ESP32 wifi BBQ thermostat and thermometer

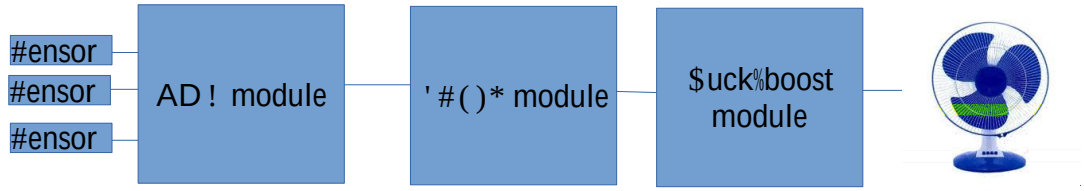
This toy was developed for my son Thomas who is an enthusiastic barbecue fan. He has several installations that require a constant temperature for a long time. Also the temperature of the meat must be monitored. This project is a followup of a bluetooth version I made earlier. Due to complaints of the limited range I made this wifi version. The thermostat itself works remarkably well.

The thermostat can be accessed as a station in network and at the same time as a accespoint for operating without a network.

The temperatures are measured with T ! sensors from a cheap Ikea thermometer.
The coal fire is controlled by regulating the airflow by means of a small fan.
It is powered from a "#$ power%pack. A standard powerbank is cheap& easy to charge and short% circuit proof.

The '#()* is a perfect controller for this task.

$lock diagram+

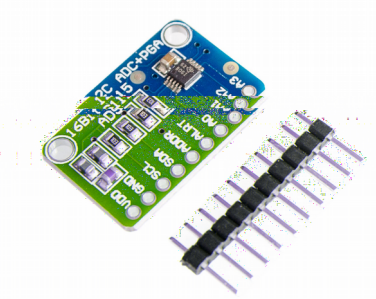


Description

The Ikea sensors & from Ikea , antast thermometer& are *--k . T ! /s.
The 0*1 and 2 value are determined by measuring the resistance at * temperatures and using the tool on this website+
3http+33www.giangrandi.ch3electronics3ntc3ntc.shtml
4ou can use other T ! /s if you like and adjust these parameters in software.

ADC module

The '#()* has a 5*bit AD ! that should be more than enough for reading the temperature within a degree or so. $ut it appeared that the accuracy of this AD ! is poor& at room temperature a measured a deviation of more than 6 degrees. That is the difference between a nice steak and a sole of a shoe. The '#(data%sheet says nothing about the specifications of the AD ! .
I found a nice AD#5551 module that has 56 bit resolution& great accuracy and 7 channels. It can only be operated whit the build%in



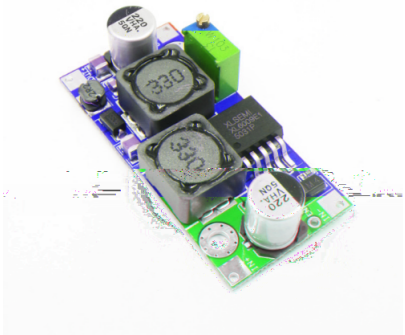
reference. The T!s are pulled%up to the)8). 9ne channel measures this)8) and serves as a reference for the other channels. The module is connected by I*!.

ESP32 module

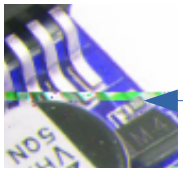
The '#(module is a :standard developmentkit; I use this one from TT<9. It has a #D card slot on the back and a user ='D.
9f course you can use another one. If your module has no #Dcard slot connect a #D!ard connector using pins+
!#+ I95) >add pullup 5-k?
@9#I+ I951
@I#9+ I9*
!=A+ I957
These pins are shared with the BTA< pins. If you use BTA< also other pins are possible but it can be necessary to lower the clk.

Buck-Boost module

@y first idea was to use a 18 fan and control the speed using a ,'T and (C@. There a few 18 fans available& and more important+ the ones I tried could not be regulated. 5*8 fans are more popular and they are a lot better to control. They operate from 7.1 to 5* 8 and have a good voltage to speed characteristic. #ince I want to supply the system with 18 I needed a stepup converter.
Again I found a nice module+ >long live alie and our other chinese friendsD?. This module is based on a E=6--F. The outputvoltage can be adjusted by a potentiometer from 5.*1 to)18. Instead of using (C@ I now can adjust the outputvoltage of the converter with the '#(DA!.

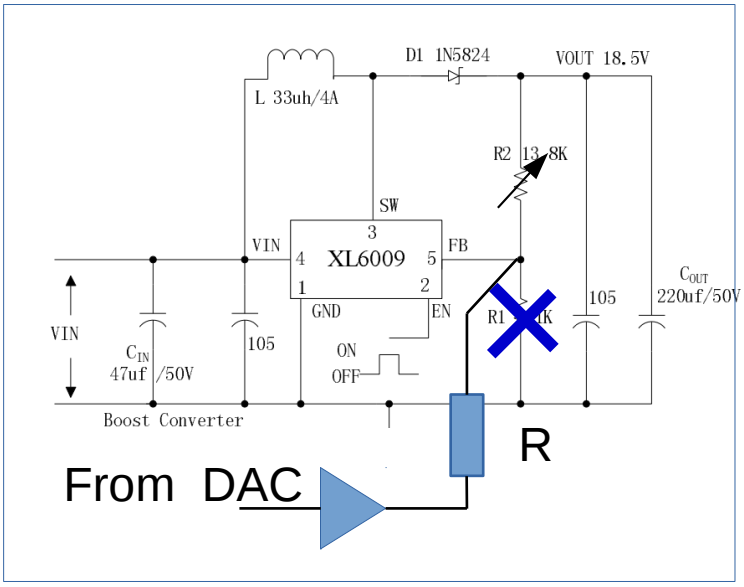


I small modification in the feedback line is needed+



Remove this resistor and solder a wire to pin 5 of IC

The E=6--F has a reference voltage of 5.*18 $y introducing an offset to the feedback the output voltage can be adjusted from Gero >8DA! H5.18? to the desired outputvoltage >8DA! I -?.
This diagram shows a boost converter. The output of a boostconverter cannot be set lower than the input voltage. In a miraculous way this module can J
Carning+ the E=6--F is specified to work from 1 %)*8.
I found out the hard way when you apply)8 the output goes mad and becomes 6-8D $lowing the output capacitor.
Don/t try this at home.

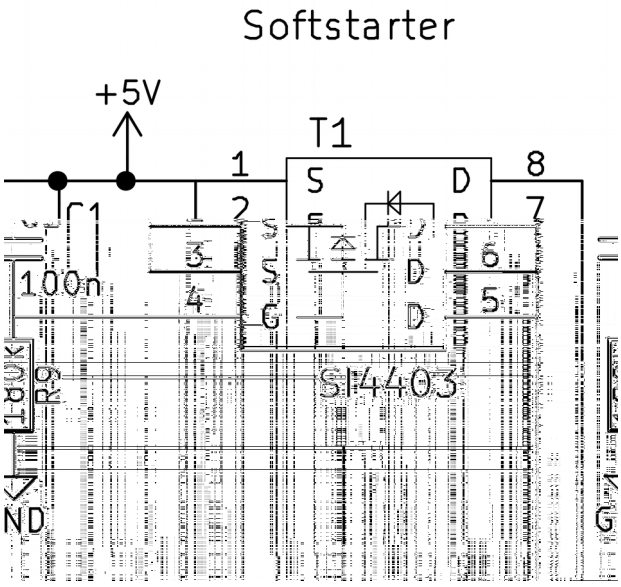


The DA ! of the '#()* cannot sink enough current > specifications KKKK? . A buffer > working from groundrail? is needed. I used a T= ! *L*& =@)1M should also work.

That/s nearly all folksD

Powerbank

After soldering all together and connecting my new 5*.1Ah powerbank I saw that after * seconds the powebanks switched off. That is not long enough for my pulled pork.
The reason is the **-u, input capacitor of the E=6--F module. The short but high chargecurrent is enough to trip the powerbank. A softstart is needed to make it work. This is achieved by a logic level (@9#, 'T& a 0 and !
I used a #9M type 5.M8 turnon voltage and a very low 0D#on.
During switching on a small amount of heat is generated.
I soldered the drain on a piece of coppertape. I think it will work without the tape also.
ow the powerbank stays on.
ote about the capacity of the powerbank+ The number of Ah is not the Ah you would eNpect to get+ To confuse the 0ussians it is the capacity of the).L8 lithium cells. A D !3D ! converter converts this voltage to 1.58. #o you end up with about 61O on the 18 side& in my case about M.1Ah.



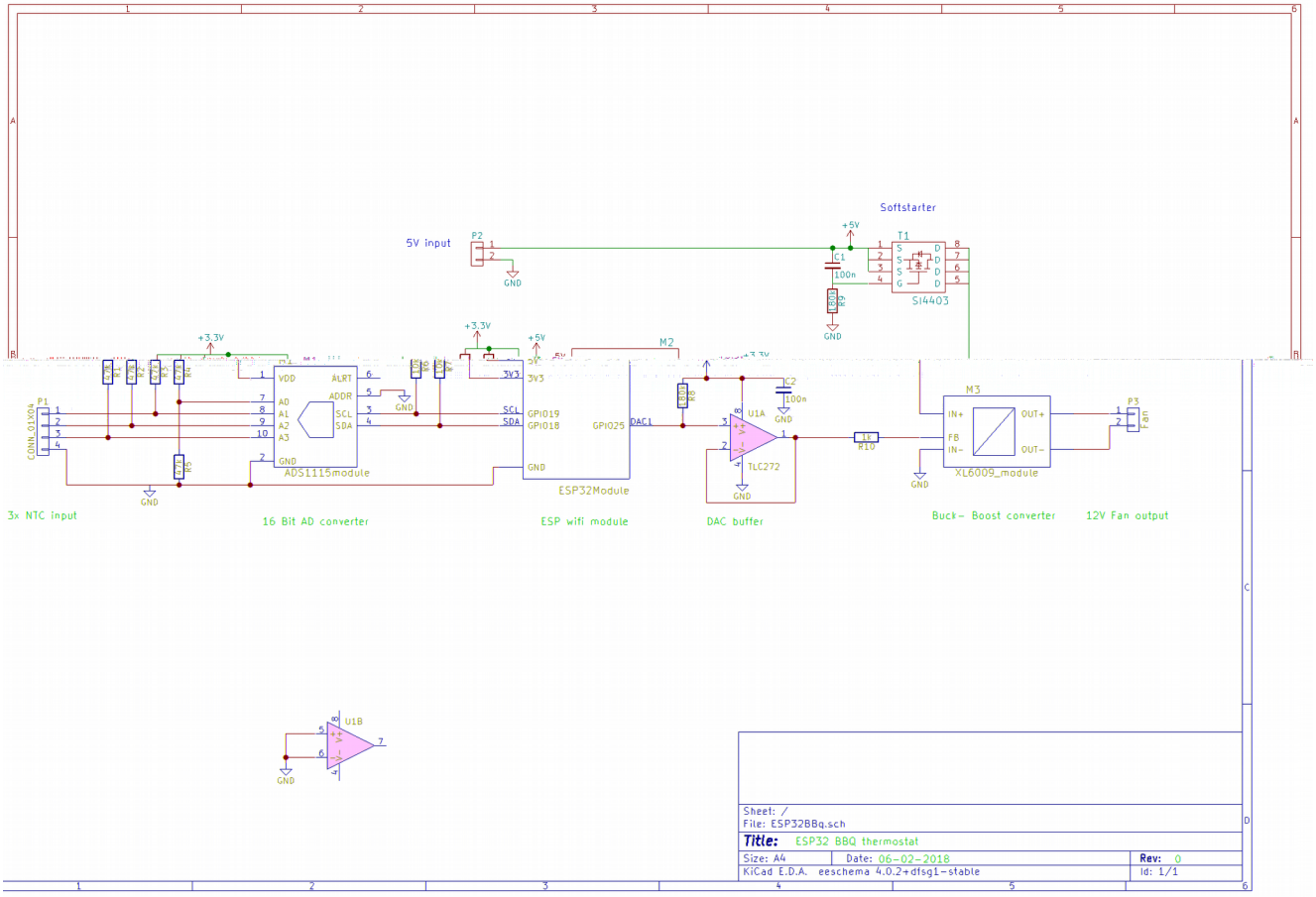
@y powerbank has one 5A and one 5.1A output& 7 status = ' D/s and a torch function. <reat chance this ic is used+
http+33www.richtek.com3(roducts3$attery @anagement3#ingle ! ell =i%Ion $attery ! harger30TF7M-

$ecause the output voltage is stable it is not possible to implement a battery monitor in the application. The output is switched off immediately when the cells becomes empty. 4ou can check the = ' Ds of the powerbank.

Fan

I used a Lcm 5*8 D ! A8 ! D '#! -L5M$*" fan from a (! processor cooler. According to the label it has a currentconsumption of -.LA& I measured -&5 A what is a lot more realistic.

Schematic diagram

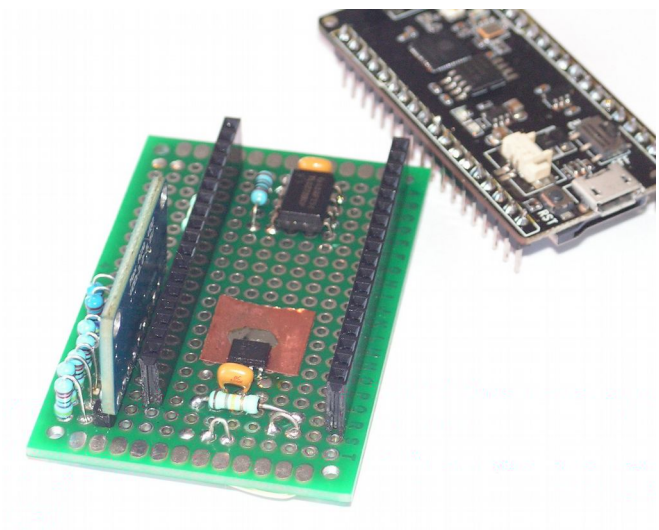


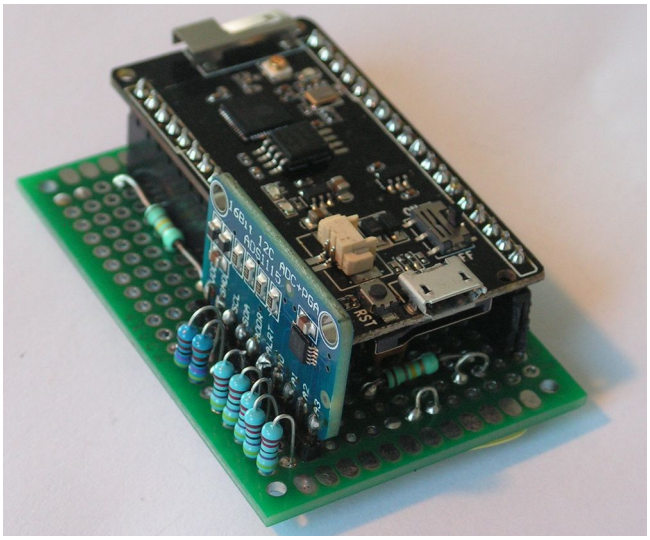
' lectronic partslist. @ost of the components you can find at Ali ' Npress

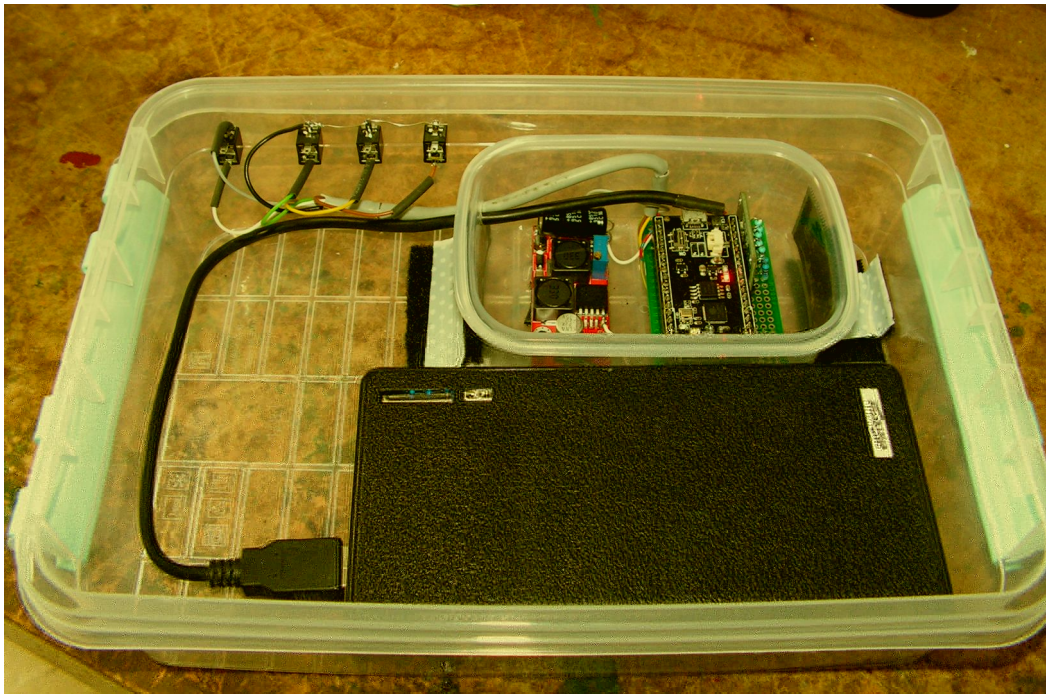
(art	Amount	remarks
' #( )* module	5	C ith #D ! ard slot ›TT< 9?
AD#5551 module	5	
E=6--F module	5	
T= ! *L* opamp	5	
, ' T #I77-)	5	0eplacement+ (*--) ' 8 <
0esistor 5k	5	
0esistor 7Lk 5O	1	
0esistor 5-k	*	
0esistor 5M-k	*	
! apacitor 5--n	*	

Construction

The hardware is build on a breadboard
Here you see the AD ! & softstart and DA ! buffer and the complete unit.





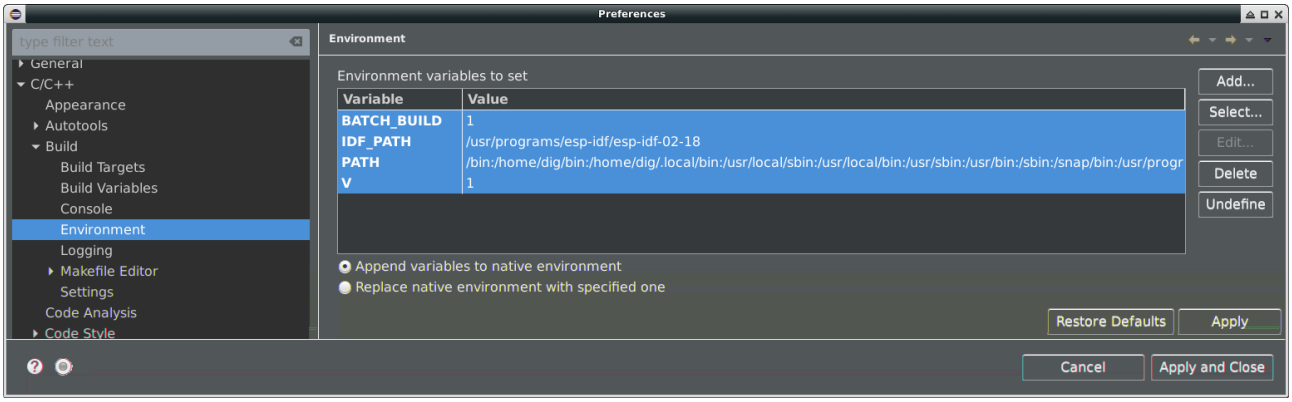


Above part and the D ! 3D ! converter are build into a small plastic boN. This is placed in a bigger boN together with the powerbank and *.1 mm jacks for the sensors and the fan. All the parts are fiNed using Hoop and =oop tape. <reat stuff.

Here you see the fan build into a semi%professional housing. The outlet is a)* mm cablegland.

Software Tooling

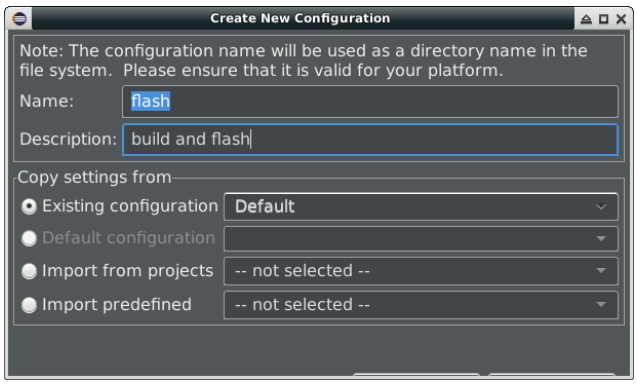
The '#()* comes with a complete development environment.
It has a well documented library >'#(%ID,?. Also a arduino library is present.
I used the '#(%ID, with the eclipse editor and debugger on "buntu 56 linuN but also Cindows is supported. ative linuN works a lot faster.
To install the #DA and ID, follow the instructions at https+33dl.espressif.com3doc3esp%idf3latest3get%started3indeN.html



In eclipse you will have to set some environment variables and the path to the compiler. I prefer to do it the workspace settings+ <o to Cindow P preferences P !3!QQ P build and set the paths.
These settings apply to all your projects in this workspace.
4ou can also make these settings locally in your projects.
There is one item about the (ATH+ it should be appended to the system path but it is replaced.
#o I put my complete path here with the path to the Ntensa compiler appended.
>+3usr3programs3Ntensa%esp)*%elf3bin?

I prefer to have the idf in my eclipse workspace visible+ goto file P import eNisting projects as makefile project and point to the idf folder.

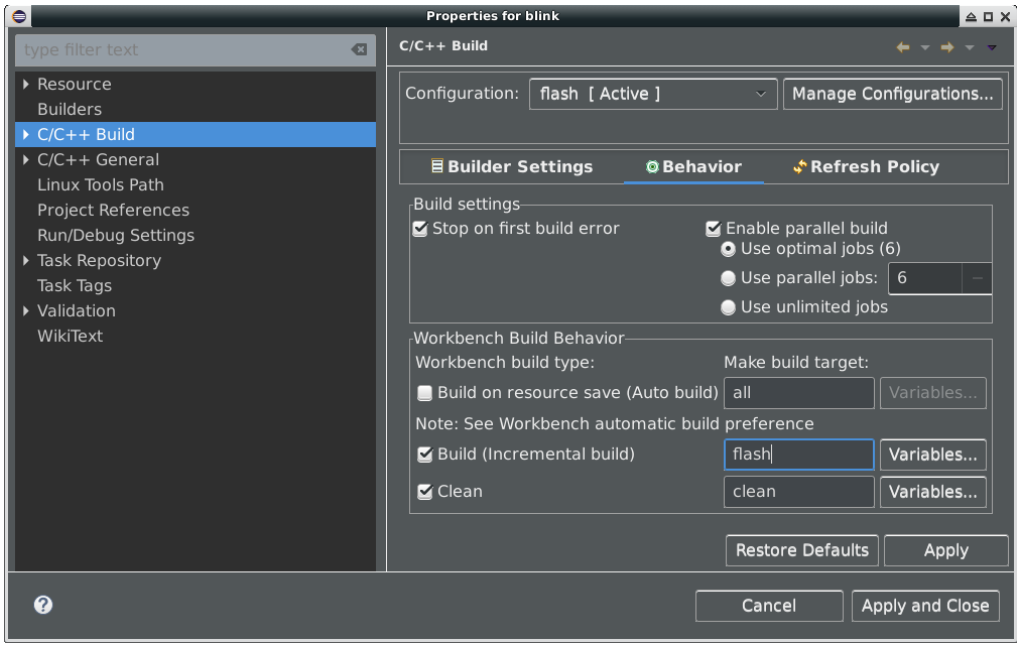
To make your first blinky project+
goto file P import eNisting projects as makefile project and point to the idf folder3eNamples3get% started P blink.
ow you have your blink project in the workspace. 4ou will have to configure your project outside 'clipse in a terminal window. #ee the '#()* doc to do this.
9nce you have a configurationfile in your project > sdkconfig? you can use this for your other projects.
4ou can build the project. The first time a lot happens+ the needed components from the idf are pulled into your project build folder in a miraculous way.
To program your module you will have to make another build configuration or modify the eNisting default one+ right click your project P build configurations P manage %H new press 9k.
#et flash to active configuration.



ow you must edit the properties for the flash configuration+ right click your project %Hproperties+ #et 'nable parallel build to speed up the compiler. >also for the other configuration?
#et @ake build target to :flash;.

!onnect your '#(board to a serial port and press make.

4our target is now being flashed.



To eNtend your first project with peripherals like timers you can use the idf peripheral eNamples files.
Bust put them in your source folder and make takes care of everything.
To have multiple sourcefolders in your project you have to copy the component.mk in these sourcefolders to include the files in the build.

9nce your first project is up and running you can use this as a template for other projects.

b+ A nice eNtension for eclipse is (ath Tools& for easy file and path handling. To install+ help P install new software or @arket place

Software description

The '#()* uses the ,ree0T9# operating system. The use of such a rtos has many advantages and also makes developing more easy. ,or eNample a blink task is a just a simple while loop+

```
while >5? R
        = ' D>on?
        taskDelay> 1--ms?
        = ' D>off?
        taskDelay> 1--ms?
S
```

A lot easier then assigning a timer interrupt.
The tasks used in this program+

blink+ A = ' D is used as a status indicator+ flashing slow means wifi is connected& fast not connected. This task also checks if some settings like ip address are changed. If so the '#(is rebooted to take effect.

HTT(#erver+ This task waits for HTT(messages to come in and processes these messages.

Thermometer+ senses the T ! /s & calculates the temperatures.

(ID+ implements the (ID > actually (I? algorithm for the ,an % DA !

Cebsite

The website is consists of HT@= and javascript code. I am not a eNactly a specialist on websites so be my guest to make the website more fancy. I use Aptana studio for editing.
The code is copied to #D card. It is also possible to embed the website in flash. It needs to be converted to !%code. This can be done using by a perl utility makefsdata+
https+33github.com3goertGenator3lwip3tree3master3contrib%5.7.-3apps3httpserverTraw3makefsdata
It gave some strange deviations > font ? to the orgininal code. I have not figured out why& so I decided to leave it to #D. > #ee the Udefine "#'T#D ! ard in httpd%fs.c?

(I settings parameters+

These parameters determine the characteristics of the control%loop.
The fan speed is calculated as follows+

```
delta = setPoint -temperature[0];
result = delta * pFactor;
iSum += delta * iFactor;
if (iSum > 0) {
      if (iSum > maxI)  // limit to maxI
            iSum = maxI;
} else {
      if (iSum < -1 * maxI) // or negative value
            iSum = -1 *maxI;
}
result += iSum;
if (result > 100)
      result = 100;
if (result < 25)  // min value for fan
      result = 0;
```

The resulting fanspeed is the sum of the proportional part+
(>(roportional? factor V delta
and the I > Integral? part factor V deltaW I sum of previous deviations. This sum is limited to the maNI value.
This calculation is made every second.
Cith a (of 1 & I of * and maNI of 7- it seems to work ok.

Operation

Connecting to your network

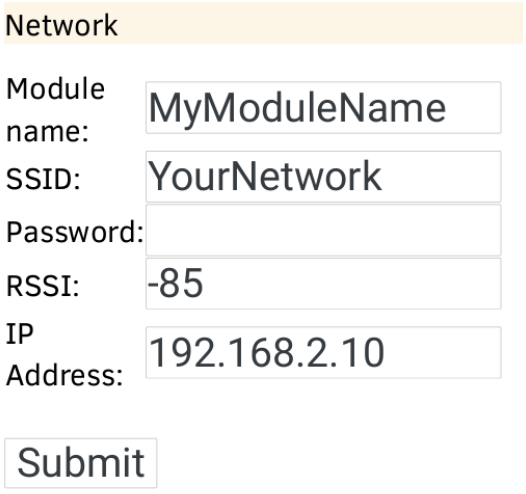
The '#(works both in Accesspoint mode > stand alone ? and in #tation mode for connection with your wifi network.
$efore connecting to your network the parameters for the #tation mode must be set in Accesspoint mode +

- In the wifi setup of your phone+ The '#(module is visible as :$$Xthermostat;. !onnect and enter password :Admin5*);. $+ the Accesspoint password is fiNed and defined in main.c in Udefine myA(pwd.
- Type in your browser address line :5F*.56M.7.5; . This is the fiNed I(address for accesspoint mode.
- The main% webpage is shown. #croll to the bottom of the screen and press the :#ettings; link.
- The settings page is shown. In the etwork paragraph fields you can enter+

  @odule name+ ame of you module that will be shown in your etworks list.

  ##ID+ name of your network

  (assword+ C (A password of your network. ot shown.
  0##I+ >indicator? The signal strength of your network as received by the '#(. =ess negative is better.
  I(address+ This is the address of your module on your network.



IP address notes

4ou have two options to set this+
=eave blank+
The address will be assigned by your router. >DH ! (?

,ill in a value+
To know which value is valid+
,ind the I(address of your phone & eg :5F*.56M. 55. F; There could be other devices in your network having nearby addresses so set the last digits of the address to a higher value eg 6-.

(ress :#ubmit;.

The module now reboots. The accesspoint you where connected to now disappears& and a new one with your new @y@odule ame appears. It will also connect to your network. C hen the connection is established the led flashes in a lower tempo.

If you used DH ! (to get the I(address you will have to connect to the new accesspoint and open the #ettings page again to read the Ipaddress. 4ou have the opportunity to set the lower digits to a higher value. This will reduce the risk that after a reboot of your router this address will be given to another device.

! onnect to your private network and enter the module I(address& eg :5F*.56M.55.6-;.
Thats all.

Screenshots

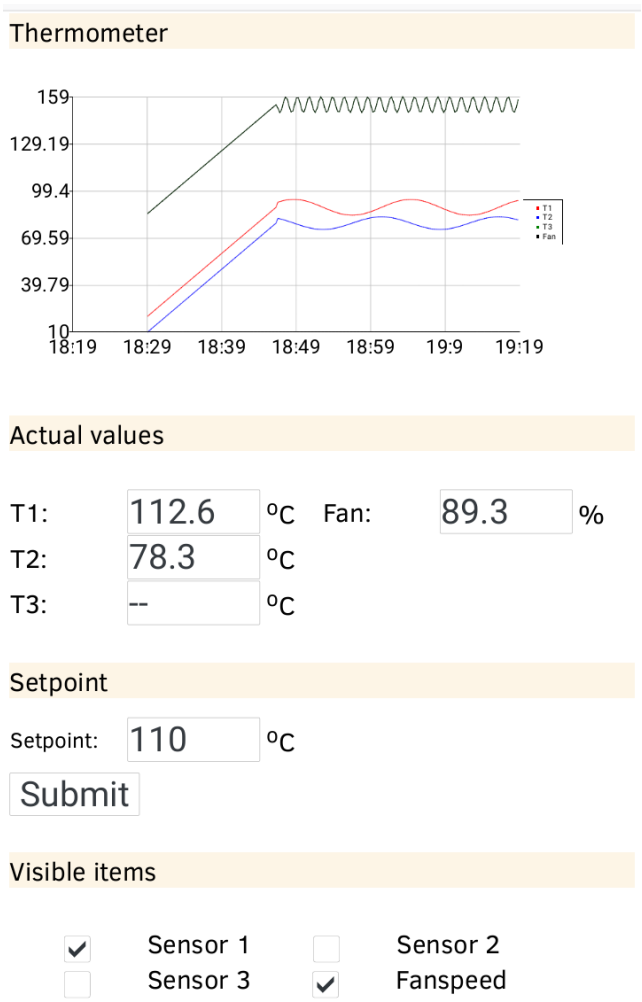


Illustration 2: Main screen

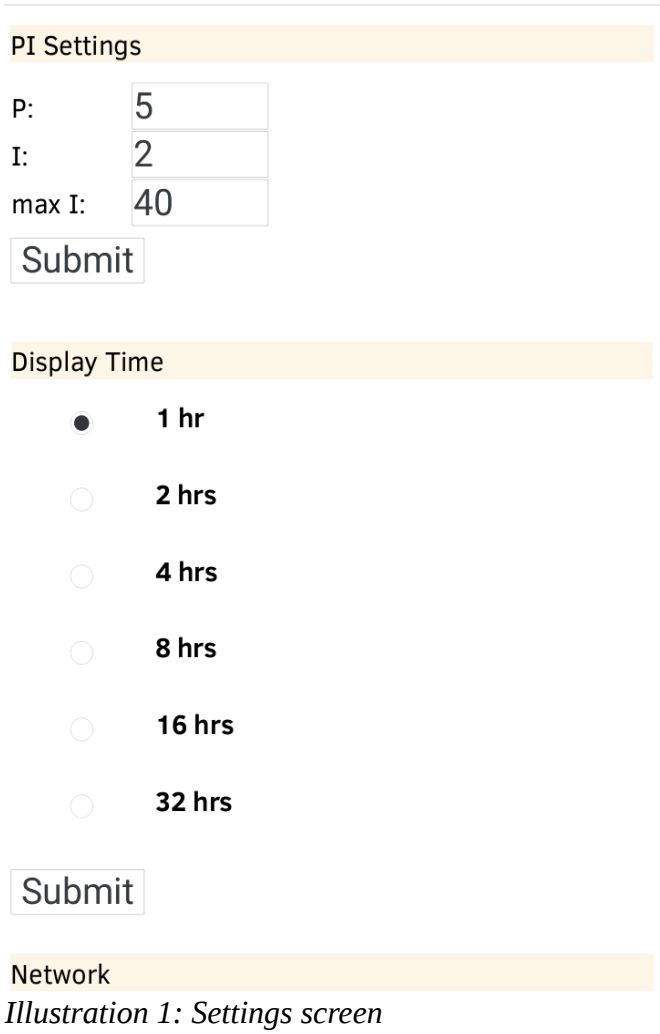


Illustration 1: Settings screen

The mainscreen shows * simulated temperature* and the fanspeed.
The timescale can be set to 5&*&7&M&56 and)* hours.
The temperatures will be updated every second.
9n the bottom of the screen you find the :settings; link.

The settings screen shows the (I settings and the Display time ›chart span? . Also the network settings are on the bottom of the screen.

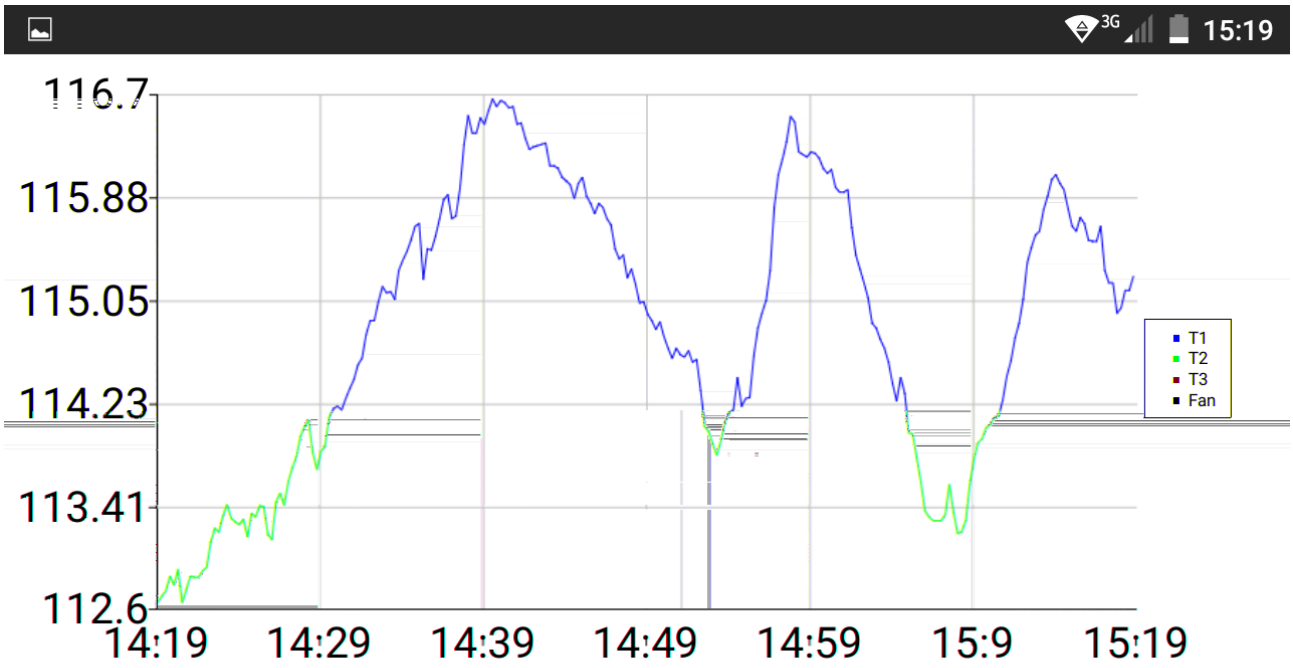


Illustration 3: real world picture

Here you see the thermostat in action. The temperature is set to 55 degrees. This temperature is kept within a few degrees. In the latest website I changed the resolution of the graph to 5 degree.

Illustration 4: Part of the BBQ plant

Summary

The '#()* is great. <reat set of pheripherals& wifi and bluetooth. 8ery good #DA.
It was easy to integrate pheriperals+ Cifi&#(I&DA!&AD!&I*!&nov0A@
The only disadvantage I noticed was the poor AD! and lack of hardware specifications.
Also the limitation of * breakpoints for the debugger can be better. $ut for that price...