycled on during both shutdown and restart phases.
Consideration should be given to the possible higher electrical energy required when using a battery powered system if you expect the Cyclic Mode thresholds to be frequently encountered.

As a guide, a complete start/stop cycle is likely to consume ~1Ah of battery capacity.

It usually takes 5 minutes for a heater to reach normal running condition, and a further 3 minutes or so to shut down.

Also note that the heater's ECU will deny restart attempts whilst completing the shutdown procedure.

External Thermostat Mode (requires GPIO input)

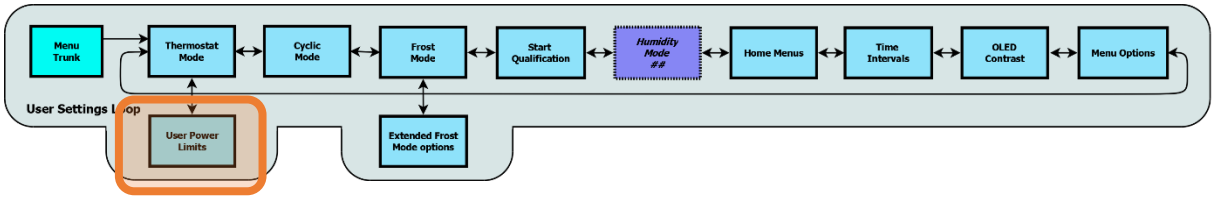
A thermostat typically used for domestic heating that provides a contact closure for heat demand can be attached to an Afterburner GPIO input.
Before you can select External Thermostat mode in the Thermostat Mode menu, you MUST first enable the External Thermostat function in the GPIO Configuration menu for the desired GPIO input.

Maximum and minimum power demands are commanded according to the external thermostat's contact being closed or open respectively.

If the heater is stopped, the initial contact closure will make the heater start.
Subsequent opening and closings of the thermostat contact will cause the heater to run at minimum and maximum power respectively.
An associated option exists in the GPIO configuration to shut the heater down if the contact remains open longer than a specified time interval, otherwise manual shutdown is required.

Cyclic Mode can still supervise this mode, also suspending the heater if it should get too warm.

User Thermostat Power Limits *(via Thermostat Mode menu)*

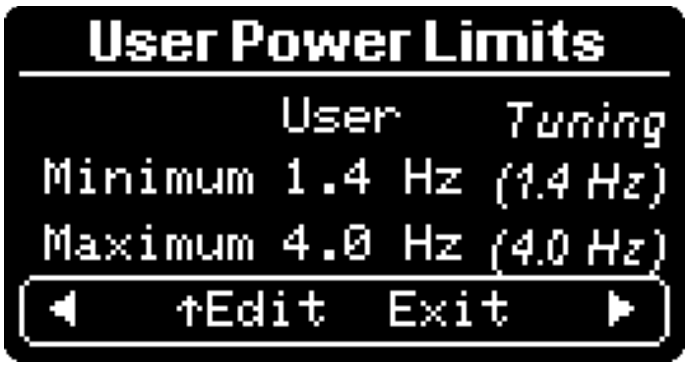


The user can limit the upper and lower heater power demands when using any thermostat mode.

These limits define the maximum and minimum pump rates and always lie within the bounds of the actual tuning limits for maximum and minimum power.

Using these limits does not alter the tuning of the heater. The ECU interpolates from the tuning endpoints.

Access to these ***User Power Limits*** is by branching away from ***Thermostat Mode*** menu by pressing **DOWN**.



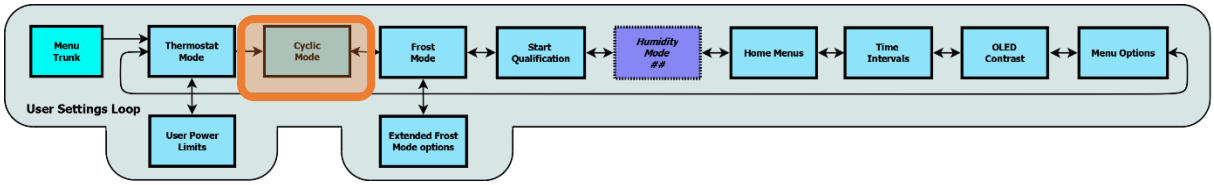
Select the minimum or maximum power limit by pressing **UP** or **DOWN**.
Adjust the setting using **LEFT** or **RIGHT**.

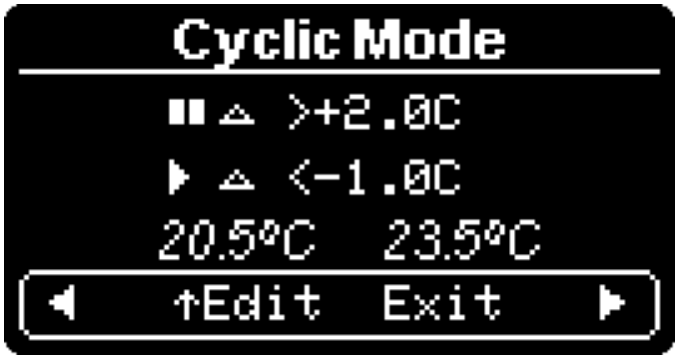
You cannot lower the minimum user limit power lower than the tuning minimum.
You cannot raise the maximum user power higher than the tuning maximum.
You cannot set the difference between maximum and minimum to be less than 5 power steps apart.

Note that each power step's actual increment in Hz is determined by the span of minimum to maximum pump speed (tuning), spread over 28 demand steps.
The actual in-use rate also gets rounded to the nearest 0.1Hz.

Save the changed settings by pressing the **CENTRE** button and confirming the save by pressing **UP** when not on the bottom navigation line.

Cyclic Mode *(User Settings menu loop)*





Cyclic Mode is a supervisor of temperature across any operation mode of the heater.

When Cyclic Mode is enabled, the heater will be requested to stop when the temperature exceeds the Cyclic Stop threshold, relative to the current desired setpoint.
The system remains armed to later restart the heater when the ambient temperature falls below the Cyclic Start threshold, relative to the current desired setpoint.

As these thresholds are relative to the current thermostat setting, the absolute temperature of these thresholds will change as the thermostat set point is altered.

Note that if Frost Mode is running and is using Frost Thermostat mode, that temporarily becomes the new thermostat setpoint and cyclic mode will also operate about that revised setpoint.

The current absolute temperatures are shown beneath the settings in italic font.

If using Fixed Hz mode, Cyclic mode will still operate and stop/start the heater, according to the last used thermostat setpoint.

Cyclic Stop

Move UP to highlight the top field, annotated with a pause icon along with a delta symbol.
The allowed adjustment range is from +1.5°C to +10.0°C relative to the thermostat setpoint.

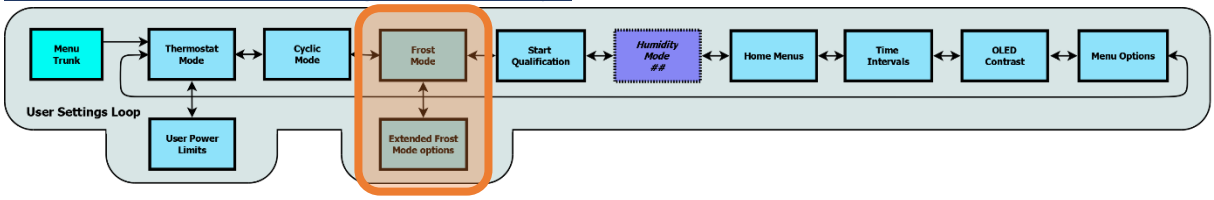
Cyclic Start

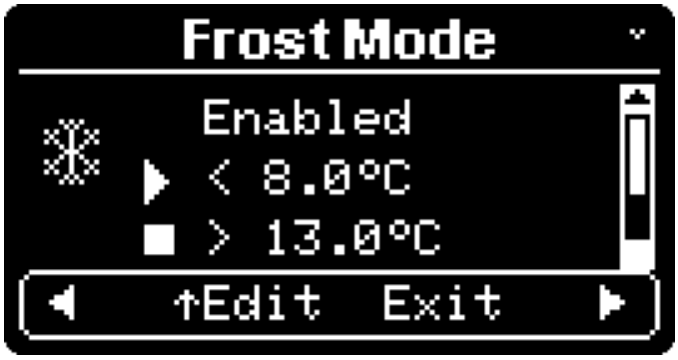
Move UP/DOWN to highlight the top field, annotated with a play icon along with a delta symbol.
The allowed adjustment range is from -10.0°C to +1.0°C relative to the thermostat setpoint.

Saving Changes

Press **CENTRE** whenever not upon the bottom menu navigation selection, followed by **UP** to confirm.

Frost Mode *(User Settings menu loop)*





Frost mode allows the heater to automatically start if the ambient temperature falls below a defined value.

IMPORTANT:
When enabled, Frost Mode will always engage if the start condition is met irrespective of whether you have already turned off the heater.
Ensure the heating ducts remain free of obstructions when unattended.

Menu items

This menu contains 4 editable items, only 3 are shown at any time.

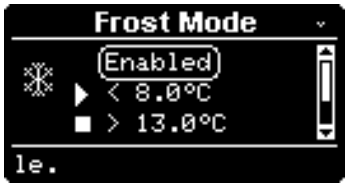
The scrollbar presented to the right shows the location of the current 3 items amongst the 4.

The upper or lower arrow of the scrollbar will flash if more selections exist in that direction, which you can navigate to by using **UP** or **DOWN** respectively.

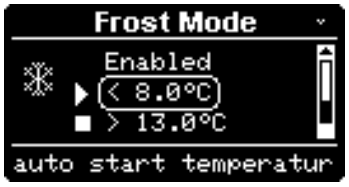
You must be upon an editable item to save the settings, by pressing **CENTRE**, then **UP**.

Enter the edit fields by pressing **UP** from the base navigation line.
Pressing **UP** or **DOWN** when at the limits of the editable items will return to the base navigation line.

Editable items

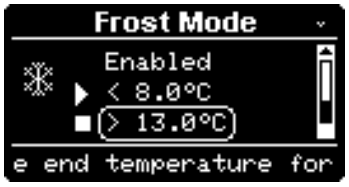
1. 

Arm or disable Frost Mode by using **LEFT**/**RIGHT**.

2. 

Define the trigger temperature that starts the heater.
eg: 8°C.

- Adjust using **LEFT**/**RIGHT**.
- Hold for auto repeat.

3. 

Define the target temperature for frost mode.

- Adjust using **LEFT**/**RIGHT**.
- Hold for auto repeat.

Selecting "System Thermostat" mode will show the current setting in inverse and cannot be selected and edited here.

4. 

Define the Frost Mode operating mode by pressing **LEFT**/**RIGHT**.

- Stop
- Frost Thermostat
- System thermostat

Frost operation modes

The Frost feature has 3 possible modes of operation.
These modes determine how the target is temperature is used, and what happens when it is reached.

Start/Stop mode

Once started, the heater will run until the entered stop temperature is reached.
The heater will then be stopped.

If a soak time is defined, (see Advanced Frost Options) the heater stop will be delayed by this period.

Frost Thermostat

Once started, the current thermostat setting will be made according to that defined for Frost Mode.
The heater will continue to run, under thermostat control once the target temperature is reached.

If a soak time is defined (see Advanced Frost Options), the heater will continue run for this period after the frost mode's target temperature was reached.
The heater will then be stopped when this period elapses.

System Thermostat

Once started, the current system thermostat setting will be used as the target temperature.
The heater will continue to run, under thermostat control once the target temperature is reached.

If a soak time is defined (see Advanced Frost Options), the heater will continue run for this period after the system's target temperature was reached.
The heater will then be stopped when this period elapses.

Advanced Frost Mode Options

The title bar of Frost Mode has an animated down arrow presented at the top right of the screen. This is an indication that HOLDING the **DOWN** button will open a sub menu, that allows access to the advanced frost mode options.

This is a sub menu of the Frost mode menus, and is shown with a border, indicating it is not part of the normal menu system.

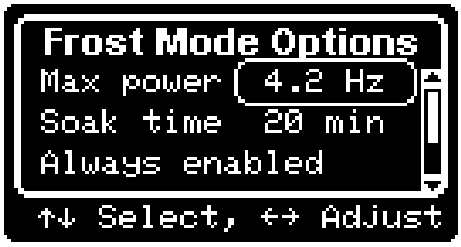
This sub menu contains 4 editable items, only 3 are shown at any time.

The scrollbar presented to the right shows the location of the current 3 items amongst the 4.

The upper or lower arrow of the scrollbar will flash if more selections exist in that direction, which you can navigate to by using **UP** or **DOWN** respectively.

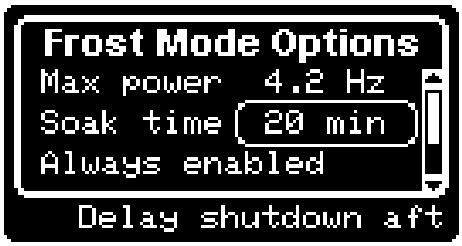
Return to the origin Frost Mode menu by pressing **CENTRE** when on any option.

Max Power



You can limit the maximum power asked of the heater during frost mode operation.
Press **LEFT**/ **RIGHT** to alter the desired power.

Soak Time



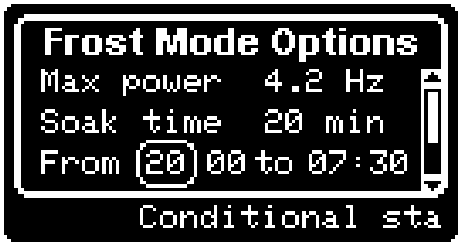
Defining a soak time alters the behaviour of frost mode when the target temperature is reached.

If a soak time is defined, the heater will ALWAYS be stopped when this period elapses after reaching the target temperature.

Otherwise, the heater will remain running unless Stop mode is selected as the frost mode.

Setting the soak time to zero disables the feature.
It can be adjusted in 5-minute increments, to a maximum of 120 minutes (2 hours), using **LEFT** / **RIGHT**.

Time Condition



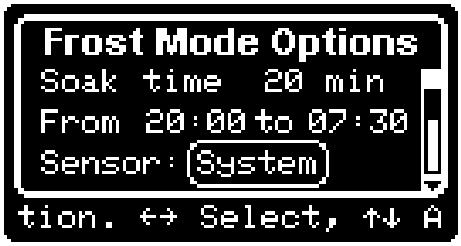
Normally, frost mode is always active.
You can restrict the time it is available by setting a start and stop time here.

Pressing **RIGHT** will change from “Always Enabled” to a pair of Hour:Minute time fields.
The left hand time being the start of the allowed interval.

If these times are left as matching values for few seconds, it will revert to “Always Enabled”.

Pressing **UP** / **DOWN** one each hour / minute field allows the time interval to be defined.
Holding **UP** / **DOWN** provides auto repeat.

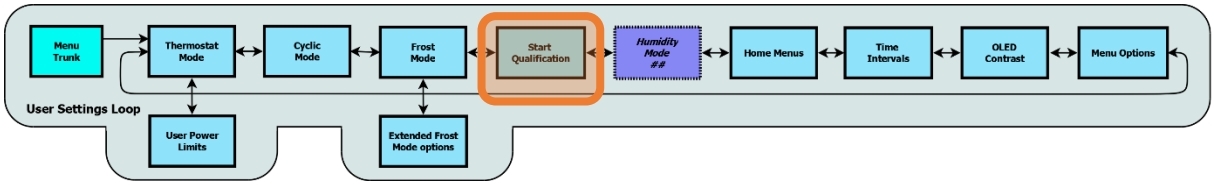
Temperature Sensor



By default, the system thermostat sensor is used for frost mode.

If you have more than a single sensor, you can nominate which one to use for frost mode by pressing **LEFT** / **RIGHT**.

Start Qualification *(User Settings menu loop)*



The Start Qualification determines how a heater start request will be honoured.

Available options are:

1. Always.
2. Deny if over thermostat setpoint temperature.
3. Suspend if over Cyclic Stop temperature.
4. Suspend if over thermostat setpoint temperature.

The menu presents the current thermostat setpoint as a downwards pointing triangle above the graphic of a sideways mercury bulb thermometer.
In the example above, the thermostat setpoint is 21.5°C.

The current ambient temperature determines the length of the "mercury" inside the bulb graphic, and the value is shown below the bulb's reservoir.
In this example the ambient temperature is 24.5°C.

The current Cyclic Mode trigger points are shown below the bulb graphic, as play and pause icons with short ticks above.
In this example Cyclic Stop is set to suspend at 2°C above the setpoint (pause icon), and restart when dropping below the setpoint (-1°C, play icon). i.e. 20.5°C and 23.5°C respectively.

Selection of the mode is made by pressing **UP** to allow the mode to be highlighted, then using **LEFT** or **RIGHT** to change the mode.
Accept by pressing the **CENTRE** button, then **UP** to confirm.

Qualification Modes

Always

The heater will always start.
Note that if cyclic mode is enabled and the ambient temperature is already greater than the cyclic stop setting, the heater will be transitioned to "suspended" immediately.

Deny if over thermostat setpoint temperature

If the ambient temperature is already above the desired thermostat setpoint the heater start request will be ignored. Otherwise, the heater is started.

Suspend if over Cyclic Stop temperature

This mode is dependent upon whether Cyclic Mode is enabled.

- Cyclic Mode enabled:
  If the ambient temperature is above the Cyclic Stop temperature the Afterburner immediately switches to Suspended mode, otherwise the heater is started.
- Cyclic Mode disabled:
  The heater start request will be ignored if the ambient temperature is already above the desired thermostat setpoint.

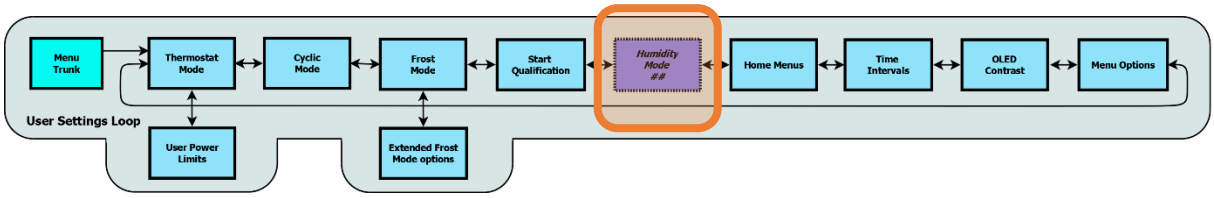
Suspend if over thermostat setpoint temperature

This mode is dependent upon whether Cyclic Mode is enabled.

- Cyclic Mode enabled:
  If the ambient temperature is above the thermostat setpoint temperature the Afterburner immediately switches to Suspended mode, otherwise the heater is started.
- Cyclic Mode disabled:
  The heater start request will be ignored if the ambient temperature is already above the desired thermostat setpoint.

Humidity Start *(User Settings menu loop)*

– Requires BME-280 environmental sensor



This menu only appears if a BME280 environmental sensor has been installed.

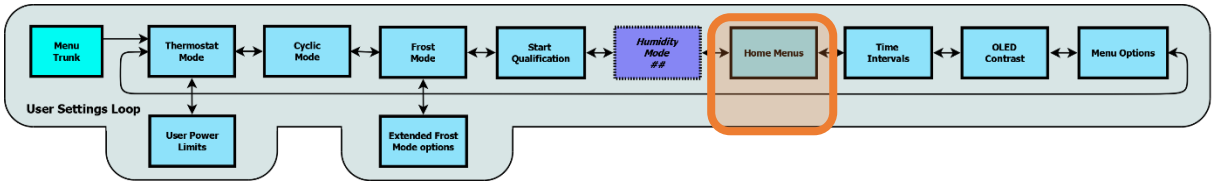
Humidity start will start the heater if the humidity rises above a defined threshold.

Presently once started, the heater will remain running until shut down by the user.

A BME280 sensor mounted to the Afterburner PCB invariably reads a higher temperature than ambient due to the heat dissipated from the ES32 module.

As a result, humidity readings from the BME280 are likely compromised to a lower relative humidity reading.

Home Menu Actions *(User Settings menu loop)*



The ***Home Menu Actions*** menu allows the user to customise which default "Root Menu" is shown for the following events:

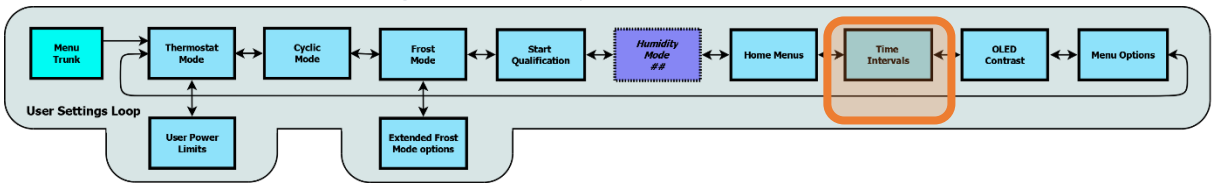
- Inactivity timeout *(hourglass icon)*
- Heater started *(start icon)*
- Heater Stopped *(stop icon)*

The available options for each event being:

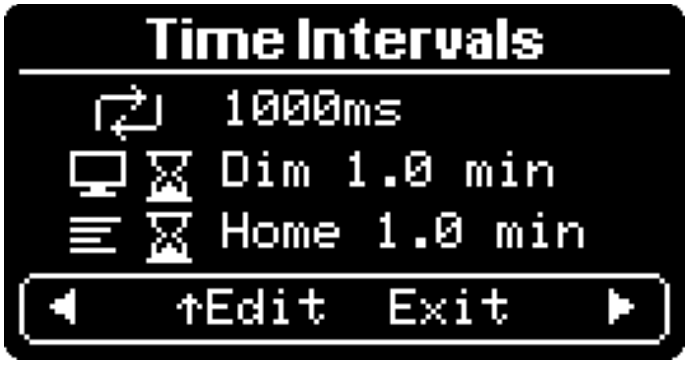
- Default menu (typically ***Basic Control***, maybe ***Clock*** when setting timers).
- ***Detailed Control*** menu.
- ***Basic Control*** menu.
- ***Clock*** menu.

The following example shows the settings for menu timeout being the ***Basic Control*** menu, starting the heater will bring up the ***Detailed status*** menu, and stopping the heater will bring up the ***Clock*** menu:

Time Intervals *(User Settings menu loop)*



The Time intervals menu allows the polling rate of the heater to be adjusted and sets the timeout values for default menu and display dimming or blanking.



Heater Polling Rate

The looping arrows icon sets the rate that the controller sends new information to the heater ECU and receives the current ECU status in response.
The default rate is 1000ms (1 second) which allows co-operation with an OEM controller.
Once running stand-alone you may choose to speed the update rate for more frequent status updates.

Display Timeout

The display timeout is shown as a monitor icon paired with an hourglass icon.
After the nominated time, the display can be made to:

- Stay illuminated.
- Dimmed.
- Blanked.

To toggle from Dim or Blank modes, ensure the 2nd line is selected (by pressing **UP**/**DOWN**), then hold **LEFT** or **RIGHT** to toggle the action between Dim or Blank.

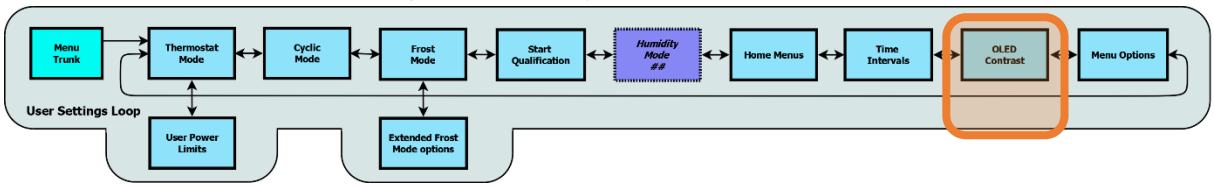
To keep the display always on, reduce the timeout value to 0, using presses of the **LEFT** button in Dim mode, or **RIGHT** button in Blank mode. The selection will then show “Always On”.

Home Menu Timeout

The Home Menu timeout is shown as a menu icon paired with an hourglass icon.
After the nominated time, the menu system will be forced to the timeout menu selected in the ***Home Menu Actions*** menu ***(User Settings menu loop)***

To prevent the menu timeout, simply reduce the time to 0 here.
It would then require human interaction to return to the control menus.

OLED Contrast *(User Settings menu loop)*



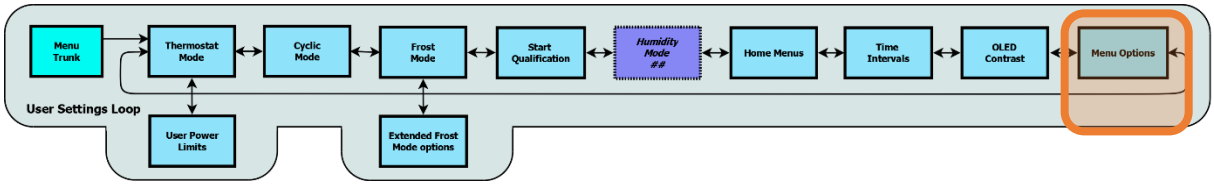
The ***OLED Contrast*** menu allows the brightness of the OLED to be varied for normal interactive operation or dimmed modes.

Select either “Dimming” or “Maximum” using **UP** / **DOWN**.

If you then adjust the setting using **LEFT** or **RIGHT**, the screen will change to a preview of the brightness you will get for the appropriate setting.

Press **CENTRE** when “Dimming” or “Maximum” are selected, then **UP** to save the settings.

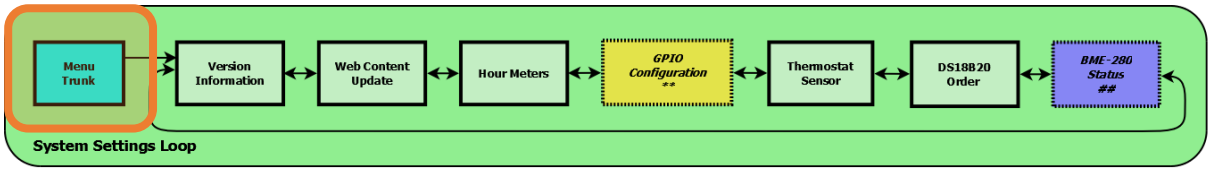
Menu Options menu *(User Settings menu loop)*



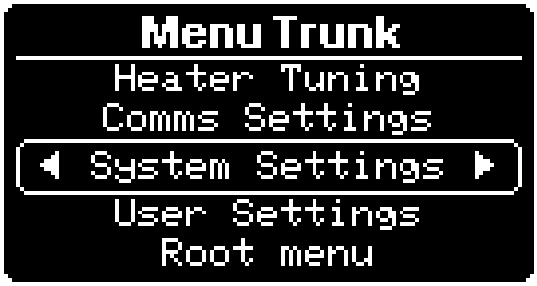
The ***Menu Options*** menu allows the menu system to be simplified to the essential operating functions.

You can also choose whether the password required for protected menus is remembered for 24 hours or needs to be re-entered every time you enter such a menu.

System Settings menu loop



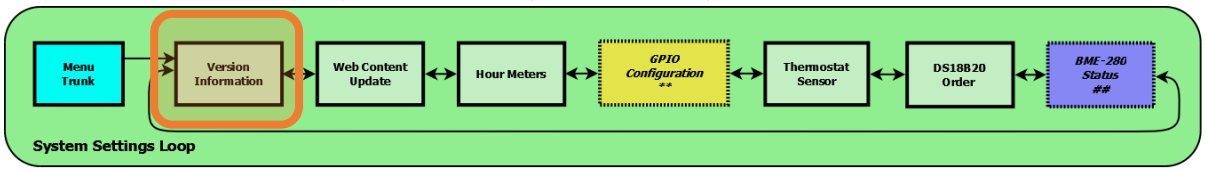
The ***System Settings menu loop*** is accessed via the ***Menu Trunk*** of the ***Root menu loop***.



Use **UP**/**DOWN** to navigate to System Settings line, then pressing **LEFT** or **RIGHT** enters the ***System Settings menu loop***.

Once you have entered the ***System Settings menu loop***, you can only return to the ***Menu Trunk*** by pressing **CENTRE** when any of the loop's menus have the bottom-most navigation line selected.

Version Information *(System Settings menu loop)*



The version information menu allows the current installed software version to be inspected and potentially automatically updated.

From this menu you can:

- Authorise automatic updating of the firmware (via STA download).
- Restore factory default values to the stored non-volatile parameters.
- Defragment non-volatile storage.

The first two lines show the current installed version, and its release date.

The third line shows the GPIO capabilities of the installed PCB.

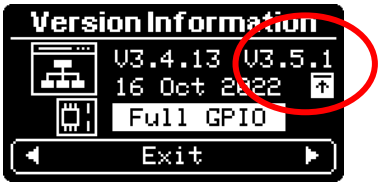
- Full GPIO
- No Analog
- No GPIO

IMPORTANT:
PCB versioning is automatically determined the very first time a board is programmed from scratch, or immediately after performing a factory default.

To ensure the PCB version is correctly detected following a factory default, it is strongly recommended to temporarily remove the 7-pin expansion port cable if it is fitted.

Provided STA mode WiFi is configured and connected to an Internet enabled network, when the **Version Information** menu is opened a check is made for a possible firmware update being available from the Afterburner web server; http://afterburner.www.mrjones.id.au .
If there is a new update available, the new version is flashed up at the top right of the **Version Information** screen, it will also flash up upon the home menu screens adjacent to the battery icon:

If no update exists, control always skips past the “get update” selection when entering the menu using **UP**.



Release Firmware Update

To automatically download and install a notified firmware update from the Afterburner website, press **UP**.
The bottom status line will then indicate the update can be performed by pressing the **CENTRE** button:

If the **CENTRE** button is pressed, you then need to press **UP** again to confirm the download.

Once started, the download of new firmware will immediately take place, progress being shown on the OLED.

Upon the download completion, the new firmware's checksum is verified and the system reboots into the new version.
Should the download fail, the current version will be maintained.

Beta firmware update

The latest Beta firmware update can instead be downloaded and installed by **holding** **UP**.

The subtle distinction is the title instead reads as "BETA Firmware update".

Non-volatile storage defragment

Pressing **UP** from the base Version menu begins the ability to perform a non-volatile storage defragment.
The defragment scrubs the reserved flash memory used for non-volatile storage then restores the current settings afresh.
This should not normally be used but is available if required, namely if untoward non-volatile storage issues become evident.
No user settings are lost performing a defragment.

Factory default

Pressing **UP** twice from the base Version menu begins the ability to perform a factory default upon all stored, non-volatile, parameters.

CAUTION:

Factory defaulting will reset the heater's fuel mixture tuning and any other customisations that may have been performed.

IMPORTANT:
GPIO capability is automatically determined the very first time a board is programmed from scratch, or immediately after performing a factory default.

To ensure the PCB version is correctly detected following a factory default, it is strongly recommended to temporarily remove the 7-pin GPIO expansion port cable if it is fitted.

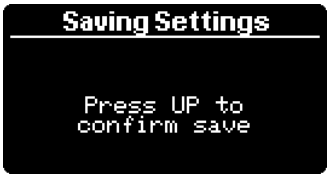
Most importantly it restores the default passwords for WiFi Access Point mode and firmware updates via a browser, and indeed the SSID of the Afterburner's Access Point:

- **SSID:** "Afterburner"
- **SSID password:** "thereisnospoon"
- **Browser update password:** "BurnBabyBurn"

After 2nd **UP** press:

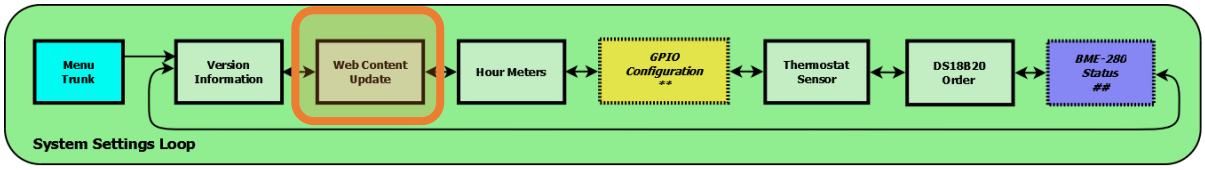
After 3rd **UP** press:

Pressing the **CENTRE** key after the 3rd **UP** press then presents a confirmation screen:



If **UP** is pressed, the factory default values are installed, and the system is rebooted:

Web Content Update *(System Settings menu loop)*



Providing the Afterburner has an active STA WiFi connection established *(which provides access to the Internet)* the Afterburner can contact the Afterburner website http://afterburner.mrjones.id.au and retrieve the latest available web content and automatically save it to the file system.

This is in lieu of using the Afterburner's inbuilt **/update** web page to upload new content.
Using /update can be problematic for some when using a mobile device to extract index.html.gz from index.html.zip, that is then required to be uploaded to the file system.

Some iOS devices may also prevent a web page from accessing the file system of the phone, this means /update cannot function correctly.

If the STA connection is not available, the following message will be presented:

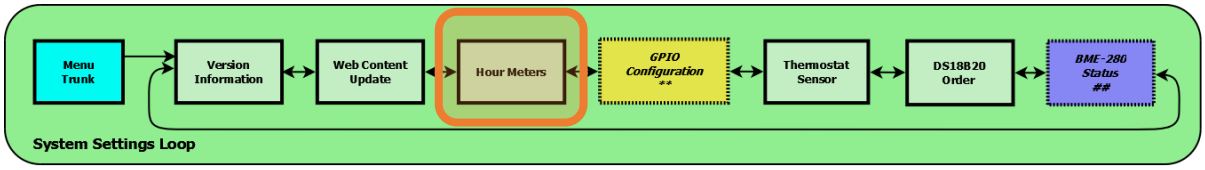
The following sequence will occur when you press **UP**.

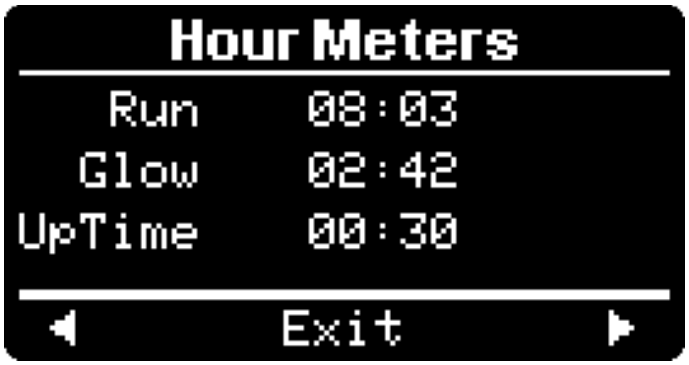
Press **CENTRE** to begin downloading the web content.

Beta web content

You can instead gather the latest beta version web content by **HOLDING UP** then **RIGHT** before pressing **CENTRE**, you can switch back to release using **LEFT**.

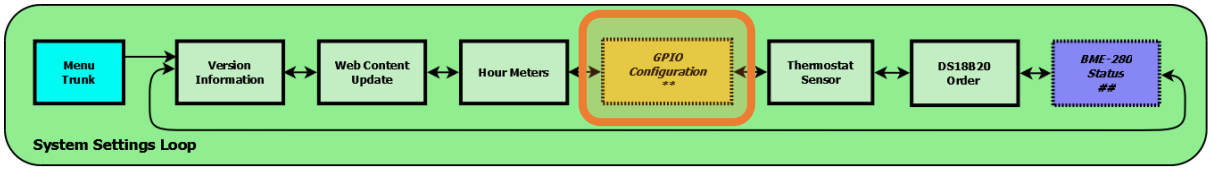
Hour Meters *(System Settings menu loop)*





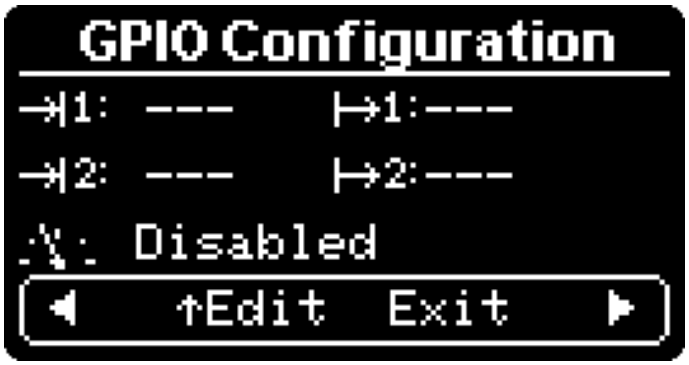
The Hour Meters menu gives an insight into heater usage and how long the Afterburner has been running since the last reboot.

GPIO configuration *(System Settings menu loop)*



The GPIO Configuration menu is only available if GPIO capability is detected on the PCB.

By default, the functions of the GPIO pins are disabled.
They must be enabled via this menu:



The top 2 left-hand entries show the input mode of the 2 digital inputs.
The 2 right-hand entries show the output mode of the 2 digital outputs.
The 3rd line shows the analogue input mode.

The GPIO line to be configured is selected by using the **UP/DOWN** keys.
The mode is then changed by using the **LEFT/RIGHT** keys.

Some modes have a further option, in which case a long hold of the **DOWN** key will allow you to switch focus to a sub menu for further settings.

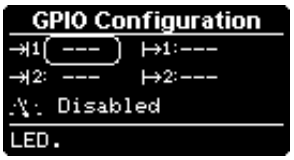
Digital Input configuration

Input #1 – Blue wire
Input#2 – Green wire

The 2 digital inputs can be configured as:

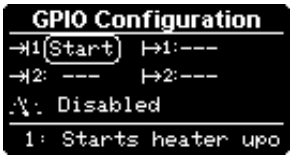
- Disabled
- Start
- Stop
- Start / Stop
- Run
- External Thermostat
- Zero Fuel Usage (reset)
- Max Power
- Pulse Counter
- Permit Start
- Inhibit Start

Disabled



Fairly obviously, no action takes place when an input is disabled.

Start

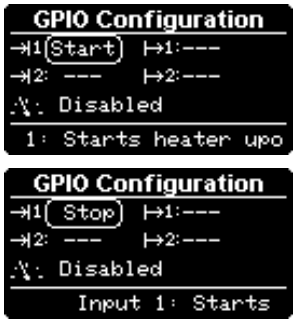


A momentary closure of the input starts the heater.
If the input is held closed for 1.5s or more, the heater will be stopped if it is running.
This mode may be useful for those wishing to use a GSM relay to start or stop the heater.
By generating appropriately timed pulses (eg 1 second or 2 seconds) a single input can be used to start or stop the heater via a single input.

Stop

Stop mode stops the heater upon a momentary closure of the input.

Start / Stop

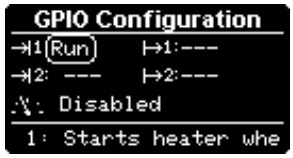


Start / Stop mode will show Start & Stop alternating in the selection field, hence the twin image shown here.

Upon a momentary closure of the input, Start / Stop mode will either start the heater or stop the heater, according to the current state of the system.

No time sensitivity exists.

Run

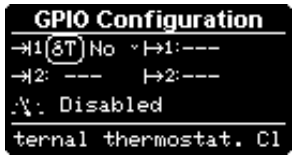


The heater will run whilst the input remains closed.

If opened the heater will be requested to stop, performing the usual shutdown sequence.

An example usage may be using a conventional “dry contact“ furnace thermostat, with the heater starting and stopping according to the condition of the thermostat’s output.
Bear in mind it takes over 5 minutes to start the heater, and a couple of minutes to shut down the heater.

External Thermostat



This mode is specifically intended for use with an external “dry contact“ thermostat.

- Closed: the heater will be made to run at maximum power.
- Open: the heater will be made to run at minimum power.

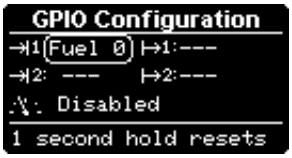
If the heater is off upon the initial closure, it is requested to start.

Additionally, a timeout can be associated with this mode.
If the contact remains open longer than the selected time interval, the heater is requested to stop.

This allows operation solely using the wall thermostat.
Initial operation will see the heater start, then cycle according to the setting.
Finally disabling the thermostat will see the heater eventually stop once the timeout elapses.
If the timeout is set to zero, the heater will always run unless commanded to turn off.

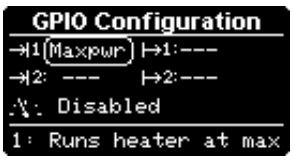
The hold time adjustment is accessed by holding down the **DOWN** key for a second or more.

Zero Fuel Usage (reset)



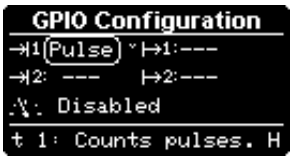
This input allows a switch to be mounted nearby the fuel tank, to be used to reset the accumulated fuel usage when the tank is re-filled.
If the input is held closed for longer than 1 second, the fuel usage counter is reset.
Resetting the accumulated fuel usage is important if you are using the Excess Fuel Usage shutdown feature to avoid running the tank dry, which usually requires the fuel line to be re-primed.

Max Power



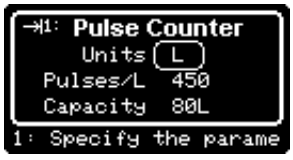
When the input is closed, the heater will be asked to run at maximum power.
If the heater was stopped, it will be started.
Upon the input opening, the heater will return to the state it was in prior to the input closure, ie standby, or normal running.

Pulse Counter



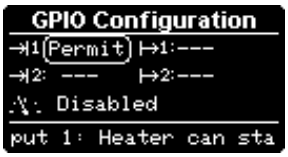
Input pulses can be counted.
The typical usage being intended for water flow meters.
Typical units have a specification of 450 counts / litre.

Holding the **DOWN** key for longer than a second allows the calibration to be defined.



The pulse count will only be retained until the next Afterburner reboot unless a I2C EERAM chip is added to the system. A TL4704 is recommended for this.
As the Afterburner does employ a watchdog timer, this is a recommended precaution.

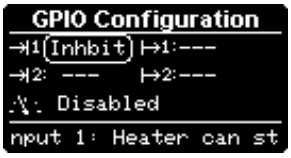
Permit Start



The input must remain **closed** to allow the heater to start and keep running.

If the input is opened whist the heater is running, the heater will be requested to shut down.

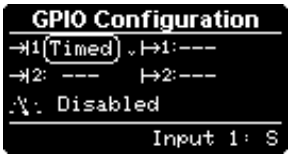
Inhibit Start



The input must remain **open** to allow the heater to start and keep running.

If the input is closed whist the heater is running, the heater will be requested to shut down.

Timed Run



The heater will be started when the input is closed.
A timer is then set to stop the heater after the defined duration elapses.
Closing the input again will reset timeout to the full duration.

Holding the input closed for a second will cause the timeout to be cancelled and heater shutdown to begin.

Hold **DOWN** to access the sub menu to define the timeout duration.

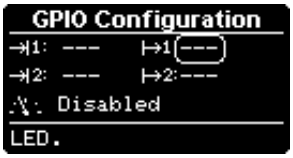
Digital Output configuration

Output #1 – Orange wire
Output #2 – Yellow wire

Either of the two digital outputs can be configured as:

- Disabled
- User Controlled
- Status LED
- Absolute temperature (under or over)
- Relative temperature (under or over)
- Heater Status
- Low Fuel
- Ventilation

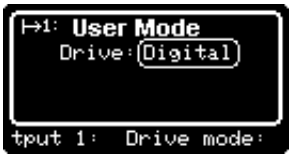
Disabled



Fairly obviously, no action takes place when a GPIO output is disabled.

User Controlled

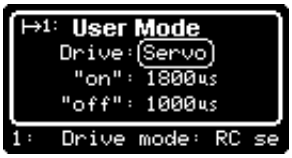
The GPIO output can be switched on or off under user command. When in the Basic or Detailed heater control menus, holding the **LEFT** or **RIGHT** buttons down will toggle the state of the 1st or 2nd output respectively.



It is also possible to control via the JSON data interface
ie: Bluetooth or WiFi applications, eg web browser, Home Assistant.

Hold **DOWN** to allow the output pin's operation mode to be defined:

- Digital
- Servo

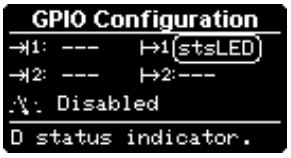


When in servo mode, you can set the servo position by adjusting the associated time value, which is the width of the generated PWM pulse.

Return to the prior menu by pressing the **CENTRE** key.

IMPORTANT:
no settings are changed until you press **CENTRE** again in the GPIO setup menu.

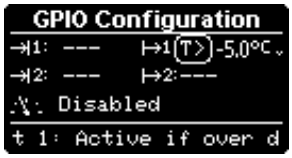
Status LED

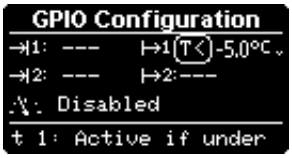


The GPIO output is intended to be attached to status LED, connected across the 5V output to the GPIO output.

- When the heater is off, the LED will be off.
- When the heater is starting, the LED will cycle in an increasing brightness manner.
- When the heater is running, the LED will be constantly on.
- When the heater is shutting down, the LED will cycle in decreasing brightness manner.
- If the heater is suspended, typically due to the cyclic mode threshold being activated, the LED will momentarily flash every second or so.

Absolute Temperature Threshold (under or over)

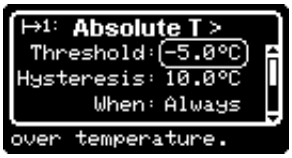




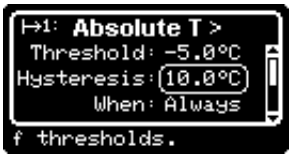
The GPIO output will operate according to the temperature of a sensor.

Normally this would be the sensor being used for the thermostat role but can be another if more than one sensor is fitted to the Afterburner.

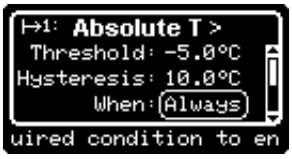
Hold **DOWN** to access the sub menu for the settings for this mode:



Define the Threshold when the output becomes active.
This works in conjunction with the Hysteresis.
For greater than, the output goes active once the temperature exceeds the threshold.
For less than, when it goes below the threshold value.



Define the Hysteresis between the threshold switch on and turning the output back off.
For the “greater than” setting, the temperature must fall more than the hysteresis below the threshold to turn the output off.
For “less than”, it must rise more than the hysteresis to turn off.



Conditions can be applied to when the output will become active:

- Always.
- Heater is on.
- Heater is off.
- Input #1 is active.
- Input #2 is active.

Define which temperature sensor the GPIO output monitors.
The System Sensor is the sensor being used for normal thermostat operation; this may be an external reading supplied via JSON.

Define the output drive mode of the pin.

- Digital
- PWM
- Servo, 2 position
- Servo, proportional

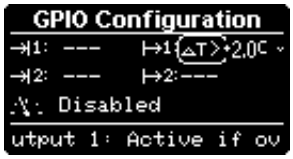
Digital is a simple On/Off switching, as determined by the threshold and hysteresis values.
PWM provides a varying duty cycle output, 100% when in the nominal ON condition, 0% for OFF. Within the hysteresis zone, the PWM is linearly proportional to temperature

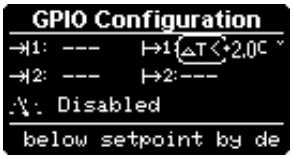
The Servo modes are either a simple 2 position, or like PWM, proportional between the limits when within the hysteresis zone.
Holding **DOWN** provides access to the servo limits.

Return to the prior menu by pressing the **CENTRE** key.

IMPORTANT:
no settings are changed until you press **CENTRE** again in the GPIO setup menu.

Relative temperature threshold (under or over)

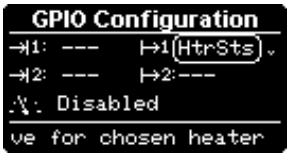




The GPIO output will operate according to the temperature of a sensor **relative to the system thermostat setting**.
Normally this would also be the sensor being used for the thermostat role but can be another if more than one sensor is fitted to the Afterburner.

There are also the same extended capabilities as described for the Absolute Temperature Threshold mode by holding **DOWN** to access the sub menu.

Heater Status



The GPIO output can be made to follow specific states of the heater's operation.

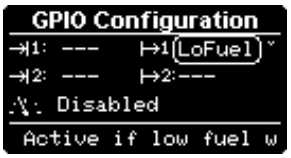
Hold **DOWN** to access the possible states when the output will be active.

Select state using **UP** / **DOWN.**
Toggle the selected state on/off (solid/hollow box) by pressing **LEFT** / **RIGHT**.
Press CENTRE to return to the GPIO setup menu.

Return to the prior menu by pressing the **CENTRE** key.

IMPORTANT:
no settings are changed until you press **CENTRE** again in the GPIO setup menu.

Low Fuel



The GPIO output is intended to be attached to a warning LED, powered from 5V.
The Fuel Warning and Tank Capacity values are defined in the heater tuning menus.
It is important to remember that the warning is for that quantity of fuel remaining in the tank.

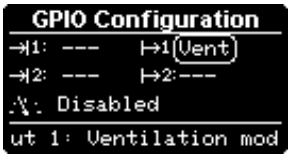
Normal	Fuel Warning (volume remaining)	Excess Fuel consumed
OFF	Flashing	ON

It is not possible to start the heater when the excess fuel error is active.
A GPIO input can be defined to conveniently reset the fuel usage after filling the fuel tank.

Hold **DOWN** to access the sub menu to control the warning behaviour when the heater is off.

Flashing
Not Flashing

Ventilation



Ventilation mode is a user controlled PWM output intended to drive a heater's fan motor.

Ventilation mode can only be activated if the heater is in the Ready/Standby state. If ventilation mode is activated, attempts to start the heater will be denied.

To activate ventilation mode, hold down the **LEFT** or **RIGHT** key in the normal heater control menu(s), according to whether ventilation mode is defined on GPIO output #1 or #2.

With suitable circuitry, the heater can be physically modified with extra circuitry to:

1. Detect the PWM signal and operate a relay to switch away from the ECU's fan output.
2. Drive a power MOSFET with the PWM signal than then runs the heater's fan motor via the switched relay.

As the heater modification requires electronics skills, the construction of the circuit board and installation within the heater is left to the end user. No prebuilt units will be offered.
This hardware is described in the Suggested external hardware chapter of this document.

Analogue input configuration

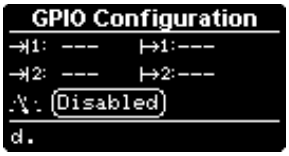
Analogue input - White wire

The single analogue input can be configured as:

- Disabled
- Enabled
- Fuel Sender

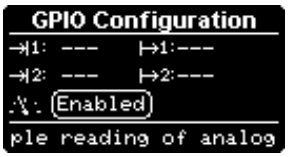
The allowed input voltage range is from 0.0V to 3.3V.
Clamping diodes and a series resistor on the ADC input help protect against excess voltage but should not be relied upon.

Disabled



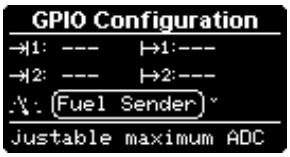
No analogue input is expected.

Enabled



The input voltage applied to the white wire is digitised and presented as a percentage of the usable range (0 – 3.3V)

Fuel Sender

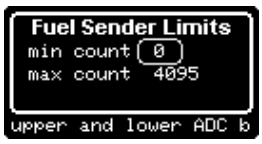


The input voltage applied to the white wire is digitised and scaled to present the value from a fuel sender in a 0 to 100% manner.

A simple constant current interface to a typical fuel sender (to keep the operation linear) will typically max out at ~2V, which is only ~60% of the ADC's full range.

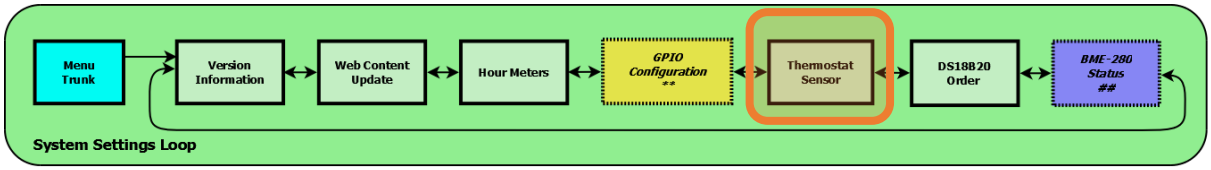
The scaling allows this to be restored to a more user friendly 100% range.

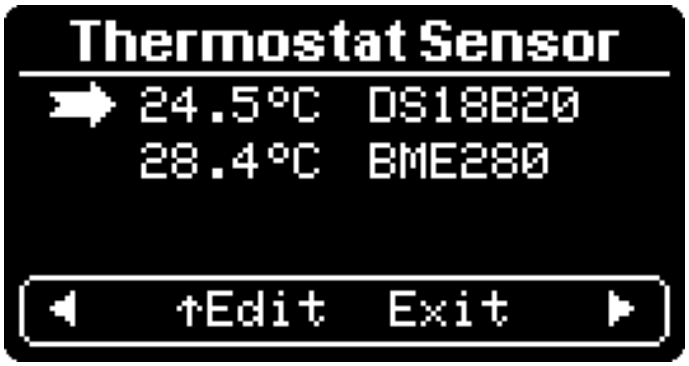
The scaling is defined as the minimum and maximum ADC counts for the empty and full tank conditions These are accessed via the Fuel Sender Limits menu by holding the **DOWN** key for 1 second.



Press the **CENTRE** key to return to the GPIO mode setup menu.

Thermostat Temperature Sensor *(System Settings menu loop)*





This menu allows you select which physical temperature sensor is used for the system thermostat function.

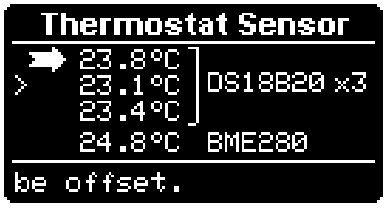
It is highly recommended to use an external DS18B20 sensor for the thermostat as it will be less affected by heat generated within the plastic case of the Afterburner.

The physical sensor being used for the System Thermostat readings is pointed to by the large solid arrow.

It is also possible to provide a temperature reading via JSON from an external device. Use the name “TempRemote” (in Celsius).
If received and kept updated the system thermostat will instead use that virtual reading.

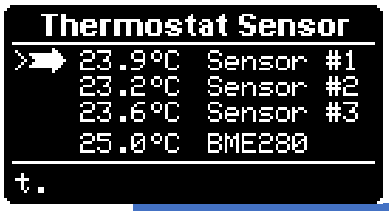
Access to the setting is guarded by the “1688” password:

The editing selection cursor is more subtle on this menu than others.
It is just a ‘>’ to the left hand side:



Here you can see the system has multiple DS18B20 sensors attached, along with a BME280.

The edit cusror is on line #2, the actual selected sensor is line #1. Pressing **LEFT** or **RIGHT** in the situation shown would change the system sensor to be that on line #2.



Every second, the screen alternates between the sensor type and the sensor's name.

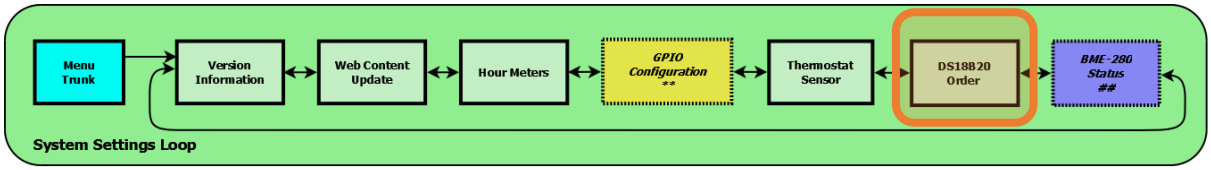
The sensor names can be defined via the web page's "Environmental" page.

The current offset applied to each sensor can be viewed and edited by holding **DOWN**.

Up to 3 DS18B20 sensors can be paralleled on the same "one-wire" interface (which refers to the data signal, ignoring the extra 2 wires required to power and run the sensor).

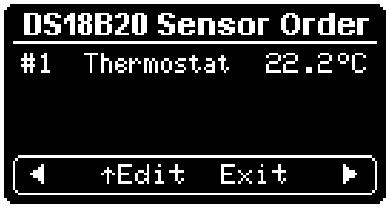
If more than one DS18B20 sensor exists, the available sensors can be prioritised in a related menu, the DS18B20 Sensor Order menu.

DS18B20 Sensor Order *(System Settings menu loop)*



Up to 3 DS18B20 sensors can be wired in parallel and used by the Afterburner.

The default is a single sensor.
If the sensor has been named this will be shown, alternating with the sensor's unique one-wire ID.
Sensor naming can be achieved via the web page's "Environmental" page.

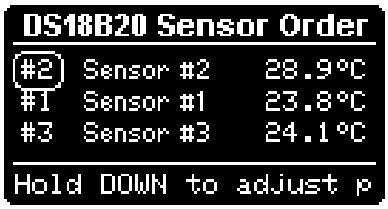


If more than one DS18B20 exists, the main Temp Sensor Order display now allows the order of the sensors to be defined.

IMPORTANT:
If you change the number of DS18B20 sensors connected to the system, make sure you force a rescan of available sensors, either:

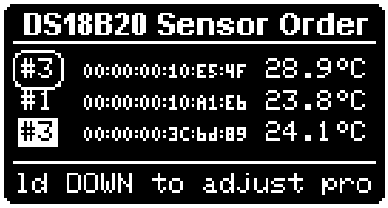
- Reboot the Afterburner.
- Hold UP in this menu to rescan.

Access to the settings is guarded by the "1688" password:



Move between sensors using **UP** / **DOWN**.

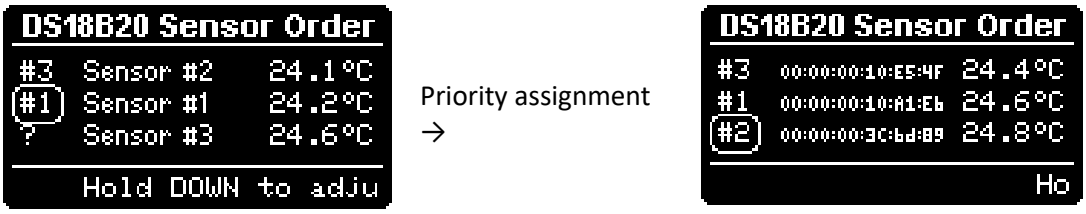
Change the selected sensor's order by using **LEFT** / **RIGHT**.



If the sensor's order matches that of another sensor, the other sensor is highlighted with a flashing background highlight.
eg: Here, sensor ID#3 is repeated.

If the sensor is left in the conflicted state, the highlighted sensor will lose its assigned order.

If a sensor has never been introduced to the Afterburner before, it will have no priority assigned against its serial number:

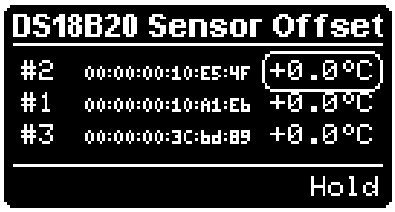


Within the system, the sensors become known according to their assigned order.
eg under the JSON names “Temp1Current”, “Temp2Current”, “Temp3Current”.
If a BME280 exists, it is always known as sensor #4.

The actual sensor that will be used for the system thermostat must be selected in the Thermostat Sensor menu.

Sensor Offset

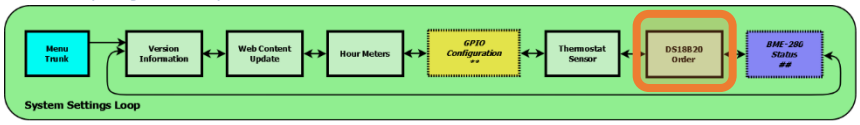
An offset can be applied to each sensor by holding the **DOWN** key.
Switch back to sensor priority by once again holding down the **DOWN** key.



Saving the settings

Press **CENTRE** when not on the base line to save the priority and offset settings.

Identifying multiple DS18B20 sensors



If I have more than 1 DS18B20 sensor all hooked onto the same wire, how does the Afterburner differentiate between them?

The answer is as shown in the DS18B20 Sensor Order menu.
Each sensor holds a unique serial number.
The one-wire bus supports a method to distinguish the sensor IDs that are present, and these IDs are later used to explicitly address an individual sensor.

Upon reboot, the Afterburner scans the one wire bus for DS18B20 sensors, learning these unique serial numbers in the process. These serial numbers are then matched against the previously configured priorities.
If you replace or add a sensor, you must repeat the priority assignment procedure.

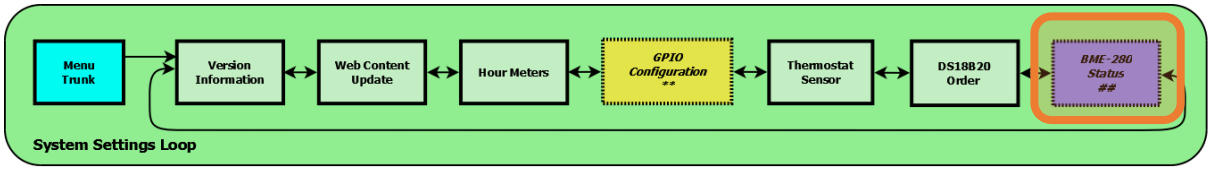
How do I work out which sensor is which?

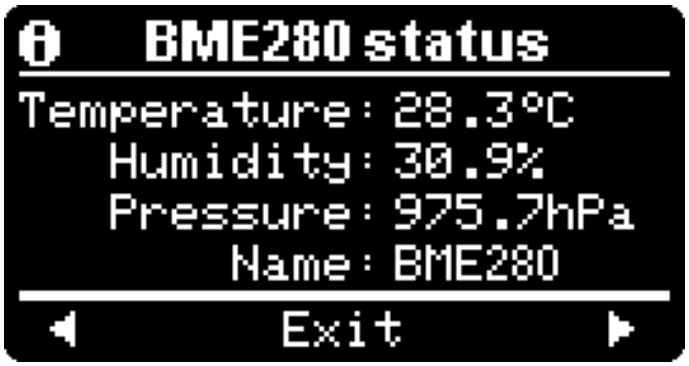
It's as simple as grabbing hold of one sensor and observing the temperature reading rise against a sensor in the DS18B20 Sensor Order menu.
Note the serial number and location of that sensor, use old school pen and paper!

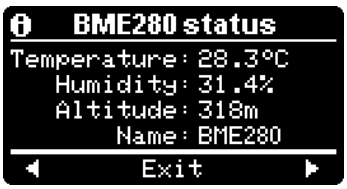
Once each sensor is identified you can then assign the order you would prefer them to appear in.
When saved, the serial numbers are then stored against the chosen priority in the Afterburner's configuration memory.
Next time it boots, and finds the same sensors, it will recreate the list order as previously defined.

The ultimate thermostat sensor will always be shown as the current temperature.
The extra sensors are normally not visible on the standard control menus.
You can view them when in the Basic control menu:
Press the **CENTRE** key, the current setpoint will be shown, along with the extra sensors.
The sensors will use the user assigned names.
The sensor readings are only shown if they are physically present.

BME-280 Status *(System Settings menu loop)*







This menu provides readings from the optional BME-280 environmental sensor.
As this menu is purely informational, the top left hosts a flashing “info” icon.

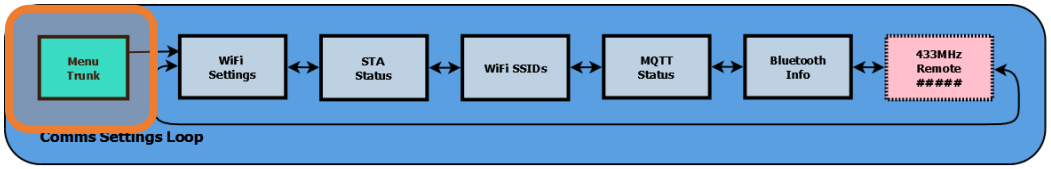
If the BME-280 sensor is not installed or fitted this menu will not be presented.

Air Pressure

The air pressure reading will be shown alternating with the derived height.
The derived height is calculated assuming a standard atmosphere of 1013.25hPA at sea level.

The pressure measured by the BME280 is the absolute air pressure and is not corrected for Mean Sea Level Pressure changes.
The derived height will thus vary during the day due to normal atmospheric pressure changes.

Communication Settings



The ***Comms Settings menu loop*** is accessed via the ***Menu Trunk*** of the ***Root menu loop***.

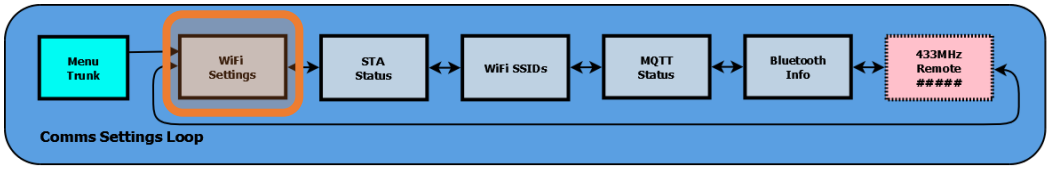
Use **UP**/**DOWN** to navigate to Comms Settings line, then pressing **LEFT** or **RIGHT** enters the ***Comms Settings menu loop***.

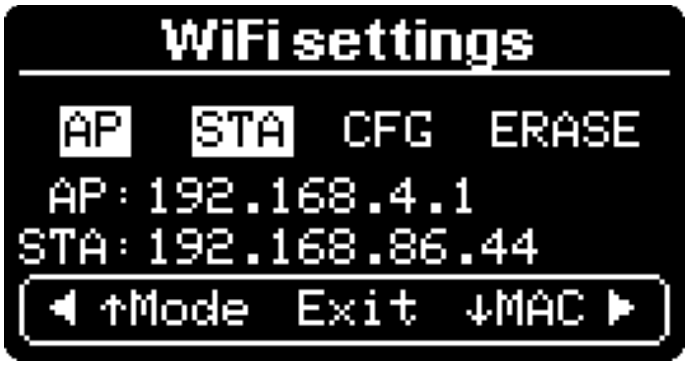
Once you have entered the ***Comms Settings menu loop***, you can only return to the ***Menu Trunk*** by pressing **CENTRE** when any of the loop's menus have the bottom-most navigation line selected.

The Afterburner supports many communications interfaces:

- Bluetooth SPP (Serial Port Protocol)
- WiFi
  - Self hosted Access Point (SoftAP mode)
  - Connect to a WiFi network (STA mode)
  - MQTT
  - Telnet
  - Websocket
  - Web server
- 433MHz UHF remote (optional extra)
- Serial

Wi-Fi Settings *(Comms Settings menu loop)*





The ***WiFi settings*** menu presents the current operating state of the Wi-Fi Interface.

IP addresses

The IP addresses of the SoftAP and STA connection are shown on the WiFi Settings menu.

Soft AP

The Wi-Fi interface host's its own Soft AP (Soft Access Point).
A Soft AP means that is not able to provide a connection to the Internet.

The IP address of the Soft AP is always 192.168.4.1 and cannot be changed.

The Soft AP can be joined by scanning for and typically connecting to the "Afterburner" SSID using a wifi capable device.
The default password required for the Soft AP is "thereisnospoon".

The Soft AP's SSID and password can be reconfigured by using the Debug Menu system.

STA Mode

STA Mode is when the Afterburner connects to another WiFi network.
*STA being short for WiFi **Sta**tion.*
Enabling STA mode typically allows the Afterburner access to the Internet.

Credentials are required to join the other network and need to be provided to the Afterburner:

- SSID to connect to.
- The required password.

The WiFi Router usually allocates the STA IP address.
This is usually from a dynamic pool of IP addresses and may possibly change unexpectedly upon reconnection.

The Afterburner also allows a static IP address to be defined.
This must be co-ordinated with network owner to ensure no IP address conflicts eventuate.

Enabling / Disabling the Soft AP or STA mode

Across the top of the menu are a series of “selection” fields; AP, STA, CFG, ERASE.

AP and STA modes are enabled when these fields are highlighted with a white background.
Inverse text if you like.

It is possible to toggle these fields on/off by initially moving **UP** to the top line, selecting the desired field (**LEFT** / **RIGHT**), then pressing **UP** again.

You must then press **CENTRE** to enact these changes.

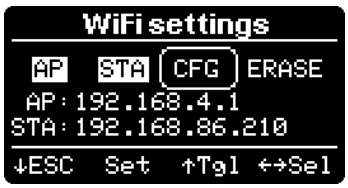
The Afterburner will then reboot after ~5 seconds.

Configuring STA mode

In earlier versions, a special web server was used to enter the credentials required for a STA connection.
This required a reboot to switch to the special web server.
Saving of the credentials using this method had proven to be problematic at times, especially if the initial STA connection attempt failed.

STA configuration is now via an always available web page.

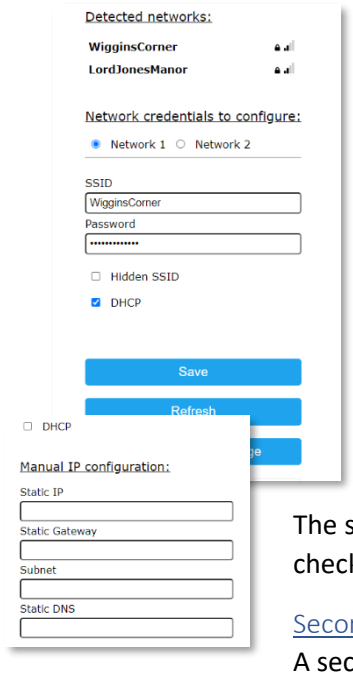
The CFG field does still exist but is ineffective.
Instead, if you do try to engage CFG mode, it provides a prompt to explain what needs to be done instead.
The hope is this educates users on this substantial shift in wifi configuration methodology.



The Afterburner now hosts an always available web page at the address “/wifi”.
Simply connect to the SoftAP and use the following URL to configure the STA credentials:

http://192.168.4.1/wifi

- http://192.168.4.1/wifi



It will take a few seconds before the web page shows in your browser.
During that time the Afterburner is performing a wifi scan to determine the SSIDs of nearby networks. Please be patient.

Select the network you wish to connect to, then supply the required password for that network.

If you need to connect to a hidden SSID you must directly type in the name of the network by hand. **IMPORTANT: SSIDs are Case Sensitive.** Also be sure to select "Hidden SSID" if it is hidden.

If you wish to use a Static IP, deselect the DHCP check box and complete the required fields.

The static IP values are dependent upon the network being connected to, check with the owner.

Second STA WiFi

A second set of STA credentials can be supplied.

If a second set of credentials are available, the Afterburner can:

- Connect to the strongest known SSID AP found.
  Scanning only takes place when the STA connection is not active.
- Rescan available SSIDs regularly and connect to the strongest AP found.
- Rescan available SSIDs regularly but prefer the 1st named SSID if both SSIDs are found, even if the 1st SSID is weaker.

These alternate scanning options are configured via the Debug Menu system.

Erasing credentials

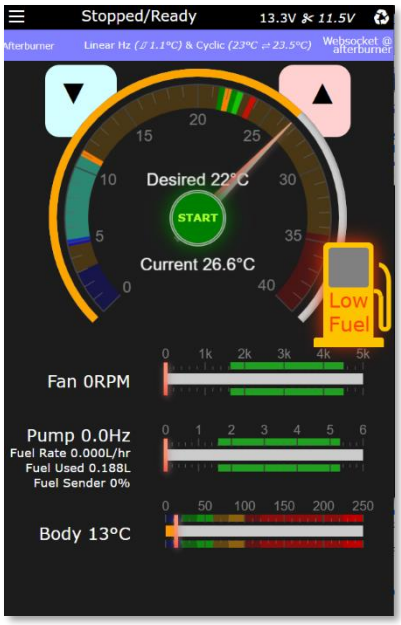
Select the **ERASE** field on the 1st line of the unit's menu.
Pressing **UP** will erase the staged credentials, but this only becomes effective if you follow through and save the change using **CENTRE**, followed by **UP**.

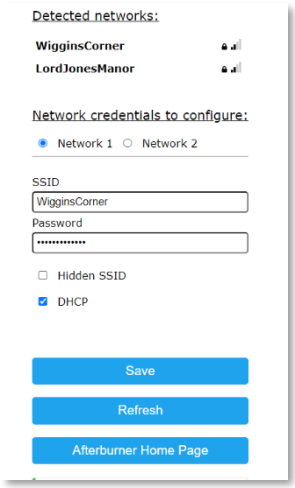
The "should save" icon will be flashing to remind you that you need to save the cleared credentials.

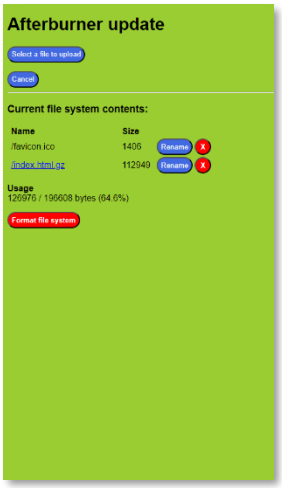
Web Server

There are three possible default web pages that the Afterburner can serve when pointing a browser to the Afterburner port 80 (default HTTP port):

- / Heater control web page : *automatically promoted to /index.html*
- /wifi STA Configuration web page
- /update Upload new firmware, or new web content (Heater control web page)

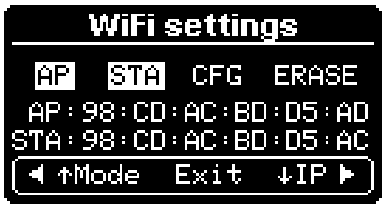






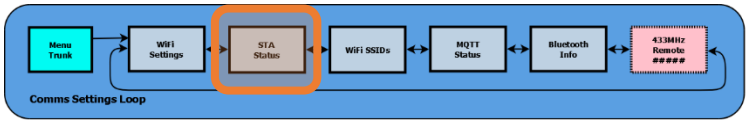
MAC address discovery

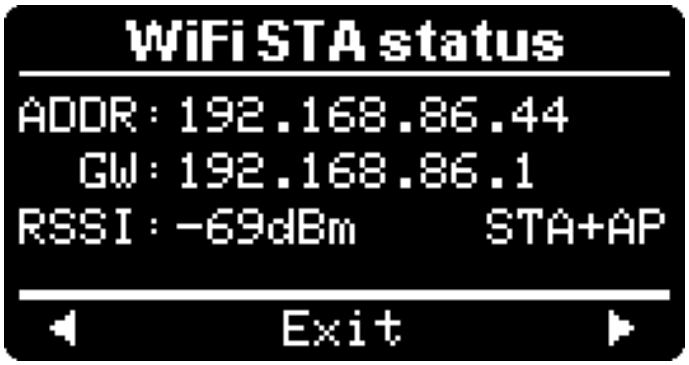
In some circumstances it is useful to know the MAC address of the TCP/IP interfaces.
This is especially useful if you wish to configure your WiFi router to always assign the same IP address for the Afterburner controller.



Press **DOWN** at the navigation line of the ***WiFi Settings*** menu to switch to showing the MAC address of each interface instead of the IP addresses.

STA Status *(Comms Settings menu loop)*





The ***WiFi STA Status*** menu provides information about the STA connection:

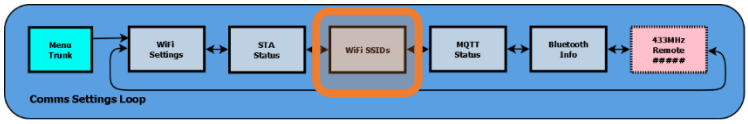
- IP address of Afterburner.
- IP address of STA gateway.
- Received Signal Strength Indicator (RSSI) of STA connection.

STA Not connected

If the STA connection is not active, it is instead shown here as:

Also, on the previous ***WiFi Settings*** page, it will alternate the STA header field highlight, along with "Not connected" showing against the STA IP address when credentials are defined, but the connection is not established:

WiFi SSIDs *(Comms Settings menu loop)*



The ***WiFi SSIDs*** known to the Afterburner are presented in this menu.

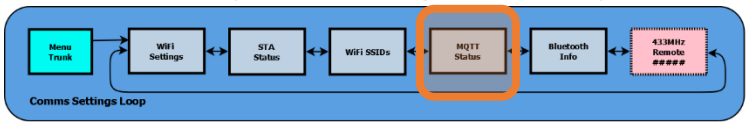
As this menu is purely informational, the top left hosts a flashing “info” icon.

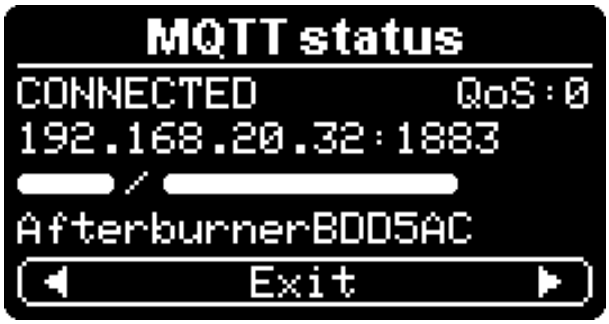
The AP SSID is that presently being advertised by the Soft AP.
The Soft AP’s SSID can be altered via the Debug Menus.

The two possible STA SSIDs are shown.

If the STA connection is active, it is printed with a white background as above, otherwise it shows as ordinary white text as here:

MQTT Status *(System Settings menu loop)*





The ***MQTT Status*** menu provides status information about the MQTT connection to a broker.

Configuration of the MQTT connection can be made via the Debug Menus.
The web page also allows configuration of the Afterburner's MQTT connection, but only when a direct web client connection to the Afterburner is used (not via MQTT).

Connection Status

The 1st line shows the current connection state of the Afterburner to the MQTT broker.
Note that an active STA connection is essential to allow MQTT connectivity.

Quality of Service

The QoS of the MQTT connection is shown here. It is recommended to leave this as 0.

Broker IP address

The IP address of the broker and the port for standard TCP MQTT protocol connections is shown on the 2nd line (port follows the colon ':').
The IP address can be entered as a domain name, or as a standard dotted IP number format.
If this line exceeds 20 characters, the text is automatically scrolled to avoid wrapping and overlaying the next display line.

Broker Username/Password

The optional username & password required for the broker is shown here redacted on the 3rd line.
If no username or password is required for the broker, they should be left blank.
If this line exceeds 20 characters, the text is automatically scrolled to avoid wrapping and overlaying the next display line.

MQTT topic prefix

The topic prefix (last line) is created by appending the last 3 octants of the STA MAC address to the string "Afterburner". This ensures any data published by your Afterburner is genuinely unique, especially important if using a public MQTT broker.

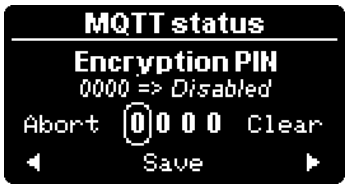
A public MQTT broker is useful as an initial test of MQTT, but ideally please consider using a private broker to improve security of your system. Eg Mosquitto running on a Raspberry Pi.
Any MQTT client you configure must ensure the exact same prefix is used, especially maintaining Case Sensitivity.

MQTT obfuscation

It is possible to define a PIN that is only known at the Afterburner and web page independently. This will cause the published topics to be scrambled and can only be understood by a web page using the same PIN.
Likewise, the payload contents for each topic are also scrambled.

This makes it difficult for opportunistic interference with the Afterburner when using a public broker.

Press **UP** to gain access to the menu where you can define a 4-digit PIN.



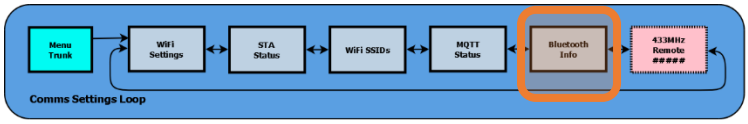
You can define the PIN by moving **UP**, then across to the 4 numeric fields.
Use **UP**/ **DOWN** to set each digit as preferred.
Press **CENTRE** to save the PIN, followed by **UP**.

If the PIN is set as 0000, the feature is disabled.
The right-most “Clear” field allows this to be quickly performed.

IMPORTANT NOTE: Home Assistant

DO NOT use a PIN if you intend to connect with Home Assistant.
Home Assistant will not be able to make any sense of PIN encoded topics.
You should also **ONLY use a private broker** with Home Assistant.

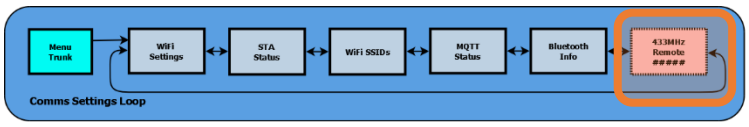
Bluetooth information *(Comms Settings menu loop)*



This menu shows the MAC address of the HC-05 Bluetooth module.

You can also optionally disable the Bluetooth module by toggling YES to NO against the Enabled: header.

433MHz Remote Receiver

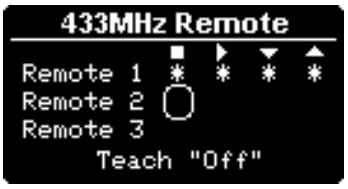


This menu will only appear if a 433MHz Receiver module is fitted to the Afterburner's PCB.

Pairing a Remote

Up to 3 uniquely coded 433MHz remotes can be paired with the Afterburner.
They must be FIXED CODE devices, not rolling code.

- Press **UP** to select a slot to program a remote control into.
- Press **RIGHT** to define the "Stop" function
  (selection box lies within the stop icon column).
  - Press the remote key you would prefer to be used to stop the heater.



- The "Start" function is then automatically selected
  (selection box lies within the start "play" icon column)
  - Press your preferred key to start the heater.

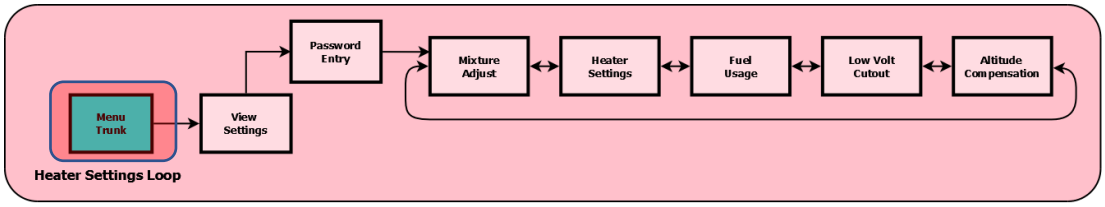
- Repeat the process for the decrease and increase functions.

Once all buttons of the key fob have been defined, you can then operate the remote keys and confirm the appropriate function now becomes highlighted.

Make sure you save by pressing the CENTRE button, and then press UP to confirm.

Whilst in the setup menu, the remote will not perform the actual required function, but its expected action can be confirmed.

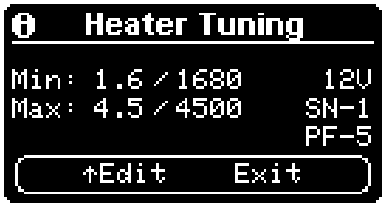
Heater Tuning menu loop



The ***Heater Tuning menu loop*** is accessed via the ***Menu Trunk*** of the ***Root menu loop***.

Use **UP** to navigate to Heater Tuning line, then pressing **LEFT** or **RIGHT** enters the ***Heater Tuning*** preview.

The initial Heater Tuning menu simply shows the current fuel mixture and heater settings.
Note: as this is an informational menu, the top left hosts a flashing “info” icon:



The currently active heater tuning settings are shown on the display.
To de-mystify SN-x and PF-x, their actual effect is toggled into view on a regular basis.

To edit the heater settings, you need to enter a password to gain access.
The password is “**1688**”.

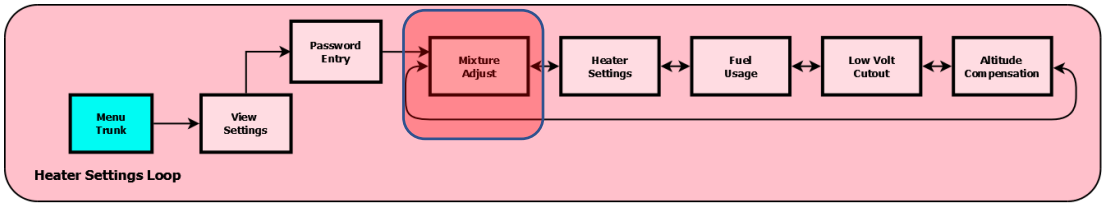
Press **UP**, a password entry menu is then presented:

- **UP** / **DOWN** adjust each digit’s value.
- **LEFT** / **RIGHT** select the next digit.

Only when “1688” is displayed, press the **CENTRE** key.
If any other value is shown, control returns to the ***Heater Tuning preview*** menu.

When the password is accepted, we leave the ***Tuning Preview menu*** and gain access to the ***Heater Settings loop***.

Fuel Mixture edit menu *(Heater Settings menu loop)*



Press **UP** to enable edit mode:

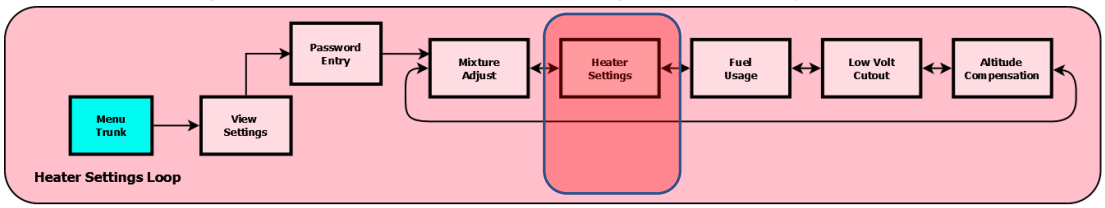
- **LEFT** / **RIGHT** adjust each setting.
  - Will auto repeat if held.
- **UP** / **DOWN** select another setting.

Abort by pressing **DOWN** until the navigation line is re-selected, then move away using **LEFT** or **RIGHT**.

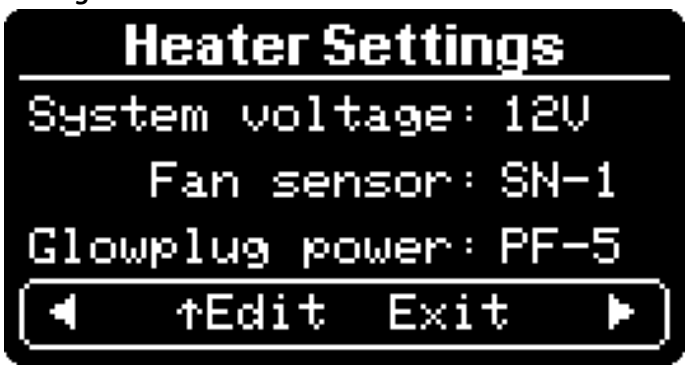
To set, save and apply the settings, the **CENTRE** key must be pressed whilst one of the setting fields is selected.
You must then confirm the changes by pressing the **UP** key.

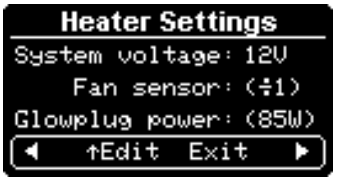
SAVING will then appear as the settings are saved to non-volatile memory:

Heater Settings edit menu *(Heater Settings menu loop)*



When at the navigation line of the Fuel Mixture menu, press **LEFT** or **RIGHT** to access the ***Heater Settings*** menu:





SN-x and PF-x are alternated from the setting name to the actual value that setting represents.

Press **UP** to enter edit mode.

- **LEFT** / **RIGHT** adjust the selected setting.
- **UP** / **DOWN** select another setting.

Abort by pressing **DOWN** until the navigation line is selected then move away using **LEFT** or **RIGHT**.

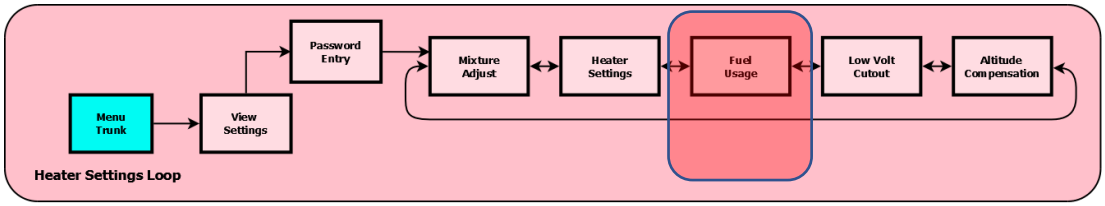
To set, save and apply the settings, the **CENTRE** key must be pressed whilst one of the adjustable settings is selected.
You must then confirm the changes by pressing the **UP** key.
SAVING will then appear as the settings are saved to non-volatile memory:

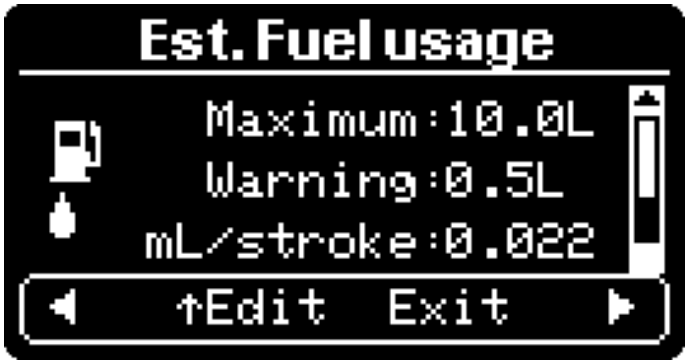
New ECUs

A common problem if an ECU is replaced is the new unit comes shipped with the 24V flag set by the factory.
Despite the settings showing 12V, this is actually out of sync with the ECU.
You need to:

- Change the System Voltage setting to 24V and **SAVE** using **CENTRE** then **UP**.
- Return the System Voltage setting to 12V and **SAVE AGAIN** using **CENTRE** then **UP**.

Fuel Usage menu *(Heater Settings menu loop)*





The Afterburner can estimate fuel usage by accumulating the pump cycles reported by the ECU over time.

Typical pumps average around 0.022mL/stroke, some 2kW heaters may use a 0.016mL/stroke pump. The pump frequency (Hz) determines how may strokes per second the pump performs.

Excess Fuel Usage Shutdown

Fully emptying the fuel tank can lead to air being introduced into the fuel line, which can be troublesome or annoying to clear depending upon the location of the pump.

To avoid this the Afterburner can be configured to shut down the heater when an excess quantity of fuel has been consumed, since the last fuel gauge reset.

The estimate is based upon the integrated actual pump rate over time, multiplied by the pump calibration defined in this menu. **The pump calibration value is not used for anything else.**

A warning can be configured when the volume of remnant fuel is less that warning value shown, prior to forced shut down.

Maximum Fuel Usage

The 1st line's Maximum Fuel usage setting determines how much total fuel is allowed to be consumed before shutting down the heater. The value can be changed in 100mL increments.
Once the accumulated usage exceeds this figure, the heater will be shut down.
If fuel usage already exceeds this value, further attempts to start the heater will be denied.

Setting maximum usage to zero disables the excess fuel shutdown feature. The menu shows "Off".

Fuel Usage Reset

When the tank is refilled, the fuel usage must be reset.
Fuel usage can be reset from the ***Quick Modes*** or ***Gauges*** menus in the ***Root menu loop***, or the web page.

A GPIO input can also be configured so a 1 second press of a push button will reset the fuel usage. Such a button mounted near the fuel tank is a convenient way to deal with the reset (and oily fingers!).

Fuel Usage Warning

To give advance warning of the shutdown potentially occurring, a warning level can be set on the 2nd line for the last remaining quantity of fuel.
The warning value can be changed in 100mL increments.

This value is the volume remaining before empty, not absolute fuel usage.

Fuel Pump Calibration

The calibration factor on the 3rd line is only used to calculate the estimated consumed fuel.
It is simply the integrated pump count multiplied by this factor that gives the volume of fuel consumed.
The result is then translated to UK or US gallons if preferred.

The calibration factor is always defined as millilitres/stroke.

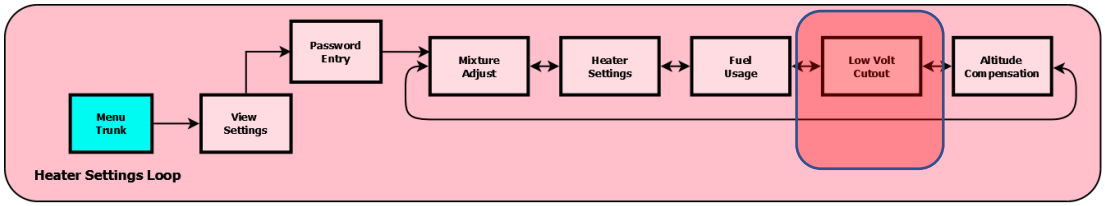
Fuel Usage Units

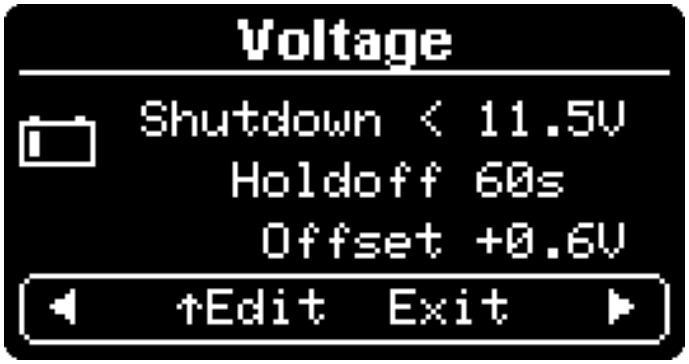
The fuel usage can be reported as:

- Litres
- US gallons *3.785L / G*
- UK gallons *4.546L / G*

Move down to the 4th edit field (off screen initially) to alter this.

Low Voltage Cutout menu *(Heater Settings menu loop)*





Whilst the ECU does provide low voltage errors, it is typically a much lower voltage than preferred, and non-adjustable.

To afford protection of a battery powering the heater from excess depth of discharge, the Afterburner can be configured to shut down the heater if the voltage reported by the ECU falls less than the threshold defined in this menu.

The voltage must remain less than the threshold for the entire Holdoff period (seconds) to guard against momentary dips such as when starting a vehicle.

Also be aware that most low voltage problems are caused due to insufficient gauge wiring being used to power the heater. The supplied wiring loom's cables are questionable.
ECU voltage will vary according to current draw.

Adjustment of Low Voltage Cutout

Select the **Shutdown** field by pressing **UP**.

Adjust the value by using **LEFT** or **RIGHT**.

If the shutdown value is reduced below 9V *(12V system)* or 18V *(24V system)*, the Low Voltage Cutout feature is disabled.

When the glow plug is operating, the LVC threshold is further lowered by 0.1V per amp of glow plug current. This is in recognition of the common voltage drop issues encountered due to sub-standard wire gauge used to power the heater.

Holdoff

The **Holdoff** is a way to guard against momentary voltage drops below the **Shutdown** value, for example when starting a vehicle.

ECU voltage offset

The **Offset** field allows the voltage reported by the ECU to be corrected if considered incorrect.

The corrected voltage value is what is used by the LVC algorithm.

Altitude Compensation

As altitude increases, air density progressively lessens.

This means a diesel heater would run progressively richer as the unit is further raised in altitude. Without adaption, this usually results in carbon build up and eventual malfunction, requiring a manual clean out of the excess carbon.

The usual adaption is to reduce the pump rate based upon a look up table that can be found on the Internet.

From version 3.5.0 firmware, the Afterburner supports the automatic calculation and application of tuning settings adapted for altitude.

The altitude can be:

a) Manually specified by the user
b) Determined from the pressure reading of a BME-280 environmental sensor.

BME-280 derived altitude

Derived altitude from the BME-280 is based upon the absolute pressure reading the BME-280 provides, referenced against an assumed standard atmosphere (1013.25hPa at sea level).

Local variations in air pressure due to synoptic changes (high & low pressure weather systems) will cause the altitude to vary in accordance.
A synoptic pressure lower than 1013.25hPa MLSP (Mean Sea Level Pressure) raises the assumed altitude.

There is also the regular diurnal variation in air pressure over a 24hr period.
This can be considered as a tidal action in the atmosphere. This causes subtle altitude variations.
The higher pressure occurs near 10AM / 10PM, and lower pressure near 4AM / 4PM.

Altitude compensation implementation

The generally agreed compensation factor is 3-4% per 1000'.
The afterburner assumes a 300m basis for this compensation, which for all intents and purposes is very close to 1000'

The compensation factor has been termed **Declination** in the Afterburner setup, or **Decline/300m**.
The user can alter this factor as they may prefer.

Sea Level Tuning Basis

When compensation is enabled, the tuning settings entered by the user for Max. Fan, Min. Fan, Max. Pump and Min. Pump are all **assumed to be for sea level**.

If a system has previously been tuned for altitude, these values will need to be revised if altitude compensation is subsequently enabled in V3.5.0+ firmware.

Tuning at Altitude

If the user does choose to tune the heater when above sea level and using altitude compensation, the values must still be entered as if you were at sea level.

The Afterburner will automatically adapt these values to increase the apparent Air/Fuel ratio, *which realistically is simply maintaining the same AFR due to the thinner air.*

The user entered values are saved in the Afterburner's non-volatile storage, and the compensated values are sent to the heater's ECU.
These compensated values thus become the live tuning basis that the ECU works with.

The compensated values are also reported back so user can monitor the end result.

If altitude changes in the future, the Afterburner will once again recalculate new values to send to the heater's ECU, but only upon a heater start event. You can also request an update whilst running via the long centre press feature in the base heater control menus.

ECU Considerations

The ECU uses EEPROM (Electrically Erasable Permanent Read Only Memory) to store the Max./Min. pump and fan settings. A few other things like system voltage, fan speed divisor and glow plug power are also saved in the ECU's EEPROM.
The EEPROM is updated whenever these values change from the previously delivered values from any controller.

An EEPROM typically has a limited number of erase / write cycles.
Conservatively this figure is 10,000 cycles.
After which, the reliability of the saved values being correctly maintained is degraded.

10,000 cycles may sound like a lot, but not if these values are continually updated as part of a feedback loop as altitude varies.

The strategy adopted by the Afterburner is to only send changed tuning values to the ECU in the following instances:

a) Immediately when the user changes the Afterburner's tuning parameters.
   OR
b) Only when the heater is initially started for a heating session AND
c) The measured altitude has shifted by more than 75% of the defined step change.
d) A user requested update of the tuning via the "stop popup menu" when the heater is already running.

Altitude Quantisation

Whilst the altitude reading from the BME-280 may be to metre resolution, the altitude used for altitude compensation is quantised to discrete finite step changes.
This done to minimise the number of actual tuning changes sent to the heater's ECU.

i.e. the real altitude is normalised to fit within distinct bands of altitude.

This is the **Quantisation Factor**, which can also be defined by the user.

If set to 300m (~1000'), the altitude bands will be 0-300m, 300-600m, 600-900m etc.

Quantisation dither

A common problem with quantised systems is the propensity to dither from one band to the next when the actual input is sitting on or near a boundary.
The effect is quite often observable with digital multi-meters where the last digit may dither back/forth.

This is not desirable as it would result in possible unnecessary changes to the ECU tuning.

To minimise this effect, the actual altitude must vary by more than 75% of the quantisation factor from the last accepted quantised altitude.

eg, if the real altitude is 600m, and the most recent quantisation altitude was 600m, it is highly likely that after quantisation, either 300m or 600m could be the result due to subtle pressure variation. The change to 300m would only be performed if the real altitude moved below 375m.
(600 – 300 x 0.75)

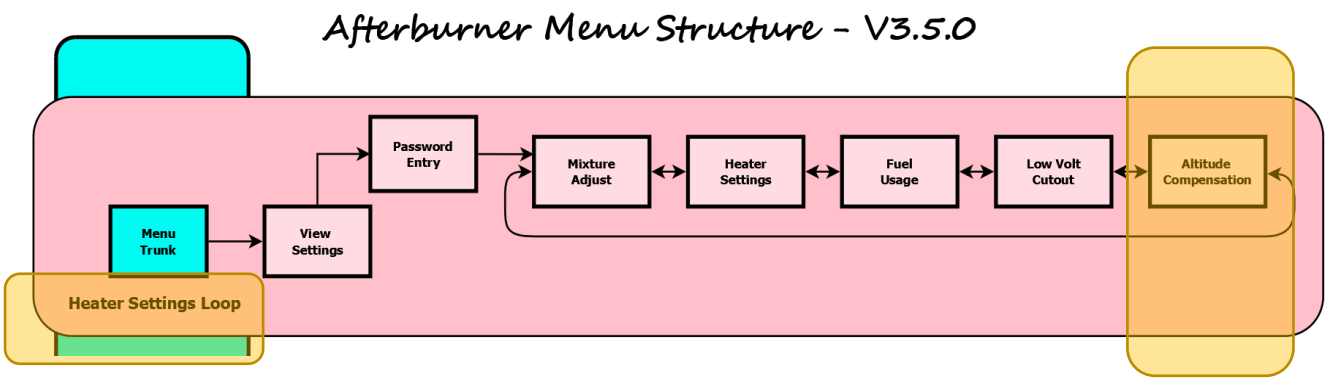
This determination ONLY takes place when a new heating session is started (timer or user invoked).
The quantised altitude remains stagnant for the entire heating session.

Configuration

Configuration of Altitude Compensation can be achieved by:

a) Altitude Compensation menu in the base unit's ***Heater Tuning menu loop***.
b) Web content V3.5 onwards.

Afterburner menus – Heater Settings Loop



The **Heater Settings menu loop** is accessed from the ***Menu Trunk***, being the topmost selection.

Pressing **LEFT** or **RIGHT** from the trunk will initially present the ***Heater Tuning*** overview:

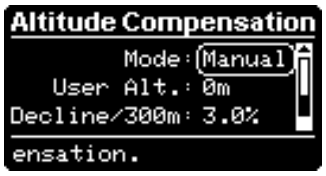
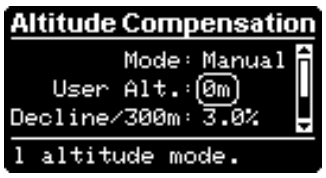
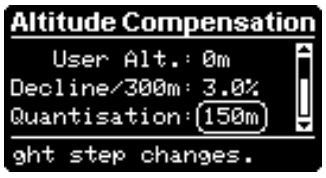
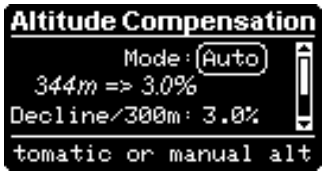
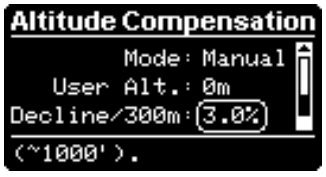
Note: the information icon will flash at the top left corner, indicating this is purely a status menu.

Entry to the actual menu loop requires the **UP** key to be pressed, then password 1688 to be entered.

Altitude Compensation is the last menu in the ***Heater Tuning menu loop*** and can be efficiently reached by pressing **LEFT** from the initial ***Mixture Adjust*** landing point in the tuning menu loop.

Altitude Compensation menu

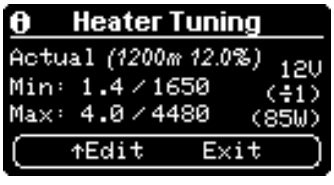
By default, altitude compensation is disabled.
The available options being: Disabled, Auto or Manual.

Manual Mode  	Manual mode allows the user to directly specify the altitude. The altitude can be manually adjusted by selecting the value adjacent to the ***User Alt.*** text shown on the 2nd line. Altitude can only be changed by discrete steps as defined by the Quantisation on the 4th line, using the **LEFT**/**RIGHT** buttons. **Manual Altitude limits** *Minimum:* 0m *Maximum:* 6000m (~20,000 ft)
Quantisation 	Quantisation is used to minimise excessive changes to actual heater tuning. Quantisation can be changed in 50m steps, using the **LEFT**/**RIGHT** buttons when the 4th line is selected. **Quantisation limits** *Minimum:* 100m (~330 ft) *Maximum:* 600m (~2000 ft)
Automatic mode 	Automatic mode is only available if the system is fitted with a Bosch BME-280 pressure sensor. The current barometric pressure is converted to altitude, assuming a standard atmosphere of 1013.25hPa at sea level. The determined altitude is presented, alongside the determined final compensation factor, based upon the nearest quantised altitude and the declination factor.
Declination 	Declination is the factor used to decrease fuel delivery per 300m of altitude increase (~1000 ft) above sea level (0m). The default it is 3% but this can be freely adjusted by the user in 0.1% steps by using the **LEFT**/**RIGHT** buttons. Eg: Declination is 3%, altitude is 1300m, quantisation is 400m. The quantised altitude will be 1200m, fuel delivery will be reduced by 12%

Monitoring altitude compensation

If altitude compensation has been enabled, *the initial tuning overview presented when leaving the Menu Trunk,* will now alternately show the basis (user entered tuning values) and the actual values in use.

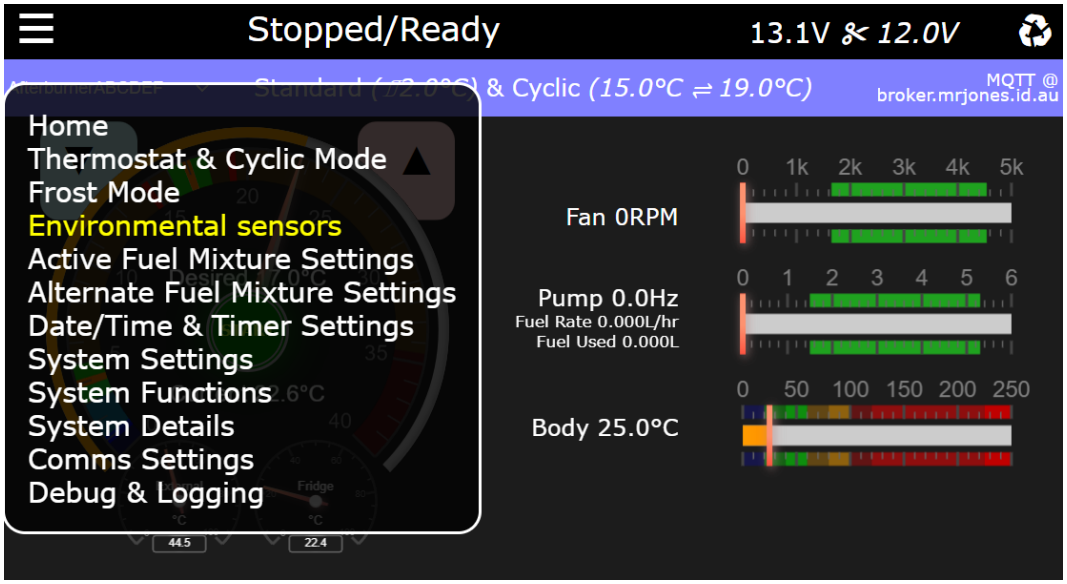
These are based upon the most recent quantised altitude upon a new heater start.



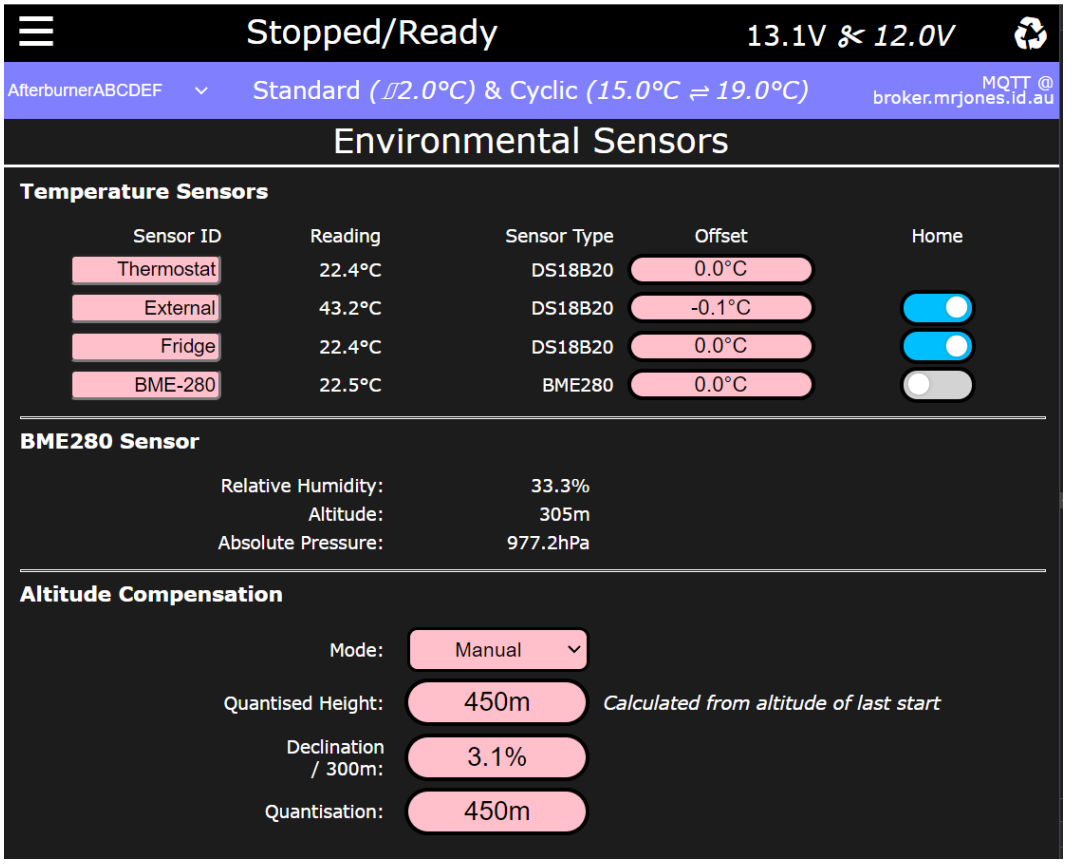
Web content – *(V3.5.0+)*

Altitude compensation can be configured using web content later than V3.5.0.

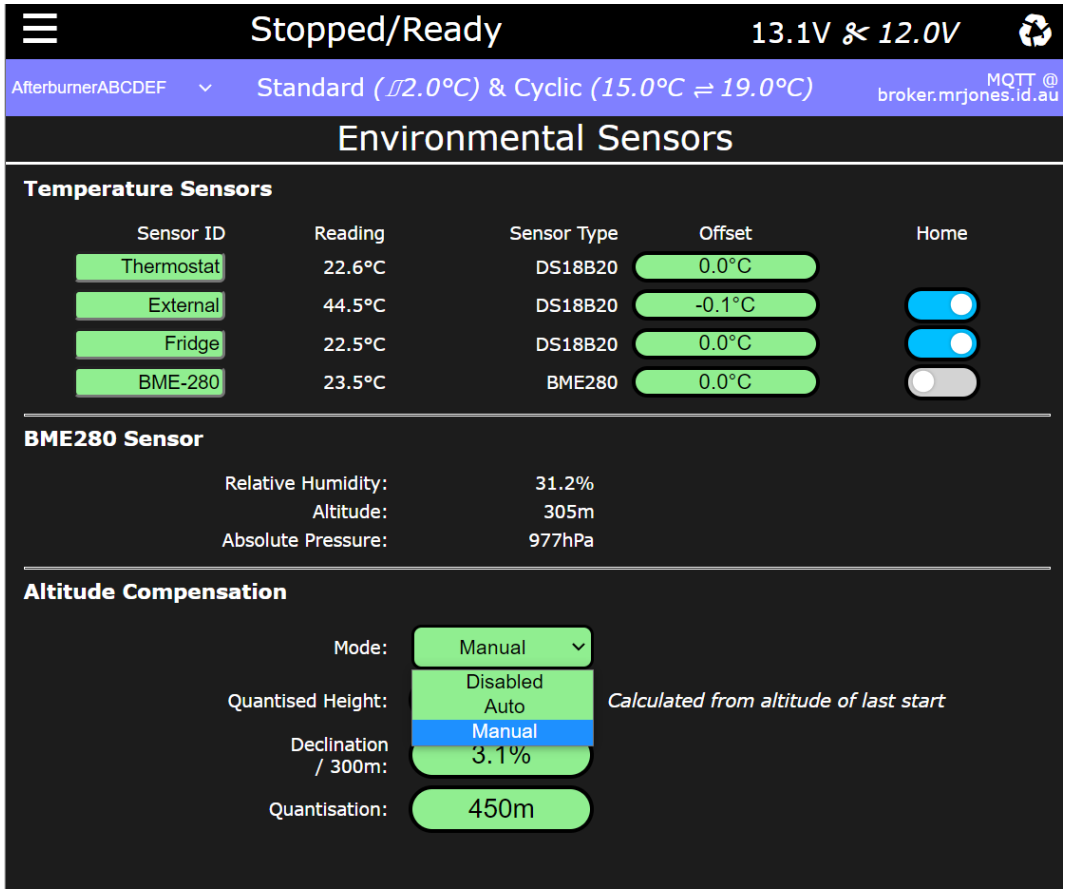
Select the **Environmental Sensors** page



Upon initial entry, all adjustable items will be disabled, and shaded with a salmon background.
The BME-280 Sensor details are only presented if a BME-280 is fitted to the system.



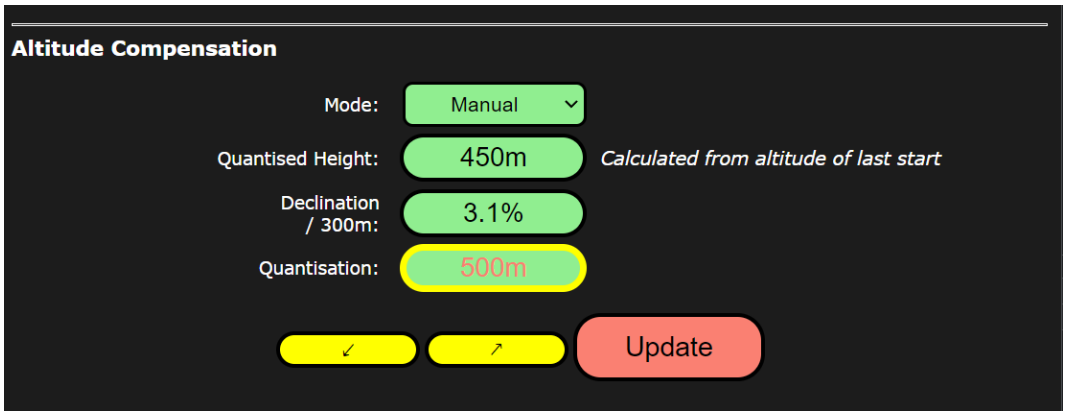
Password 1688 is required to be entered to enable the fields:



The example shown is when the drop list is opened to select the Altitude Compensation operation mode.

The Auto selection is only available if the system has a BME-280 fitted, otherwise only Manual or Disabled can be selected.

The function of the remaining fields is as per the Afterburner menu descriptions.



Any values altered from original are highlighted in salmon text.
The Update button will only be presented if any value is different to the original value.

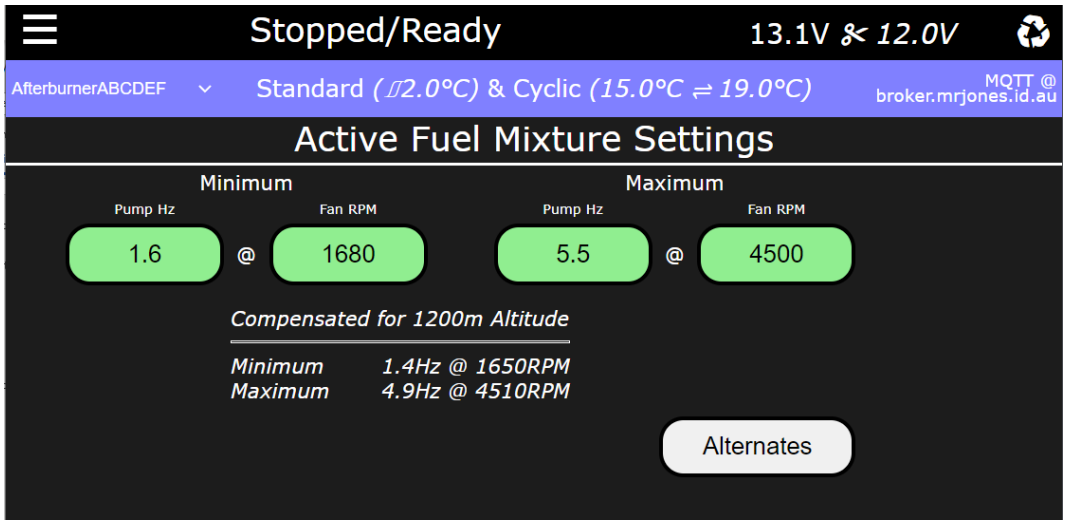
Manual altitude, Declination and Quantisation factors can either be directly entered by clicking upon the field when already highlighted or using the yellow up/down adjustment buttons.
The Quantised altitude cannot be altered by the user when in Automatic mode.

The currently focused input field that will be affected by the up/down buttons is circled in yellow.

Changes are sent to the Afterburner and remembered when the Update button is clicked.

Monitoring altitude compensated values

The compensated tuning values can be observed on the Active Fuel Mixture Settings page



433MHz UHF Remote control

Supplied UHF remote control key fob

If the Afterburner was purchased with a UHF transmitter key fob, it will already be paired with the Afterburner.

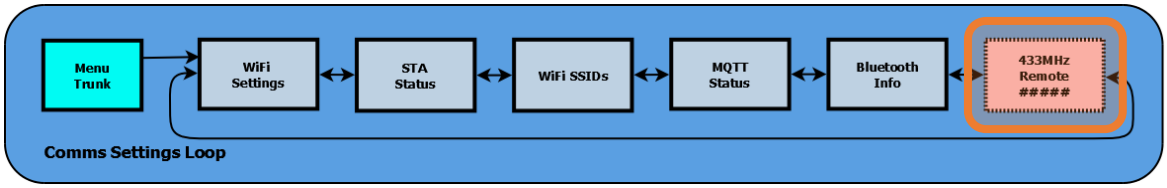
The programmed “20-bit unique code” of the remote is written on a sticker attached to the remote’s packaging.
If you purchased multiple Afterburner units, these code stickers will also be stuck to the rear of each Afterburner unit to allow the units to be matched up with their remotes.

You can choose to reassign the button roles (next page), but as supplied the functions are as shown below:

OEM UHF remote control fobs

A compatible OEM key fob, as shown below, can also be paired to the Afterburner.
Please follow the instructions on the next page to pair the unit.
The Afterburner MUST have a UHF receiver fitted for this to succeed.

433MHz Remote setup menu (*Comms Settings menu loop)*



This menu is found in the ***Comms Settings menu loop***.
The setup menu only appears if a 433MHz Receiver module is fitted to the Afterburner's PCB.

Pairing a Remote

Up to 3 uniquely coded 433MHz remotes can be paired with the Afterburner.
They must be FIXED CODE devices, not rolling code.
You can also use an AC123 3-button roller shutter remote.

- Press **UP** to select a slot to program a remote control into.
- Press **RIGHT** to begin defining the "Stop" function
  (selection box lies within the stop icon column).
  - Press the remote key you would prefer to be used to stop the heater.
  - The asterisk appearing indicates a code has been staged for the function.
  - **If an AC123 remote, all other fields are automatically completed.**
- The "Start" function is then automatically selected
  (selection box lies within the start "play" icon column)
  - Press your preferred key to start the heater.
  - **Start/Stop is shared and uses the centre button on an AC123 remote.**
- Repeat the process for the decrease and increase functions.

Once all buttons of the key fob have been defined and **saved** (**CENTRE** press when away from the root navigation line), you can operate the remote control's keys and confirm the appropriate function now becomes highlighted.

Whilst in the setup menu, the remote presses will not perform the actual required function, but its expected action can be confirmed on the display with the appropriate cross refence being highlighted as the key is pressed.

When NOT in the 433MHz Remote setup menu, the remote control will perform the expected action.

Communications

The great advantage the Afterburner offers is the ability to have full control and monitoring of your heater from your smart phone device.

Connection methods overview

The primary methods being:

- SPP Bluetooth *(Serial Port Protocol)*
- WiFi

Bluetooth access

Android devices support classic SPP Bluetooth.

iOS devices do not support SPP Bluetooth which is the protocol supported by the Afterburner hardware.
WiFi connectivity is fully supported on iOS devices.

WiFi access

WiFi connectivity can be hosted directly by an inbuilt access point, or preferably configuring the Afterburner to connect to an existing WiFi network that allows Internet access.

Allowed WiFi modes are:

- **AP only** The Afterburner hosts an Access Point – NO Internet connectivity
- **AP+STA** The After hosts its own AP, and is connected to a WiFi network
- **STA only** The Afterburner is only connected to a WiFi network

The last two modes allow the Afterburner to gain Internet access.

Having Internet access available allows the Afterburner to detect and on demand update the operating firmware.
It can also readily obtain the latest web page content.

Internet access is essential for MQTT functionality.
MQTT can also be used to interface with Home Assistant.

WiFi access also allows debug monitoring and some setups best achieved with a real alphanumeric keyboard.

WiFi capabilities

WiFi connections allow the following control and monitoring methods

- Direct web page
- MQTT for remote Internet access control and monitoring.
- Telnet for some Debug Menu setups and internal debug monitoring.
  Debug Menus are also accessible via the web content.

Bluetooth SPP Connectivity *(Serial Port Protocol)*

Compatibility

The Bluetooth connection is via Bluetooth (Serial Port Protocol).

SPP is not supported by iOS for 3rd party applications. It is impossible to use Bluetooth SPP on an iOS device.

Android devices however can readily support Bluetooth SPP.
An "Afterburner" application is available via Google Play Store:
https://play.google.com/store/apps/details?id=appinventor.ai_mrjones_id_au.AfterburnerApp_V3_1_4

Using the Android application, you can control and monitor your heater via the Bluetooth connection.
The App also supports connections via websocket or MQTT if preferred.

Android App usage pre-requisite

You must:

1. Pair first the Afterburner with the device using the Android system's Bluetooth Manager.
2. Only can you then successfully use the "Afterburner" app on your Android device.
   You need to select the previously paired device in the app's Bluetooth connection manager.

Android System Bluetooth pairing

1. Using your Android device's Settings menu, locate the Connections menu.
2. If not already turned on, enable Bluetooth.
3. Press upon the Bluetooth text header.
4. The device will now typically scan for any Bluetooth devices, also showing previously paired devices.
5. Scroll to the Android display and select the "Afterburner", or "AfterburnerWithBLE" device from the Available Devices list.
6. To pair you need to enter the correct passcode, which is "1234".
   The passcode can be changed using the Debug Menus.
7. The Afterburner device should now appear in the devices paired with your device.

Android Application

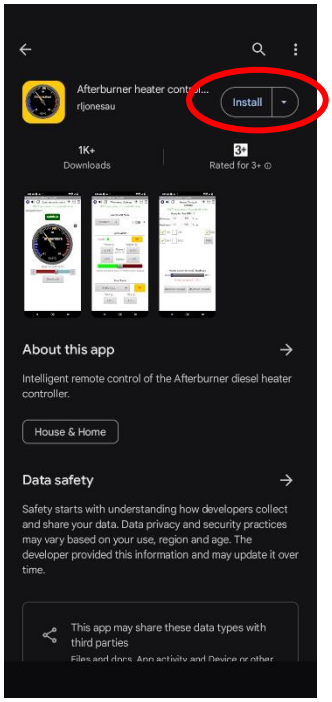
The Android application is a custom design, created using MIT App Inventor 2:
http://ai2.appinventor.mit.edu/
Unfortunately this tool is hard to maintain, and the application's development has reached the limit of my sanity.

The compiled application however is available via Google Play.

Installing the Android application

Install the "Afterburner" app from Google Play Store. It can be found by searching for Afterburner, or this link:
https://play.google.com/store/apps/details?id=appinventor.ai_mrjones_id_au.AfterburnerApp_V3_1_4

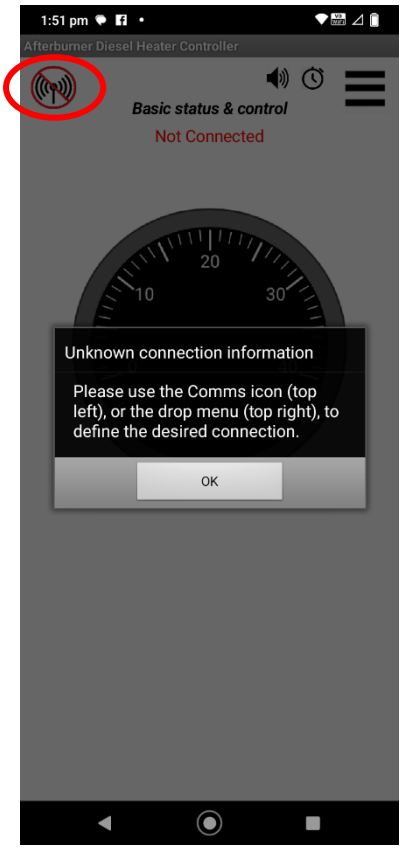
Within Play Store, locate the Afterburner app and click upon Install.



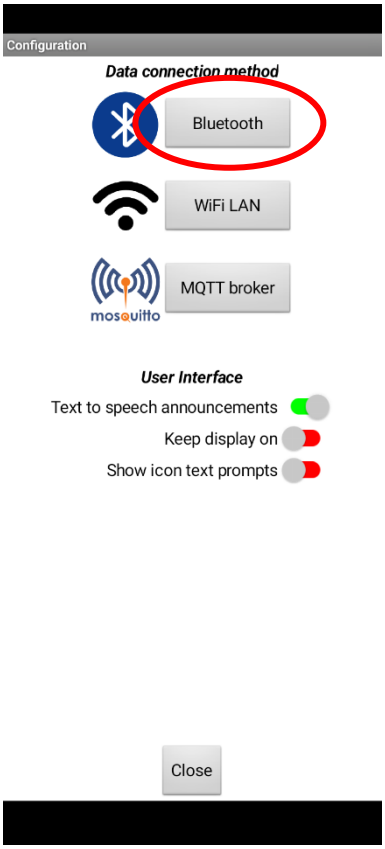
Once installed, the app icon will be present on your list of installed applications.

Click on the icon to open the app.

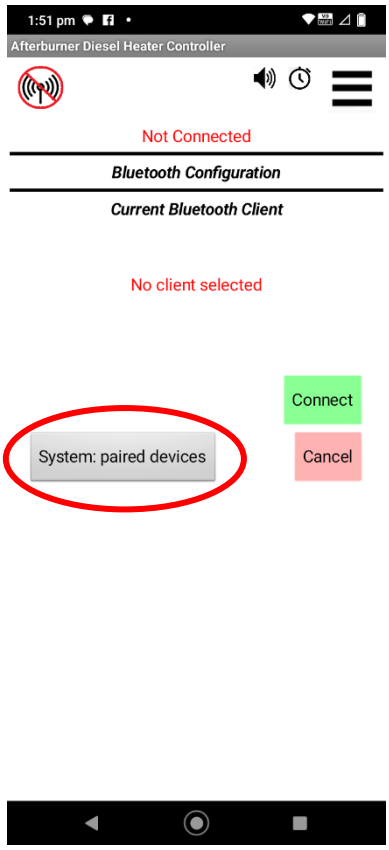
When no prior devices are known to the application.
You will need to click upon the comms icon at top left.



Three possible communication methods are presented.
Open the list of previously paired Bluetooth devices.



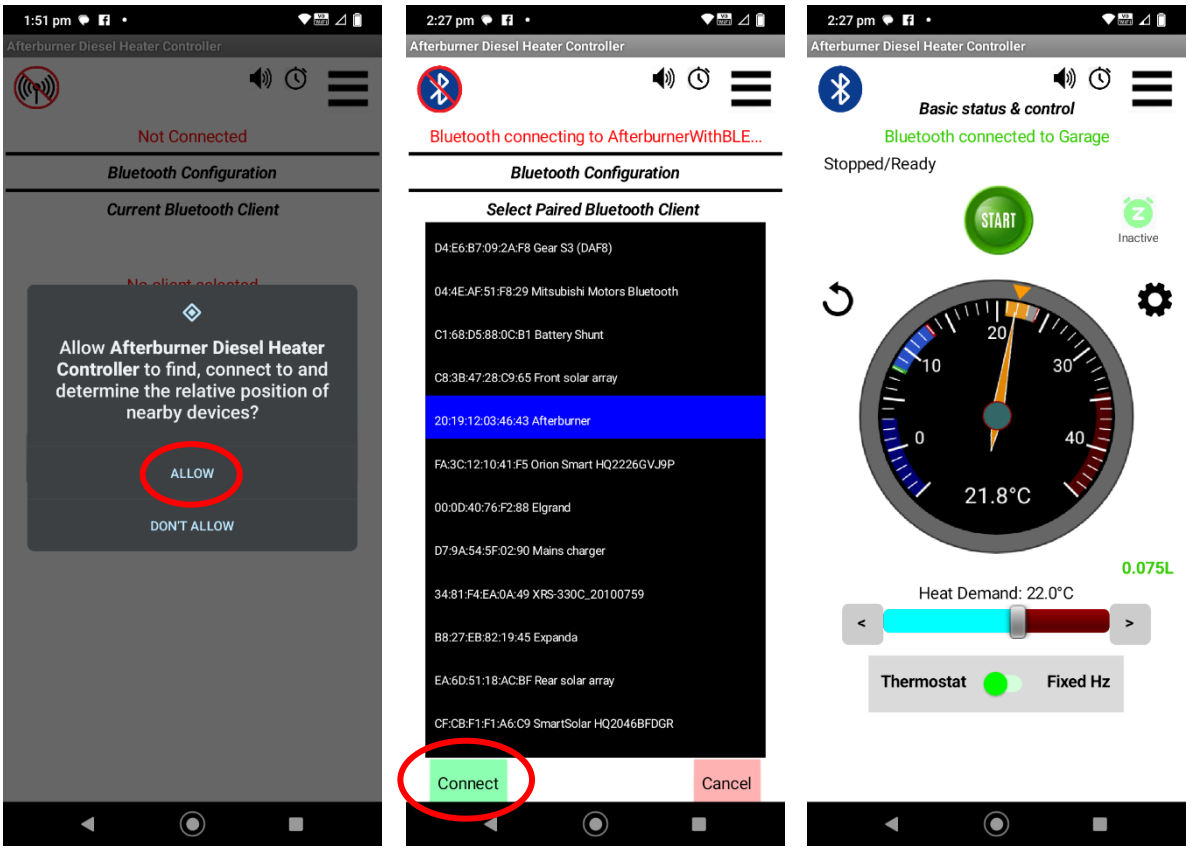
Click on System: paired devices.



You must allow this action, otherwise you cannot view the previously paired devices:

Locate the paired Afterburner in the list, select it, then click upon Connect at bottom left.

Once the paired Afterburner is connected, you should be greeted by this display.



The app remembers the last successful connection and re-uses that next time it is opened.

Operation brief

Pressing the large green START button should proceed to start the heater.
This is changed to a STOP button when running and is non clickable during shutdown.

The pointer is the actual temperature, which is also printed within the lower gauge (21.8°C here).

You can adjust the desired temperature by:

- using the Heat Demand scrollbar under the gauge;
- clicking and dragging the orange triangle about the rim of the gauge.

The dark blue and dark red bands at either end of the gauge's scale indicate the limits of the thermostat's settable range.

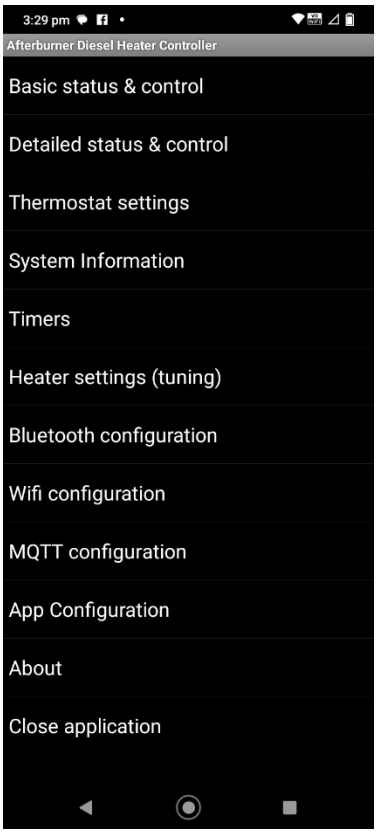
The orange band about the setpoint indicates the thermostat's hysteresis.

Cyclic mode (if enabled) is the grey area about the setpoint with red and green markers for the stop/restart thresholds.

Frost Mode (if enabled) is the blue band, in this instance about 10°C.
Green marker shows frost start, red shows the frost stop setting.

Menu

The hamburger at top right of the app opens the menu to switch to other pages.



Basic status & control

The default entry mode.

Detailed status & control

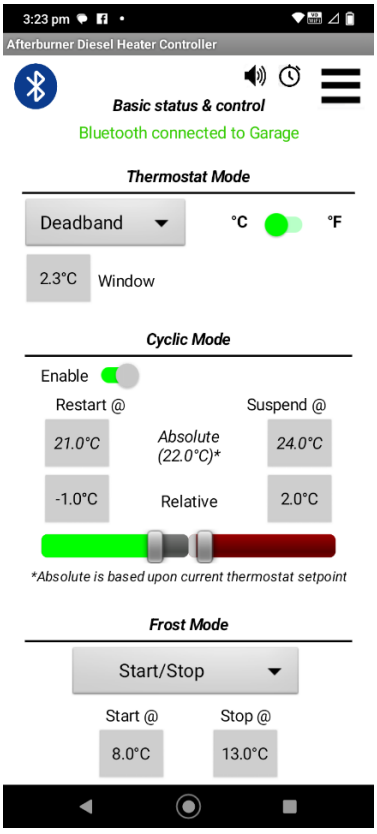
This mode is much the same as Basic status mode, but allows the presentation of extra detailed information about the heater status to be presented.

This information can be useful for fault diagnosis, and heater tuning.

Close Application

Close the application!

Thermostat Settings

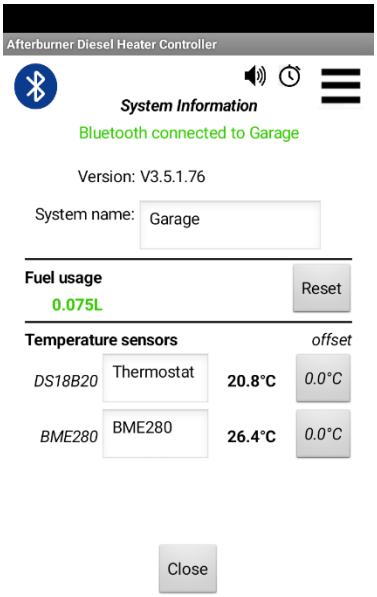


Clicking on the gear wheel at top right of the gauge will open the thermostat settings.
You can also select via the menu hamburger.

You can set the type of thermostat, Cyclic Mode, and Frost Mode parameters.

Clicking on the recycle icon, top left of gauge, results in a refresh of the JSON data from the Afterburner.
This should not normally be required.

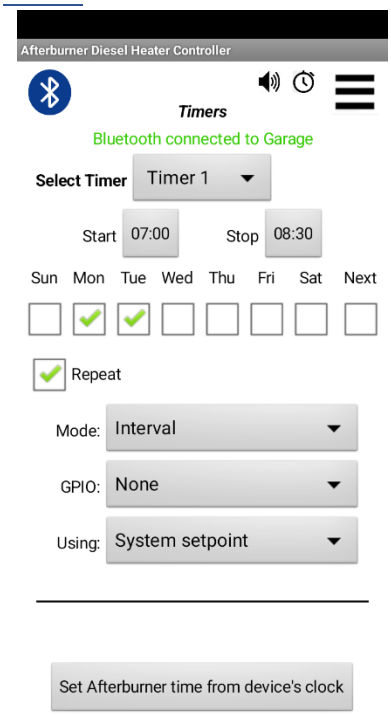
System information



Here you can:

- View the Afterburner's firmware version.
- Define the system's name.
  This name propagates through the system, and alters the Home Assistant auto discovery naming, and also the ID shown in the web page for multiple available MQTT connections.
- Name the temperature sensors
  Give each sensor a name, typically describes its location (max 10 characters).
- Offset the temperature sensors
  Can apply a simple offset to the sensor readings.
- Monitor and reset fuel usage
  This is the estimated value, derived by the Afterburner from integrating reported pump speed over time.

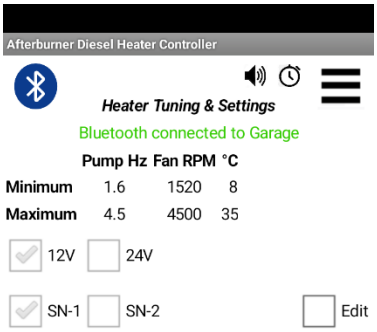
Timers



Here you can adjust the settings of the 14 Afterburner timers:

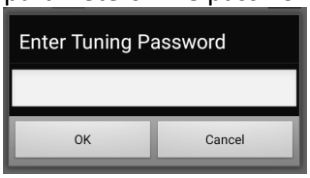
- Set the start and stop times
  The timer mode determines which fields appear.
- Set the days of operation.
- Set if the timer should repeat.
- Define an optional GPIO output to become active when the timer is active.
- Define the temperature to use for the timer:
  Default system thermostat,
  Specific temperature for the timer,
  Specific Fixed Hz Demand.
- Set the Afterburner's Real Time Clock to that of the device being used.

Heater Settings

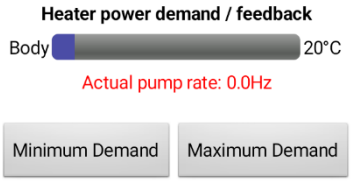


Here you can perform tuning of the air fuel mixture of the heater.
By default, the settings are simply presented as they are.

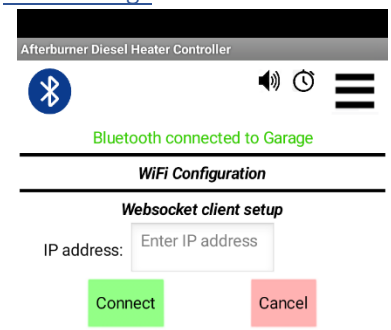
Click upon the Edit checkbox to enable edit fields for the parameters. The password is 1688.



A subset of controls then also appears that allow the ready selection of max and min power during tuning.
The edit fields are momentarily locked out whilst the pump speed is transitioning to the new speed.



Wifi Settings

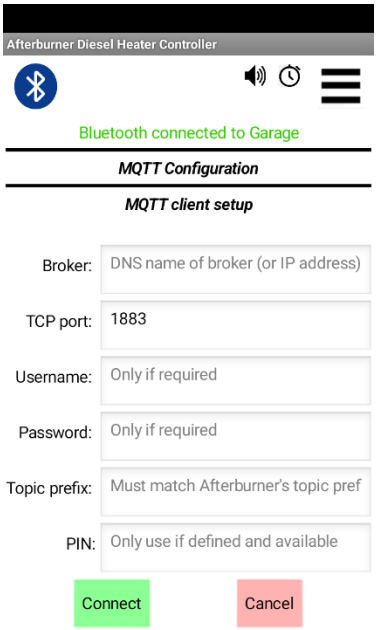


The app can use a websocket to the Afterburner to collect the JSON data to populate the status fields and provide control of the Afterburner.

A websocket is also how the web content controls and monitors the Afterburner.

Simply enter the IP address of the Afterburner to connect to.

MQTT Settings



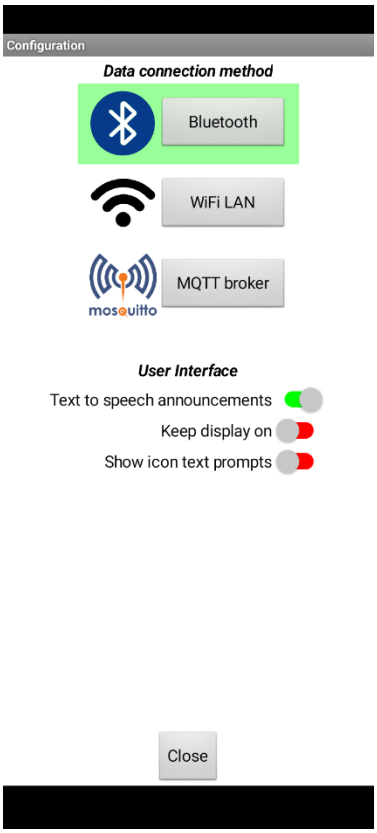
The app can connect to the Afterburner via an MQTT broker to collect the JSON data to populate the status fields and provide control of the Afterburner.

Enter the details of the broker, paying attention to the fact the app uses TCP MQTT connections, not a websocket as the web page uses.
ie The TCP port number entered should be the same value as the Afterburner is also configured to use.

Usage of a PIN is optional but recommended for public brokers.
Do not use a PIN when also using Home Assistant.
The PIN must match that defined on the Afterburner.

Note these settings only define the app's client settings, not those of the Afterburner itself.

App configuration



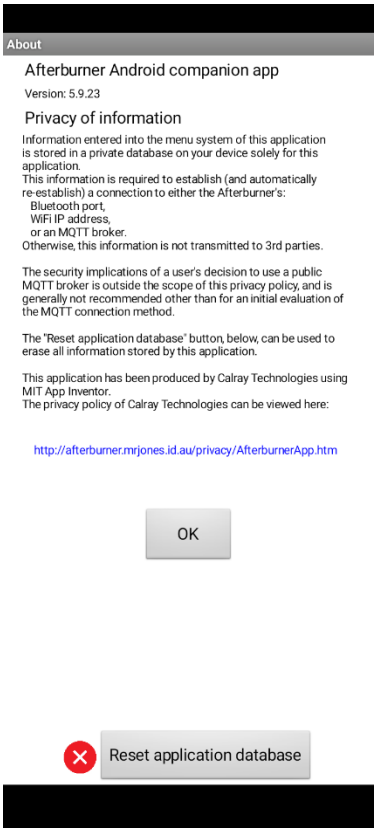
Here you can pick the communications method the app uses to connect to the Afterburner.

Clicking any of the connection methods will open the corresponding setup menu for that mode.

The User Interface options are used to alter the behaviour of the app:

- Text to Speech
- Keep the display active
- Show text annotation on the main menu against the icons

About



This is an obligatory page required by Google Play when publishing apps on their platform.

Essentially the app does not capture any private information, other than the essential credentials needed to access your Afterburner system.

A warning is given about the non-recommendation of using public MQTT brokers.

To completely forget any information entered, press upon the Reset application database button.
This forgets all prior connection information, and to continue using the app you will need to reconfigure those settings.
Once again, a Google Play requirement.

WiFi Connectivity

The Afterburner can communicate over a 2.4GHz WiFi connection.
5 GHz wifi routers are not supported.

WiFi connection modes

The ESP32 processor allows the following WiFi modes:

- SoftAP (Inbuilt Access Point) No Internet connectivity is available, hence "soft" AP.
- STA (Station) mode – The Afterburner connects to an existing WiFi network Access Point.

Soft Access Point

The Afterburner hosts its own Access Point.
This is known as AP mode, or more correctly SoftAP mode as no Internet connectivity is available via this access point.

The SoftAP is primarily provided to enable a steppingstone to configuring STA mode, joining a proper Internet capable WiFi network.
The SoftAP can however also serve the web page for controlling and monitoring the heater.

Connecting to the SoftAP

When browsing for available WiFi networks, the SSID for the SoftAP will be named **Afterburner**.
It is possible to change this name and/or password via the Debug Menus available or telnet, serial debug port or the web page's "Debug & Logging" page.

- Select the SSID **Afterburner**
- Supply the password **thereisnospoon**

The connecting device should then connect and be given an IP address in the 192.168.4.x subnet.
The Afterburner's SoftAP IP address will always be 192.168.4.1.

Your device will probably warn that there is no Internet connectivity (which there isn't).
Likewise, there is no gateway IP address.

STA – Station Mode

STA mode is where the Afterburner joins another WiFi network.
Typically this will be an Internet connected home WiFi network.

The WiFi router the Afterburner is connecting to (as a Station) is referred to as an Access Point.
This should not be confused with Afterburner's own Soft Access Point.

STA WiFi Configuration

To allow the Afterburner to join an already existing WiFi network the credentials needed to join that network need to be defined.

When first received, there will not be any credentials stored to join another WiFi network.
The Afterburner can only offer its own inbuilt SoftAP (Access Point).

STA credentials can be configured in several ways:

- The Debug Menu system, via telnet, debug serial or web page.
- /wifi – special Afterburner web server URL

WiFi protocols

Available features via WiFi:

- Web server (port 80 – typically serves a web page to control the heater).
- Websocket server connection (port 80/81, JSON status and control).
- TCP MQTT client connection for remote access (status and control), needs STA.
- Telnet debug interface (port 23).

Web server URLs

The Afterburner's web server interface:

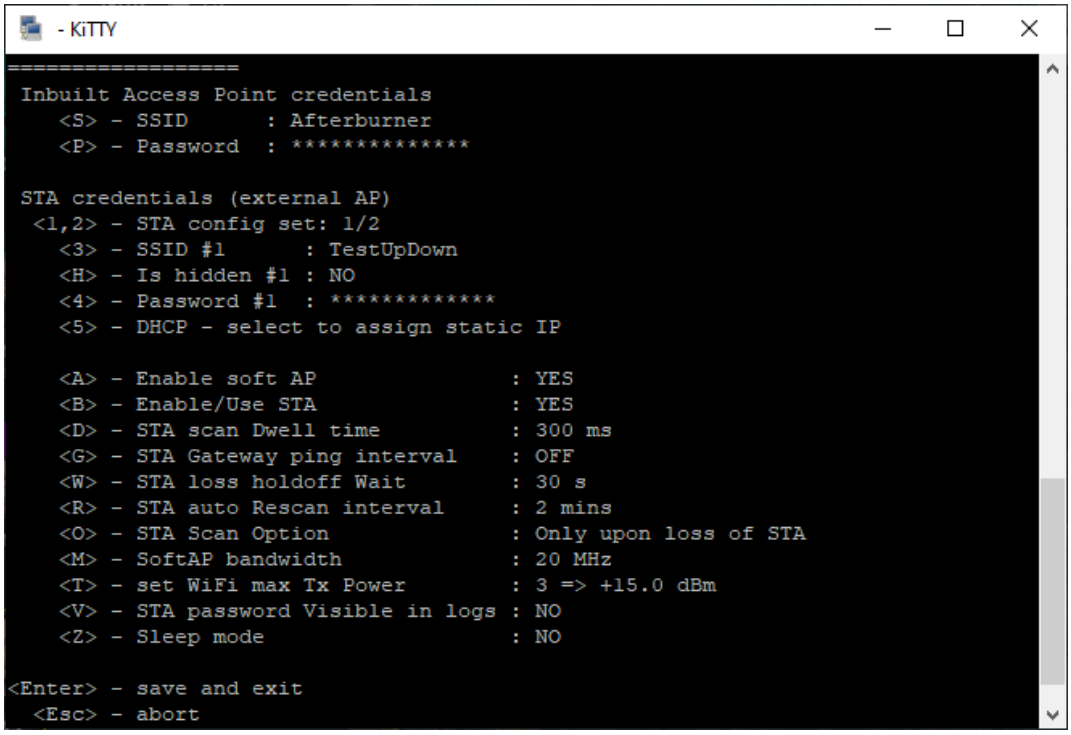
- / An updateable web page to control and monitor the heater.
- /update Upload of new firmware or web content.
- /wifi Configure the STA connection to join another WiFi network.

STA configuration via Debug Menus

- telnet
  - Discover the Afterburner's STA IP address using the OLED menus.
  - Alternatively, the Afterburner's SoftAP can be used.
    The IP address is then 192.168.4.1.
  - telnet to the Afterburner's IP address (port 23).
- Web content
  - Use the "Debug & Logging" page of the web content.
- Serial
  - Open a terminal session at 115200 Baud via a suitable TTL serial adapter.

Either connection method allows access to the debug menus.
From there you can then access a WiFi configuration menu.

- *<Enter>* will reveal a list of all configuration menus.
- ***wifi<Enter>*** will open the WiFi configuration menu.



- Ensure that Enable / Use STA is set to **YES** *(option B)*, as well as defining the required STA credentials *(via options 3 & 4)*.

Keystroke	Function
S	Enter SSID for Afterburner's SoftAP.
P	Enter the password for the Afterburner's SoftAP.
1/2	Select STA configuration set #1 or #2.
3	Enter the SSID for the selected configuration set.
H	Specify if this SSID is hidden.
4	Enter the Password for the selected configuration set.
5	Select DHCP or Static IP address, if static IP is enabled:
6	Static IP gateway address
7	Static IP subnet mask
8	Static IP DNS server
A	Toggle SoftAP on/off.
B	Toggle STA mode on/off.
D	Define the time spent dwelling on each channel during a WiFi scan (default 300ms).
G	Define the interval to ping the STA gateway, used to confirm connection is workable. A timeout disconnects / reconnects STA
W	STA reconnect holdoff. Delay time before a STA connection is reattempted.
R	Automatic rescan interval for available STA Access Points.
O	STA rescan options (only upon loss, auto: strongest RSSI, auto: prefer SSID1)
M	SoftAP default bandwidth (20MHz or 40MHz)
T	Maximum WiFi transmit power. (Lower is generally better)
V	Toggle visibility of STA password in debug logs during STA connection.
Z	Toggle STA sleep mode. When enabled, STA power consumption is reduced, but latency increases.
<Enter>	Save and exit the parameters
<Esc>	Abort any changes

STA only mode

If you wish to switch to STA only, you can do so:

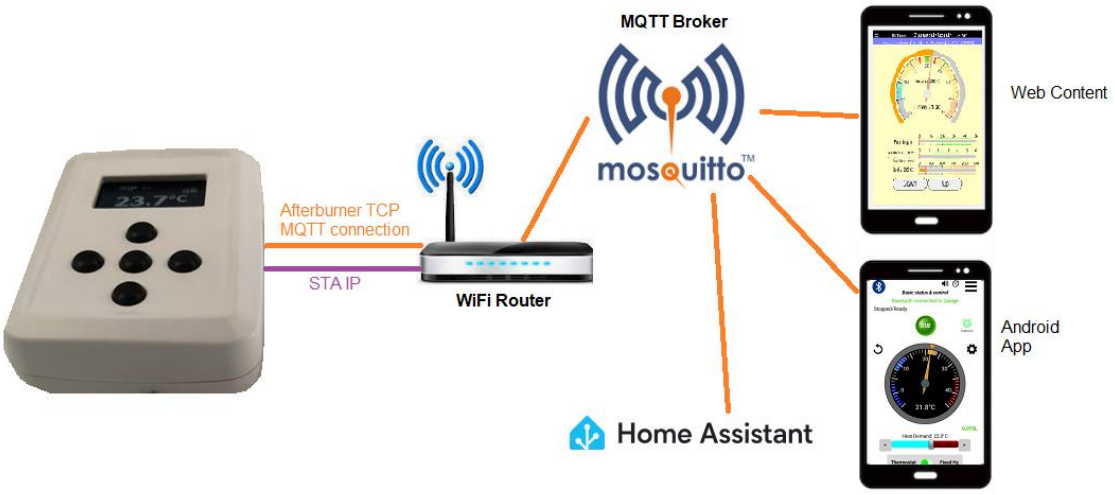
- Via the telnet/serial debug interface (***wifi** menu, toggle **A** option OFF, **B** option ON).*
- Via the OLED's WiFi Settings menu by toggling the AP choice off, STA On.

If the SoftAP is disabled and the STA AP is not joinable, there will be no WiFi connectivity.

MQTT configuration

The exchange of JSON encapsulated command/status information can occur via an MQTT broker. A subset of status values are also published via individual /sts topics.

- The Afterburner can function as an MQTT Client
- The web content or Android App can function as an MQTT Client
- 3rd party tools can function as an MQTT client (e.g., Home Assistant)



The crucial glue that binds MQTT clients together is the Topic Prefix, which must match exactly in each client. Case Sensitivity most definitely applies.

If the topic prefix matches, the broker subsequently allows access to the Afterburner.

Primarily, the Afterburner must be able to connect to a broker.
This means it must be configured to use STA WiFi mode.
i.e., the Afterburner must be connected to a suitable WiFi network with Internet access.

MQTT can be configured by:

- The Debug Menus (includes web content, “Debug & Logging” page).
- A direct web server connection to the Afterburner, using the web content.

Essential MQTT configuration steps

1. Configure STA
    a. You MUST have an STA wifi connection working that can access your chosen broker.
    MQTT does not operate via the SoftAP wifi connection.

2. Configure the Afterburner to connect to your chosen broker.
    a. The Afterburner broker connection MUST use a non-SSL, traditional TCP MQTT port.
    Typically this is port number 1883 but do check your preferred broker’s details.
    b. The topic prefix MUST be unique on the broker.
    The default Afterburner topic is Afterburner, followed by the last 6 digits of the Afterburner’s own STA MAC address. The complete MAC address is already a unique value in the world. The first 6 digits of the MAC are the vendor ID for Espressif, the ESP32 manufacturer and omitted.
    c. Usage of a username and password may not be required.
    Check the details for your chosen broker.
    d. **Do not use a PIN if you plan to use Home Assistant.**
    Do not try to run Home Assistant via a public broker, use a private broker.
    e. Do not forget to ENABLE the MQTT function on the Afterburner.

3. Configure an MQTT client to connect to the chosen broker.
    a. The essential glue for communication to function via a broker is the topic prefix.
    The client topic prefix must EXACTLY match the topic prefix that was defined in the

Afterburner.
Case sensitivity is very important.
Beware of trailing spaces.

b. It is important to realise that any MQTT client is NOT directly connecting to the Afterburner.
The MQTT client only connects to the broker.
    i. The broker will agree to exchange messages that match the topic prefix.
        1. It relays status messages from the Afterburner to a client(s).
        2. It relays client command requests to the Afterburner.
    ii. Multiple clients can connect to the broker, using the same topic prefix.

c. The MQTT client may use either a websocket or TCP MQTT connection to the broker.
You must use the appropriate port for your chosen broker.
    i. The web content must use a websocket. (typically, port 8000)
    ii. The Android app uses a traditional TCP MQTT connection. (typically, port 1883)
    iii. For any other client it's best to check the documentation for that client.
    e.g. Home Assistant can use either.
    iv. The web content will support an SSL broker connection, when launched from a secure https connection. Check the port number required (if available on broker).
    e.g. https://mrjones.id.au/afterburner/mqtt.html

d. Usage of a username and password may not be required.
Check the details of your chosen broker.

e. When using the web page, do not forget to select "MQTT broker" at the top of screen as the JSON source.

4. It is possible that you can connect to the broker, but you cannot find the Afterburner.
    a. Ensure the Afterburner IS connected to the same broker.
    b. Ensure the topic prefix used by the client matches EXACTLY.
    c. If using the PIN feature, ensure the PIN matches,.
    Do not use a PIN if you plan to use Home Assistant.

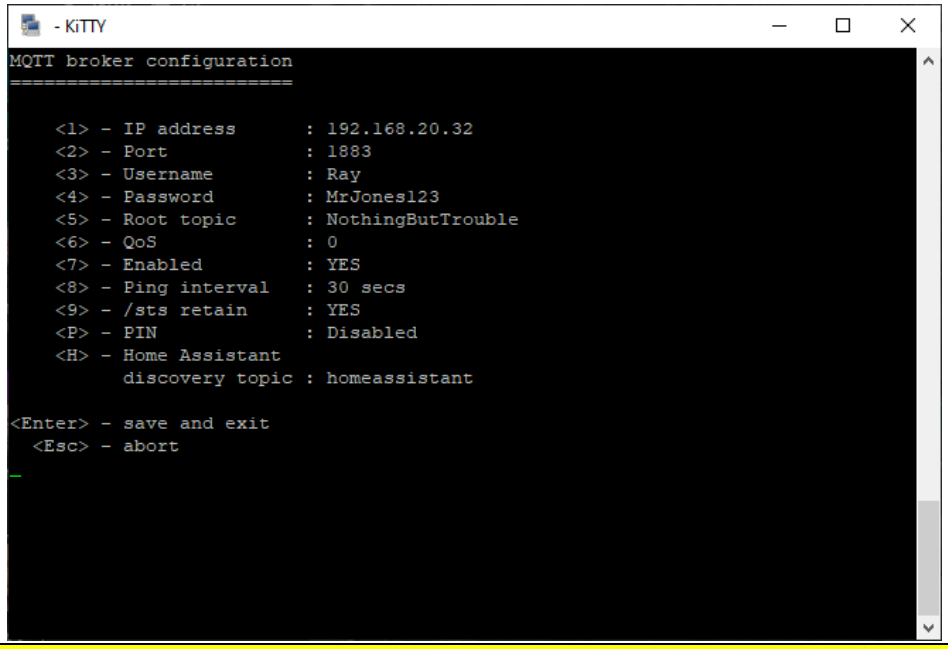
Configuring MQTT Debug Menus

- telnet
    - Discover the Afterburner's STA IP address using the OLED menus.
    - Alternatively, the Afterburner's SoftAP can be used.
    The IP address is then 192.168.4.1.
    - telnet to the Afterburner's IP address (port 23).
- Web content
    - Use the "Debug & Logging" page of the web content.
- Serial
    - Open a terminal session at 115200 Baud via a suitable TTL serial adapter to the debug serial port.

Any method allows access to the Debug Menus.
From there you can then access a MQTT configuration menu.

- *<Enter>* will reveal a list of all configuration menus.
- **mqtt*<Enter>*** will open the MQTT configuration menu.

- **mqtt*<Enter>***



- **Be sure to enable the MQTT function via option 7.**

Keystroke	Function
1	Enter broker's IP address
2	Enter broker's port *(**MUST** be the broker's **TCP port** - typically 1883)*
3	Enter the optional username needed for the broker
4	Enter the optional password needed for the broker
5	Enter the **unique** topic prefix.
6	Enter the desired Quality of Service *(default 0)*
7	Enable or disable the MQTT client connection to broker
8	Ping interval – special ping topic to check connection
9	Retain /sts topics, recommend YES
P	PIN definition – scramble communications over a public broker
H	The topic prefix used by your Home Assistant install for auto discovery
<Enter>	Save and exit the parameters
<Esc>	Abort any changes

Configuring MQTT via web page

Afterburner MQTT client configuration

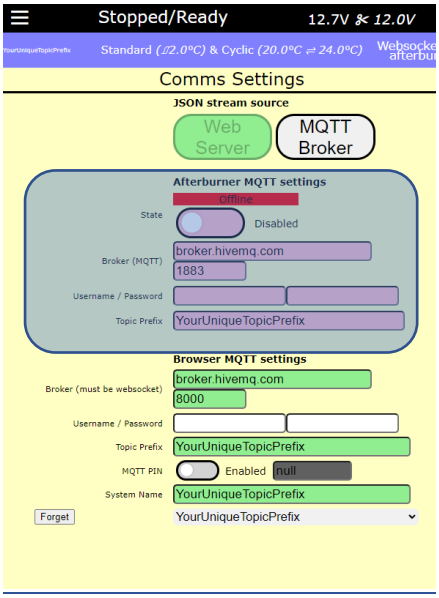
The Afterburner's MQTT client settings can only be configured when the JSON stream source is set as the Web Server option.
Reconfiguration of the Afterburner's MQTT connection via an MQTT connection is disallowed.

Either the SoftAP or STA IP addresses can be used.

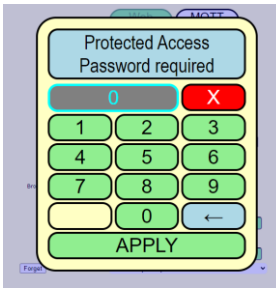
The Afterburner's settings to act as a MQTT client are located beneath the upper **Afterburner MQTT settings** header.
By default they are protected, and shown with a salmon background colour.

These settings are for the Afterburner's MQTT connection.

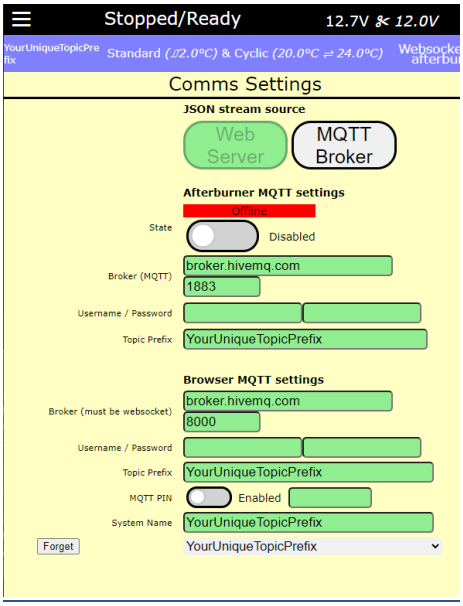
Protected Afterburner settings



Password entry

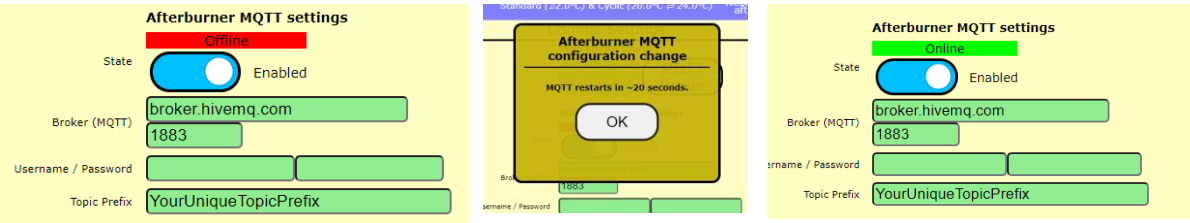


Unlocked Afterburner settings



1. Click upon any one of the salmon coloured disabled fields, as highlighted above
2. At password entry prompt, enter the protected access password.
   The default value being **1688**:
3. The Afterburner MQTT Settings will be unlocked and acquire a green background.
   - **Broker:**
     Complete according to the broker you are using.
     The example shows the IP address of a popular, free & insecure, option.
     The use of insecure public MQTT brokers is strongly discouraged, good for initial testing though.
   - **Port:**
     Must be the broker's **TCP port**, not websocket.
     1883 is a typical value for the MQTT TCP port that the Afterburner requires.
   - **Username:**
   - **Password:**
     Only complete if required by the broker.
     The example broker does not require these.
   - **Topic Prefix:**
     Must be unique for **your** system, hence the wording used in the example.
     By default this will be AfterburnerXXXXX, where XXXXXX is the last 3 octets of your already "unique in the world" MAC address.
     The default topic prefix value is already unique, but it can be changed if preferred.

- **State** slide switch:
  Enables the Afterburner's MQTT client.
  - After enabling, a popup will appear warning of a 20 second delay.
  - After 20 seconds the Afterburner will attempt to connect to the broker.
  - The status should change from a red Offline condition to a green Online condition.

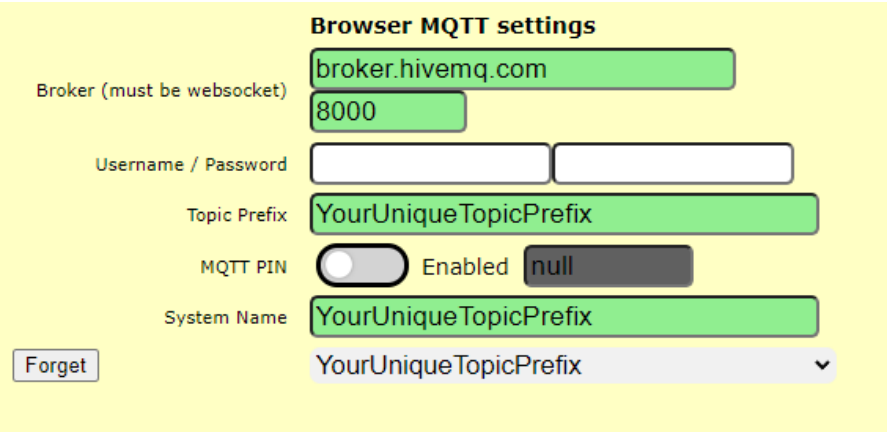


The Afterburner is now connected, and ready for interaction via the broker.

It will publish status changes to the broker, using the specified topic prefix, and also subscribe to commands using the same topic prefix.

Using the web content as a local MQTT client

The lower set of fields beneath the **Browser MQTT settings** heading are used to allow the web content to function as an MQTT client.
Initially, we will use these to test and prove the MQTT broker connection is working as required via your LAN connection.
(i.e. your device is typically holding a 192.168.x.x private IP address)



- **Broker**
  The IP address must match what was used for the Afterburner client's configuration.
- **Port**
  Must be the broker's websocket port, not the TCP port.
  The usual MQTT websocket port is 8000 but do check the chosen broker's requirements.
- **Username**
- **Password**
  Only complete if required by the broker.
- **Topic Prefix**
  Must exactly match that used for the Afterburner's client configuration.
- **MQTT PIN**
  Allow encryption of the MQTT payload and topic names.
  Recommended to be enabled with public brokers.
  For a first setup, leave the PIN disabled to remove one level of complexity.
  DO NOT use a PIN with Home Assistant, it will not be able to decrypt the messages.
  The PIN must also be specified on the Afterburner via its menu system.

- **System Name**

  Allows you to use a human friendly name to remind you of the system you are controlling rather than the more cryptic (unique to the world) Topic Prefix.

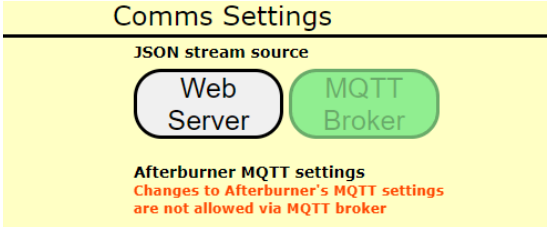
  This is especially useful if you have more than one Afterburner!
  e.g., “Caravan”, “My awesome van”, “Shed” etc.

  When a new topic prefix Is entered, the System Name will automatically be set identically.
  This field may however automatically change after connection should the connected system already have a predefined name.

  When connected, the System Name is sent to and stored by the Afterburner. It will automatically propagate to any other device (Bluetooth, web or MQTT client).

Enabling MQTT for the web browser

At the top of the Comms Settings page, click upon the **MQTT Broker** button.



This switches the JSON information feed to be sourced via the MQTT broker, instead of directly from the Afterburner.

The upper *Afterburner MQTT Settings* fields are disabled as changes to these parameters are not allowed via the MQTT broker. (Akin to potentially shooting yourself in the foot!)

The title bar will go through a series of connection messages and should eventually turn blue showing a successful connection and establishment of data flow via the broker.

If your Topic Prefix is wrong, it may well recycle the connection, or simply be left stuck at a green “Subscribing” header.
The green header indicates the broker connection is open, but the nominated Afterburner is not currently present on the broker – this is most likely a topic mismatch, or the Afterburner is offline.

Using the web page as an Internet MQTT client

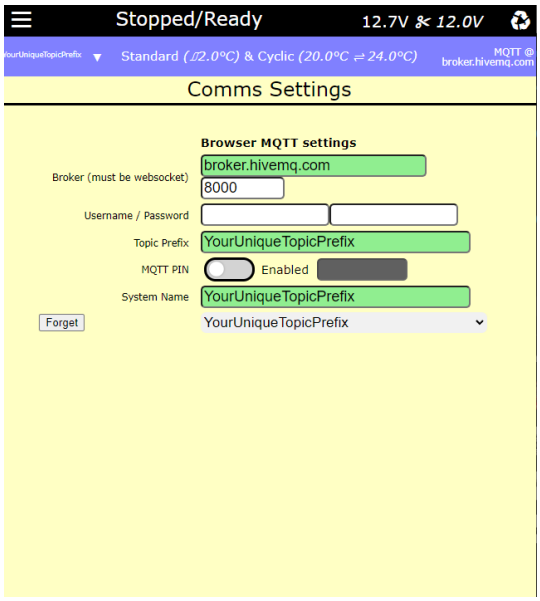
Loading the web page directly from the Afterburner is one way to exercise the MQTT client connection from a browser but is extremely limited.
It will work on your local network, but other than testing it supplies no real advantage over simply using the usual websocket for the exchange of JSON information.

It is not advisable to expose the Afterburner’s web server directly to the Internet, so an alternative source is needed to supply the web content.

http://afterburner.mrjones.id.au/mqtt.html
is a copy of the same web content you can load onto the Afterburner but served from a real web server, always accessible from the Internet.

When loaded this way, the web content is aware of the HTML file's source location.
To minimise confusion, the Comms Settings page of the web content is altered to remove the Afterburner MQTT Client settings, leaving only the browser MQTT settings.
The option to choose the Web Server or MQTT Broker JSON source is also removed.
When loaded this way, only MQTT can be used.

As the web page was loaded from a different server than the earlier test, the browser's MQTT settings will need to be re-entered.
The settings are required to be identical to those used in the previous test.



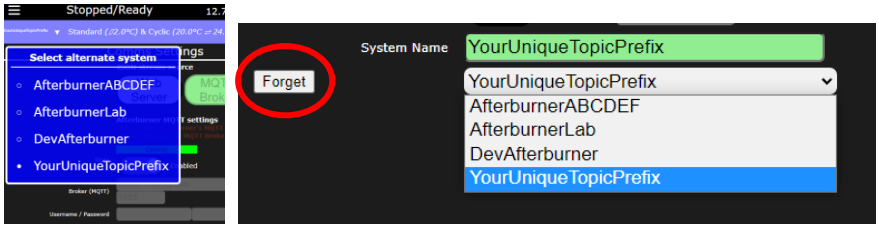
The Browser Client Settings are saved to the web browser's "Local Storage".
Local storage retains the values for next time http://afterburner.mrjones.id.au/mqtt.html is accessed, **providing the same browser is also used.**

Switching between multiple MQTT connected Afterburners

Whenever the System Name is changed, it is added to a drop list at the bottom of the Comms Settings page.

The content of this drop list is also mirrored to the top left of the title bar, allowing rapid switching between multiple Afterburner systems.

- The addition of names to the drop list is fully automatic
  - Whenever a new topic prefix is defined
  - Whenever the System Name is edited
- Zombie system names will be left behind in the drop list.
  - To remove a zombie name:
    - Select a zombie name.
    - Click on Forget to the left of the drop list.



Improving MQTT security

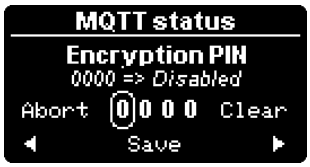
A PIN can be independently defined for both the Afterburner and Web browser clients.

- Defining a PIN will result in the topic names and payload data being encrypted.
- The PIN is explicitly defined in the Afterburner.
- The same PIN must be defined for the MQTT client connection in the browser.
- **The PIN is never transmitted across the MQTT link.**
- The PIN must match on each client to allow communication.
- An incorrect PIN will result in a topic mismatch and no communication is possible.
- A value of 0000 on the Afterburner disables the PIN function.
- If the PIN is disabled, MQTT works using plain text.
- **Do not use a PIN if you intend to use Home Assistant.**

Defining the Afterburner's MQTT client PIN

1. In the ***Comms Settings menu loop***, access the ***MQTT Status*** menu:

2. Press **UP** to begin the defining the PIN.
3. Move **RIGHT**, then use **UP** / **DOWN** to set each digit to the desired PIN value.

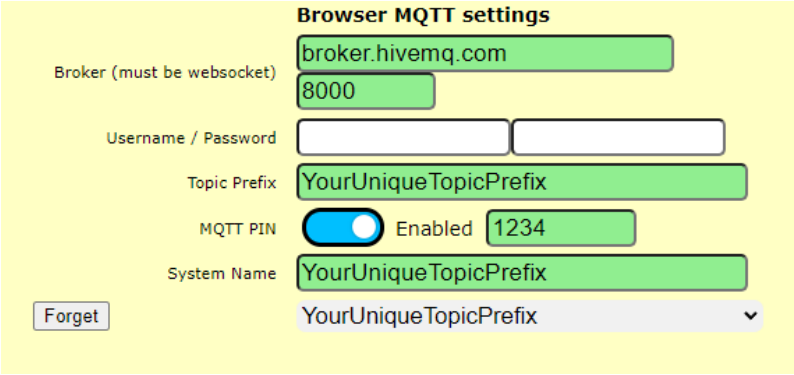


4. Once the desired value is shown, press **CENTER**.
5. Press **UP** to confirm.
6. The MQTT client connection will be disconnected.
7. The MQTT client connection is re-connected 20 seconds later, using the defined PIN as a basis for encrypting both the topics and payload in each direction.
8. The PIN is shown along with the topic prefix on the status page.

Defining the Web browser's MQTT client PIN

1. Within the Browser MQTT Settings, enable the **MQTT PIN** slide switch.

2. Enter the same PIN value as defined on the Afterburner.



3. Note: Each System Name can use a different PIN.
   Ensure the bottommost drop list has the correct system selected.

Home Assistant

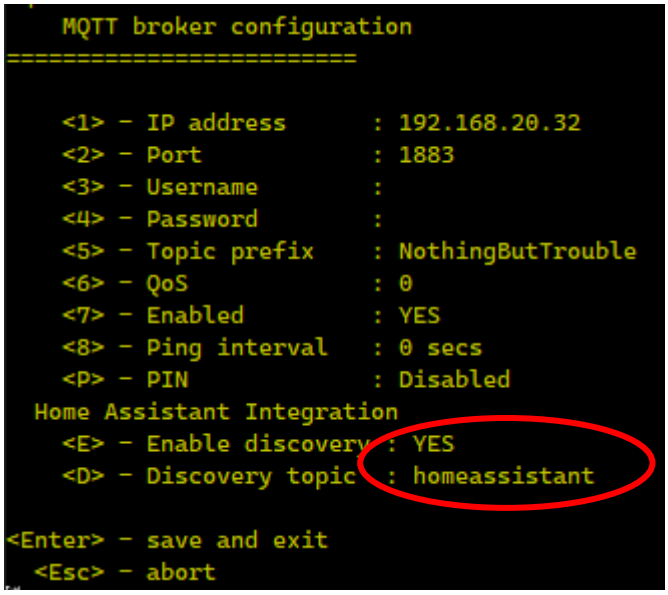
Home Assistant is a popular open-source home automation package.

The Afterburner can be quickly integrated with Home Assistant via Home Assistant's MQTT Auto Discovery.

You must have the Afterburner's MQTT client configured and operating prior to attempting to use auto discovery.

MQTT Auto Discovery

The Afterburner publishes a multitude of topics to the MQTT broker, under the special Home Assistant auto discovery topic prefix.



The default topic prefix used by Home Assistant is ***homeassistant***, and subsequently that is the default prefix used by the Afterburner for auto discovery.

As it is possible to change this prefix within Home Assistant, the ability to alter the prefix also exists in the Afterburner via the mqtt Debug Menu.

You can also disable auto discovery entirely if preferred.

Note:
The Afterburner deliberately blocks publishing auto discovery to known public brokers.
It is simply a foolish insecure endeavour to ever use Home Assistant via something like HiveMQ.

Broker auto discovery topics

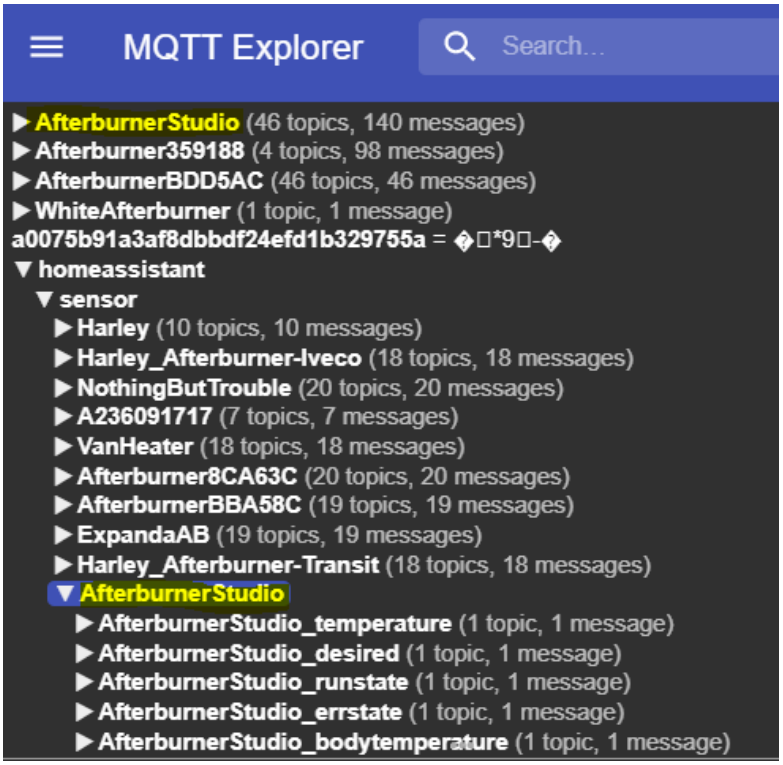
MQTT auto discovery is a collection of sensors, switches, climate etc topics, published by various systems on a broker beneath the root ***homeassistant*** topic.

The Afterburner further publishes its various entities beneath the same topic prefix as it would use for normal MQTT traffic.
Adding this extra layer helps to keep the Afterburner's discovery topics better grouped on the broker.

A useful application you can use to inspect all topics present on a broker is "MQTT Explorer".

https://mqtt-explorer.com/

These screenshots are taken using MQTT explorer and show the expanded ***homeassistant*** topic branch on my broker, and ultimately some of the various "sensor" entities for the specific Afterburner using a topic prefix of ***AfterburnerStudio***.



At the very top, you can see the fundamental ***AfterburnerStudio*** topic prefix where the actual status and command traffic flows.

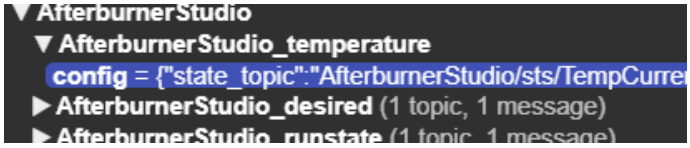
Portions of that topic prefix tree are referenced by the auto discovery information beneath ***/homeassistant/sensor/AfterburnerStudio*** which describes each **sensor** entity being exposed.

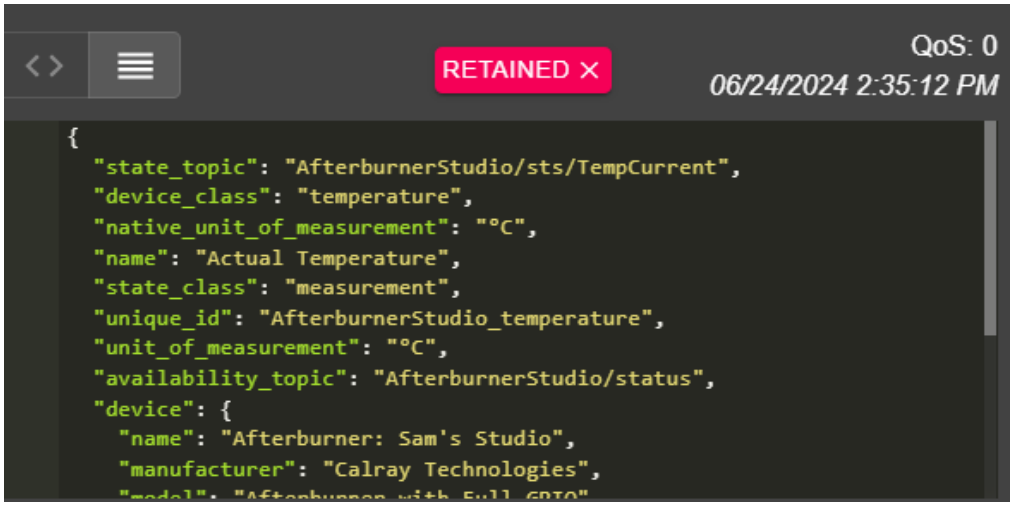
There are also **/binary_sensor**, **/climate**, **/number**, **/select** and **/switch** auto discovery topics published beneath **/homeassistant** by the Afterburner.

Example auto discovery entity details

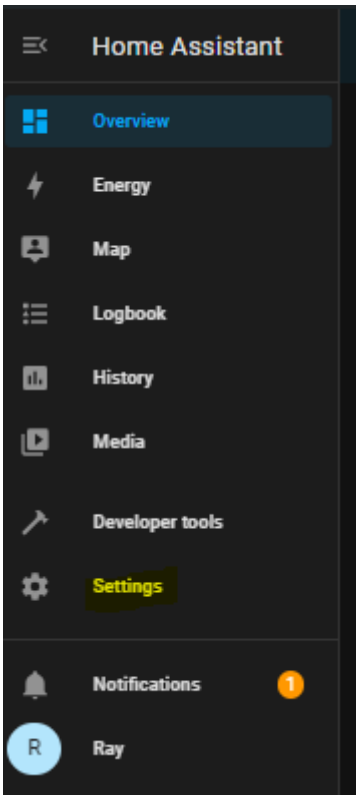
As an example, the auto discovery topic to define the "Actual Temperature" entity is expanded, which in this example references the ***AfterburnerStudio/sts/TempCurrent*** topic, which is the usual status data published by the Afterburner for reporting the current temperature.

Those familiar with Home Assistant YAML configuration files may note some similarities.





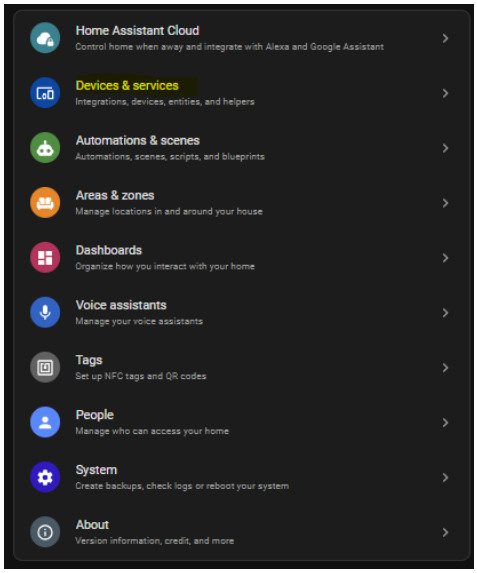
Home Assistant configuration



When visiting Home Assistant's web interface, eg: http://192.168.20.20:8123/lovelace/default_view you will see a sidebar when you can access various parts of Home Assistant.

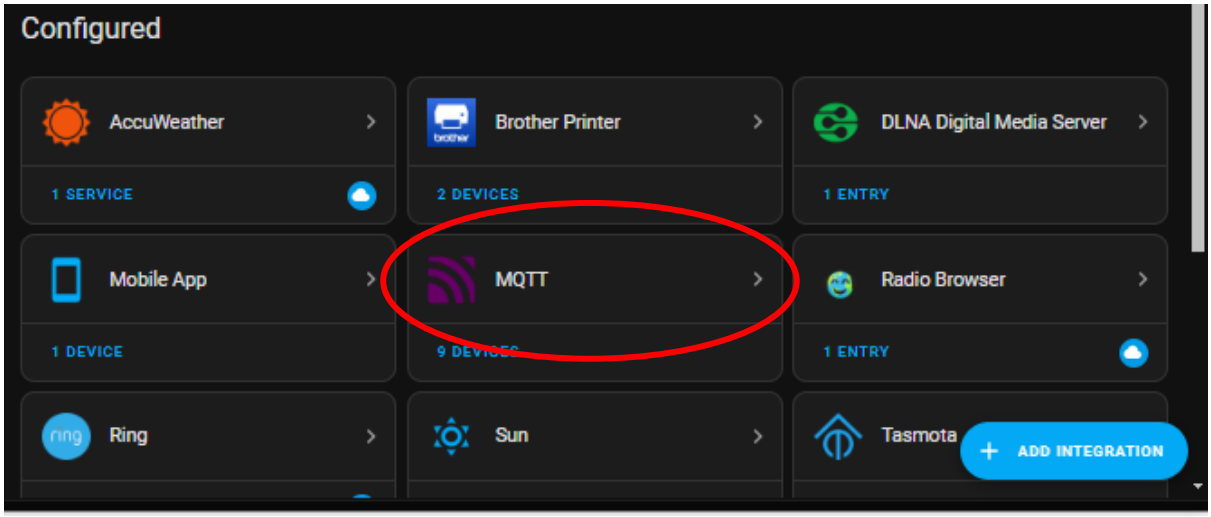
To import the Afterburner's auto discovery, you need to open the Settings option, near the lower left.

You then need to open "Devices and Services"

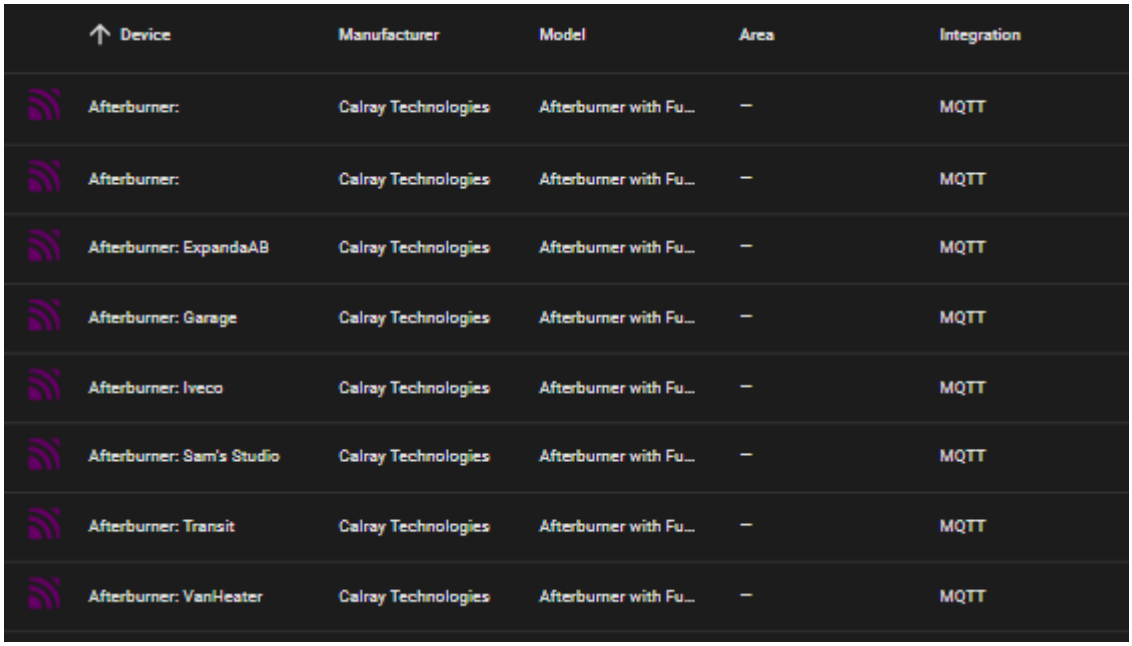


You are then presented with the integrations currently configured for use with Home Assistant.

The MQTT integration may not already be configured.
If not, use Add Integration at the lower right, locate the MQTT integration and configure to suit your broker.



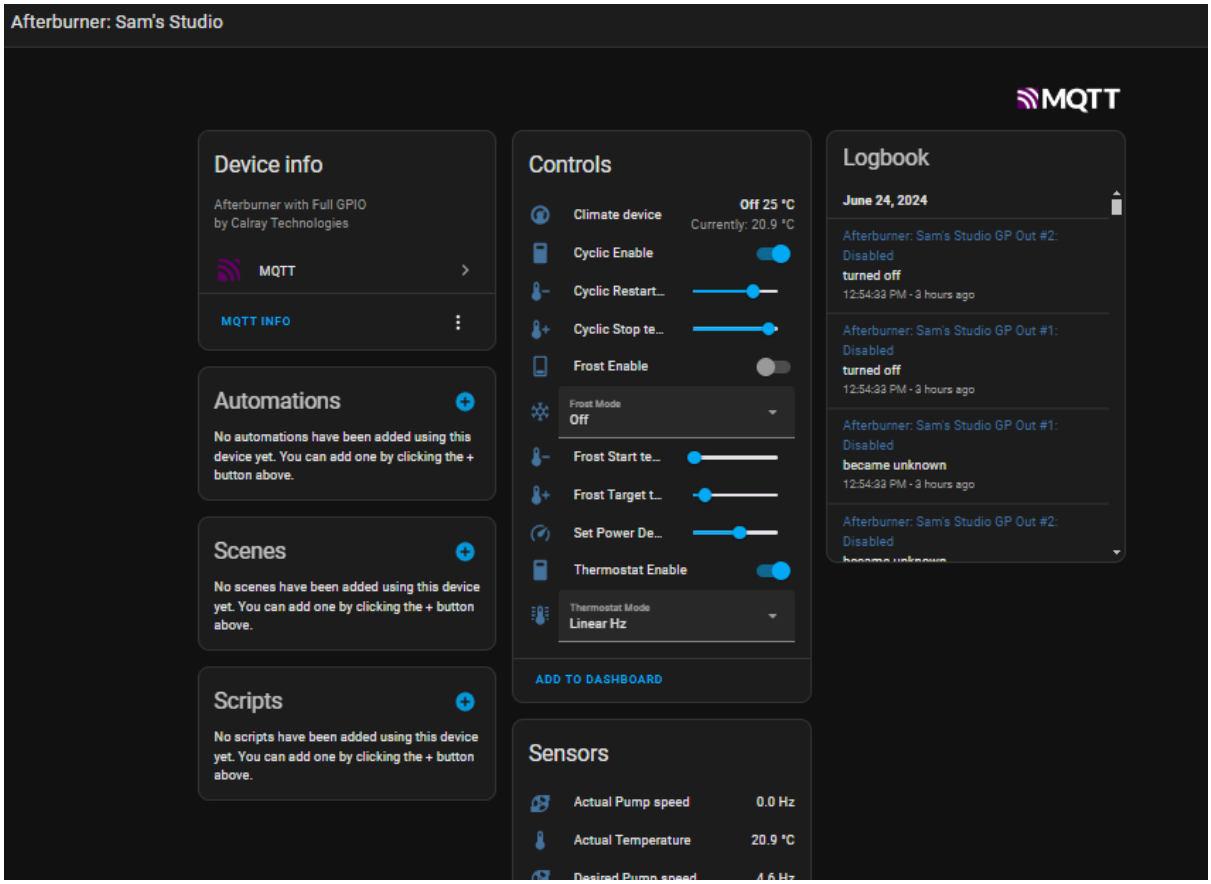
Opening the MQTT integration will then reveal available auto discoverable systems:



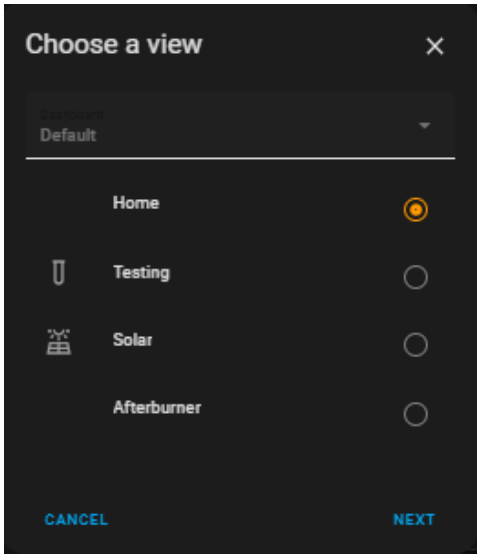
Device	Manufacturer	Model	Area	Integration
Afterburner:	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner:	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: ExpandaAB	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: Garage	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: Iveco	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: Sam's Studio	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: Transit	Calray Technologies	Afterburner with Fu...	–	MQTT
Afterburner: VanHeater	Calray Technologies	Afterburner with Fu...	–	MQTT

This is a good example of why giving your Afterburner a “system name” helps to better identify between multiple Afterburners, as shown here.
Note that the first two selections are unnamed, making it vague which unit they really are.

Continuing with the ***AfterburnerStudio*** example, we click upon **Afterburner: Sam’s Studio**.
The distinction here being “AfterburnerStudio” is the unique topic prefix, and “Sam’s Studio” is the system’s “friendly name”.

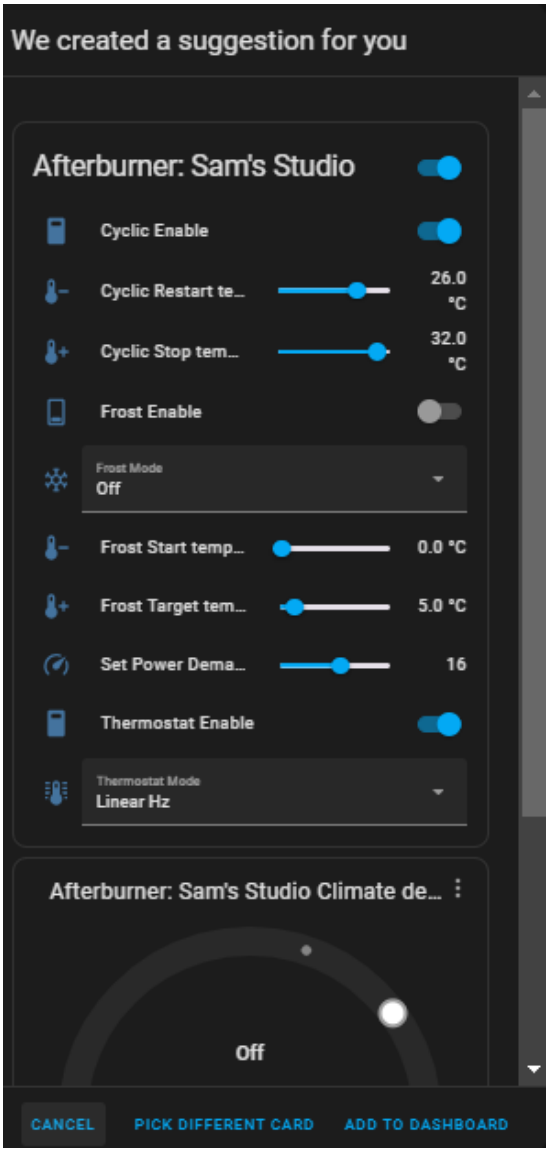


You then need to add the various panels to a dashboard that is then viewable via the Overview, by clicking upon “Add to Dashboard” at the bottom of each panel.



The provided Afterburner panels being

- Climate
- Sensors
- Diagnostic

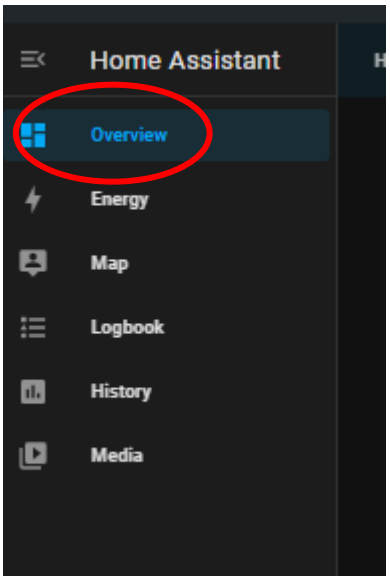


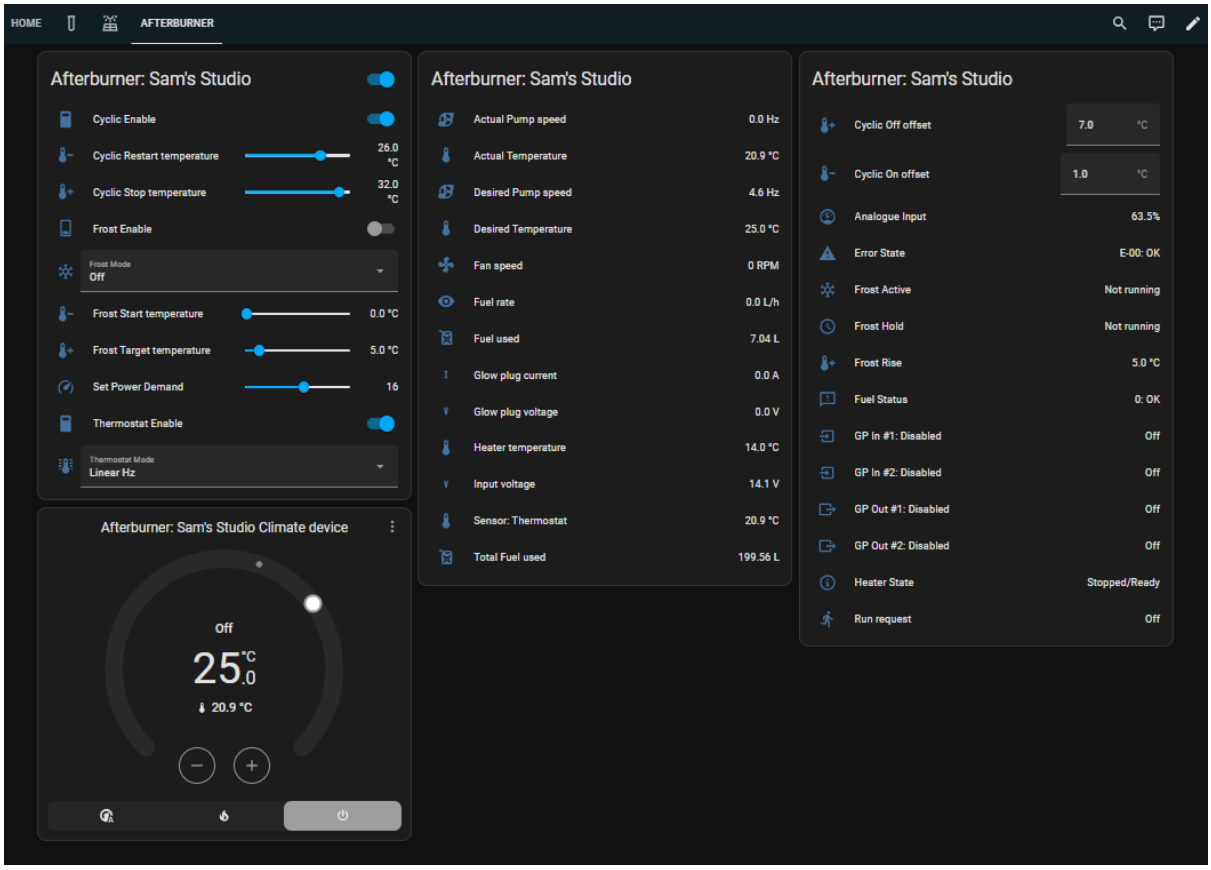
A suggested panel layout for the dashboard is presented, before ultimately adding it to the chosen dashboard.
You can also add new dashboards via the edit mode of Overview:

Use the default suggested layout in most instances.

Click upon **ADD TO DASHBOARD** at lower right.

Ultimately once all panels have been added to a dashboard, you can then view via Overview:

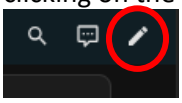




You may notice at the top of the climate panel, there is a switch, which is preferably not there.

This is the first exercise in editing the default panels to better reflect how you'd prefer them to appear.
You can of course remove other info you do not really desire to monitor, but for this purpose, we will remove that uppermost switch.

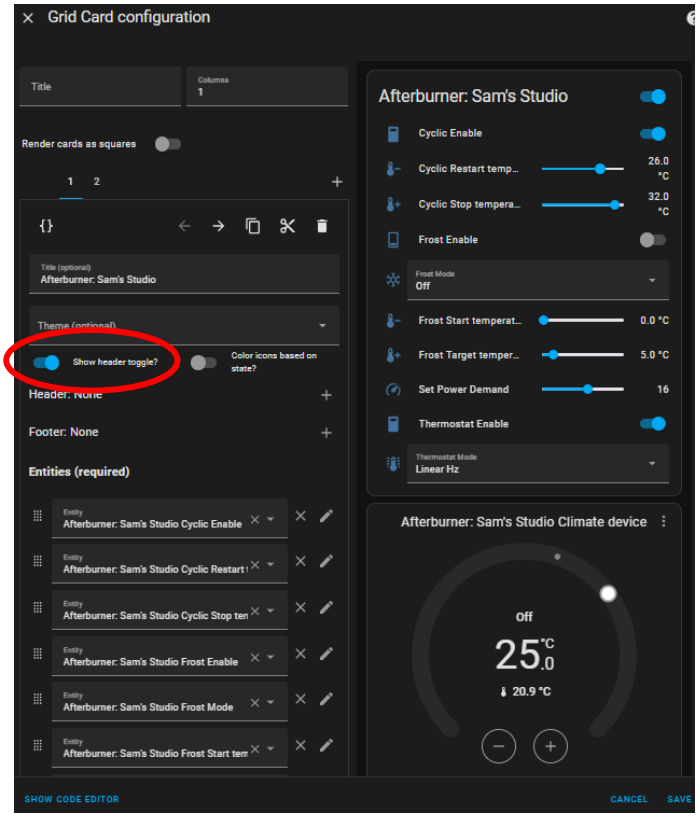
Enable editing of the dashboard by clicking on the pen icon (top right).



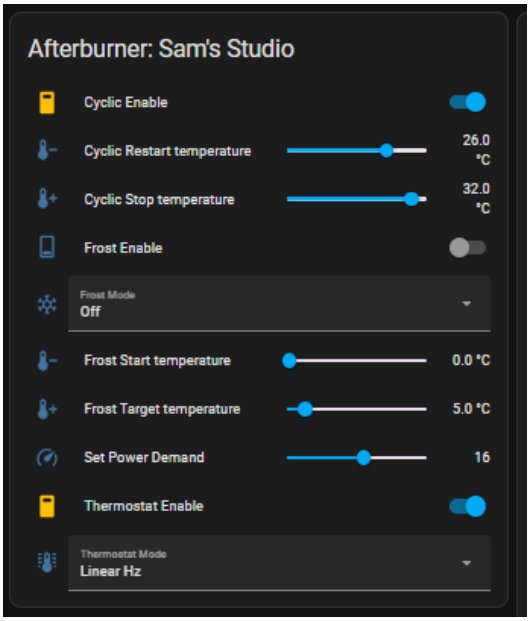
Then at the bottom of the climate card, click upon **EDIT** option that is now available.

You need to uncheck the "Show header toggle" setting.
You may also like using "Color icons based on state".

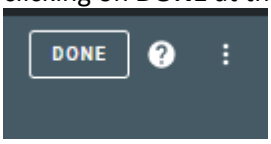
Finally **SAVE** at bottom right.



After hiding the header toggle and enabling Color icons based on state the climate panel will look something like this:



The final thing to do is leave editing mode, by clicking on **DONE** at the top right of screen.



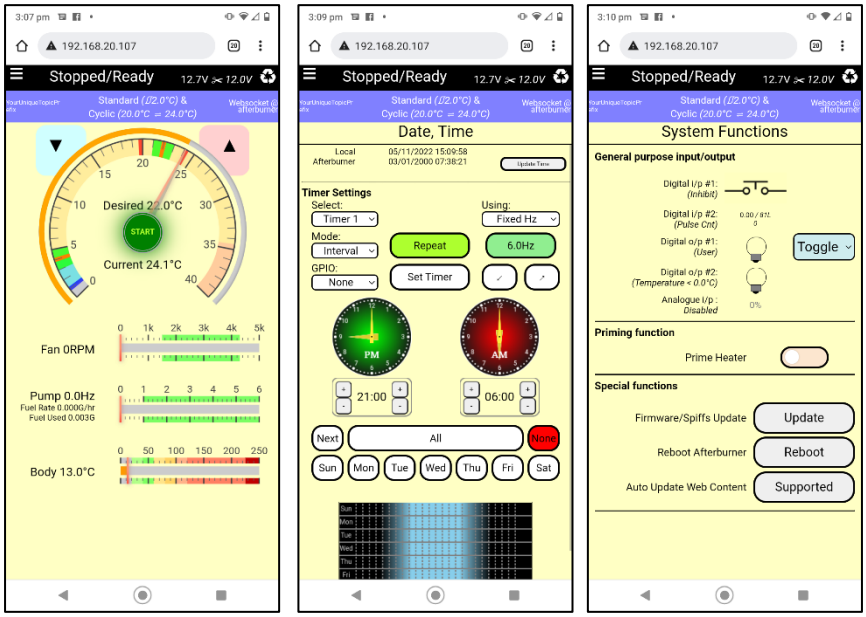
Further manipulation of the layout is up to user preference, but auto discovery allows a user to add an Afterburner to Home Assistant very easily.

Of course, once added, it can also be included in custom automations if desired.
There are endless possibilities.

Web interface

Heater Web Control

The primary purpose for WiFi connectivity to the Afterburner is to be able to control and monitor your heater via a web browser.



The first “home” page allows basic heater control; on/off, temperature demand, fuel reset.

To toggle thermostat mode, you need to use the Thermostat menu which you can conveniently access by clicking upon the central text field in the blue bar atop the screen or select Thermostat Mode from the “hamburger” menu.
On touch devices, you can also swipe left or right to switch between sequential pages.

Several menus are available via the menu “hamburger” at the top left:

- Home
- Thermostat, Cyclic Mode
- Frost mode
- Environmental Sensors
- Active Fuel mixture Settings
- Alternate Fuel Mixture Settings
- Date/time & Timer Settings
- System Settings
- System Functions
- System Details
- Comms settings
- Debug & Logging

Web page storage location

The web page is retrieved from a special File System partition in the ESP32’s FLASH memory.
As the partition is only ~180kB usable the file is saved as a compressed .gz file: index.html.gz
The web content is 100% independent to firmware and must be updated separately.

The file system contents can be updated by using the Afterburner's inbuilt **/update** web page. Details on how to upload are in the System updates section.

The Afterburner's ***Web Content Update*** menu in the ***System Settings menu loop*** can also be used to load the latest official release, provided STA WiFi is configured and connected.

The HTML content loaded by the browser simply provides the framework for the GUI presentation. All information is always exchanged over a websocket.

Web page as a websocket client

By default, the web page attempts to open a websocket to the same server as the page was loaded from, using port 80 or 81.

Over the websocket, the JSON encapsulated command and status information will flow.

Web page as an MQTT client

The web content can alternatively gather the JSON encapsulated command and status information via an MQTT broker, instead of a websocket directly from the Afterburner's web server.

Either method still uses a websocket, but the internal handling mechanisms alter.

On the Comms Settings page, the user can switch from sourcing the JSON data directly from the Afterburner's websocket server, or from an MQTT broker of their choice.

Afterburner MQTT configuration

To use MQTT, the Afterburner must firstly be setup to connect to and publish to a MQTT broker.

Once correctly configured, you will be able to access your heater wherever you have internet access!

Browser MQTT configuration

The web content can be directed to use the same MQTT broker via the web page's Comms Settings menu.

Remote Internet access

One of the great advantages of using MQTT is to hide Afterburner's web server from the Internet. This means you cannot load the web content directly from the Afterburner.

For convenience when using MQTT, you can instead load the web content from http://afterburner.mrjones.id.au/mqtt.html

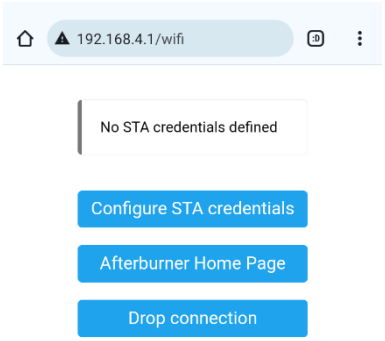
STA Configuration via /wifi URL

A STA configuration page is available via the **/wifi** URL

The served web page appears identical to the traditional STA configuration page but there are significant differences:

- The Afterburner does not have to be rebooted to use the /wifi web page.
- The Afterburner will not reboot after saving the STA credentials.
- A choice to return to the normal Afterburner web page is presented.

A new system will not have any pre-defined STA credentials, so the following page will be presented when first opening /wifi:

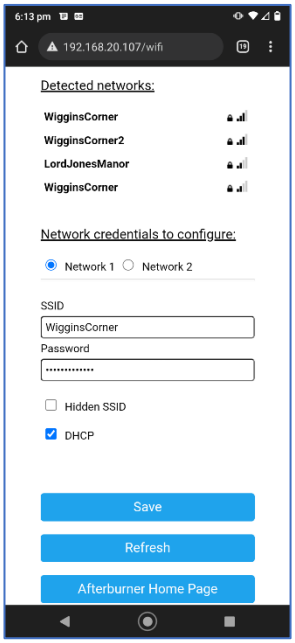


Configure STA credentials web page

Upon first entry, the Afterburner scans across all WiFi channels, detecting which Access Points are available nearby.

This delays the initial presentation of the WiFi configuration page.

Once the WiFi scan is completed, the list of available access points is presented:

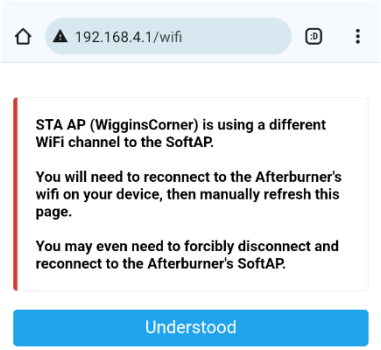


Basic Usage

- Click upon the SSID for your network.
- Enter the password for that network.
- Define a static IP if required by deselecting DHCP.
- Press **Save.**
    - The SSID credentials are saved.

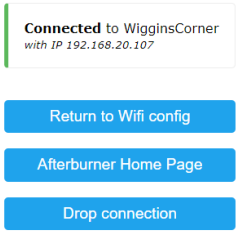
- It is highly likely the chosen Access Point will be using a different channel than the Soft AP is presently using. If that is the case, as the ESP32 only has a single radio, the Soft AP must be shut down, and restarted on the same channel as the proposed Access Point.

    - This necessitates the device has to be reconnected to the Afterburner's SoftAP to see the result of the STA attempt.



- The Afterburner scans for available networks.
- The strongest known network SSID is chosen, based upon signal strength.
- An STA connection attempt is made to the chosen router.

- The result of the process will be observable upon the subsequent /wifi web page.



If a STA connection is successful, the web server connectivity is then available via:

- The Afterburner's inbuilt access point (192.168.4.1, when connected to SoftAP).
- The STA IP address that was given by your router (shown on the /wifi summary).

These IP addresses are also visible via the OLED's WiFi Settings menu, beside the **AP:** and **STA:** entries, respectively.

Note that to use the IP address of 192.168.4.1 you must be connected to the Afterburner's access point.

Advanced Usage

Second SSID

- A second SSID can be defined.
- Switch between sets of credentials by selecting **Network 1** or **Network 2.**
- Each set independently holds the proper settings.

Hidden SSID

A router with a hidden SSID will not appear in the WiFi scan's list of available AP's.

You can select the **Hidden SSID** checkbox and specify the name in the SSID field.

When the Afterburner scans for WiFi networks, it will explicitly request the hidden SSID.
If present, the SSID will then appear in the WiFi scan results and hence become connectable.

If two SSIDs are defined, and either are marked as hidden, the WiFi scan is repeated.
A scan is explicitly performed for the hidden SSID, it's the only way an AP using a hidden SSID can be located.
This will typically double the time needed to set up a STA connection.

Whilst a hidden SSID may at first appearances be a way to hide your access point, it is flawed due to any client needing to connect needs to broadcast the SSID anyway.

Illicit eavesdropping can soon determine the name of a hidden SSID due to this aspect.

System updates: /update URL

The inbuilt /update URL allows the user to upload:

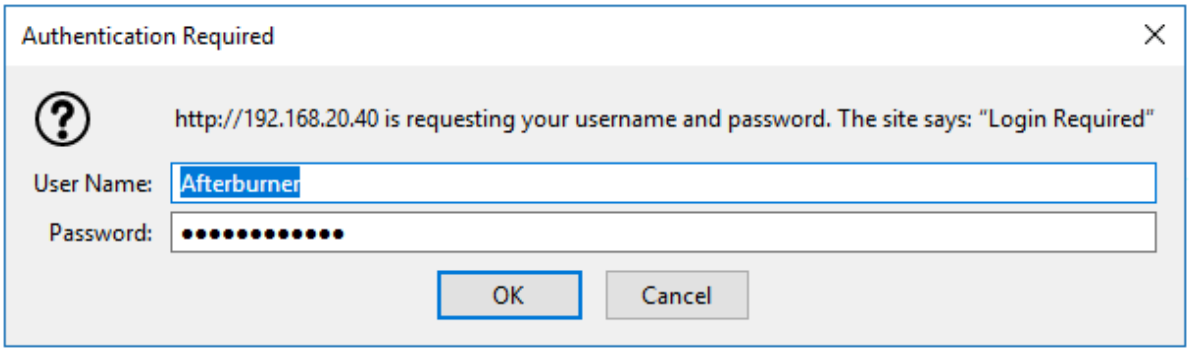
- New firmware
- New Web content

Opening /update

Using a web browser, open the Afterburner's /update web page.
Note the Afterburner can be accessed using the inbuilt access point (192.168.4.1) or via a WiFi network, supplied both devices are registered on the same WiFi network.

Browse to the Afterburner's IP address, e.g., if using SoftAP mode http://192.168.4.1/update

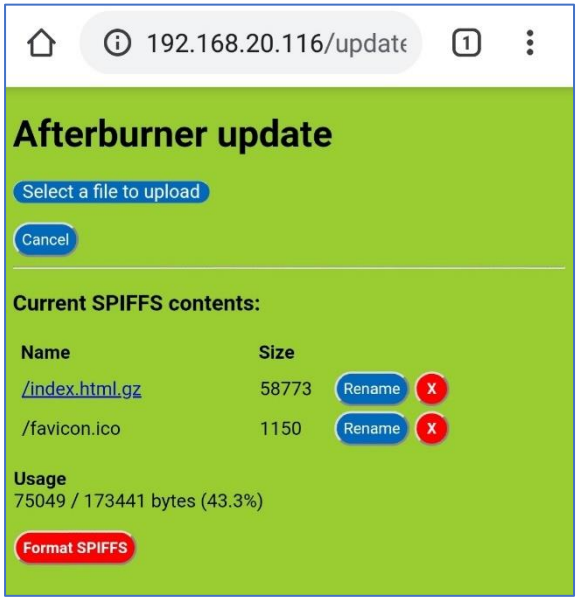
This will then present a password confirmation page:



The required credentials are:

- Username: **Afterburner**
- Password: **BurnBabyBurn**

The following screen should then be presented:

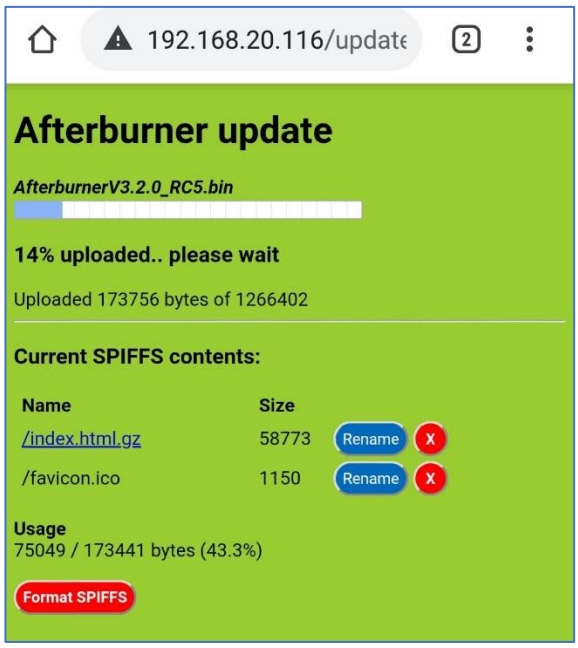


Firmware update

Download the desired **pre-compiled firmware (binary image)** from http://afterburner.mrjones.id.au/firmware.html and save to the local PC, or even mobile phone. The new firmware file must end with a .bin file extension.

Click upon **Select a file to upload** and locate the binary image previously downloaded from http://www.mrjones.id.au/afterburner/firmware.html.

Click upon the throbbing **Upload** button to start the upload of new firmware to the Afterburner. The Afterburner display will show progress, as will the web browser:



Once the download completes, the checksum is verified and the system reboots into the new firmware.

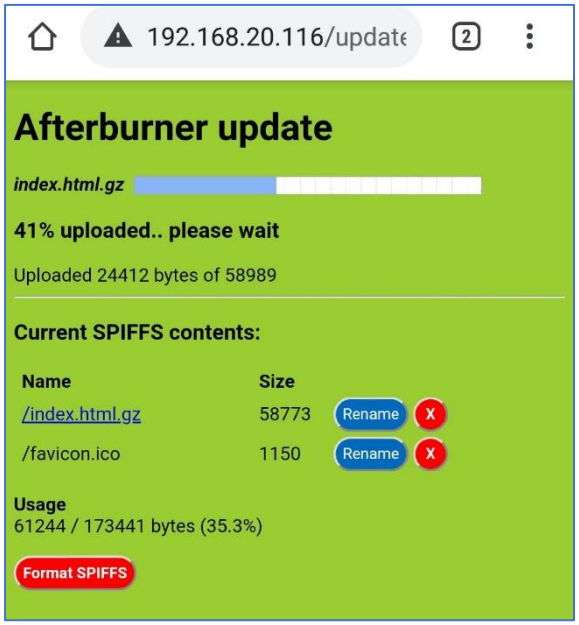
Should the download fail, the Afterburner still reboots, but the existing version will be kept.

File system uploads (web content update)

/update can also be used to upload new web page content to the File System partition.

The same procedure is followed, but instead of selecting a binary image, select the new *(typically index.html.gz compressed HTML web page content)* file to upload:

/favicon.ico is a small icon file used by the browser, typically placed in the tab of the browser.



Debug menus

Debug Menu system

The debug menu system, as the name suggests, is primarily a way to monitor debug information from the system, that may be of possible assistance when encountered unexpected behaviour.

By default, debug information freely flows once connected to a debug port.

The debug port can be:

- The Debug Serial Port within the Afterburner (3.3V, non buffered UART).
- A telnet connection via WiFi to the Afterburner.
- The web content also allows access to the Debug Menus, and possibly can be used to capture debug logs. The browser does require an experimental flag “File System Access” to be enabled to allow logging. Some Chrome based browsers may support this.

Debug Serial Port

The Debug Serial Port is directly connected to the ESP32’s “UART0” peripheral.

The serial port is configured with the following UART parameters

- 115200 baud
- 8 data bits, no parity, 1 stop bit

In normal operation, debug information will be visible with no prompting required.
It simply streams as required.

The Debug Serial Port is raw 3.3V logic.
It should not ever be connected to a true RS-232 serial port (typ. +-12V signalling)

There are various “USB-Serial” adapters available that can be used.

The FTDI base FT232-RL module is a popular choice, as pictured.

An advantage of this module is the data signals can be set to be 3.3V, not 5V, levels, preventing any potential damage to the ESP32.
The 3pin header beside the 6 way interface is used to set 3.3V or 5V operation.

The Afterburner PCB’s Debug Port is pinned to directly connect to this type of USB adapter.

The transmit and receive signals are marked as “Tx” and “Rx” on each PCB. These markings refer to the signal as it applies to **that** PCB.
“Tx” is the signal leaving the PCB, “Rx” is the signal arriving at the PCB.
This means when connecting the module to the Afterburner’s header, “Tx” connects to “Rx” on the counterpart PCB.

“Dupont leads” are commonly used to create the bridge between the PCBs as both the Afterburner and USB adapter both use male pinned headers. If a socket were on the USB adapter it would be able to plug directly onto the Afterburner *(matching 0V with 0V (GND))*, so please bear this in mind when connecting the leads and do not “crossover” Tx and Rx signals.

Firmware updating via Serial

In desperation, you can also use the Debug Serial port to upload firmware to the ESP32.

Prior to upload, the Afterburner must be prepared by holding the BOOT switch whilst exercising the EN switch. This will start the inbuilt bootloader that can interact with the "ESPtool" application that is used to upload new firmware.

Telnet

A telnet connection can be established to the Afterburner, via WiFi, using a suitable application on a PC.
A popular choice for a Windows PC is PuTTY, which can support serial or telnet connections.
https://www.putty.org/
There are also derivatives of PuTTY that you may prefer.

The telnet connection can function over the Afterburner's inbuilt Soft AP or STA wifi connection.

The telnet port is the usual port 23, at the appropriate IP address of the Afterburner.

Whilst the debug information produced by the Afterburner firmware is available via telnet, some system debug information ONLY appears via the serial port.
The serial port can always be used to collect debug information (e.g. from a rebooting system) but telnet relies upon the wifi system being able to operate, which of course requires stable operation.

Web content

The "Debug and Logging" page of the web content certainly allows access to the Debug Menus.
Actual debug logging is typically dependant upon a special experimental flag being set in the browser to enable "File System Access". Browsers typically sandbox your file system and prevent the saving of generic local files. File downloads from a server though are of course normally supported.

Debug logs

In either instance, once a connection is established, debug information freely flows.
A telnet connection receives the prior ~8kB of log data upon the initial connection.
A serial port only receives any fresh debug information.

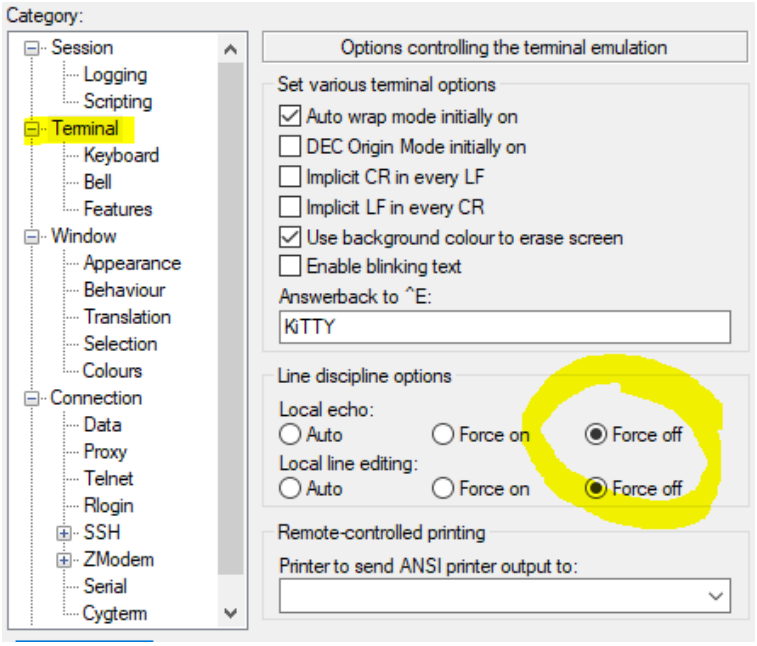
Capturing debug logs can be a useful way to post inspect the information spat out by the Afterburner.

Client configuration for interactive access

It worth ensuring your client software is configured correctly for successful interaction with the Afterburner's debug menus.

Notably for PuTTY clients:

- Disable line editing
- Disable local echo



Once connected, the debug menus can be directly accessed if you know which menu you wish to exercise, or simply hit <Enter> to observe the available menus.

```
ROOT MENU COMMAND OPTIONS
=========================

wifi   - setup wifi
mqtt   - setup MQTT parameters
reset  - reset usage counters
debug  - debug functions
secure - set passwords etc
start  - start qualification
option - special options
bobil  - enable and configure Bobil Manager
```

wifi

Allows configuration of:

- Soft AP's advertised SSID & password
- Defining credentials to connect to a wifi network
  - Two sets of credentials can be entered.
- Defining Fixed IP address if required
- Configuring assorted advanced wifi related options
  - Scan Dwell time
    - How long the systems scans each wifi channel for available STA APs.
      It is recommended this is at least twice as long as the typical beacon time used by the specific AP of interest.
  - Gateway ping timeout
    - Can be used to force an STA reconnection if the gateway of the host network becomes unreachable.
  - STA loss holdoff

        - Delay undertaken before rescanning for available STA Aps upon loss of an STA connection.
    - STA auto rescan
        - Allow rescanning of available Aps whilst already connected, optionally switching to a stronger AP.
        - Define time period between rescans
    - SoftAP bandwidth (20 or 40 MHz)
        - The Soft AP's bandwidth will follow that of the connected STA AP.
        - When STA is not connected, define the bandwidth the Soft AP should use.
        - Congested wifi areas will likely have problems when set to 40MHz.
    - Maximum Tx power
        - The maximum power transmissions from the Afterburner will use.
        - Using too high a power may lead to undesired distortion of the RF signal and be worse rather than better.
    - STA Password visibility in logs
    - Sleep mode
        - Using sleep mode will lower power consumption, but responsiveness of wifi will suffer, leaving sleep disabled is recommended.

mqtt

- Allows configuration of an MQTT broker connection
    - IP address
    - Port (must be TCP MQTT port)
    - Optional Username/Password
    - Unique topic ID prefix
    - Quality of Service (recommend 0)
    - Ping Interval
        - Automatic publish of a ping message, expecting the broker to echo it back. Failure to respond will cause an mqtt reconnection.
    - PIN
        - Defining a PIN scrambles the topics and payloads, making it more secure when using a public broker.
        - **A PIN cannot be used with Home Assistant**
- Home Assistant integration options
    - Specify the auto discovery topic your Home Assistant installation is using (typically 'homeassistant')
    - Enable publishing of auto discovery topics from the Afterburner.

reset

- Reset hour meters
- Reset fuel usage
    - Current estimation
    - Total accumulated usage
- Reboot the Afterburner
- Defragment Non Volatile Storage (NVS) used to store persistent configuration items
    - Excess fragmentation can lead to inability to save configuration changes.
- Factory Default
    - Reset the NVS to a virgin configuration.

- **All settings are lost**

debug

Special options to enhance debug data collection and many are not much use for mere mortals, but useful to the developer at rare times

The following may however be useful at times

- JSON reporting
  - On by default, but can be disabled to remove these messages from view if desiring a clearer log capture.
- Monitoring of actual data traversing to/from the heater ECU
  - Set the terminal width wider to collect the entire line without wrapping!
- Report NVS contents
- Report wifi scanning

secure

- Add or define passwords
- Alter Bluetooth ID / PIN

start

Start qualification options

option

- Protocol mode
  - Alters parts of the protocol data sent to the heater. Experimental!
    - Knob or LCD, forced 0m is recommended.
- Heater comms dead-man
  - If an E-07 “Comms Error” persists longer than this, reboot the Afterburner.
- Use MOSFET instead of active devices for heater interface, only for experimental use.
- User interface
  - SH1106 OLEDs require a 2 pixel sideways shift, others do not.
    Switching this option should clear noise bands at left edge (non SH1106) or lost right hand edge (SH1106)
  - Keypad orientation
    - Landscape orientation of unit with screen to left or right.
- Thermostat resolution
  - 0.5 / 1.0 °C demand steps (64 levels)
  - Minimum settable temperature.
- System name
  - Especially useful for multiple units via MQTT, and Home Assistant
- Retries - with care
  - Auto restart after E-08 (flame out)
  - Auto restart after E-10 (failed to start)
- Download and install latest (STA wifi required)
  - Release firmware
  - Beta firmware
  - Beta web content

bobil

Special GPIO output mode control, for potential integration with a Bobil water heater attachment

- Target water temperature
  - Hysteresis between stopping and restarting heating of water
  - Start threshold
    - Difference between water temperature and heater body temperature to divert heat towards heat exchanger.
- Mode

  The bobil mode can also be altered via the Start pop menu, but cannot be disabled. It can only be disabled or initially enabled here in the debug menus.

  - Disabled (Normal GPIO)
  - Heat air only
    - Divert airflow away from heat exchanger
  - Heat water and run
    - Divert heat toward heat exchanger until water is hot, then divert to direct air heating
  - Heat water and stop
    - Divert heat toward heat exchanger until water is hot, then stop the heater
- Servo Positions
  - Divert heater to heat exchanger
  - Divert heat away from heat exchanger

Heater Operation Overview

Much of the heater operation is entirely at the behest of the ECU mounted within the heater body.

The ECU constantly monitors the running conditions of the heater and may throw faults when conditions are not as expected.

The ECU reports in which “run state” it is presently operating.

Heater operation sequence

Startup

The startup sequence of the ECU is autonomous and progresses through these run states:

1. Heating glow plug
2. Igniting
3. Ignited
4. Running

The Afterburner has no control during the startup sequencing.

It can however request the ECU to stop the heater, and the ECU will switch immediately to the shutdown sequence.

Running

Once fully ignited and running, the status of the ECU changes to "***Running***".
This indicates the system is now obeying the user's desired power demand.

Only once “Running” state is achieved does the ECU accept power demands from the Afterburner.

Shutdown

Once again, like startup, the shutdown sequence is autonomous and entirely controlled by the heater’s ECU.
The sequence being:

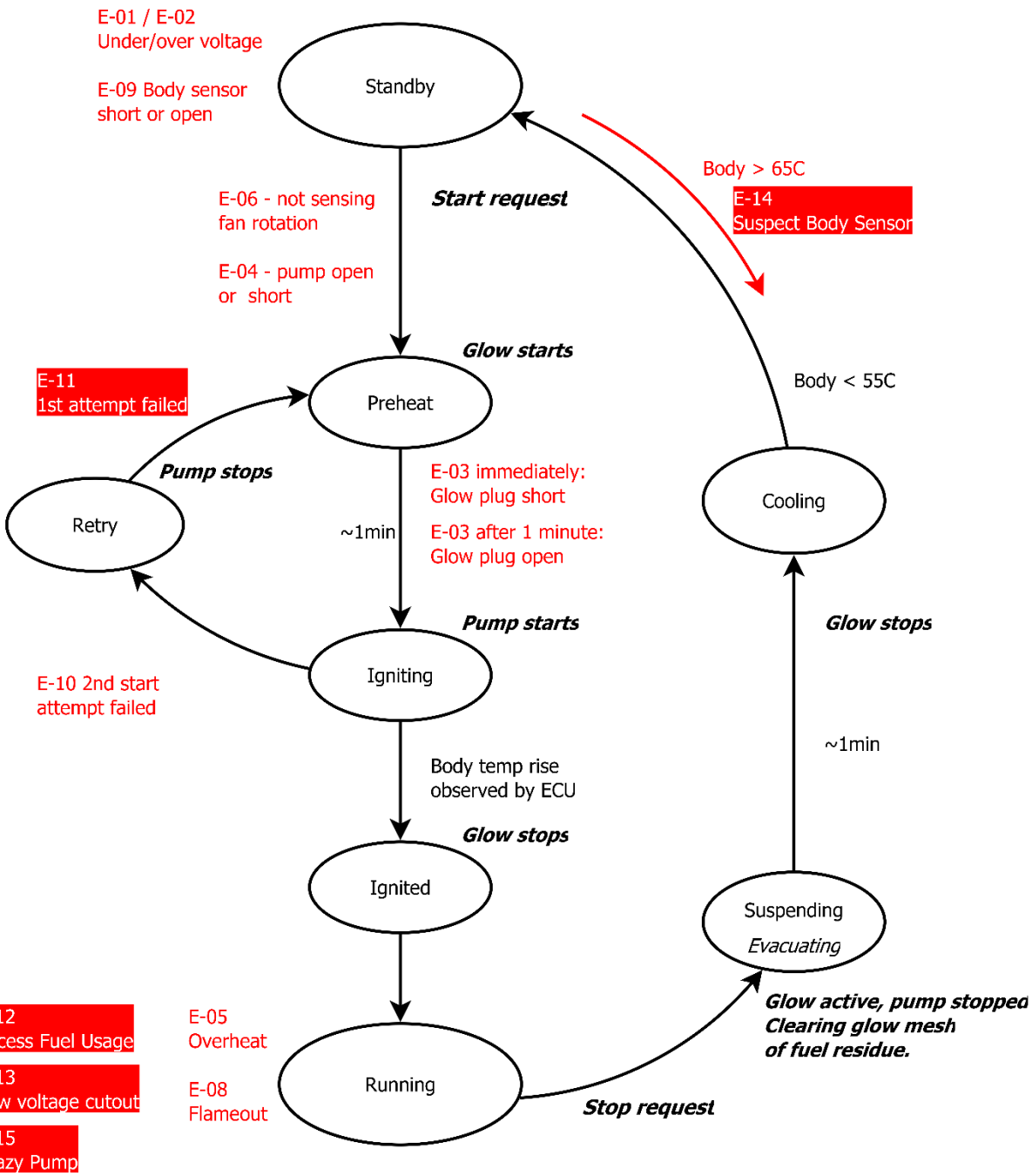
1. Shutting down.
2. Cooling.
3. Stopped/Standby.

During the initial shut down interval, the ECU stops the fuel pump and energises the glow plug.
The glow plug is heated to ensure that the mesh that does surround the glow plug has no remnants of fuel remaining.
Any remaining fuel may congeal to wax, clog the mesh, and make the following start difficult to achieve.

The following cooling phase continues to run until the ECU determines the body temperature of the heater has fallen below 55°C.

It is not possible to restart the heater until the entire shutdown sequence is completed.

Typical ECU flow of operation



Error Summaries

RED TEXT Indicate faults thrown by the ECU, and when they typically occur.
Faults like voltage, fan or pump can happen at any time other than standby.

Inverse RED TEXT Indicate faults created by the Afterburner, based upon ECU status values, and are when they typically would be thrown.

Errors are cleared when a fresh start request is created but may well return if the fault persists.

Fault Codes

ECU faults - up to E-10

- **E-01: Undervoltage**
  - The ECU has detected an undervoltage (input voltage) condition.
  - Check ECU is configured for the correct system voltage.
    - Likely Remedy: Deliberately switch to 24V, save, then back to 12V saving again (or vice versa).
- **E-02: Overvoltage**
  - The ECU has detected an over voltage (input voltage) condition.
  - Check ECU is configured for the correct system voltage.
    - Likely Remedy: Deliberately switch to 24V, save, then back to 12V saving again (or vice versa).
- **E-03: Glow plug fault**
  - The ECU has detected either a short or open circuit of the glow plug.
    - E-03 immediately => short circuit
    - E-03 after ~ 1minute => open circuit.
- **E-04: Pump electrical fault**
  - The ECU has discovered an electrical issue with the pump circuit.
    - Check the plug is fully seated, check no wiring shorts to chassis!
- **E-05: Overheat**
  - ECU has decided the heater body temperature is excessive whilst running.
    - Check the airflow into / out of the heater is not obstructed!
- **E-06: Fan Fault**
  - ECU is not sensing that the fan is rotating.
    - Make sure the ECU is correctly mounted in the heater.
    - Check the hall effect sensor on the ECU is correctly located in its housing.
- **E-07: Comms Fault**
  - Communications between the Afterburner and the heater is failing.
    - Check the wiring is intact, unplugging / re-plugging all connections may benefit.
    - Ensure no other device is producing EMI that may be corrupting the digital data stream.
- **E-08: Flame Out**
  - The ECU has detected the heater has cooled down unexpectedly.
    - Check fuel delivery, no air trapped in fuel line.
    - Check heater is correctly tuned and not full of soot!
- **E-09: Body sensor**
  - The ECU has detected the heater body sensor is faulty, either open or short circuit.
    - Ensure the sensor is correctly plugged into the ECU.
- **E-10: Ignition Fail**
  - The ECU has made 2 attempts to start the heater but failed.
    - Check fuel delivery, no air trapped in fuel line.
    - Check heater is correctly tuned and not full of soot!
    - Ensure input voltage stays reasonable during start, not falling excessively. Typically, >12V recommended.

Afterburner faults - beyond E-10

- **E-11: First Ignite Fail**
  - The Afterburner has detected that the ECU has failed its first start attempt.
    - The ECU will automatically try a second time.
- **E-12: Excess fuel usage**
  - The Afterburner has determined fuel usage since the last reset has exceeded the tank volume specified by the user.
    - New starts will be denied unless the fuel usage is reset.
- **E-13: Low Voltage Cutout**
  - The Afterburner has sensed the reported ECU voltage has remained beneath the user defined cut off voltage for the required period of time.
- **E-14: Suspect Body Temperature Sensor**
  - The Afterburner has observed the ECU unexpectedly shift from “Standby” to “Cooling” states.
    “Cooling” should only ever follow “Shutdown”.
    - Cause: a faulty heater body temperature sensor that is reporting an incorrectly high reading (>65°C) when cold.
- **E-15: Crazy Pump**
  - The Afterburner has detected the ECU reporting an “in use” pump rate 20% greater than the defined maximum rate.
  - This is a rare fault of the ECUs, so a precautionary shutdown of the heater has occurred to avoid filling the heater with excess fuel (and smoke clouds etc).

GPIO Interface

Afterburner PCBs can be fitted with extra input and output conditioning circuitry to allow the ready addition of external switches or status indicators/relays.

GPIO Expansion port

A 7-pin JST PH header is provided to allow

- 2 contact closure inputs
- 2 open collector outputs
- 1 analogue input
- 5V Power & 0V (ground) sources

Wire Colour	Purpose
Blue	Digital input #1
Green	Digital input #2
Orange	Digital output #1
Yellow	Digital output #2
White	Analogue input
Red	Power, +5V (from heater ECU)
Black	Ground, 0V

NOTE: the PCB header locations of 5V, 0V and the Analogue input shifted locations on production PCBs from hardware version V3.5 onwards.
The flying lead supplied with a unit is correct for the unit supplied.

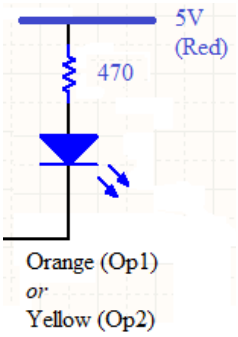
The 5V output (red wire) incorporates a 200mA polyfuse and a blocking diode to prevent back powering the ECU.

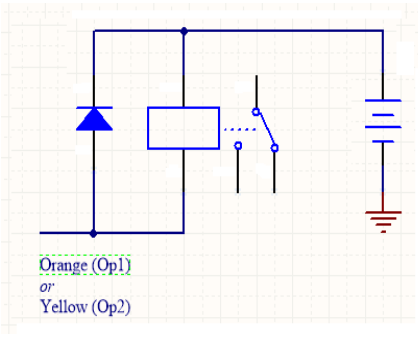
Each GPIO output includes a series 100mA polyfuse to help protect the transistors from inadvertent shorts of the GPIO outputs to a power source.

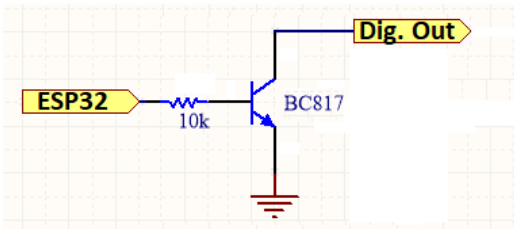
The GPIO inputs include diode blocking and clamping of external voltages.
The input signals are only intended to be switch closures to the provided 0V signal.

Digital Outputs

Orange or Yellow wires







Afterburner digital output circuitry

User furnished equipment: Driving an LED

User furnished equipment: Driving a relay.
The diode must be included to prevent back EMF damaging the transitor insiode the Afterburner.

The 2 digital outputs are offered as open collector devices.
An open collector can only provide a path to ground when active.
When inactive, the impedance is high and current cannot flow to ground.

The load can be a 12V device, eg: relay, if desired.
The sink current should remain less than 50mA in most instances.
The 0V of a 12V source must share the same ground as the heater's power supply.

No protection against inductive loads is present on the Afterburner.
External diodes or similar quenching devices must be used with inductive loads, e.g. relay coils.

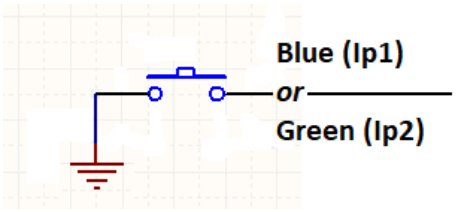
When driving a relay, a diode must be installed across the relay's coil as shown to manage the back EMF when the relay is turned off.
Not doing so may harm the open collector output with the excess voltage spike generated as the magnetic field rapidly collapses.

It is important to understand that the GPIO outputs do not produce a voltage.

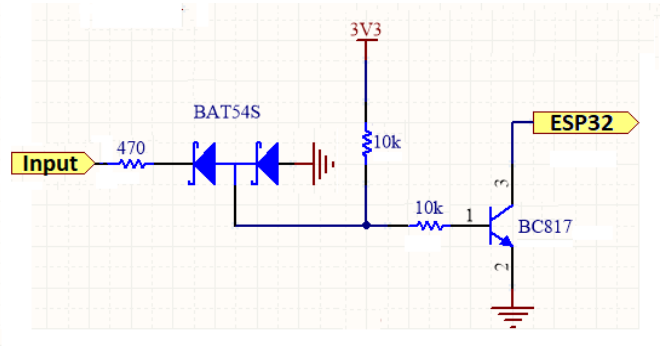
Visibility of the signal is only possible once some form of load is attached, to a power supply that shares the same 0V as the heater system.
This may be as simple as a resistor from 5V to the GPIO output

Digital Inputs

Blue or Green wires.



: User furnished equipment



Digital Input circuit of production Afterburner

Digital Input Functional description

A digital input is considered as being active when the external pin is connected to the same 0V reference used by the Afterburner.

As the production PCBs use an input transistor the input is inverted to a high level at the ESP32.

During initial birthing (or factory reset), the PCB version is identified so the correct digital input behaviour occurs for either the prototype or production PCBs, so a 0V input is always considered as an active input.

Digital Input technical summary

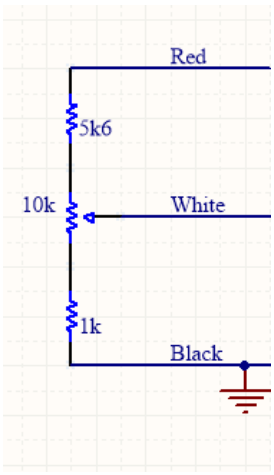
Diode array:
Blocks positive external voltages.
Shunts negative external voltages to 0V.

The external input is pulled up by the 10kΩ resistor; transistor conducts, a logic 0 is present at the ESP32 input.
A contact closure to 0V on the input prevents the transistor conducting, creating a logic 1 at the ESP32 input.
(ESP32 uses internal pullup)

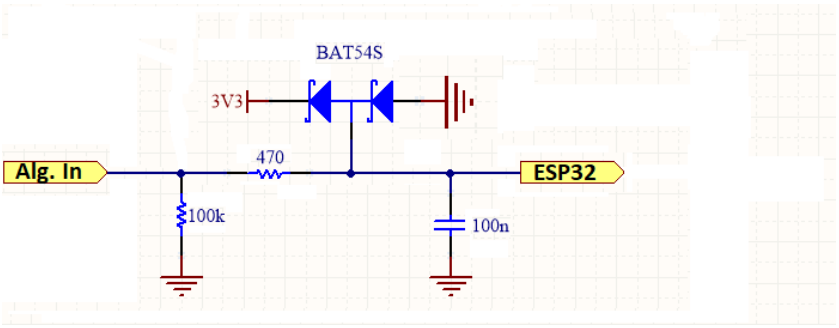
An open input typically presents ~1.9V at the input pin.

Analogue Input

White wire



Suggested input circuit for a potentiometer



Analogue input circuit of the production Afterburner

Analogue Input Functional description

The ESP32 analogue input accepts a voltage in the range from 0.0V to 3.3V.
The power supplied from the Afterburner on the GPIO connector is 5V so if using a pot you must pad the top end with a resistor to limit the maximum expected voltage, as shown above.
Note that there are clamping diodes in the input circuit, but these are a safety feature and should not be relied upon.

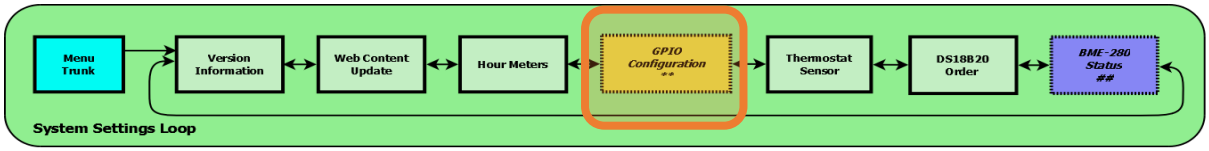
Analogue Input technology summary

Diode array clamps to 3.3V or 0V.

100k pull down only exists on V2.1+ PCBs.

Series 470Ω resistor limits clamping current via diodes, and plus minor filtering with 100n capacitor.

GPIO configuration *(User Settings menu loop)*



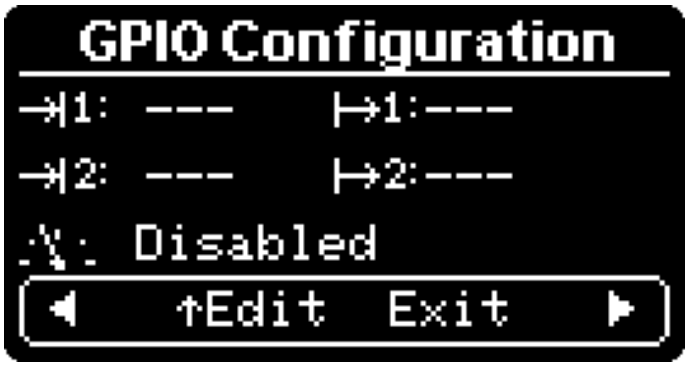
The GPIO Configuration menu is found in the ***System Settings menu loop*** and is only made available if GPIO capability was detected on the PCB.

You can jump directly to the ***GPIO Configuration*** menu from the ***Root menu's GPIO Status*** menu by pressing **UP** or **DOWN**.

You can return directly back to the ***Root menu's GPIO Status*** menu by pressing **DOWN** or **CENTRE** when on the base, menu selection line.

The ***GPIO Configuration*** menu only appears if GPIO hardware has been installed to the Afterburner PCB.

The assignment of GPIO functions is via this menu:



The upper 2 left hand entries show the input mode of the 2 digital inputs.
The upper 2 right hand entries show the output mode of the 2 digital outputs.
The 3rd line shows the analogue input mode.

The GPIO signal to be configured is selected by using the **UP/DOWN** keys.
The mode is then changed by using the **LEFT/RIGHT** keys.

Some modes have a further option, in which case a long hold of the **DOWN** key will allow you to switch focus to the extended parameter(s).

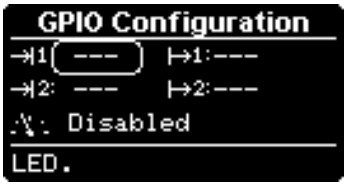
Digital Input configuration

Input #1: Blue wire, Input#2: Green wire

The 2 digital inputs can be independently configured as:

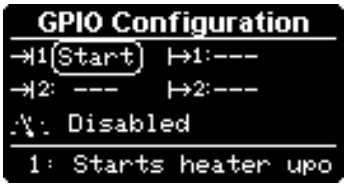
- Disabled
- Start
- Stop
- Start / Stop
- Run
- External Thermostat
- Zero Fuel Usage (reset)
- Maximum Power
- Pulse Counter
- Permit Start
- Inhibit Start
- Timed Run

Disabled



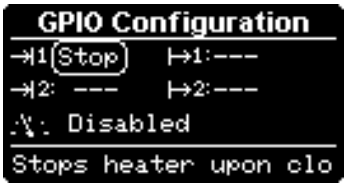
Fairly obviously, no action takes place when an input is disabled.

Start



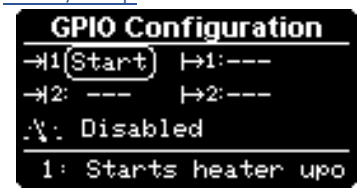
A momentary closure of the input starts the heater.
If the input is held closed for 1.5s or more, the heater will be stopped if it is running.
This mode may be useful for those wishing to use a GSM relay to start or stop the heater.
By generating appropriately timed pulses (eg 1 second or 2 seconds) a single input can be used to start or stop the heater via a single input.

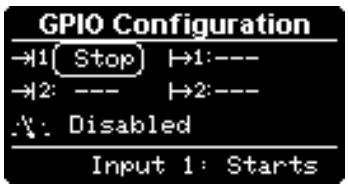
Stop



Stop mode stops the heater upon a momentary closure of the input.

Start / Stop



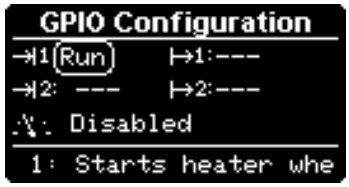


Start / Stop mode will show Start & Stop alternating in the selection field, hence the twin image shown here.

Upon a momentary closure of the input, Start / Stop mode will either start the heater or stop the heater, according to the current state of the system.

No time sensitivity exists.

Run

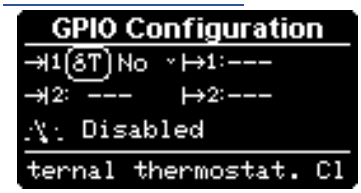


The heater will run whilst the input remains closed.

If opened the heater will be requested to stop, performing the usual shutdown sequence.

An example usage may be using a conventional “dry contact“ furnace thermostat, with the heater starting and stopping according to the condition of the thermostat’s output.
Bear in mind it takes over 5 minutes to start the heater, and a couple of minutes to shut down the heater.

External Thermostat



This mode is specifically intended for use with an external “dry contact“ thermostat.

When the contact is closed, the heater will be made to run at maximum power. When the contact is open the heater will be made to run at minimum power.

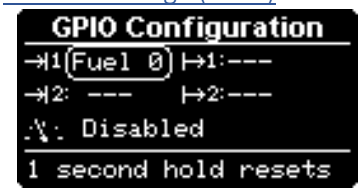
If the heater is off upon the initial closure, it is requested to start.

Additionally, a timeout can be associated with this mode.
If the contact remains open longer than the selected time interval, the heater is requested to stop.

This allows operation solely using the wall thermostat. Initial operation will see the heater start, then cycle according to the setting. Finally disabling the thermostat will see the heater eventually stop once the timeout elapses.
If the timeout is set to zero, the heater will always run unless commanded to turn off.

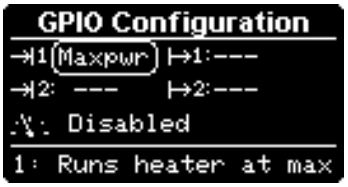
The hold time adjustment is accessed by holding down the **RIGHT** key for a second or more.

Zero Fuel Usage (reset)



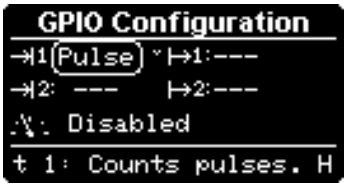
This input allows a switch to be mounted nearby the fuel tank, to be used to reset the accumulated fuel usage when the tank is re-filled.
If the input is held closed for longer than 1 second, the fuel usage counter is reset.
Resetting the accumulated fuel usage is important if you are using the Excess Fuel Usage shutdown feature to avoid running the tank dry, which usually requires the fuel line to be re-primed.

Max Power



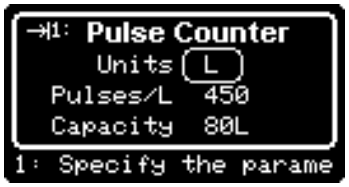
When the input is closed, the heater will be asked to run at maximum power.
If the heater was stopped, it will be started.
Upon the input opening, the heater will return to the state it was in prior to the input closure, ie standby, or normal running.

Pulse Counter



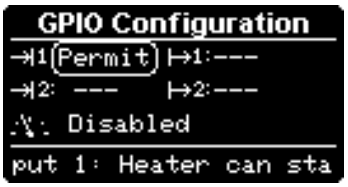
Input pulses can be counted.
The typical usage being intended for water flow meters.
Typical units have a specification of 450 counts / litre.

Holding the **RIGHT** key for longer than a second allows the calibration to be defined.



The pulse count will only be retained until the next Afterburner reboot unless a I2C EERAM chip is added to the system. A TL4704 is recommended for this.
As the Afterburner does employ a watchdog timer, this is a recommended precaution.

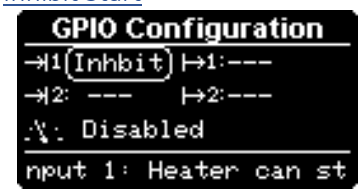
Permit Start



The input must remain **closed** to allow the heater to start and keep running.

If the input is opened whist the heater is running, the heater will be requested to shut down.

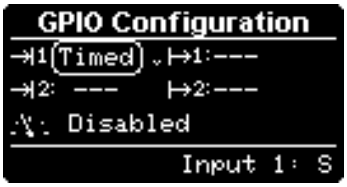
Inhibit Start



The input must remain **open** to allow the heater to start and keep running.

If the input is closed whist the heater is running, the heater will be requested to shut down.

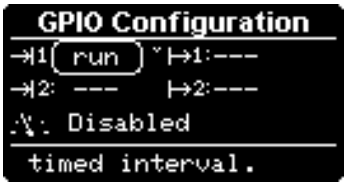
Timed Run



Closure of the input will start the heater.

It will continue to run until the associated time duration elapses.

Closing the input whilst already running will reset the timeout to the specified value.



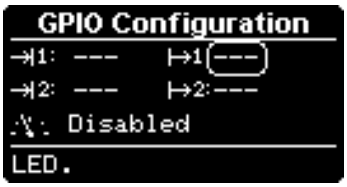
Digital Output configuration

Output #1: Orange wire, Output #2: Yellow wire

Either of the two digital outputs can be configured as:

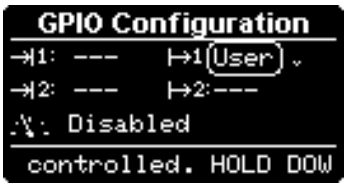
- Disabled
- User Controlled
- Status LED
- Absolute temperature (under or over)
- Relative temperature (under or over)
- Heater Status
- Low Fuel
- Ventilation

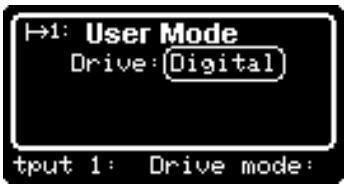
Disabled

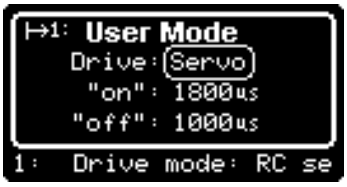


Fairly obviously, no action takes place when a GPIO output is disabled.

User Controlled







The GPIO output can be switched on or off under user command.
When in the heater control modes, **holding** the **LEFT** or **RIGHT** buttons down will toggle the state of the 1st or 2nd output respectively.
It is also possible to control outputs via the JSON data interface ie: Bluetooth or WiFi applications, eg web browser, Home Assistant.

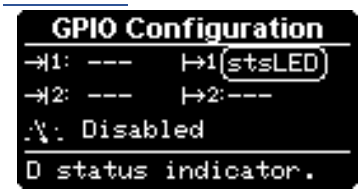
Holding **DOWN** opens the output mode configuration.
One of two possible modes for the output can be configured.

1. Digital
2. Servo

Digital Mode is simply the output is active or inactive.

Servo Mode is a PWM signal, as typically used to control a radio control servo motor.
The position of either state is defined as the width of the PWM pulse. Limits being 0.9ms & 2.1ms, *the values are shown as µs in the menu*.

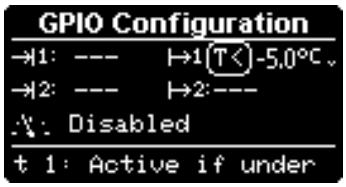
Status LED

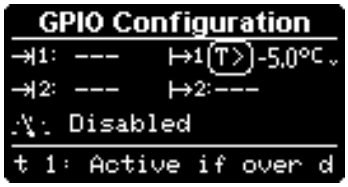


The GPIO output is intended to be attached to an LED, connected across the 5V output to the GPIO output via a resistor.

- When the heater is off, the LED will be off.
- When the heater is starting, the LED will cycle in an increasing brightness manner.
- When the heater is running, the LED will be constantly on.
- When the heater is shutting down, the LED will cycle in decreasing brightness manner.
- If the heater is suspended, typically due to the cyclic mode threshold being activated, the LED will momentarily flash every second or so.

Absolute Temperature Threshold (under or over)

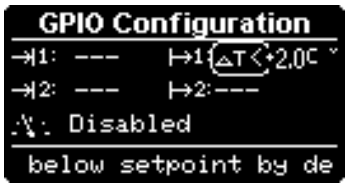


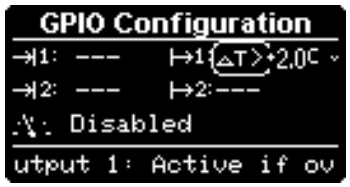


The GPIO output will operate according to the temperature of a sensor.

Normally this would be the sensor being used for the thermostat role but can be another if more than one sensor is fitted to the Afterburner.
This selection is achieved, as is the temperature threshold, via the threshold mode extended capabilities menu.

Relative temperature threshold (under or over)





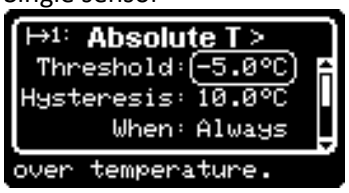
The GPIO output will operate according to the temperature of a sensor **relative to the system thermostat setting**.
Normally this would also be the sensor being used for the thermostat role but can be another if more than one sensor is fitted to the Afterburner.

There are also the same extended capabilities as the Absolute Temperature Threshold Extended Capabilities, as described previously.

Temperature Threshold modes - Extended Capabilities

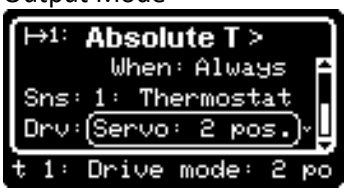
Holding the **DOWN** key whilst a temperature threshold mode selection is shown (absolute or relative, under or over) allows the threshold and extended capabilities to be defined.

Single sensor



Multiple Sensors

Output Mode



Navigation between the fields is by using the **UP** & **DOWN** keys.
Note this menu spans several lines, only 3 are ever present at one time.

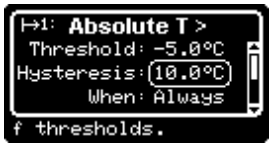
Adjust a field using the **LEFT** & **RIGHT** keys.
Return to the prior menu by pressing the **CENTRE** key.
Note: no settings are changed until you press CENTRE again in the host GPIO setup menu.

The output signal ID and actual GPIO mode are shown on the top line of the menu.

Threshold adjustment (1st field)

Adjustment of the threshold takes place in the 1st field, using the **LEFT** & **RIGHT** keys.
The step change is 0.5°C (1°F).

Hysteresis



Hysteresis is used to prevent the output rapidly oscillating when near the threshold.
The magnitude of the hysteresis value adjustment varies according to the current value:

Hysteresis value	< 1.0°C	1.0°C < 5.0°C	> 5.0°C
Step change	0.1°C	0.5°C	1.0°C

The output behaviour of according to output mode and hysteresis is as follows:

Digital On/Off output mode, over temperature

The output activates when the temperature exceeds the defined threshold.
It only returns inactive when the temperature falls below the threshold minus the hysteresis.

eg: threshold = 25°C, hysteresis = 5°C ⇒ Output on when > 25°C, output off when < 20°C.

Digital On/Off output mode, under temperature

The output activates when the temperature falls below the defined threshold.
It only returns inactive when the temperature rises above threshold plus the hysteresis.

eg: threshold = 25°C, hysteresis = 5°C ⇒ Output on when < 25°C, output off when > 30°C.

PWM output mode, over temperature

The output is 100% PWM (full on) when the temperature exceeds the defined threshold.
The output is 0% PWM (full off) when the temperature is below the threshold minus the hysteresis.

eg: threshold = 25°C, hysteresis = 5°C ⇒ 100% PWM when > 25°C, 0% PWM when < 20°C.

PWM output mode, under temperature

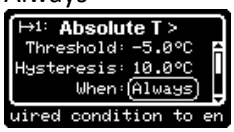
The output is 100% PWM (full on) when the temperature is below the defined threshold.
The output is 0% PWM (full off) when the temperature is above the threshold plus the hysteresis.

eg: threshold = 25°C, hysteresis = 5°C ⇒ 100% PWM when < 25°C, 0% PWM when > 20°C.

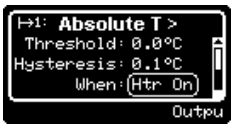
Conditional operation ("When" field)

Despite the temperature condition being met, a condition may be required before it is activated:

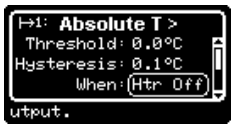
Always



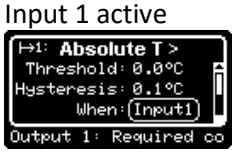
Heater On



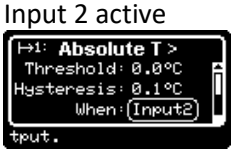
Heater Off



Input 1 active



Input 2 active



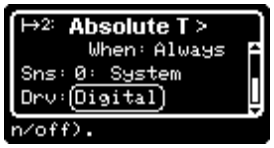
Sensor ID Selection

The sensor used for the temperature reading is selected according to its logical index.
The primary thermostat is sensor ID 0. The next priority is sensor ID 1, etc. for as many sensors are fitted (maximum of 3 DS18B20s plus a possible BME280).

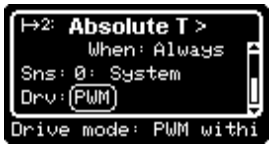
Output Mode ("Op" field)

The output can be a pure digital on/off signal, a pulse width modulated signal spanning the hysteresis range, or a PWM RC servo signal.

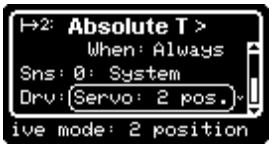
Pure digital output



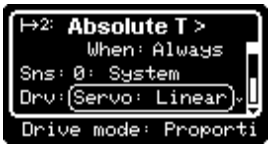
PWM output



Servo, 2 position

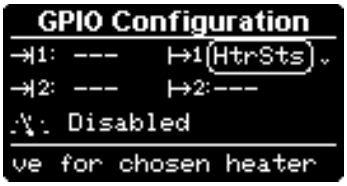


Servo Proportional



Servo Modes require the endpoint positions to be defined as time periods.
Note that this is a further sub menu from the mode's own sub menu, requiring a hold of **DOWN** to access:

Heater Status

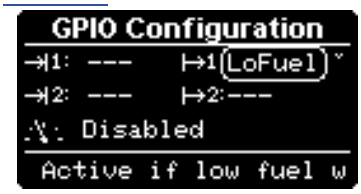


The GPIO output can be made active upon specific heater states.

Hold **DOWN** to access the specific states when the output should be active.

- Standby
- Starting
- Igniting
- Ignited
- Running
- Stopping

Low Fuel



The GPIO output is intended to be attached to a warning LED, powered from 5V via a series resistor.
The Fuel Warning and Tank Capacity values are defined in the heater tuning menus.
It is important to remember that the warning is for that quantity of fuel remaining in the tank.

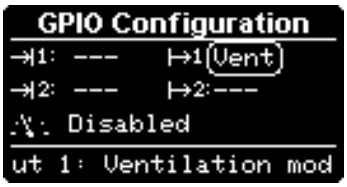
An extended option (via long **DOWN** press) allows the behaviour to be altered when the heater is off.
NO means the LED will only flash when fuel is low, and the heater is running.

Normal	Fuel Warning (volume remaining)	Excess Fuel consumed
OFF	Flashing	ON

It is not possible to start the heater when the excess fuel error is active.

A GPIO input can be defined to reset fuel usage.
A switch could be conveniently mounted nearby the fuel tank for use after re-filling the fuel tank.

Ventilation



Ventilation mode is a user controlled PWM output intended to drive a fan motor.

Ventilation mode can only be activated if the heater is in the Ready/Standby state. If ventilation mode is active, attempts to start the heater will be denied.

To activate ventilation mode, hold down the **LEFT** or **RIGHT** key in the normal heater control menu(s), according to whether the mode is defined on GPIO output #1 or #2.

With suitable circuitry, the heater can be physically modified with extra circuitry to:

3. Detect the PWM signal and operate a relay to switch away from the ECU's fan output.
4. Drive a power MOSFET with the PWM signal than then runs the heater's fan motor via the switched relay.

As the heater modification requires electronics skills, the construction of the circuit board and installation within the heater is left to the end user. No prebuilt units will be offered.
This hardware is described in the Suggested external GPIO hardware chapter of this document.

Analogue input configuration

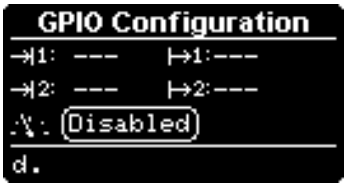
Analogue input - White wire

The single analogue input can be configured as:

- Disabled
- Enabled
- Fuel Sender, with optional low fuel shutdown.

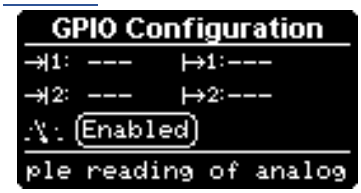
The allowed ADC input voltage range is from 0.0V to 3.3V.
Clamping diodes and a series resistor on the ADC input help protect against excess voltage but preferably should not be relied upon.

Disabled



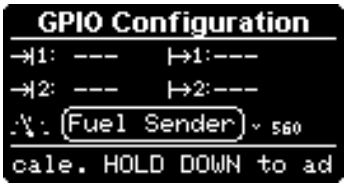
No analogue input is expected.

Enabled



The input voltage applied to the white wire is digitised and presented as a simple percentage of the usable range (0 – 3.3V)

Fuel Sender



Interfacing a fuel sender can be problematic as the voltage produced may well not use the entire ADC range, and the sender's response is not linear with distance.

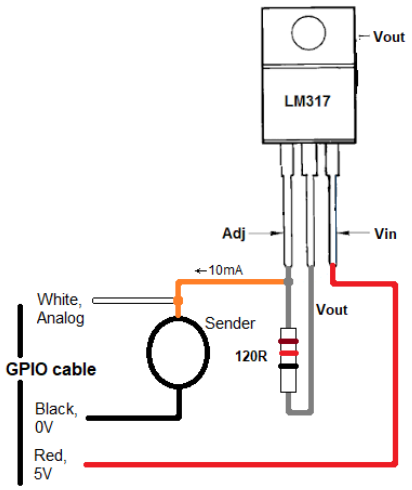
The Fuel Sender mode allows both these issues to be dealt with.

If a Fuel Sender Warning level is defined, the Afterburner will shut down and prevent future starts when the fuel sender level falls beneath 1%.
The "Excess Fuel Usage" error, E-12, is also produced.
Low fuel sender detection always takes precedent over the estimated fuel usage feature present in the heater tuning menus.
Refilling the tank so the low fuel warning is removed will automatically clear the E-12 status.

Fuel Senders

Fuel senders are based upon a float riding up/down a shaft, producing a varying resistance according to position.

There are generally two types of senders, 0-190Ω, or 240-33Ω senders.
The first value corresponds to the resistance when in the empty position.



The best way to drive these units is with a constant current source.

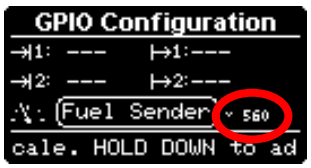
The sender itself is connected between ground and the current source, generating a voltage proportional to the resistance of the sender, which is then applied to the Afterburner's analogue input.

A simple 10mA constant current source can be readily created with an LM317 adjustable voltage regulator, and a 120Ω resistor.
However, this can only typically max out at around ~2V due to a minimum required voltage drop across the LM317, and its own 1.2V output (when sourced from the 5V supply).

As 2V is only ~60% of the ADC's full range, mapping is used to create a 0-100% range.

Endpoint mapping

Mapping the end points converts the actual empty & full ADC values to a more user friendly 0-100% range. 0% being empty.

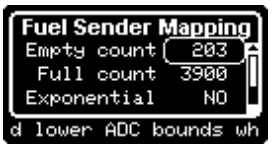


It is best to determine the ADC values for full and empty prior to using the Fuel Sender Mapping submenu.
Simply observe the numeric ADC value shown on the parent "GPIO Configuration menu" alongside the "Fuel Sender" option when the sender is manually forced to the full and empty positions.

These values are the ADC counts to be entered for the empty & full tank conditions.

Note: A 240-33Ω sender produces maximum voltage when empty, vs a 0-190Ω sender producing a minimum voltage when empty.
Mapping the endpoints produces a consistent 0 & 100% tank capacity. Out of bounds are clamped.

The "Fuel Sender Mapping" submenu is accessed by holding the **DOWN** key for 1 second when the "Fuel Sender" option is the selected item on the "GPIO Configuration" menu.



Exponential correction

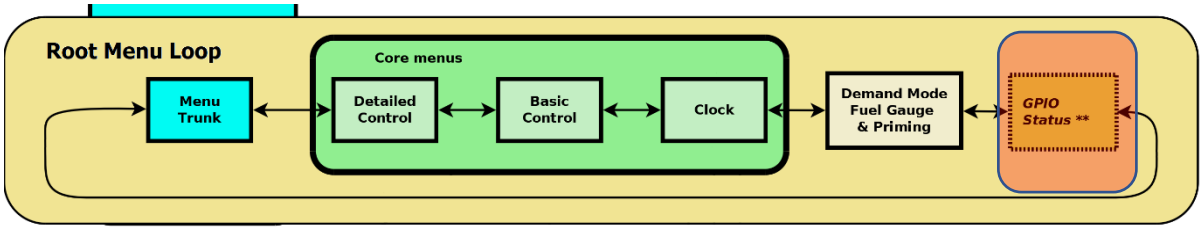
You may find the sender does not change resistance in a linear fashion with range, especially 240Ω-33Ω senders. Enabling exponential correction will linearise the reported percentage.

Warning threshold

Setting a Warning percentage enables low fuel shutdown when the tank reading falls below 1%.
You receive a pre-emptive warning by setting the warning level as desired.

Return to the host GPIO configuration menu by pressing the **CENTRE** key.

GPIO Status menu *(Root menu loop)*



The GPIO status menu resides in the ***Root menu loop*** and allows the current signal states of the GPIO port to be visualised.

This menu will only appear if GPIO hardware has been installed to the Afterburner PCB.

Digital Inputs

The 2 digital inputs are represented by the incoming arrow icons to the top left of the screen.

Depending upon how the GPIO inputs have been configured, the icons presented adjacent to the inputs will be one of the following:

-	Disabled	Changes at the input are ignored
▶	Start	Momentary closure will start the heater, a long closure will stop.
■	Stop	A momentary closure will stop the heater.
▶■	Start / Stop	Alternate momentary closures will start or stop the heater.
	Run	The heater will run whilst the input remains closed.
δT	External Thermostat	The heater will cycle high/low power according closed/open.
0	Fuel Usage Reset	The fuel usage counter will be reset upon a 1 second hold.
MAX	Maximum Power	Heater runs at maximum power when closed. Reverts to original state when open – may be stopped or resume.
Σ	Pulse counter	Pulses are accumulated and scaled to represent a volume of fluid.
✓	Permit Start	Heater starts will be denied if the input is open.
✗	Inhibit Start	Heater starts will be denied if the input is closed.

The switch icon shows the state of the digital input:

	The input is open circuit.
	The input is closed to ground.

Digital Outputs

The 2 digital outputs are represented by the outgoing arrow icons to the top right of the screen.

-	Disabled	The output remains inactive.
	LED Status	An attached LED will dynamically indicate the heater run state.
	User	The output is controlled by user command.
	Absolute Temperature threshold (under or over)	The output is active according to the defined **absolute** temperature threshold.
	Thermostat relative threshold (under or over)	The output is active if the temperature over or under the thermostat setting by the defined value.
	Heater status	The output is active whenever the heater is not in the standby/stopped condition.
	Low Fuel indicator	An attached LED will flash when in warning state, illuminate solid when excess fuel consumed.
Vent	Ventilation mode	User can manually control a fan speed, the PWM duty cycle will be shown.

The state of the output is reflected by the 'bulb' icon.
PWM and servo output modes still use the 'bulb'.
The bulb is lit for any PWM or proportional servo positioning when not in the off condition.

	The output is inactive
	The output is active

Analogue input

The input voltage applied to the Analogue input is presented as a percentage between 0.0V and 3.3V.
The actual ADC reading is shown in small text when enabled, along with the low fuel warning setting if enabled for Fuel Sender mode. 

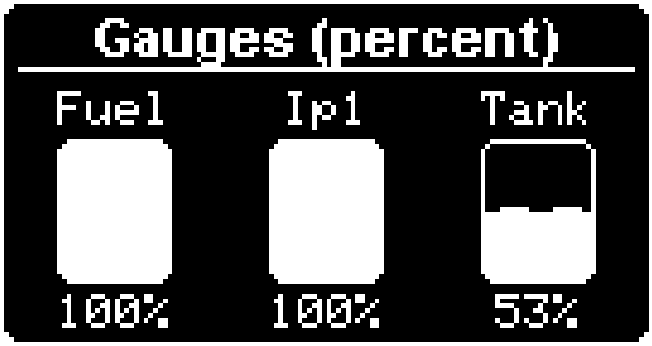
User interaction

If a digital output has been defined as User Controlled or Ventilation mode, the current state can be toggled by holding down the **LEFT** or **RIGHT** keys:

The **LEFT** key toggles digital output #1
The **RIGHT** key toggles digital output #2

"Analogue" gauges

If a GPIO digital input is configured as a Pulse counter, the GPIO analogue input is enabled, or the Maximum Fuel Usage has been defined, a bar graph style gauge will be created and can be viewed in the ***Gauges*** menu of the ***Root menu loop***.



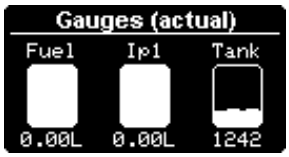
The initial view is a s a percentage for each gauge.

Each gauge is titled, according to the source of the value being shown:

- **Fuel** Estimated Fuel Usage (integrated actual pump rate).
- **Ip1**
  Ip2 Pulse Counter GPIO input.
- **ADC** GPIO Analogue input reading.
- **Tank** Fuel Sender attached to the GPIO Analogue input.

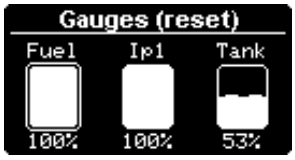
Showing actual values

Press the **DOWN** key to reveal the actual litres value (for instance) behind each gauge.
For the GPIO Analogue input, this will be the ADC digitised value *(0-4095).*



Resetting usage (for resettable inputs)

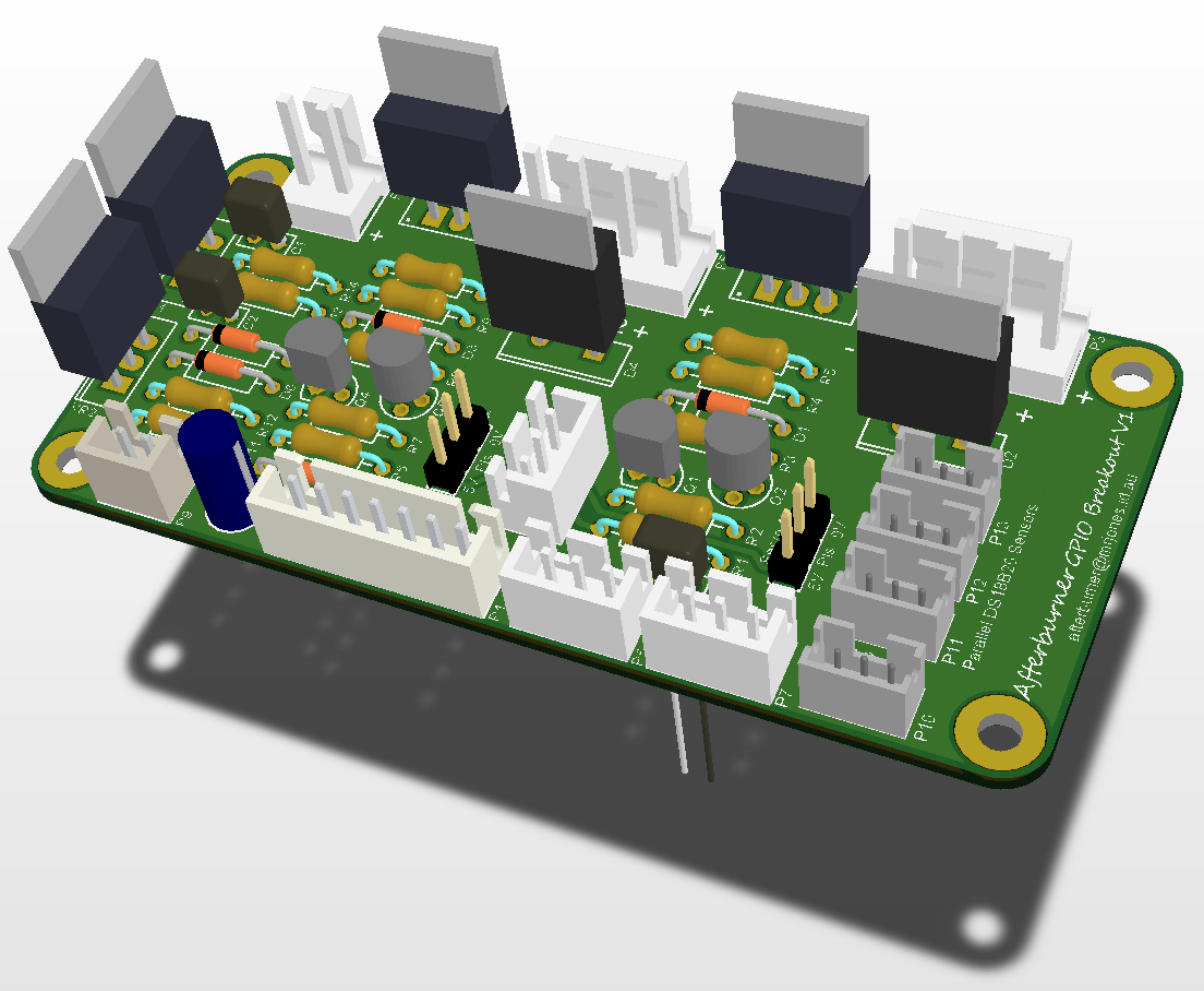
Press **UP** to enable reset mode.
This mode is only available if any of the presented gauges can be reset. i.e. GPIO pulse inputs or estimated fuel usage.
You cannot reset an ADC derived reading, nor select it.



A loop will circle the selected resettable gauge and rapidly flash, use **LEFT** or **RIGHT** keys to make the selection.
Press the **CENTRE** key to select the reset action, then press **UP** to confirm.

Suggested external GPIO hardware

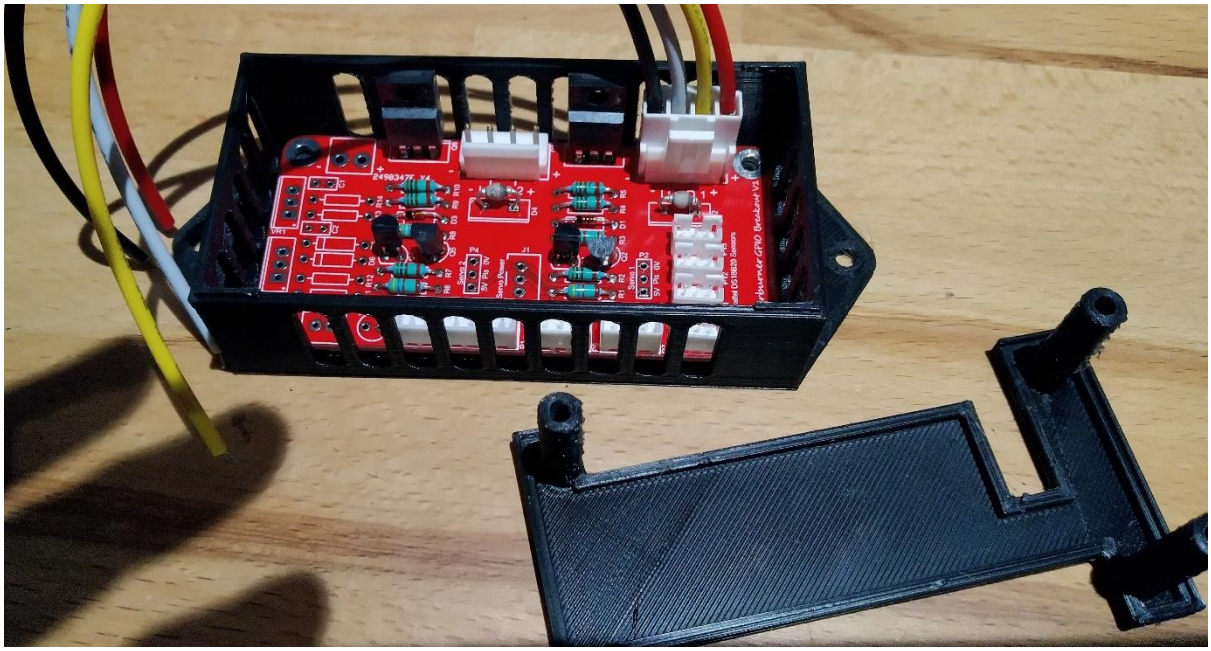
GPIO breakout PCB



This circuit board offers:

- Power MOSFET outputs for fans or pumps
- Resistive Fuel Sender interface
- A place to connect additional DS18B20 temperature sensors
- Headers with 5V power for the Digital inputs (eg flow sensor inputs)
- Through hole parts, no fiddly SMD skills required.

The board design is only offered as Gerber files. It is expected people would build their own versions especially as not all parts may be needed in all instances. (eg:, no fuel sender, leave the bits out!)



Prototype of GPIO breakout ready for installation in my own caravan.

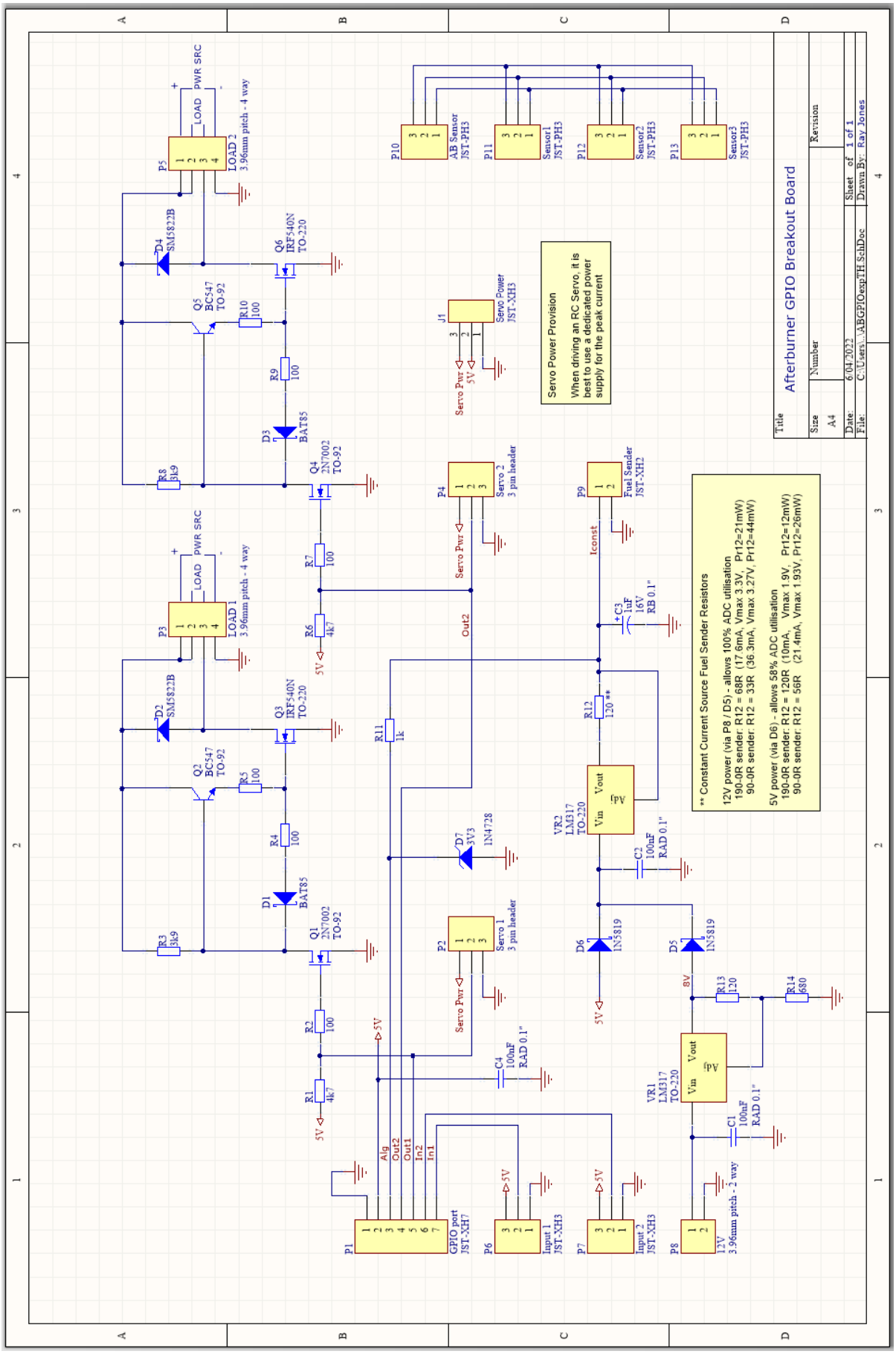
Here it is being used with a secondary DS18B20 temperature sensor installed in the heat exchanger of the absorption fridge and a pair of ventilation fans to assist convection are controlled using the Afterburner's Absolute Temperature threshold (over temp) in PWM mode.

In addition, a water flow meter is fitted to GPIO input #1 to measure water usage from the freshwater tank.

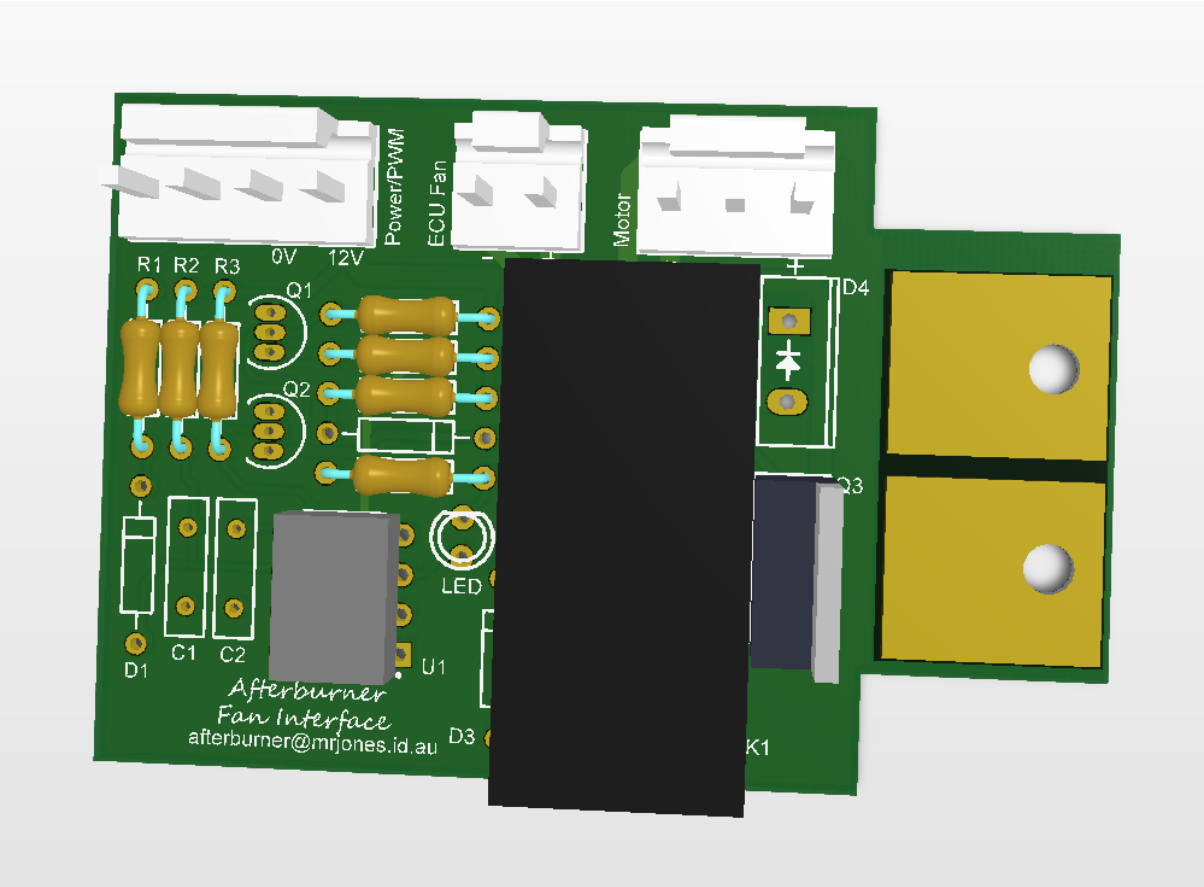
Adding an extra DS18B20 is simplified by using the JST PH-3 headers, all hooked in parallel.

I do not have a fuel sender so those parts were omitted (to left).

STL files for the 3D printed case are available.


Afterburner GPIO Breakout Board
Servo Power Provision
When driving an RC Servo, it is best to use a dedicated power supply for the peak current
** Constant Current Source Fuel Sender Resistors
12V power (via P8 / D5) - allows 100% ADC utilisation
190-0R sender: R12 = 68R (17.6mA, Vmax 3.3V, Pr12=21mW)
90-0R sender: R12 = 33R (36.3mA, Vmax 3.27V, Pr12=44mW)
5V power (via D6) - allows 58% ADC utilisation
190-0R sender: R12 = 120R (10mA, Vmax 1.9V, Pr12=12mW)
90-0R sender: R12 = 56R (21.4mA, Vmax 1.93V, Pr12=26mW)
P1 GPIO port JST-XH7
P2 Servo 1 3 pin header
P3 LOAD 1 3.96mm pitch - 4 way
P4 Servo 2 3 pin header
P5 LOAD 2 3.96mm pitch - 4 way
P6 Input 1 JST-XH3
P7 Input 2 JST-XH3
P8 12V 3.96mm pitch - 2 way
P9 Fuel Sender JST-XH2
P10 AB Sensor JST-PH3
P11 Sensor1 JST-PH3
P12 Sensor2 JST-PH3
P13 Sensor3 JST-PH3
J1 Servo Power JST-XH3
VR1 LM317 TO-220
VR2 LM317 TO-220
Q1 2N7002 TO-92
Q2 BC547 TO-92
Q3 IRF540N TO-220
Q4 2N7002 TO-92
Q5 BC547 TO-92
Q6 IRF540N TO-220
D1 BAT85
D2 SM5822B
D3 BAT85
D4 SM5822B
D5 1N5819
D6 1N5819
D7 3V3 1N4728
Out2
Iconst
8V
5V

Ventilation mode heater modification

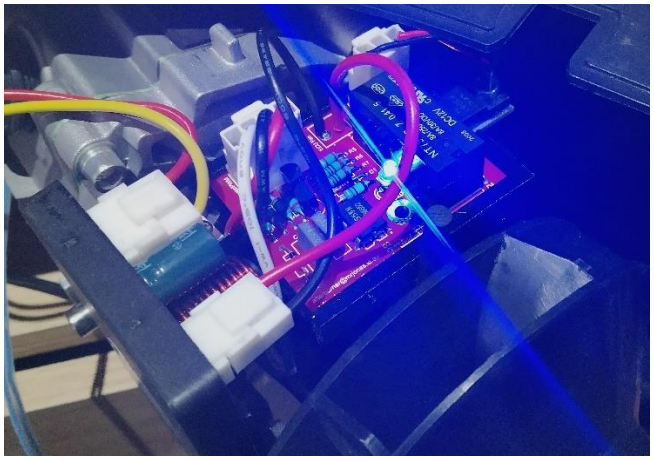


This circuit board features:

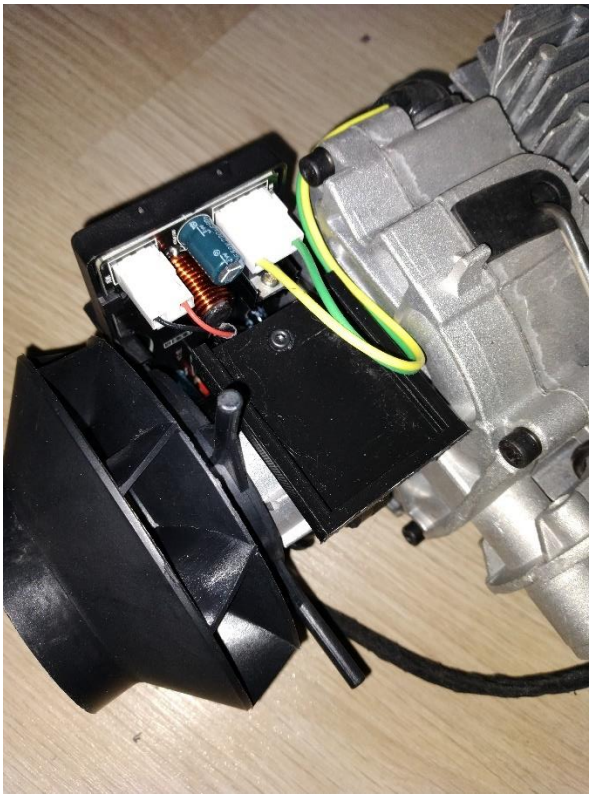
- Directly connects to an Afterburner Digital output configured for “ventilation mode”.
- A power MOSFET to drive the heater’s fan motor
- A relay to swap the ECU’s fan control for the PWM drive from the Afterburner
- Through hole parts, no fiddly SMD skills required.

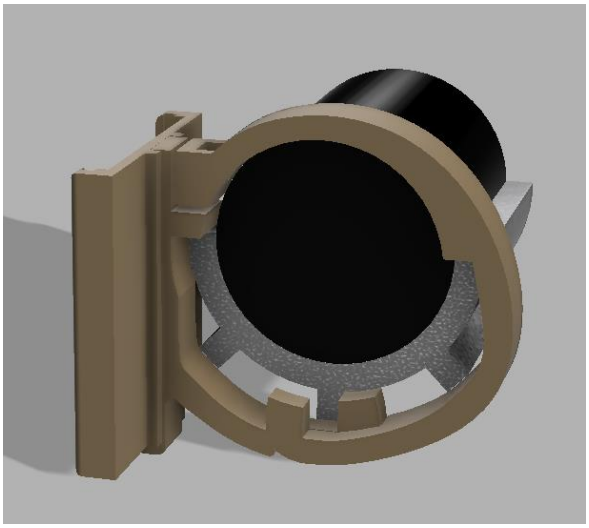
The board design is only offered as Gerber files. It is expected for people to build their own versions especially as a fair bit of skill is involved to fit within the heater’s body and picking up 12V power from the ECU’s circuit board.

A 3D printed bracket assembly (3 parts) wraps about the motor body, fitted vertically below the ECU’s Fan output connection. It will fit inside a 2kW unit, but it is a bit tight.

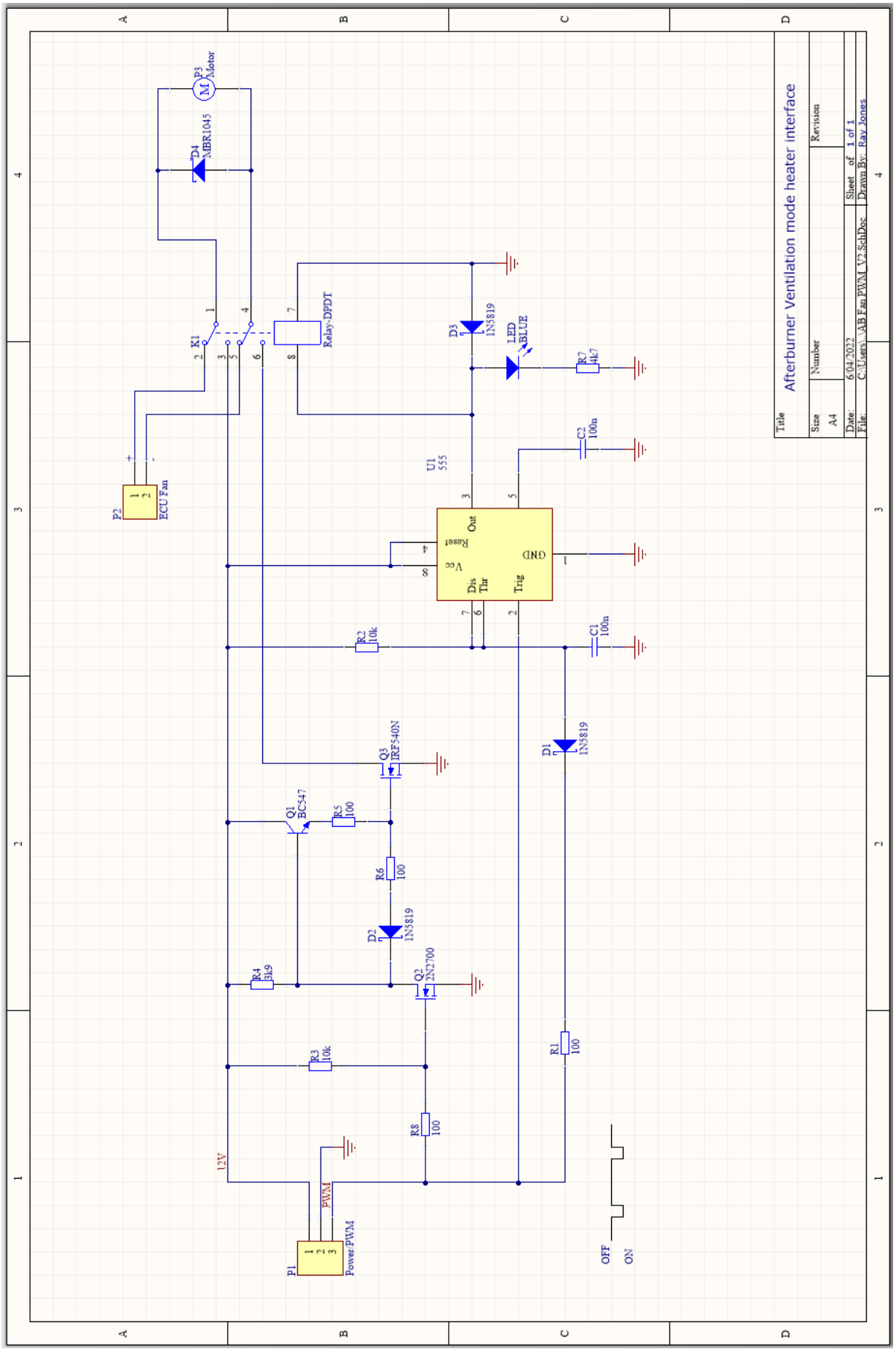


Prototype assembled and running inside a 2kW heater body.
The Afterburner is supplying a PWM signal from a GPIO output.
The blue LED illuminates when the relay is activated and is meant to signify “cool” mode.





3D printed PCB holder that fits about the motor body and alloy casting.
STL files are available for this bracket.


Afterburner Ventilation mode heater interface
Title
Size A4
Number
Revision
Date 6.04.2022
File C:\Users\...\AB Fan PWM V2.SchDoc
Sheet 1 of 1
Drawn By: Ray Jones
P3 Motor
D4 MBR1045
K1
Relay-DPDT
D3 1N5819
LED BLUE
R7 4k7
C2 100n
U1 555
P2 ECU Fan
Out
Reset
Vcc
GND
Dis
Thr
Trig
R2 10k
C1 100n
D1 1N5819
Q3 IRF540N
Q1 BC547
R5 100
R6 100
D2 1N5819
Q2 2N2700
R4 3k9
R3 10k
R8 100
R1 100
12V
PWM
P1 Power-PWM
OFF
ON

Bobil integration

The Afterburner firmware supports a special “bobil” mode.

The Bobil Manager allows automatic control of the water pump and a servo-controlled air diverter (if fitted) of a Bobil integration.

The manager is enabled and configured via the debug menu system.

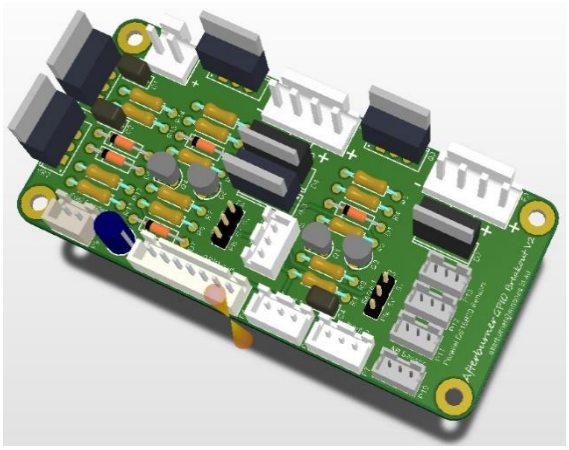
Once enabled, the Bobil Manager’s operation mode can be changed using the “start popup” when first requesting a heater start from the Afterburner unit’s control panel.

Hardware Interface - GPIO required

Bobil mode is only possible if the Afterburner is equipped with GPIO.

The standard Bobil controller is not required, but an interface between the Afterburner’s GPIO port and pump and servo is required to be added.

Afterburner Interface



The GPIO chapter includes a suggested schematic for interfacing to higher power devices like a water pump. Gerber files are available for a PCB design.

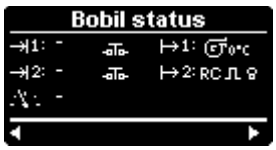
The servo output simply requires a pull up resistor to 5V to create the pulse, but it is strongly recommended the servo motor is powered by an independent 5V power source. The GPIO adapter PCB design allows the addition of a “7805” voltage regulator for this precise reason, obtaining power from the 12V supply for the water pump.

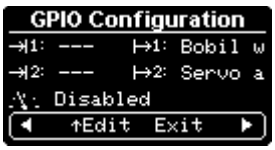
GPIO Configuration

The Bobil Manager takes over the Afterburner’s GPIO output control functions and assumes the following:

GPIO output #1. Water pump.
GPIO output #2. An RC servo for controlling the position of a hot air damper.

You are not able to alter the function of the GPIO outputs via the GPIO Configuration menu, it will instead show the Bobil modes being applied.

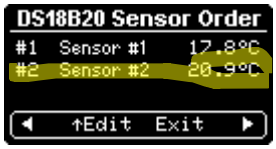




Extra temperature sensor

An extra DS18B20 sensor must be fitted to provide feedback on the water temperature.

When multiple sensors exist, their priorities must be assigned in the DS18B20 sensor menu. The water temperature is assumed to be from the sensor assigned as #2.



Sensors can be renamed via the web page or Android App (Max. 10 characters).
Suggestion: name this extra sensor "Water".

The GPIO adapter PCB design also includes provision to readily attach the maximum number of DS18B20 sensors (3).

Debug menu system

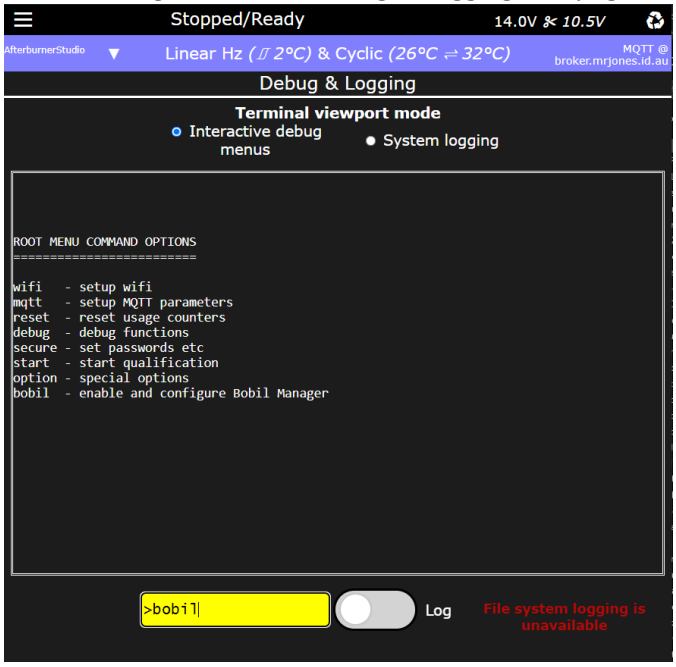
The Bobil Manager must initially be enabled via the debug menu system.

The debug menu system can be accessed via:

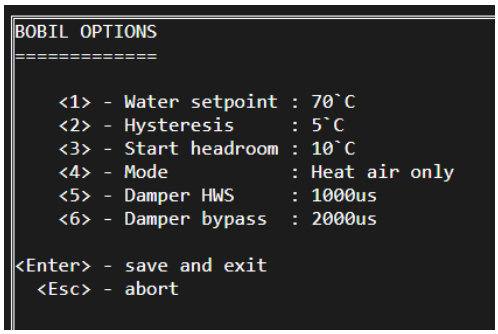
- The debug serial port:
  - (3.3V, 115200 baud, 8 data bits, 1 stop bit, no parity).
  - eg: use the FT232RL USB adapter commonly found on eBay etc.
- Open a telnet session to the Afterburner's IP address.
- Web content > V3.5.1

Once connected, the available menus can be shown by hitting ⏎ (ENTER).

The following shows the "Debug & Logging" subpage of the web page:



->



To make an adjustment, firstly type the number shown in the angled brackets <> - do not press enter.
eg: **1** => select then set the desired water temperature.

Bobil Manager options

<1> - Set water temperature.
The value entered here will be the target water temperature when the Bobil Manager is instructed to “heat water”.

The temperature is taken from the secondary temperature sensor, as assigned in the ***DS18B20*** menu of the ***System Settings menu loop***.
The primary sensor remains as the air temperature sensor in the usual thermostat modes.

Whilst in the ***Basic Control*** menu, you can observe the water temperature by pressing the **CENTRE** button.
The current setpoint is shown, along with any extra sensors.
In this case sensor #2 should be the temperature probe used to sense water temperature.

<2> - Hysteresis
The value entered here determines the restart threshold.

After heating the water, the pump is stopped, and hot air is diverted away from the Bobil heat exchanger. The water will naturally cool.
This is shown on the state diagram as the “Heated” state.

If the heater is still running and the water temperature falls drops by the hysteresis amount, water heating is resumed. The pump is started, hot air is directed to the Bobil heat exchanger.

<3> - Start threshold
The value entered here determines the point at which the water pump is initially activated.
The difference between the heater body temperature and water temperature must be greater than this value before the pump is started.
This ensures the pump does not run when the heat exchanger is cold, potentially chilling the water instead.
The state diagram shows the “Preheat” state where this condition is tested for.

Assuming an RC servo is controlling a hot air diverter, whilst the pump is off, the heat exchanger is receiving the heater output air flow.
The pulse width for the servo in this state is set by option <5>.

<4> - Mode
The value entered here determines the operating mode of the Bobil Manager.

1. “**Disabled**”
   Bobil Manager function is disabled.
   GPIO outputs are configured by the Afterburner’s usual GPIO configuration menus.
2. “**Heat air only**”
   No water heating.
   Hot air is always diverted away from the Bobil heat exchanger.
   GPIO outputs are configured and controlled by the Bobil Manager.
3. “**Heat water and run**”.
   When the water temperature reaches the desired target the heater is left running.
   Hot air is diverted away from the Bobil heat exchanger once the water temperature is

reached.
GPIO outputs are configured and controlled by the Bobil Manager.

4. "**Heat water and stop**".
Once the water temperature reaches the desired target the heater is stopped.
Hot air is steered towards the Bobil heat exchanger until the water temperature is reached.
GPIO outputs are configured and controlled by the Bobil Manager.

<5> - Servo Damper - Bobil heat exchanger
The value entered here determines the RC servo pulse width delivered to GPIO output #2 when water heating is required. i.e. hot air is directed via the Bobil heat exchanger.
This allows the position of the servo arm to be adjusted for best fit.

<6> - Servo Damper – bypass
The value entered here determines the RC servo pulse width delivered to GPIO output #2 when water heating is NOT required. i.e. hot air bypasses the Bobil heat exchanger.

The pump will not run when hot air is diverted away from the Bobil heat exchanger.

Runtime control of Bobil Manager

Holding the **CENTRE** button of the Afterburner for approximately one second prepares for heater start.

An intermediate popup screen appears before the actual heater start requested is made.
If nothing is done, this menu will time out and invoke the actual heater start.

Using the **DOWN** button, you can navigate down the list presented.

An animated icon appears top right showing the timeout elapsing.
If the timeout elapses, the selected action takes place.
Hitting the **CENTRE** key will hasten the closure of this popup menu.

You can abort the start request by selecting the last line.

If the Bobil Manager has been enabled in the debug menus, a line is present that allows the Bobil Manager's operation to be changed.

You must initially use the debug menus to enable the Bobil Manager feature.
Disabling the Bobil Manager removes this option from the start popup menu.

The choices being:

- Heat air only.
- Heat water then keep running once heated.
- Heat water then stop running once heated.

Use the **DOWN** key to navigate to the 3rd line that show one of those selections.
Use the **LEFT** / **RIGHT** buttons to change the mode.

The selected mode will be remembered, and automatically applied next time you start the heater.
You do not need to bump down to this 3rd line every time.

Viewing water temperature

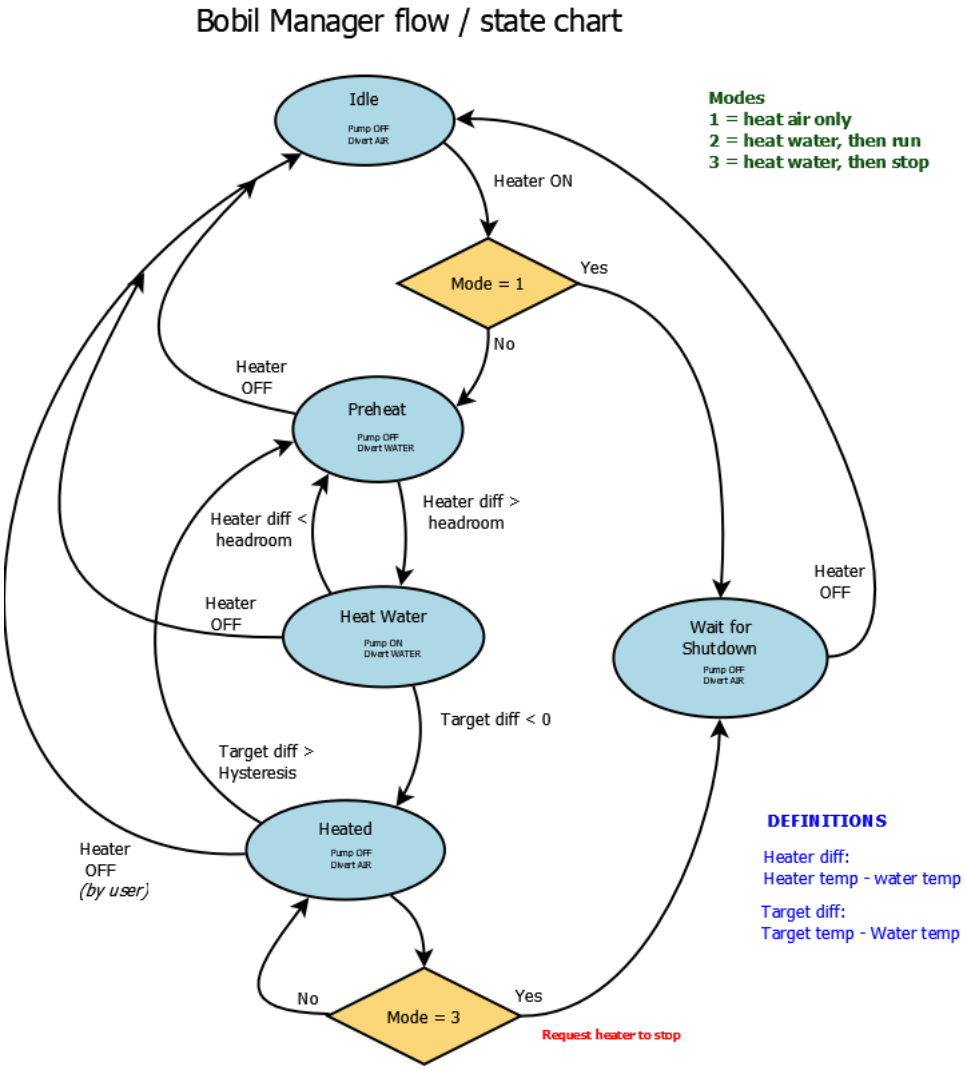
When in the Basic Control menu, a short press of the center button will briefly present the setpoint, and the reading of any other sensors.

In the situation of a Bobil integration, the second sensor is assumed to be for measuring the water temperature.

Center press ->

Bobil Manager State diagram

This state diagram illustrates the logic used by the Bobil Manager.



The state is always “Idle” whenever the heater is off.
Only if the Bobil Manager is enabled can it transit away from Idle.

When the heater is started, and Bobil Manager mode is “heat air only”, the Bobil Manager immediately jumps to the “Wait for shutdown” state.

Otherwise, the heater airflow is directed towards the Bobil heat exchanger and waits in the “Preheat” state until the relative heater body temperature rises above the water temperature by the required “start threshold”.
The manager then transitions to the “Heat Water” state.
The pump is started; hot air continues to flow via the heat exchanger.

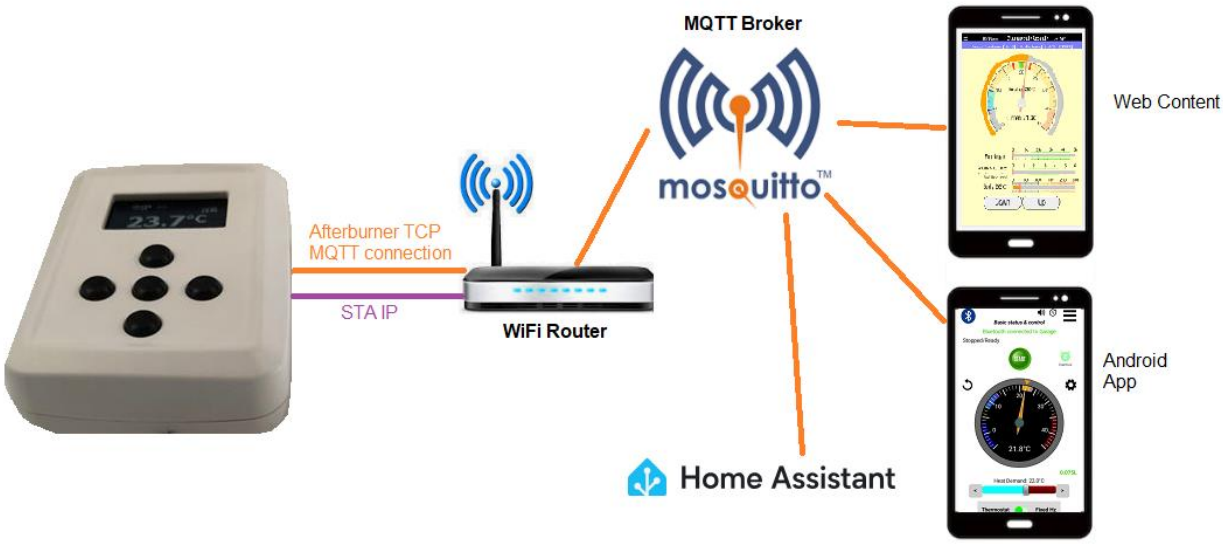
Once the target water temperature is reached, it transitions to the “Heated” state.
The pump is stopped; air flow is diverted away from the heat exchanger.

If the Bobil Manager mode is “heat water then stop”, the heater is instructed to stop and the manager moves to the “Wait for shutdown” state.

Otherwise it stays in the “Heated” state unless the water temperature falls below the reheat threshold (returning to “Preheat” state), or the user stops the heater.

At any point, if the heater is stopped, the state returns to Idle.

MQTT Technical Description



The Afterburner can connect to an MQTT broker allowing the ability to integrate information from the Afterburner into a larger home automation scheme or controlling and monitoring your heater via a remote connection over the Internet.

Preferably you host your own private MQTT broker on your own home network, or elsewhere on the Internet.
Internet based brokers readily allow remote access as they are already beyond any local firewall, but nothing prevents you making your own private broker visible from the Internet by adding it to your router's exposed connections.
The details of exposing a private broker are beyond the scope of this document as it is very dependent upon what site equipment is in use.

The use of public MQTT brokers, such as HiveMQ, are useful to get a feel for the MQTT concept, but extended reliance is **NOT RECOMMENDED** as they are not secure, and anyone can maliciously access your system.

Topics – publishing and subscribing

The crux of MQTT is using topics to provide or collect information to/from a broker for a specific device.
In MQTT speak, this is Publishing and Subscribing.

The broker is akin to an office building.
A topic is akin to an agreed meeting room in that same office building to meet and exchange information.

Publishing is the act of pushing a topic to the broker, along with a data payload.
Clients gather data by creating a **subscription** to the same topic when they connect to the broker.
It is perfectly possible to have multiple clients all subscribed to the same topic.

The broker maintains a list of subscribed topics and the clients that have subscribed to that topic.
When new topics are published, they are then automatically relayed by the broker to the connected client(s).

Topic retention

It is quite possible a topic may simply be lost at the broker if no one has subscribed to it.

An option does exist for "retention" by the broker in published messages, but this **should not be used** for commands published to the Afterburner. Using retention on commands leads to weird repeating actions when the Afterburner re-establishes the broker connection.
The Afterburner can use retention for the subset of special status topics, and this is recommended when using the Home Assistant auto discovery entities.

The Afterburner does not set retention when publishing "JSONout" messages.

Afterburner topics

In the Afterburner, there are two conventions used for the topic names:

- "Global" topic
  This supplies detailed information within a JSON encapsulated payload.
  There may be multiple name value pairs included in the JSON payload.
- "Specific" topic
  A topic that only supplies information about one specific entity, being the topic name.

The specific status topics are only a subset of the full information available via the global JSONout topic but are sufficient to supply remote control and monitoring of the Afterburner by simple MQTT clients. These specific status topics are typically retained by the broker, an option exists in the Debug Menus to alter this.

The Home Assistant auto discovery references these specific status topics as they are also usually defined to be retained by the broker.
It is nonsensible to retain the "JSONout" topic as the payload is highly variable and usually contains more than one entity.

Topic prefix

It is important that the information to/from an Afterburner is uniquely named.
This is especially important should you have multiple Afterburner's attached to the same broker.
It is vital that each system uses a unique topic prefix.

A guaranteed unique name can be achieved by including the last 3 hex octets of the Afterburner's MAC address. (The first 3 MAC octets are constant and name the vendor/device, i.e., Espressif ESP32)
Do not include the colons, they may lead to unpredictable behaviour.

The firmware by default creates such a topic prefix, appending the MAC octets to "Afterburner".
The user can choose their own prefix if preferred.

E.g.: if your MAC is 24:0A:C4:C0:AB:95, the default topic prefix will be ***AfterburnerC0AB95***.

The following descriptions use ***topicPrefix*** to show this unique name.

Last Will and Testament

Upon connection to a broker, the Afterburner publishes a special retained topic that says the Afterburner is available and "online".

The broker is also informed of a "Last Will and Testament" value for that same topic.
Should the connection be lost unexpectedly, and the specified timeout expires, the broker will replace online with "offline" as the status.

Online Notification

When the Afterburner sets up the broker connection, the following topic is published and retained by the broker:

Topic	Payload
topicPrefix/status	"online"

Last Will and Testament

Before the Afterburner sets up the broker connection, the Last Will & Testament is also defined. Should the broker connection unexpectedly disappear, the broker will then publish the following after 1 minute:

Topic	Payload
topicPrefix/status	"offline"

Control and Status

Global Topic: *topicPrefix***/JSONout** *(not retained)*
Specific Topics: start with *topicPrefix***/sts** *(recommend retention)*

Publish

The Afterburner publishes to the following topics (outgoing status):

Global Topic	Payload
topicPrefix/JSONout	JSON encapsulated string supplying full detailed status of the heater state. The payload is highly variable, typically only delivering the value of changed states.

Specific Topics	Payload
topicPrefix/sts/Run	0=heater OFF, 1=heater ON
topicPrefix/sts/RunState	An integer enumeration showing the current ECU state of the heater
topicPrefix/sts/RunString	String that describes the running state of the heater
topicPrefix/sts/RunReq	Flag to indicate if unit should be running
topicPrefix/sts/RunHA	Run mode to suit Home Assistant (auto, on, off)
topicPrefix/sts/ModeHA	Home Assistant mode (off, heating, idle, cooling)
topicPrefix/sts/TempDesired	Desired temperature in °C
topicPrefix/sts/CyclicTemp	Desired temperature in °C (equals TempDesired)
topicPrefix/sts/TempCurrent	Current temperature in °C – from sensor used for thermostat
topicPrefix/sts/Temp2Current	Current temperature in °C – from optional second sensor
topicPrefix/sts/Temp3Current	Current temperature in °C – from optional third sensor
topicPrefix/sts/TempBody	Current temperature in °C of the heater's casing
topicPrefix/sts/ErrorState	An integer enumeration showing the current error state of the heater
topicPrefix/sts/ErrorString	String that describes the error state of the heater
topicPrefix/sts/Thermostat	0=fixed pump demand, 1=thermostat mode active
topicPrefix/sts/FixedDemand	Fixed Hz setting

topicPrefix/sts/PumpFixed	Desired pump delivery rate, in Hz
topicPrefix/sts/PumpActual	Current pump delivery rate, in Hz
topicPrefix/sts/FanRPM	Current fan RPM
topicPrefix/sts/InputVoltage	Current input voltage to heater unit
topicPrefix/sts/GlowVoltage	Current voltage applied to glow plug
topicPrefix/sts/GlowCurrent	Current amperage applied to glow plug
topicPrefix/sts/FuelUsage	Accumulated fuel consumption since last reset, mL
topicPrefix/sts/TotalFuelUsage	Total fuel consumption, mL
topicPrefix/sts/FuelRate	Current rate of fuel consumption, mL/hr
topicPrefix/sts/FuelAlarm	Status of excess fuel alarm
topicPrefix/sts/FrostRun	Flag to indicate if frost mode is running
topicPrefix/sts/FrostHold	Frost mode hold time
topicPrefix/sts/FrostEnable	Frost mode enable flag
topicPrefix/sts/FrostOn	Frost mode start temperature
topicPrefix/sts/FrostRise	Frost mode “rise” parameter, -ve for frost thermostat mode.
topicPrefix/sts/FrostTarget	Absolute frost mode target temperature
topicPrefix/sts/FrostMode	Frost Mode operation mode
topicPrefix/sts/CyclicEnb	Cyclic mode on/off status
topicPrefix/sts/CyclicOn	Cyclic Mode relative On setting
topicPrefix/sts/CyclicOff	Cyclic Mode relative Off setting
topicPrefix/sts/AbsCyclicOn	Cyclic Mode absolute On setting
topicPrefix/sts/AbsCyclicOff	Cyclic Mode absolute Off setting
topicPrefix/sts/ThermostatMode	Thermostat mode
topicPrefix/sts/Altitude	Altitude in meters
topicPrefix/sts/PulseVolume1	GPIO Pulse counter 1 (if enabled)
topicPrefix/sts/PulseVolume2	GPIO Pulse counter 2 (if enabled)
topicPrefix/sts/GPin1	GPIO input #1 state
topicPrefix/sts/GPin2	GPIO input #2 state
topicPrefix/sts/GPout1	GPIO output #1 state
topicPrefix/sts/GPout2	GPIO output #2 state
topicPrefix/sts/GPanlg	GPIO analogue input value, as a percentage

Subscribe

The Afterburner subscribes to the following two topics (incoming control):

Clients publishing to these topics should **NOT** use retention.

Global Topic	**Payload**
topicPrefix/JSONin	JSON encapsulated command, using defined dictionary names

Specific Topics	**Payload**
topicPrefix/cmd/#	# = wildcard wildcard can be any valid single JSON dictionary name and will be treated as if it were the payload of a ***topicprefix***/JSONin topic.

A client can choose whether to publish commands to the Afterburner using either /JSONin or /cmd/*JSONname*. The difference is JSONin must be formatted JSON string, /cmd is just the direct value as the payload.

e.g. Both of the following are valid and functionally equivalent usages:

Topic	Payload
topicPrefix/JSONin	{"TempDesired":22}
topicPrefix/cmd/TempDesired	22

The /JSONin topic can support multiple names, while the /cmd/xxx is singular

e.g., This is valid for /JSONin, but must be sent as individual /cmd's:
/cmd cannot combine two values.

Topic	Payload
topicPrefix/JSONin	{"TempDesired":22,"Run":1,"Thermostat":1}

JSON dictionary

A more complete list of the JSON names is defined in the JSON dictionary document.

Hardware overview

Two types of PCB have been produced.

1. The prototype PCB has a green solder mask and is open source.
   Gerber files are part of the repository at https://gitlab.com/mrjones.id.au/bluetoothheater.
2. Later variants were modified to fit within an off the shelf ABS case. The solder mask of the production PCB is red.
   These PCBs are proprietary and are only available as completely assembled and tested units.

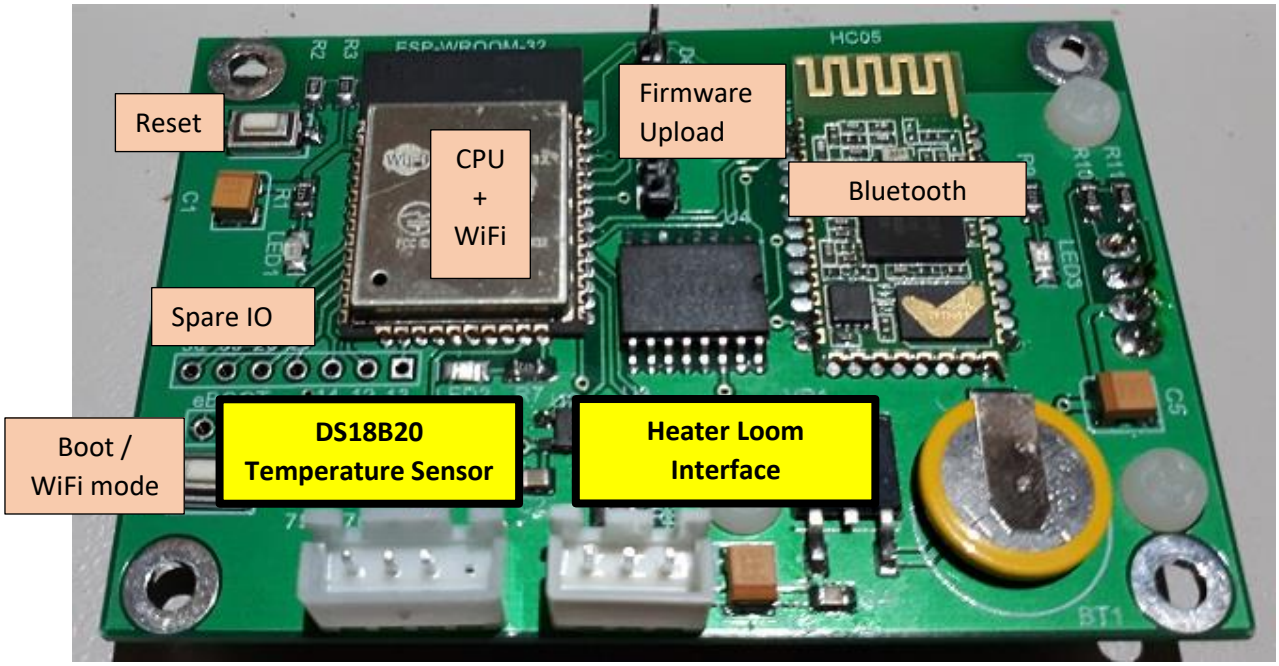
The firmware remains fully capable with any variant of PCB.

The primary difference of the later proprietary PCBs is additional circuitry to provide buffered input and output signals for the purposes of user expansion:

- 2 contact closure inputs (to ground).
- 2 open collector transistor outputs (switching to ground), to drive indicators or relays.
- A single analogue input.
- Header position for a 433MHz receiver module.
- Later PCB versions (V3.1+) provide a location to readily expand the I2C bus.
- A footprint to mount a BME280 pressure sensor.

With either PCB variant, the digital inputs are made active by connecting the exposed sense line to ground. Noting that this is the bare unprotected ESP32 pin on the prototype hardware.

Prototype PCB (Mk1)



Prototype PCB - Unused ESP32 pins

Spare IO

Seven unused pins of the ESP32 are brought out to a 7-way header location.
These can be used for customised extensions if so desired.

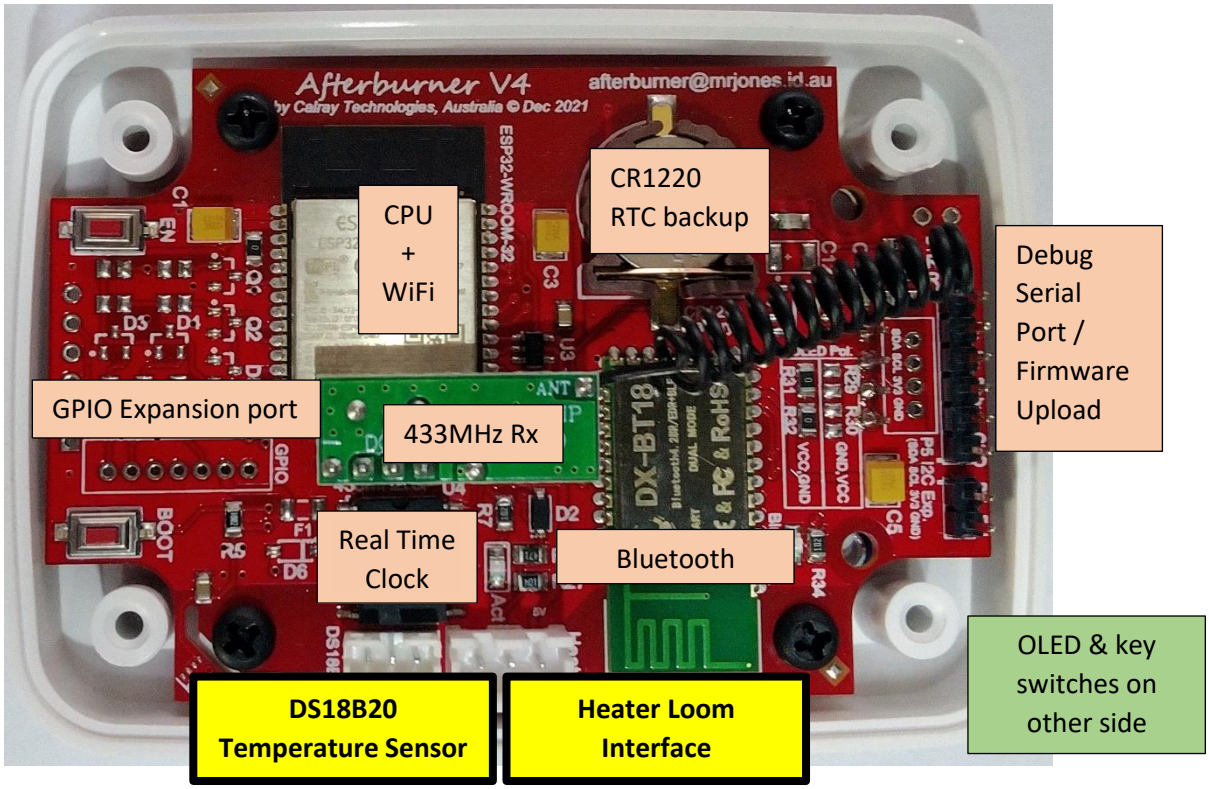
A neat feature of the ESP32 is it hosts a pin multiplexer. Generally, any internal peripheral can be steered to these pins!

These pins are also most of the signals, bar one required to use the JTAG debug tool.

Note:
The silk screen overlay on the initial production of Mk1 Afterburner PCBs erroneously labelled the first two pins, the correct numbering is the highlighted numbers in the image above.
The functionality of the circuit is not affected.

Gerber files of the protype PCB are available via GitLab for those that wish to self-build.

Production PCB



All version PCBS have equivalent core componentry.
The physical locations of parts have been shifted to accommodate the case standoffs.
Later PCB versions have better separation of the 2.4GHz antennas (WiFi / Bluetooth).

GPIO Expansion port

Extra component locations exist on the production PCBs for the GPIO expansion port buffering.

On GPIO equipped units, a 7-pin JST PH header is provided to allow:

- 2 contact closure inputs
- 2 open collector outputs
- 1 analogue input
- 5V Power & ground sources

Wire Colour	Purpose
Blue	Digital input #1
Green	Digital input #2
Orange	Digital output #1
Yellow	Digital output #2
White	Analogue input (0-3.3V)
Red	Power, +5V (from heater ECU)
Black	Ground, 0V

NOTE: the PCB header location of 5V, 0V and the Analogue input shifted locations on V3.5+ PCBs. The supplied JST flying lead is correct for the unit supplied.

Firmware updates

As the Afterburner software is still undergoing continual development, it may be necessary to upload a new firmware version in the future.

The following methods are available for firmware updates *(ordered easiest to hardest):*

- Prompted automatic self-update from the Afterburner web site.
- Browser upload.
- Serial port upload, via a batch file.

Firmware updates using wifi connectivity internally employ OTA *"Over The Air"* methods, though for security reasons this technology is not directly exposed for user access as it was with early firmware.

The ESP32's memory is portioned to have two 1.9MB firmware partitions.
Only one is ever the active partition.

New firmware is always downloaded (staged) into the alternative inactive partition, leaving the current firmware unaffected.

Following upload of a new firmware image, the new image's integrity is confirmed and validated. Only if OK is the ESP32's bootloader reconfigured to use the alternative partition upon subsequent reboots.

When the unit does reboot, the freshly updated partition becomes the active partition, and the new firmware is executed.

Automatic update

Provided the Afterburner is connected to a WiFi network, which provides Internet connectivity, the Afterburner can interrogate the Afterburner project web site (http://afterburner.mrjones.id.au) and determine if a new firmware version is available.
This happens once per hour in the background.

If a newer firmware is found, the Afterburner will animate an "Update available" icon upon the display's header area.
It will NOT automatically download the new firmware unless authorised by the user.

To authorise the upgrade, navigate to the Version Information menu, which is the first menu in the System Settings menu group.

Presuming an update is available, a larger animation takes place to the top right of the Version Information menu:

To authorise the download, press **UP**, **CENTRE**, **UP**.

The Afterburner will proceed to download the new firmware, showing the progress on the display:

Once the download completes, per OTA, the checksum is verified and the system reboots into the new firmware.

Should the download fail or a checksum error exists, the existing firmware partition remains as the active partition and the pre-existing firmware will be executed upon reboot.

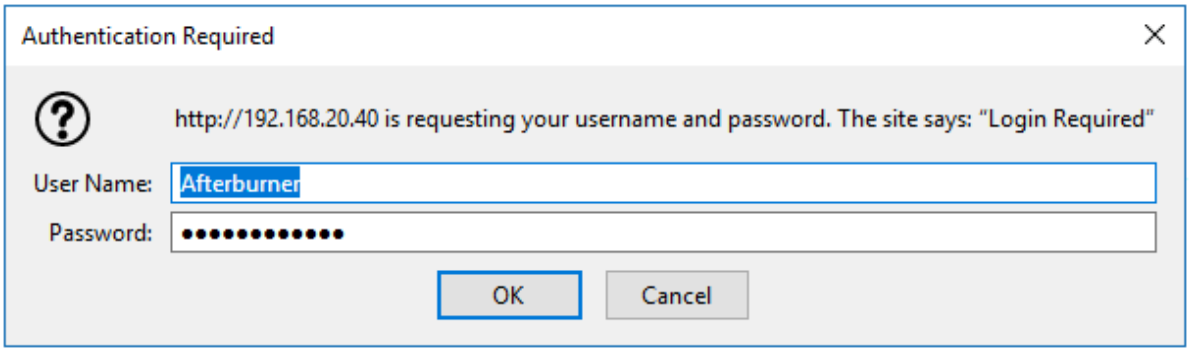
Browser update

Download the desired **pre-compiled firmware (binary image)** from http://afterburner.mrjones.id.au/firmware.html and save to the local PC, or even mobile phone.

Using a web browser, open Afterburner unit's browser update web page.
Note the Afterburner can be accessed using the inbuilt access point (192.168.4.1) or via a WiFi network, provided both devices are registered on the same WiFi network.

Browse to the Afterburner's IP address, eg if using AP mode http://192.168.4.1/update

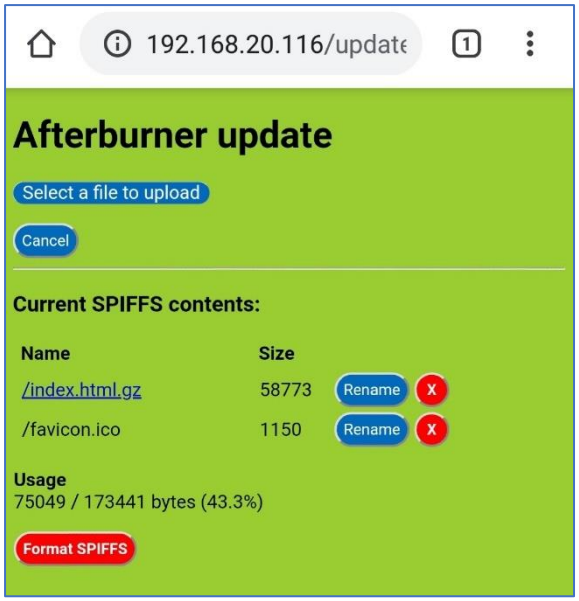
This will then present a password confirmation page:



The required credentials are:

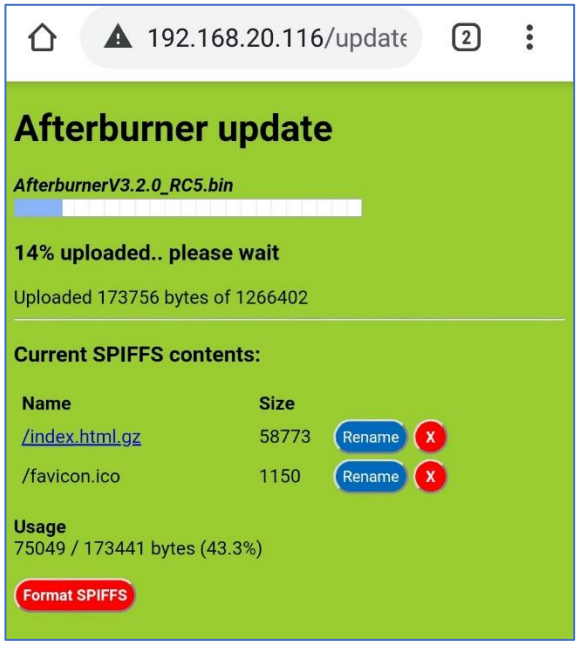
- **Username**: Afterburner
- **Password**: BurnBabyBurn

The following screen should then be presented:



Click upon **Select a file to upload** and locate the binary image previously downloaded from http://www.mrjones.id.au/afterburner/firmware.html.

Click upon flashing **Upload** button to start the upload of new firmware to the Afterburner, the Afterburner display will show progress, as will the web browser:

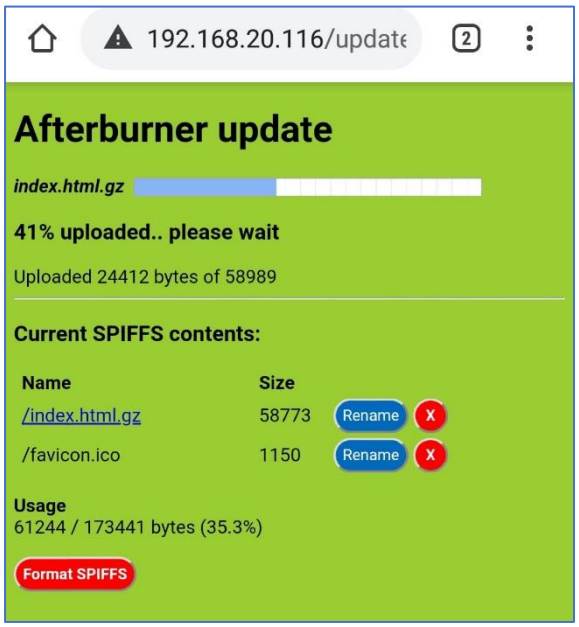


Once the download completes, the checksum is verified and the system reboots into the new firmware.
Should the download fail, the Afterburner still reboots, but the existing version will be retained.

File System uploads

Browser update can also be used to upload new web page content to the File System partition, instead of using the Arduino IDE.

The same procedure is followed, but instead of selecting the binary image, select the new *(typically .gz compressed HTML web page content)* file to upload:



The web content file when downloaded from http://afterburner.mrjones.id.au/firmware.html will be as a .zip file.

Browsers will typically try to open a .gz file as actual web content (which is what happens when you browse the Afterburner's web server), but the .zip file will be saved into a download location.
You will need to extract index.html.gz from the downloaded index.html.zip file.

Only attempt to upload the .gz file.

The further extracted index.html file simply is far too large for the Afterburner's file system to accept.

Serial update (batch file)

Plug a FTDI USB adapter, **that has been strapped for 3.3V operation**, into a Windows PC.
Using Device Manager determine the correct COM port of the USB adapter.

Connect the Tx, Rx and GND signals between the FTDI adapter and the Afterburner's debug serial port pins.

Tx must go to Rx, and Rx must go to Tx.
i.e. the headers of each unit are nominally a direct 1:1 pinout.

Prepare the Afterburner for serial bootload by performing the following sequence:

1. Press and HOLD the **BOOT** button *(can connect **BT** pin near debug header to 0V)*.
2. Press and Release the **EN** button. *(can connect **EN** pin near debug header to 0V)*.
3. Release the **BOOT** button.

The ESP32 is now ready to receive firmware over the debug serial port.

Download the desired **pre-compiled firmware (binary image)** from
http://www.mrjones.id.au/afterburner/firmware.html and save to a local Windows PC.

Download the **Firmware uploading scripts**, also available from the above web link.

Extract the uploading scripts to a convenient directory on the PC.

Copy the downloaded binary image to the same directory.
Rename the binary image to **Afterburner.bin.**

Modify the COM.bat file to correctly reflect the COM port that will be used to upload new firmware to the Afterburner *(immediately following "–port")* **DO NOT CHANGE ANYTHING ELSE**:

```
esptool.exe --chip esp32 --port COM11 --baud 921600 --before
default_reset --after hard_reset write_flash -z --flash_mode dio -
-flash_freq 80m --flash_size detect 0xe000 boot_app0.bin 0x1000
bootloader_qio_80m.bin 0x10000 Afterburner.bin 0x8000
Afterburner.partitions.bin
```

Execute **COM.bat.**

The upload to the Afterburner will now take place over the serial connection:

```
C:\Users\ray\OneDrive\Documents\bootload>esptool.exe --chip esp32 --port COM14 --baud 921600 --befo
ter hard_reset write_flash -z --flash_mode dio --flash_freq 80m --flash_size detect 0xe000 boot_app
er_qio_80m.bin 0x10000 Afterburner.bin 0x8000 Afterburner.partitions.bin
esptool.py v2.6-beta1
Serial port COM14
Connecting....
Chip is ESP32D0WDQ6 (revision 1)
Features: WiFi, BT, Dual Core, Coding Scheme None
MAC: 30:ae:a4:8c:a6:3c
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 921600
Changed.
Configuring flash size...
Auto-detected Flash size: 4MB
Compressed 8192 bytes to 47...
Wrote 8192 bytes (47 compressed) at 0x0000e000 in 0.0 seconds (effective 1365.3 kbit/s)...
Hash of data verified.
Compressed 17664 bytes to 11528...
Wrote 17664 bytes (11528 compressed) at 0x00001000 in 0.2 seconds (effective 802.9 kbit/s)...
Hash of data verified.
Compressed 1270064 bytes to 712290...
Writing at 0x0001c000... (9 %)
```

Once the download completes, you will need to press (ground) the **EN** switch again to reboot the ESP32.

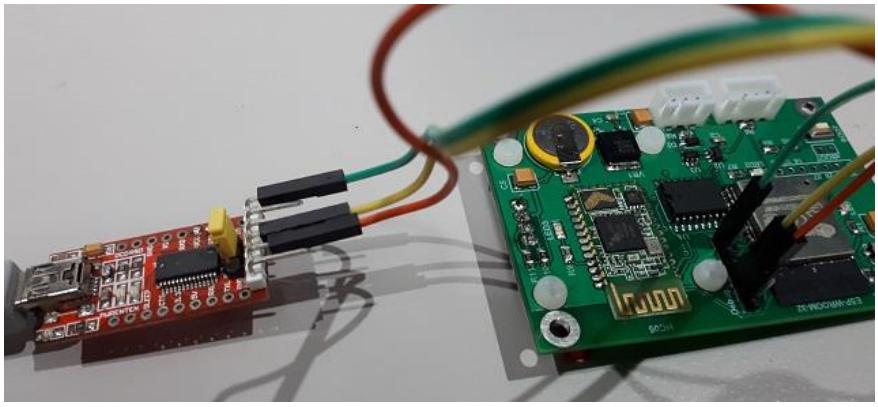
Note that whilst this procedure is the most tedious to perform, it is the only way to recover a bricked system, in the unlikely event that should ever occur.

Native internal bootloader

The Afterburner PCB does include any bootloader assistance hardware as fitted to the dev boards. Ie. USB to serial device.
The required serial port to perform bootloading of firmware is provided as a 6-pin header
The PCB provides pushbuttons for the **EN** and **BOOT** pins.
The Mk2 PCB also brings the **EN** and **BOOT** pins to a header adjacent to the serial port connection.
The process to prepare for serial boot load is quite simple to deal with once understood.

Required Hardware

New firmware is uploaded to the ESP32 via its debug/programming serial port.
No USB to serial support is provided on the Afterburner PCB.
To provide a USB to serial connection, a **FTDI232 USB adapter** (or similar) is required.
Only the GND, power, Tx & Rx pins should be connected to the Afterburner's debug/programming port.
Note that the ESP32 is a 3.3V processor, so ensure the USB to Serial adapter board is set to 3.3V mode.

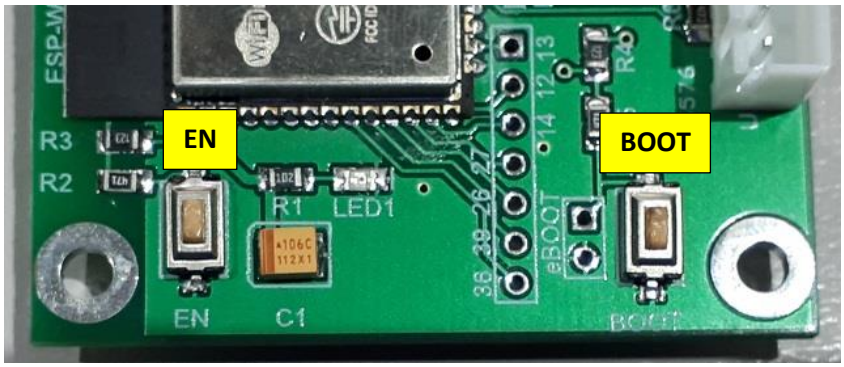


Serial Bootload Process

Prepare the ESP for bootload.

The ESP32 processor needs to be prepared for serial bootloading by using the following sequence:

1. Press and HOLD the **BOOT** button.
2. Press and Release the **EN** button.
3. Release the **BOOT** button.



The above sequence can be performed at any time prior to the firmware upload.
It does not need to happen at the moment the upload is being attempted.
If the ESPtool appears to be stuck trying to connect to the ESP32, you can try repeating the button sequence to enable the ESP32's bootloader.

When EN is held, power to the ESP32 is removed.
When EN is released and BOOT is held down, the ESP32's internal bootloader will be started.
*The ESP32 will then simply wait in the bootloader until triggered by **ESPtool** during the firmware upload process.*

Note: these switches are also brought out next to the debug port header fields and can instead be used to perform the correct EN & BOOT sequencing.

If a serial debug session is active, the following message should then appear:

```
rst:0x1 (POWERON_RESET),boot:0x3 (DOWNLOAD_BOOT(UART0/UART1/SDIO_REI_REO_V2))
waiting for download
```

IMPORTANT
Bootloading will fail if a serial debug session remains active with a terminal program.
ESPtool will be unable to use the already occupied serial port.
Ensure the serial debug session is closed before the upload takes place.

Serial Upload

Completion of serial upload

Despite ***ESPtool*** advising it has rebooted the processor "Hard resetting via RTS pin..", this did not happen because only the data lines are connected. RTS is not brought through.

Once uploading is completed, YOU finally need to **press and release the EN button** again to reboot the ESP32 processor.
The BOOT switch must not be operated at this time.

File system upload (web content)

The pages served by the web server to control the diesel heater are stored in a special area of flash memory in the ESP32 known as the file system partition.
This is formatted to use LittleFS.

It is very easy to upload the web pages to the file system.

Serial

Like firmware updates, file uploads can also work over a serial connection using the ESP32's internal bootloader and ESPtool.

The file to be uploaded is a binary image that is to be directly uploaded to the file system partition.

If using serial bootloading, ensure the USB to serial adapter is connected to the Afterburner's debug/programming port, and the ESP32 is ready for bootloading by performing the EN/BOOT button sequence.

Wifi

Uploaded web content must remain in the .gz container.
Due to idiosyncrasies of browsers, new content is delivered within a .zip container.
A .gz download will typically be extracted by the browser and proceed to execute the web content which is not the desired effect.
You will need to use a tool to unzip the .zip file to obtain the .gz file.
Do not further extract the .gz file.

Browse the Afterburner's inbuilt file system uploader using the URL suffix /update

Eg: http://192.168.4.1/update when using a Soft AP connection to the Afterburner.

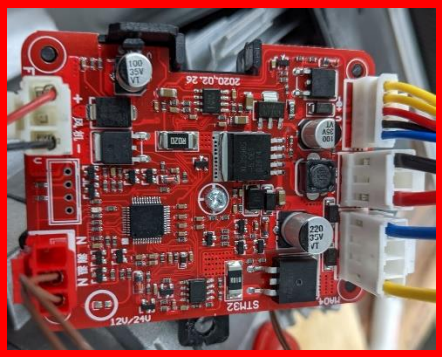
You will be prompted for a username and password.

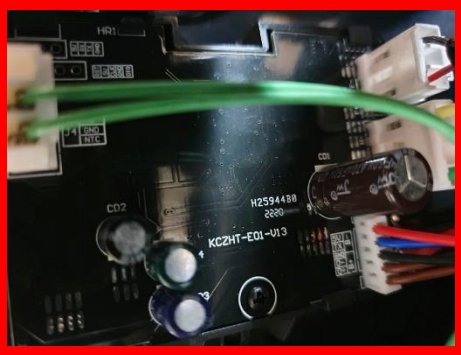
- Username: **Afterburner**
- Password: **BurnBabyBurn**

These can be changed using the debug menu system if you prefer (secure menu).

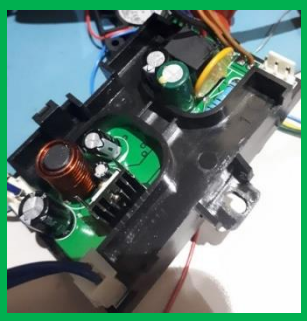
Migrating to a compatible ECU

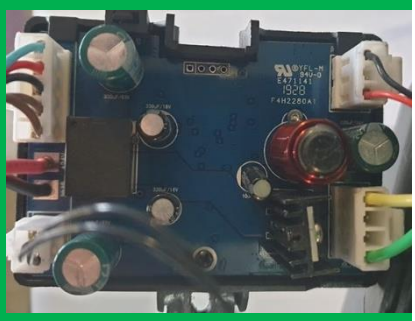
From BAD





To GOOD



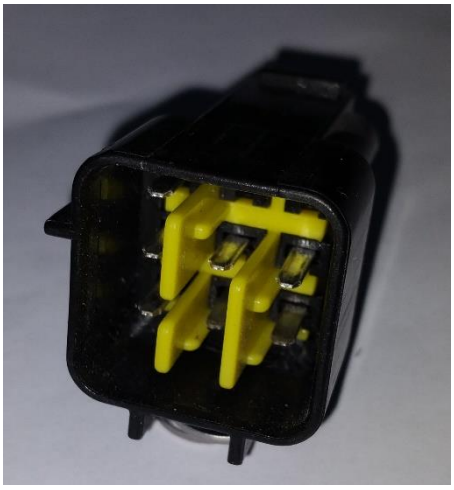


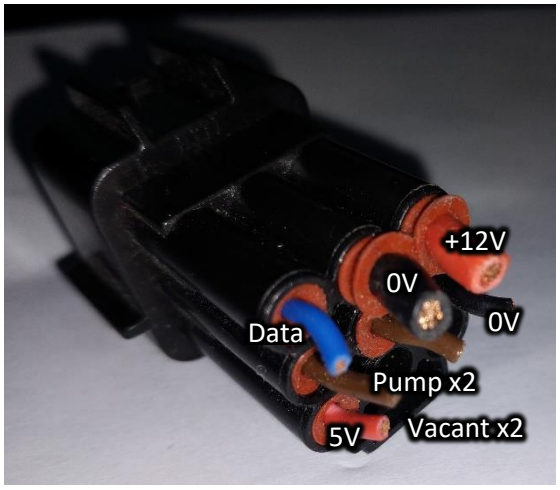
Introduction

The ECUs furnished with the “blue digit LCD” based heaters (and many others) are not compatible with the Afterburner.

Compatible ECUs can be readily sourced from eBay, Amazon or AliExpress, typically of similar appearance to the lower image in the green box on the previous page. Search for **HA45214A0.**

The first aspect to check is whether the ECU you have now has the correct style of square, 3x3 9-pin plug.
If so, your existing wiring loom is compatible (it usually is).

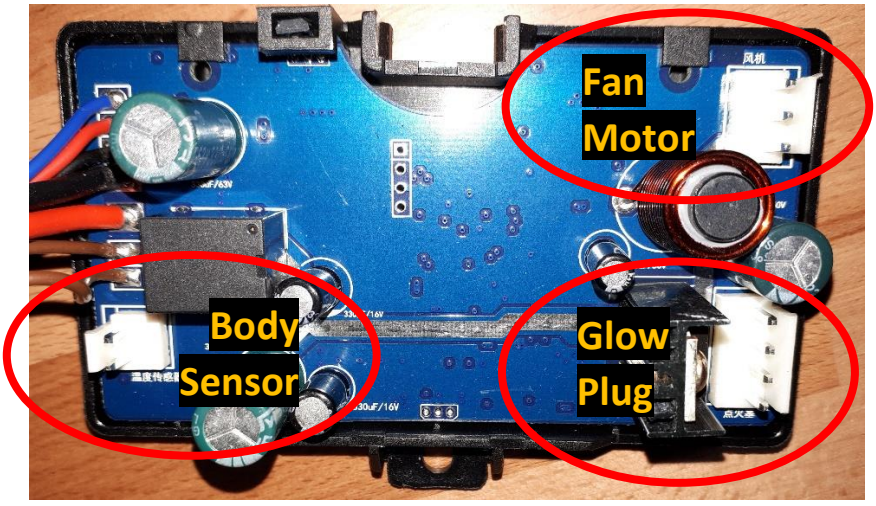




Internal wiring location changes

Internally, the headers for the fan motor, glow-plug and body temperature sensor will usually be differently located than the old ECU.

For the main wiring harness, pass the harness’s grommet through the nearest side entry position, relocating the blanking grommet to the opposite side of the heater casing if need be.



The body sensor may be on a 3-pin socket, but only 2 pins are present on the new ECU’s header. Simply align the adjacently wired 2 pins of that socket with the pins of the ECU’s header.

The fan socket always has a vacant middle position.

The glow plug is always the 4-pin plug.

Software Configuration

Please do not attempt to run the old, incompatible, controller alongside the Afterburner as described in the Installation Guide.
The Afterburner and old controller use entirely different communication protocols, and there are no settings to harvest from the old controller anyway.
If you do try, all you will get is an E-07 “Comms Error” reported.

The Afterburner’s default fuel settings are typical for a 5kW system.
A tuning table is included at the end of this guide.
Final tuning is best achieved using a CO meter to monitor for low CO emissions.

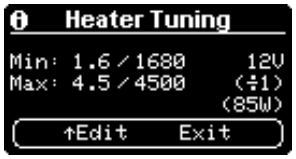
Dealing with the usual E-01 fault

New compatible ECUs are usually shipped factory configured for a 24V system.
This causes an E-01 “Low voltage” error to be thrown soon after powering up the system, despite a healthy 12V source.

This is remedied by visiting the Afterburner’s Heater Tuning menus:

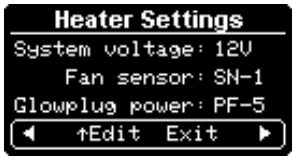
1. Navigate to the ***Menu Trunk***, using the **LEFT** or **RIGHT** keys.
2. Use **UP** presses to highlight the **Heater Tuning** selection.

3. Enter the ***Tuning Overview*** by pressing **LEFT** or **RIGHT.**

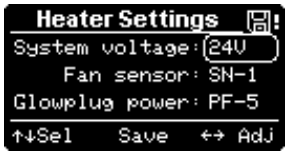


4. Press **UP** to enter the actual tuning menus, you will need to enter the 1688 password.

5. Press **RIGHT** to show the ***Heater Settings*** menu.

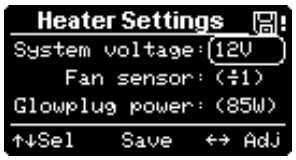


6. Use **UP** presses to select the **System Voltage** field.
7. Press **LEFT** or **RIGHT** to **change to 24V – Yes, 24V!**



8. Save the change by pressing **CENTRE**, then **UP** to confirm.

9. **Wait a few seconds.**
10. Re-select the **System Voltage** field.
11. Press **LEFT** or **RIGHT** to **change back to 12V.**



12. **Save again** by pressing **CENTRE**, then **UP** to confirm.
13. The ECU will now be correctly set for 12V and will also have adopted the default Afterburner tuning parameters.
    If E-01 fails to go away, try repowering the heater.

Conclusion

The Afterburner can now be used as desired, have cleared the problems that are usually encountered when replacing the ECU with a compatible unit

Diesel heater elevation settings

5KW 39 cm

1.6 hz	1680 rpm	low	sea level-2,500 ft
5.0 hz	4500 rpm	high	
1.4 hz	1680 rpm	low	2,500 ft-5,000 ft
4.5 hz	4500 rpm	high	
1.3 hz	1680 rpm	low	5,000 ft-7,500 ft
4.0 hz	4500 rpm	high	
1.2 hz	1750 rpm	low	7,500 ft-10,000
3.5 hz	4500 rpm	high	

2KW 32-34 cm @Colorado Safaris
(.022 & 18.5-20 pumps)

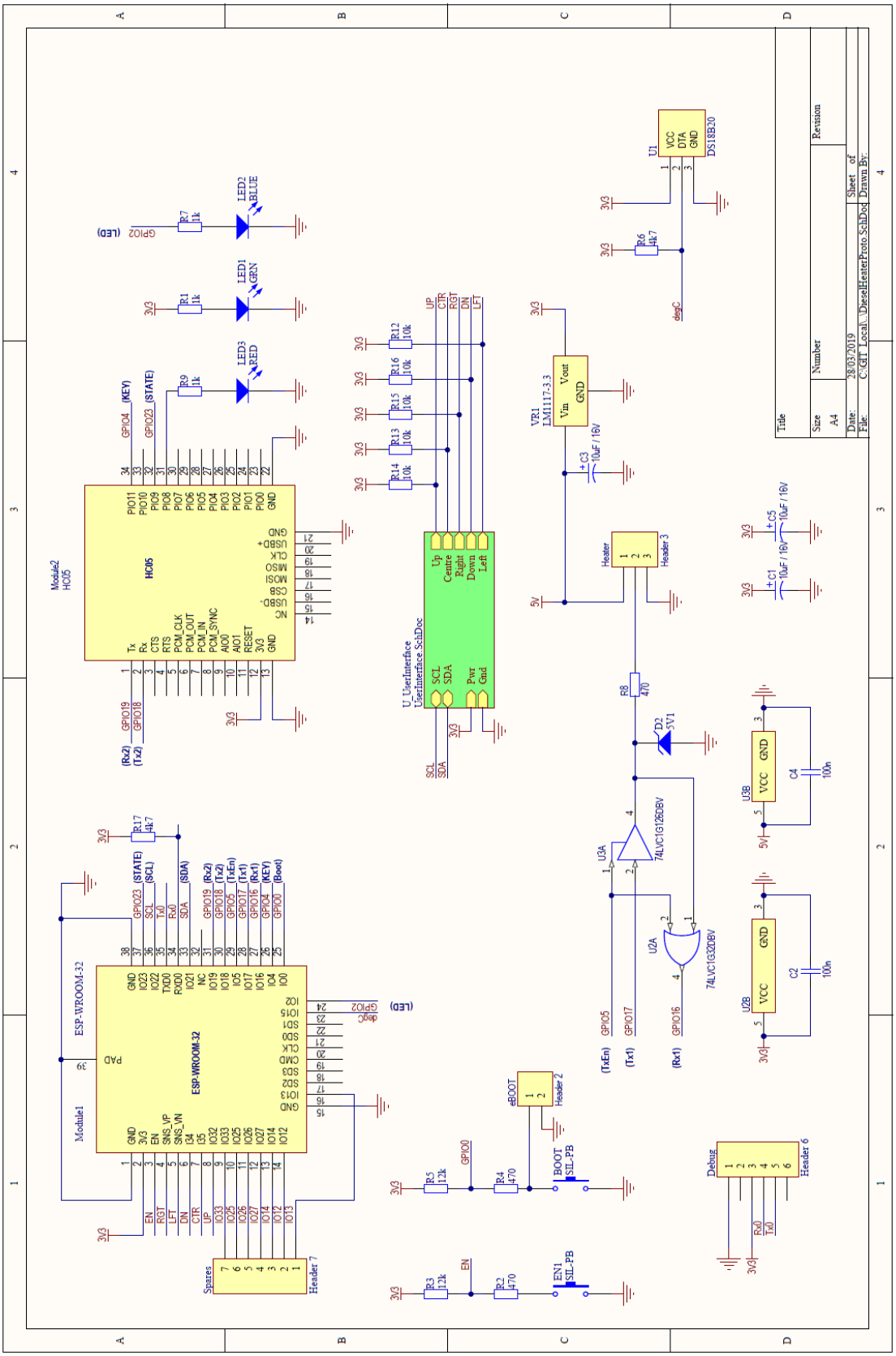
1.0 hz	1500 rpm	low	sea level-2,500 ft
3.0 hz	4500 rpm	high	
.9 hz	1500 rpm	low	2,500 ft-5,000 ft
2.7hz	4500 rpm	high	
.8 hz	1500 rpm	low	5,000 ft-7,500 ft
2.4hz	4500 rpm	high	
.8hz	1750 rpm	low	7,500 ft-10,000
2.1 hz	4500 rpm	high	

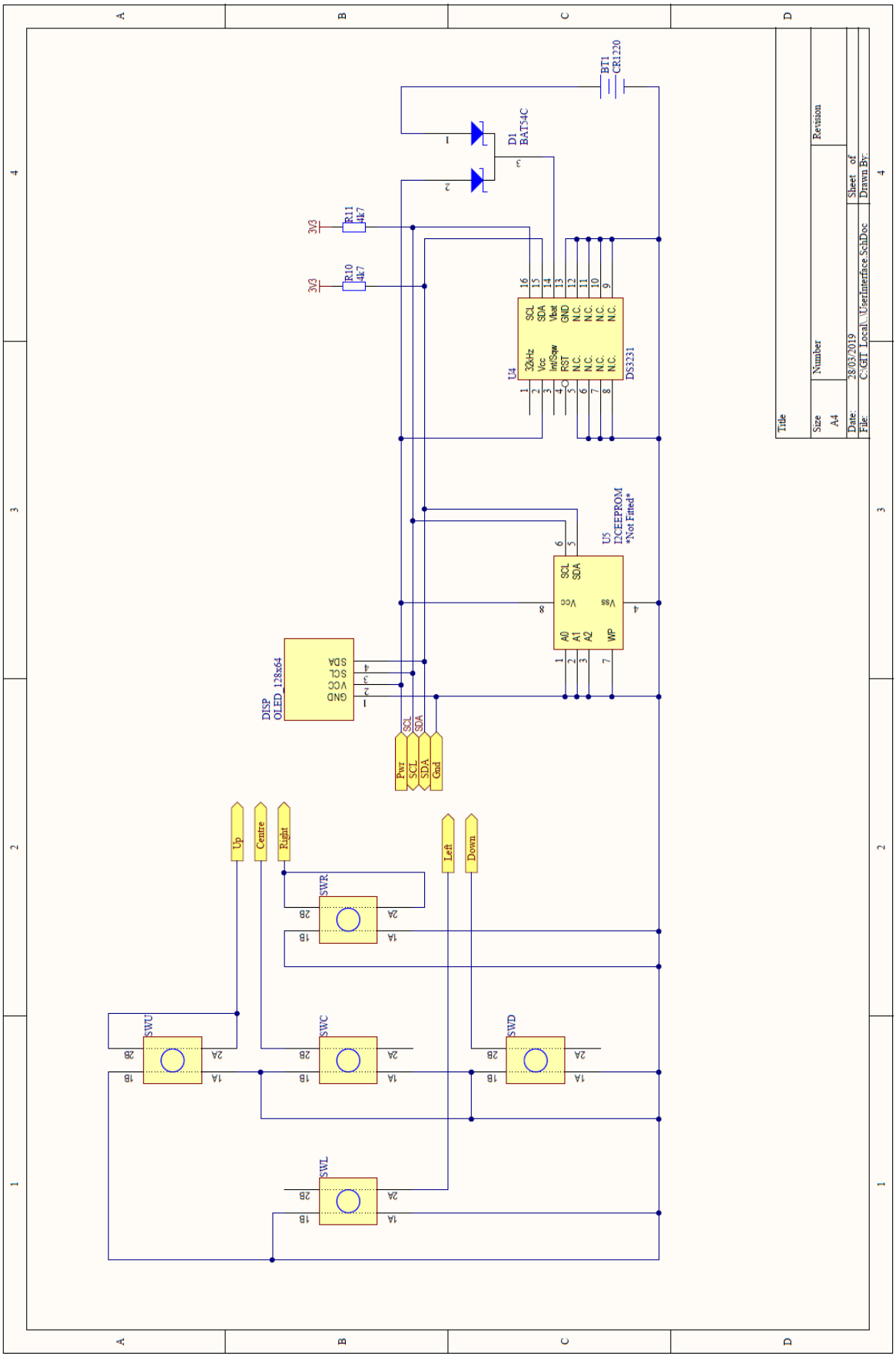
Assumes .022 fuel pump. For .016 pump x1.375 the fuel

Tim P

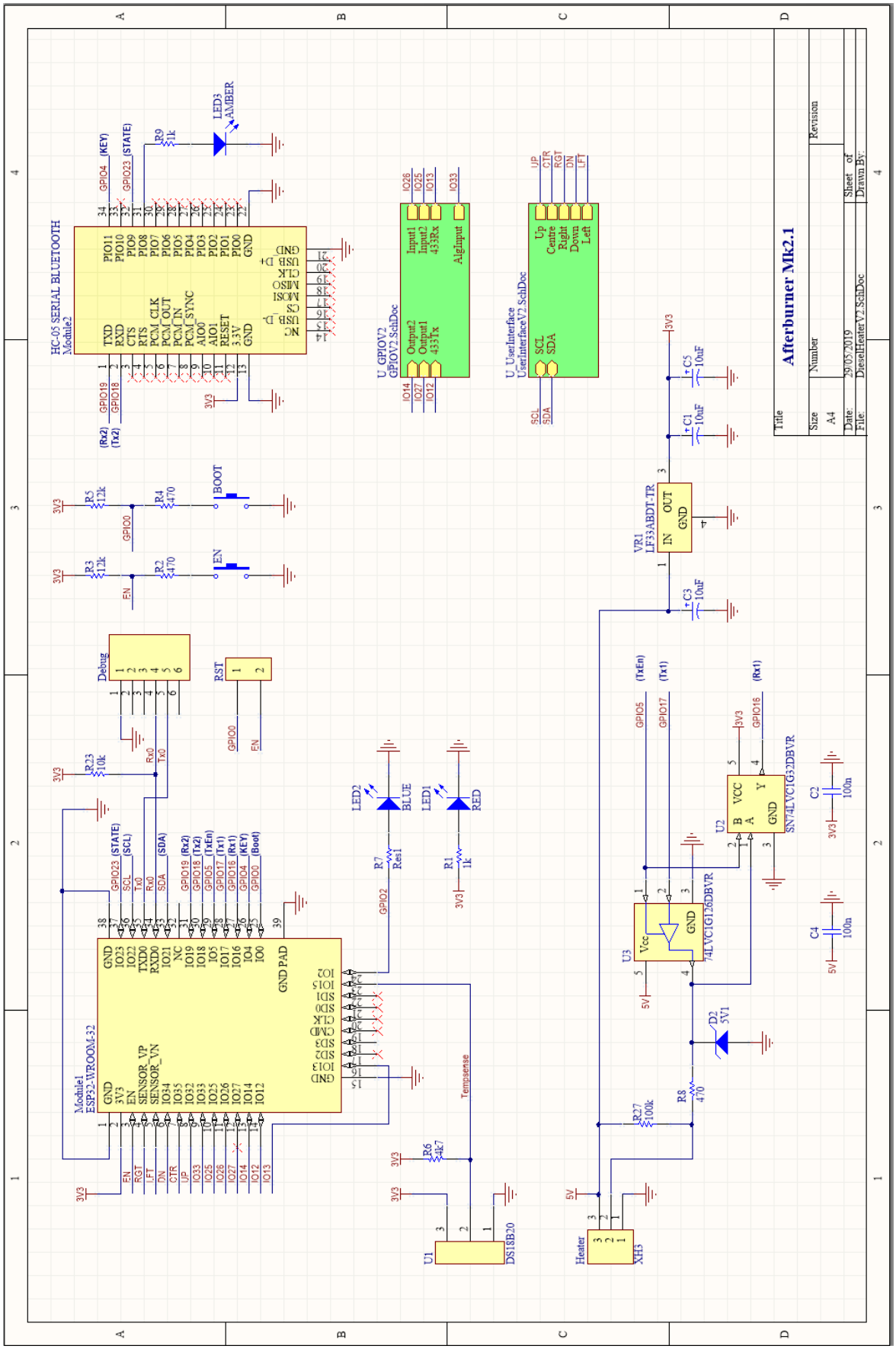
Schematics

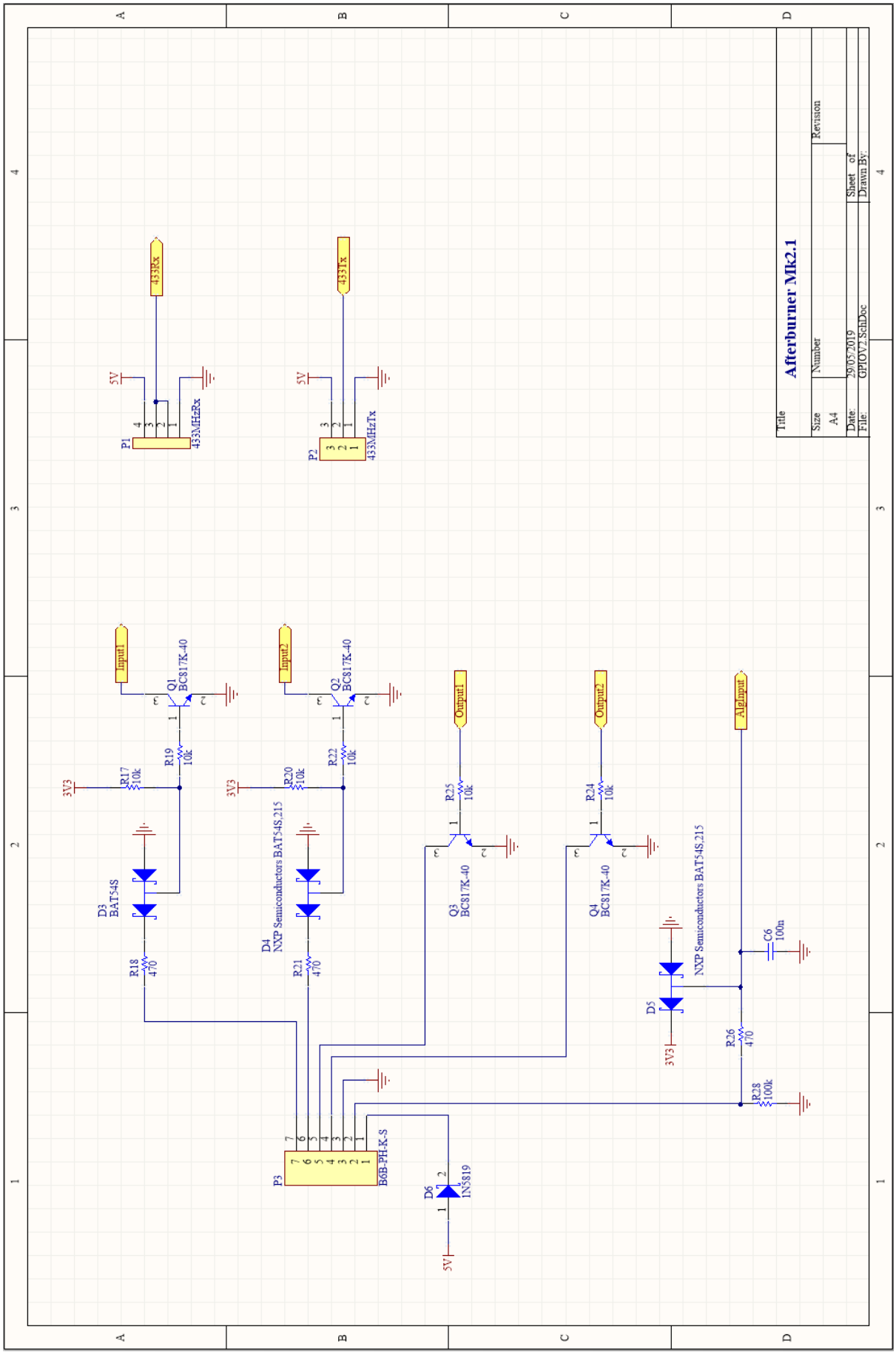
Prototype PCB

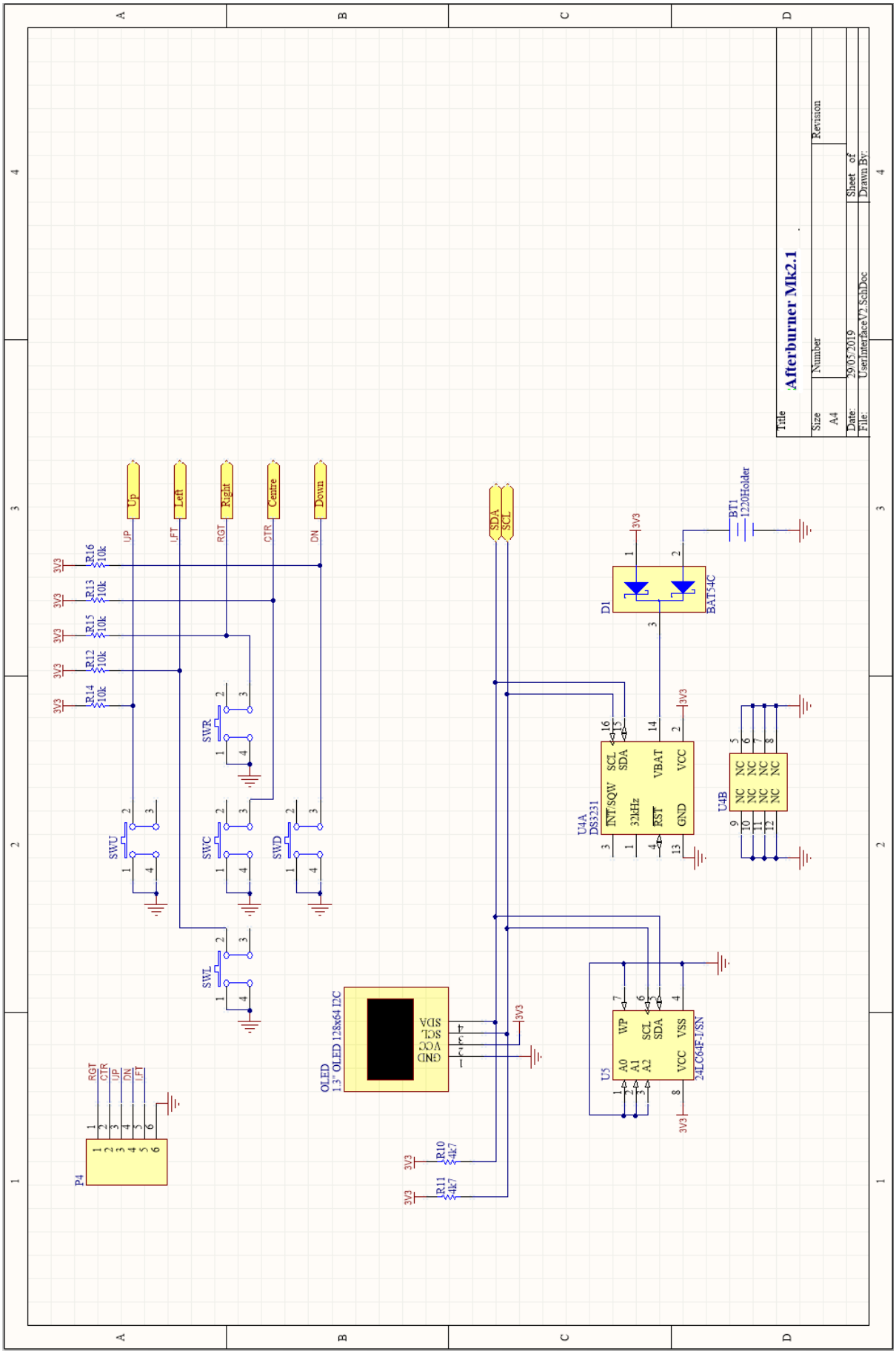



BT1
CR1220
D1
BAT54C
R11
4k7
R10
4k7
3V3
U4
DS3231
SCL
SDA
Vbat
GND
32kHz
Vcc
Int/Sqw
RST
N.C.
U5
I2CEEPROM
Not Fitted
A0
A1
A2
WP
Vss
DISP
OLED 128x64
GND
VCC
SCL
SDA
Pwr
Gnd
Up
Centre
Right
Left
Down
SWU
SWC
SWD
SWR
SWL
Title
Size
A4
Number
Revision
Date:
28/03/2019
File:
C:\GT Local\...\UserInterface.SchDoc
Sheet of
Drawn By:

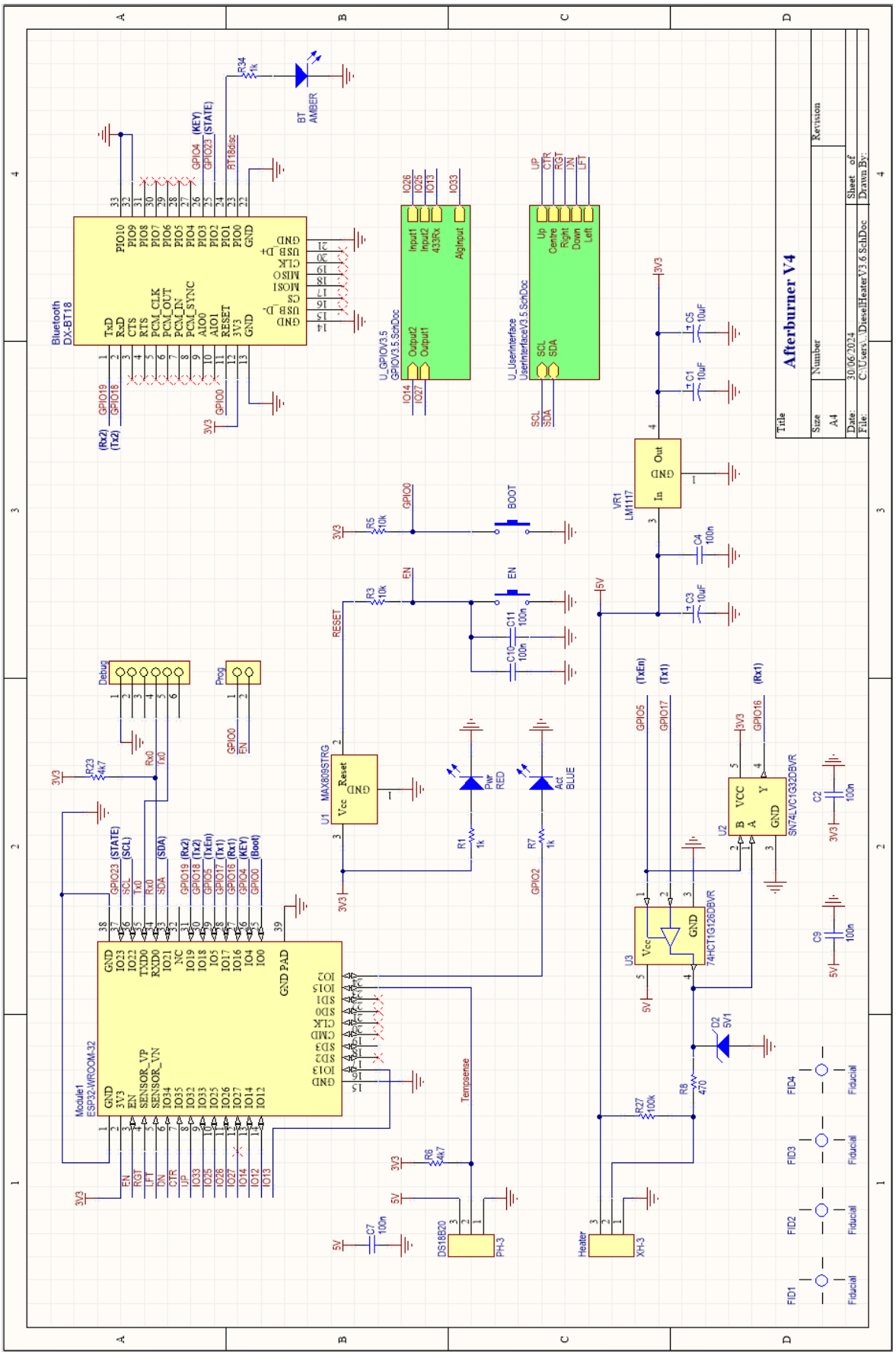
Production PCB

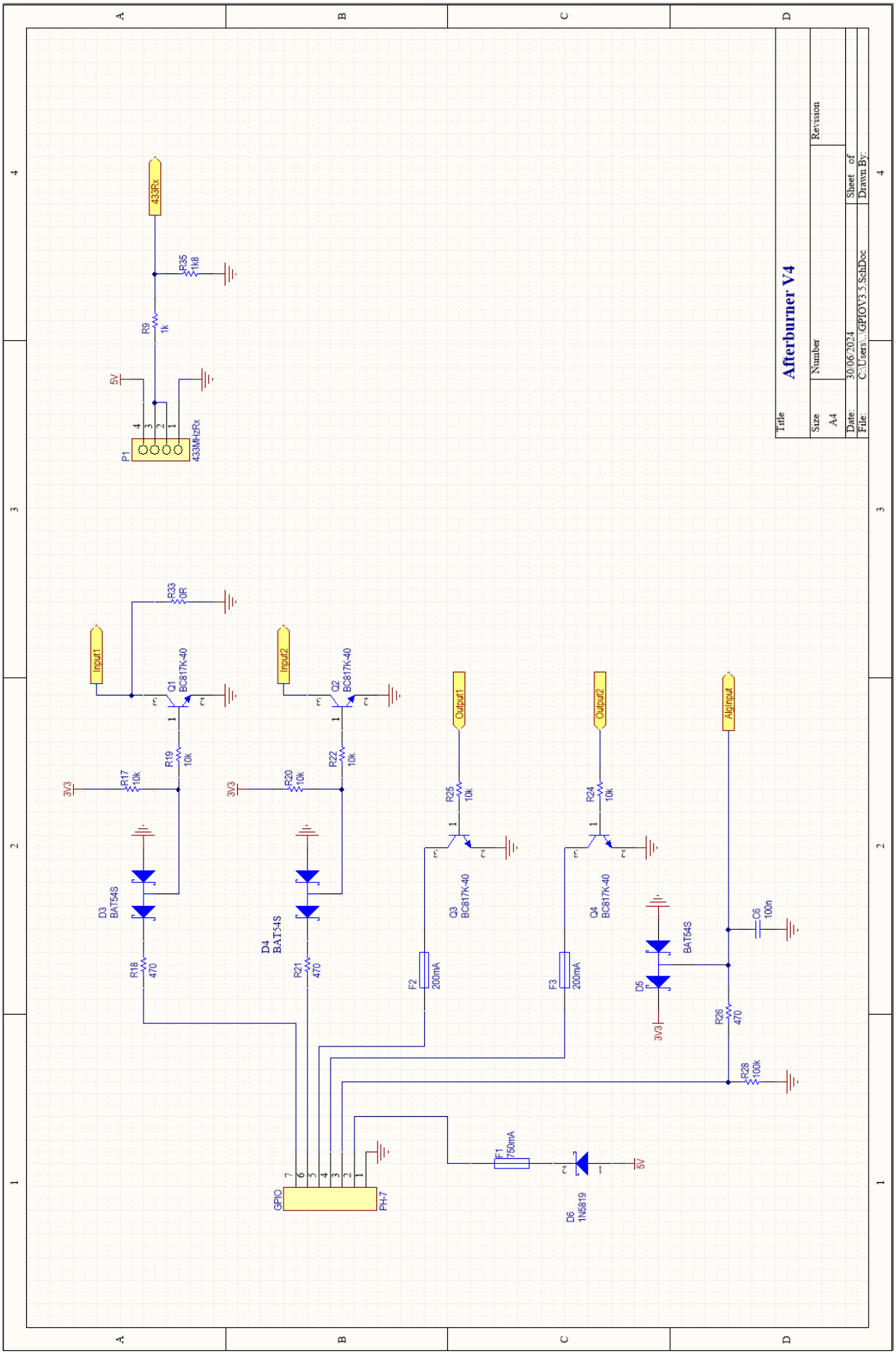



Afterburner Mk2.1
Title
Size
A4
Number
Revision
Date: 29/05/2019
File: GPIOV2.SchDoc
Sheet of
Drawn By:
433Rx
433Tx
5V
P1
433MHzRx
P2
433MHzTx
Input1
Input2
Q1
BC817K-40
Q2
BC817K-40
3V3
R17
10k
R19
10k
R20
10k
R22
10k
D3
BAT54S
D4
NXP Semiconductors BAT54S,215
R18
470
R21
470
Output1
Output2
R25
10k
R24
10k
Q3
BC817K-40
Q4
BC817K-40
AgInput
D5
NXP Semiconductors BAT54S,215
C6
100n
R26
470
R28
100k
P3
B6B-PH-K-S
D6
1N5819


Afterburner Mk2.1
Up
Left
Right
Centre
Down
SDA
SCL
SWU
SWL
SWR
SWC
SWD
R16 10k
R13 10k
R15 10k
R12 10k
R14 10k
D1
BAT54C
BT1
1220Holder
U4A
DS3231
U4B
U5
24LC64F-I/SN
OLED
1.3" OLED 128x64 I2C
R10 4k7
R11 4k7
P4
3V3

Production PCB - V4




433Rx
R35 1k8
R9 1k
5V
P1
433MHzRx
R33 0R
Input1
Q1 BC817K-40
R19 10k
R17 10k
3V3
D3 BAT54S
R18 470
Input2
Q2 BC817K-40
R22 10k
R20 10k
3V3
D4 BAT54S
R21 470
Output1
R25 10k
Q3 BC817K-40
F2 200mA
Output2
R24 10k
Q4 BC817K-40
F3 200mA
AlpInput
C6 100n
BAT54S
D5
3V3
R26 470
R28 100k
GPIO
PH-7
F1 750mA
5V
D6 1N5819
Title
Afterburner V4
Size
A4
Number
Revision
Date: 30/06/2024
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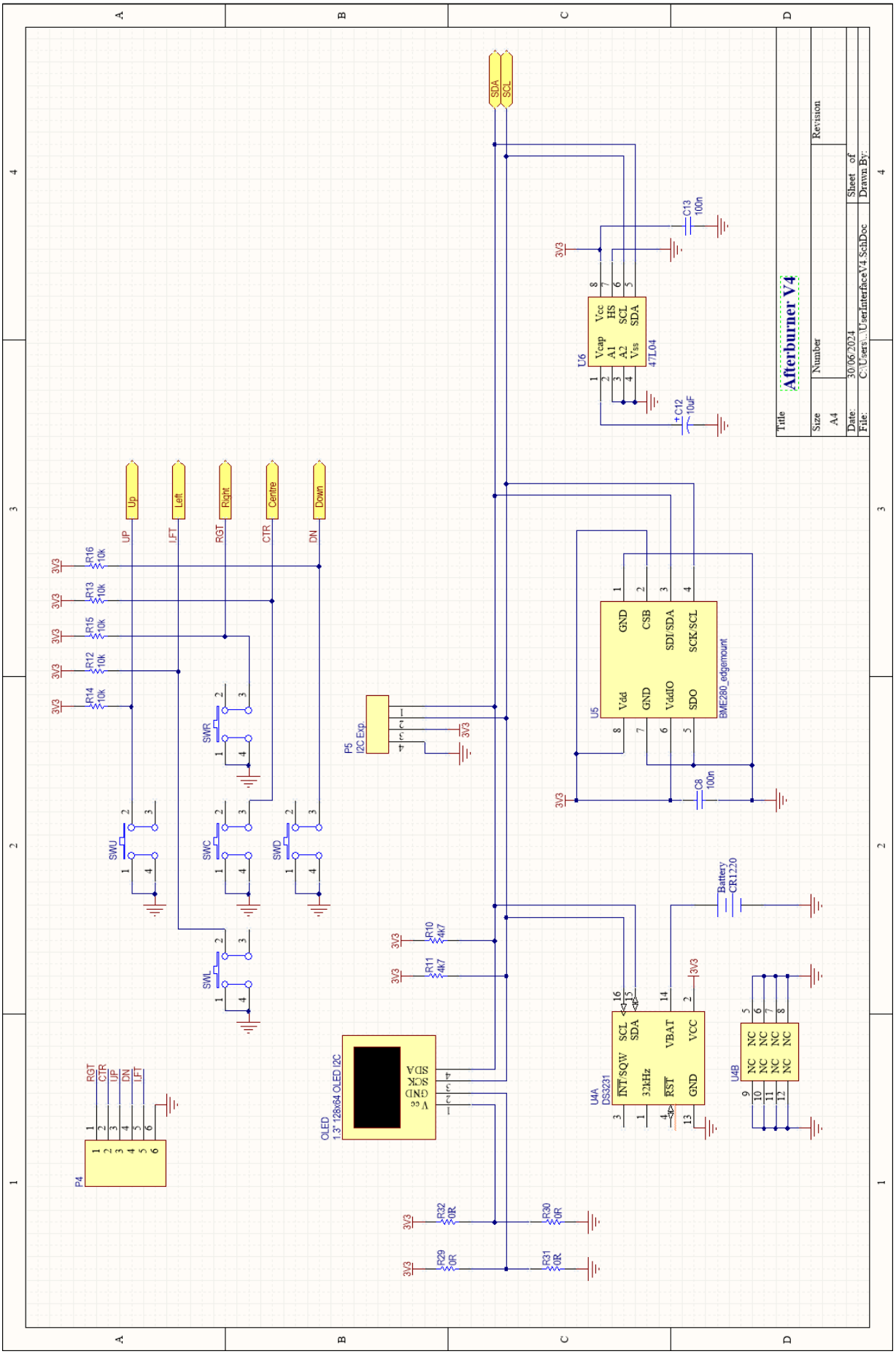
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Title
Size
A4
Number
Revision
Date:
30/06/2024
File:
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SDA
SCL
Up
Left
Rgtt
Centre
Down
UP
LFT
RGT
CTR
DN
SWU
SWL
SWR
SWC
SWD
R16 10k
R13 10k
R15 10k
R12 10k
R14 10k
P5
I2C Exp
P4
OLED
1.3" 128x64 OLED I2C
R10 4k7
R11 4k7
U5
BME280_edgemount
GND
CSB
SDI/SDA
SCK/SCL
Vdd
VddIO
SDO
C8 100n
U6
47L04
Vcap
A1
A2
Vss
Vcc
HS
SCL
SDA
C13 100n
C12 10uF
U4A
DS3231
INT/SQW
32kHz
RST
VBAT
VCC
Battery
CR1220
U4B
NC
R32 0R
R30 0R
R29 0R
R31 0R
3V3