Building a The Things Network Gateway

Tools needed

- Soldering iron
- Solder
- Side-cutter
- Small screw driver
- Two tubes or blocks, 15mm height
- Drill 6mm (pigtail / antenna)
- Drill 8mm (Ethernet cable and power connector)
- Iron saw
- File

The parts

- Proma 131030 casing 168x103x56
- 4 Resistor 330 Ω Axial 0207 0.25 W
- 4 Resistor 10 kΩ Axial 0207 0.25 W
- Transcend Premium 8 GB microSDHC-kaart Class 10
- 4 LEDs 3mm blue, white, red, green
- Terminal Block 2p
- 10uF / 16V Capacitor
- DC power connector, 5.5 mm 2.1 mm
- HN Power HNP10I-050-C Power Supply 5 V/DC 2000 mA 10 W
- Female connector 40p
- 2x20p tall female header for Raspberry Pi
- iC880A-SPI – LoRaWAN Concentrator 868MHz
- Pigtail for iC880A-SPI or iC880A-USB
- Antenne 1/2 wave 868 MHz SMA 90
- PCB by Charles Hallard. Reference https://github.com/ch2i/iC880A-Raspberry-PI
- Raspberry Pi 3 model B
- 30mm m3 Nut, 3 m3 bolts
- 2x 30mm x 100mm plastic strip 1.5 or 2mm thick
- 10 cm power wire
- 5 cm wire

remark: this manual is describing version 1.0, Charles has updated his site to a new board v1.1. The main difference is the cut-out for the PI connectors

The PCB has several options we will NOT use in this workshop, but you can later on use them if needed:

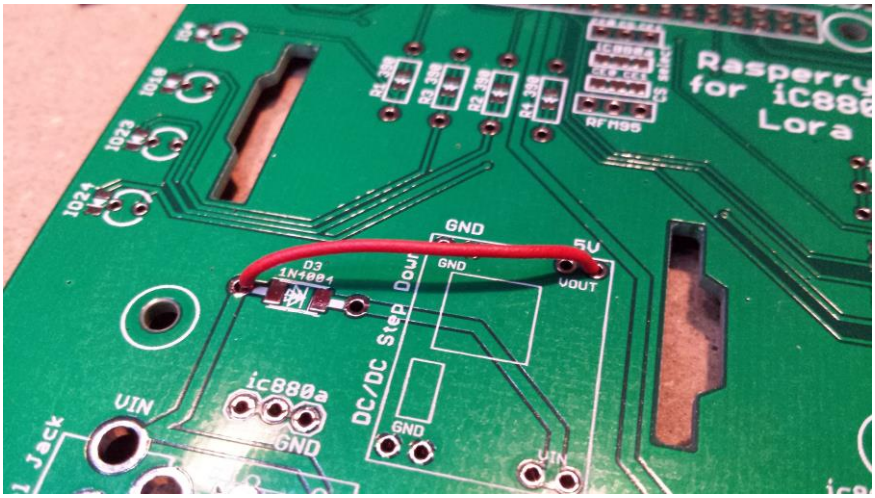
- Creating a single channel gateway with a RFM95 chip and D1, D2 and D3 or a dual channel gateway with the LinkLabs module (though the LinkLabs module is no longer produced).

- Adding Grove connectors to add Grove sensors by http://www.Seeedstudio.com , you can add your own Grove sensors to give your gateway extra local functionality. The I2C pull up resistors R5 and R11 will be mounted.
- Adding a DC-DC convertor for use with Power over Ethernet. You can supply power over the Ethernet wire with a POE Splitter such as these and POE injector as this one . Adjustable DC/DC step down like this one or this one (same footprint this is why I'm using this one) but there are so much even some directly to 5V.
- We will mount the LEDs but they are only for test purposes. If you want to make them functional, you have to find a way to mount them in the casing somewhere.
- We will use one terminal block for the 5V power.

We will mount all the parts EXCEPT for the 2x20p Raspberry PI connector on the side were the parts are referenced on the silk screen (LEDs on the left, Power connector at the bottom)

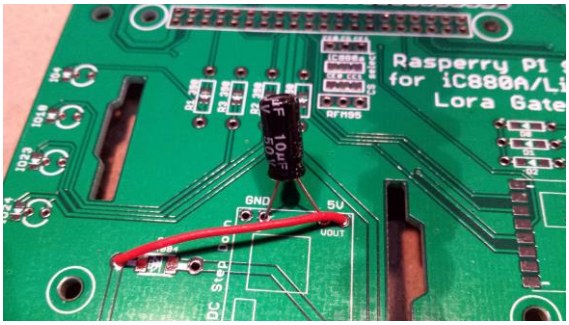
Bypass the DC-DC converter

VIN will be directly connected to a proper 5V power. If we respect the polarity of the power, we can leave D3 as well. Connect the wire from the anode / plus side of the diode D3 to the VOUT 5V pin of the convertor.



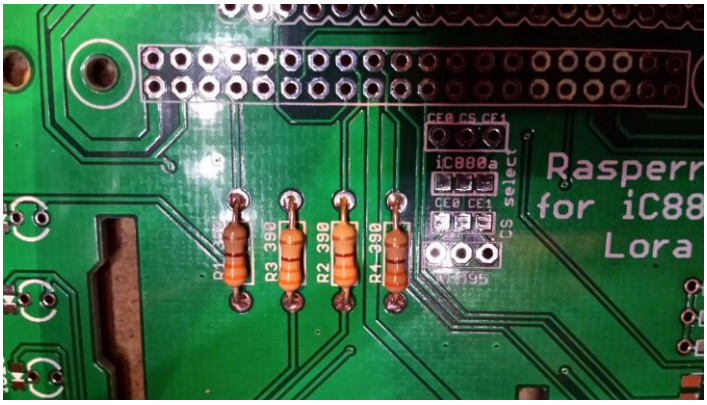
Placing the 10uf capacitor

Put a 10uF / 16V (or more) capacitor between the other 5V hole and one of the GND holes. Look at the polarity of the capacitor. The MIN side should be in the GND hole.

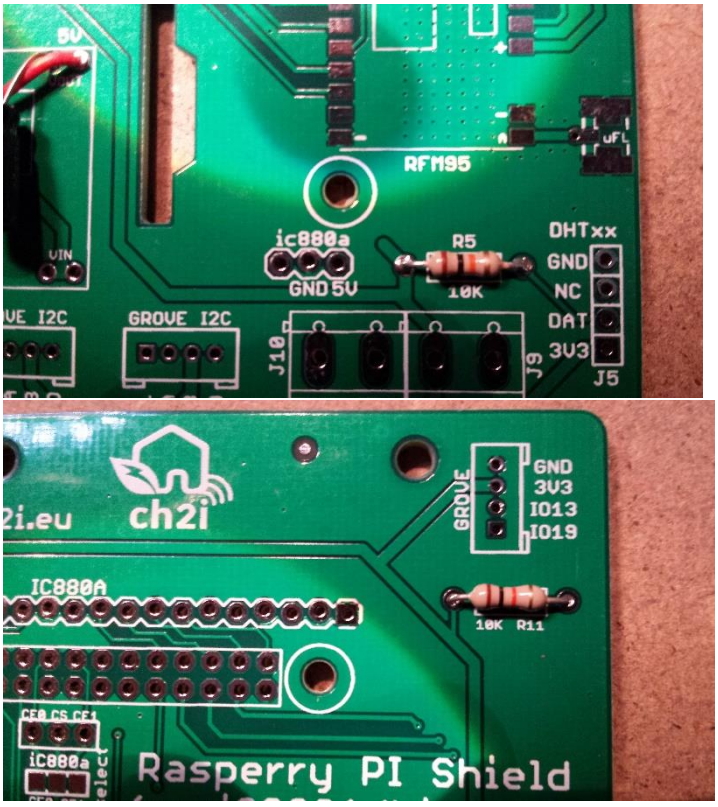


Mount the resistors

Mount the 4 resistors 330 ohm (orange – orange – brown) R1, R2, R3 and R4. (on the PCB it is 390, no problem here, just brighter LEDs).

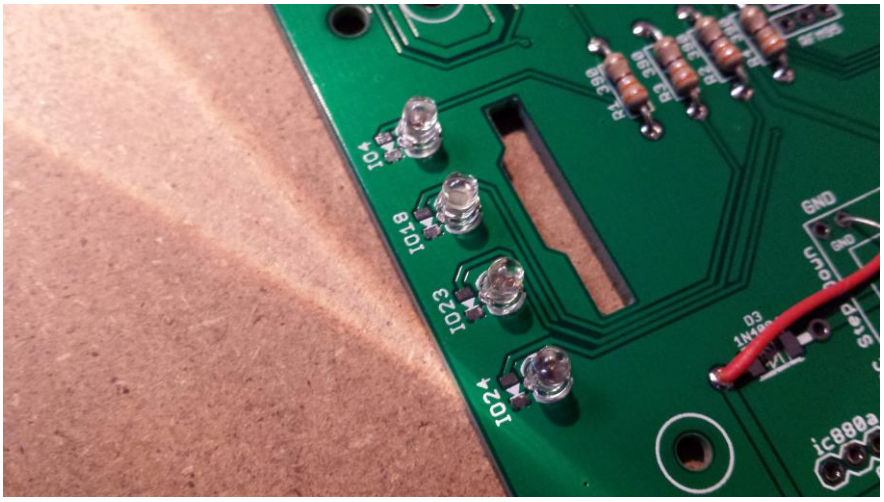


Mount the 2 resistors 10K (brown-black-orange) R5 and R11.



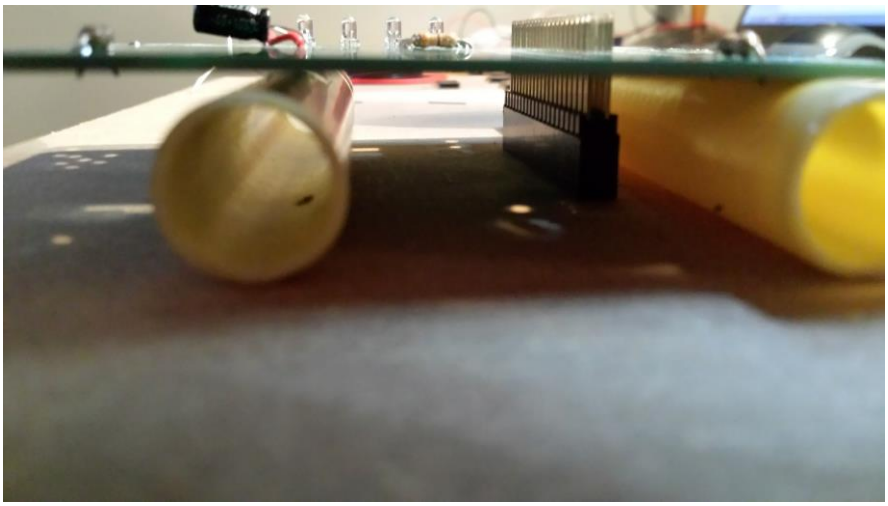
Mount the LEDs

Mount the LEDs. They have different colours (Red, White, Blue, Green). IO24 is green, IO23 is red, IO10 is white, IO4 is blue. The Led's cathode is the shortest wire and should be at the outside of the board.



Mount the Raspberry Pi connector 2x20p

Mount the connector ON THE BACKSIDE. Because of the height of the connectors on the Raspberry PI, we have to level this connector above the PCB. Use some distance block (or in this case a 3/8” tube used by electricians. The top of the connector should be 15mm above the PCB. This will leave enough room for the USB and Ethernet connector of the Raspberry Pi. Solder the two opposite corners of the connector. Check the straightness of the connector. If it is OK, solder the rest of the pins. Be careful for short circuits here. It can destroy the PI!



If you are using a ‘prototype’ connector shown bellow, you can put the connector straight on the PCB.

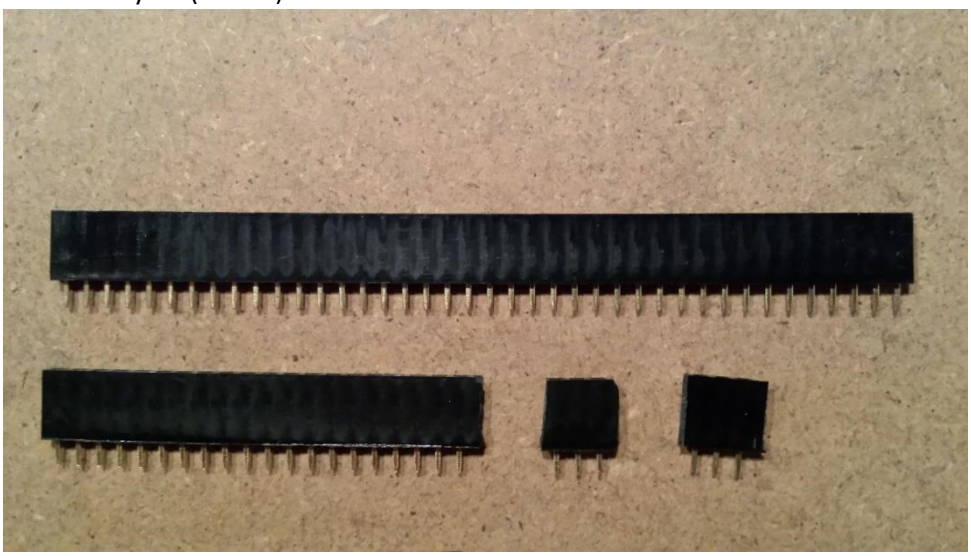
Solder a bridge on ‘CE0’ on the ic880a select connector.

Put a little solder on the CE0 connection of the ic880a select connector to make a ‘bridge’. Make sure there is a good connection!

Cut the 40p connector

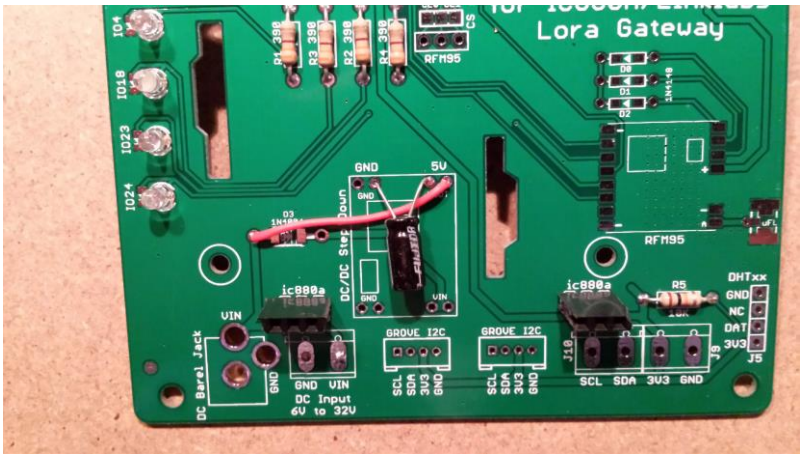
The three connector for the imst880a board can be cut from one 1x40p connector. 2x 3p connector and 1x 20p connector is needed. The strip is easily cut on a pin, this will destroy one pin, but we need

in total only 26 (not 40).

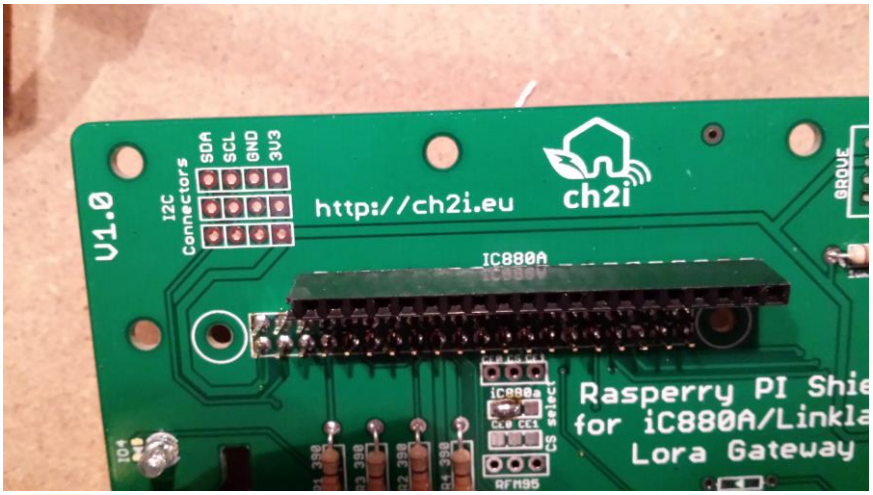


Solder the ic880a connectors

Solder first the two small ones. Solder just one pin, and adjust them to be straight and tight to the PCB. Than solder the other two pins.

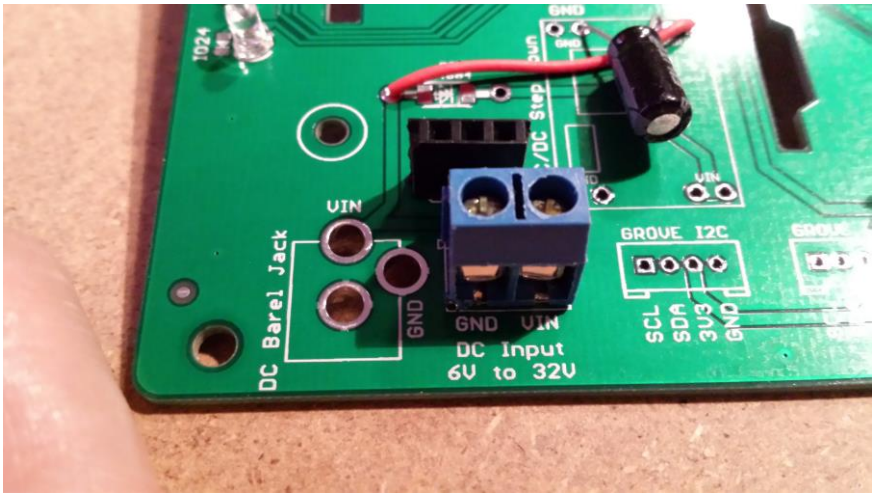


The 20 pin connector can be placed, solder again just one outside pin, adjust and solder the rest. Be careful for any short circuits here. It can destroy your boards!



Mount the terminal block

Mount the terminal block on the DC input spot, just besides the DC barrel jack we will not use.



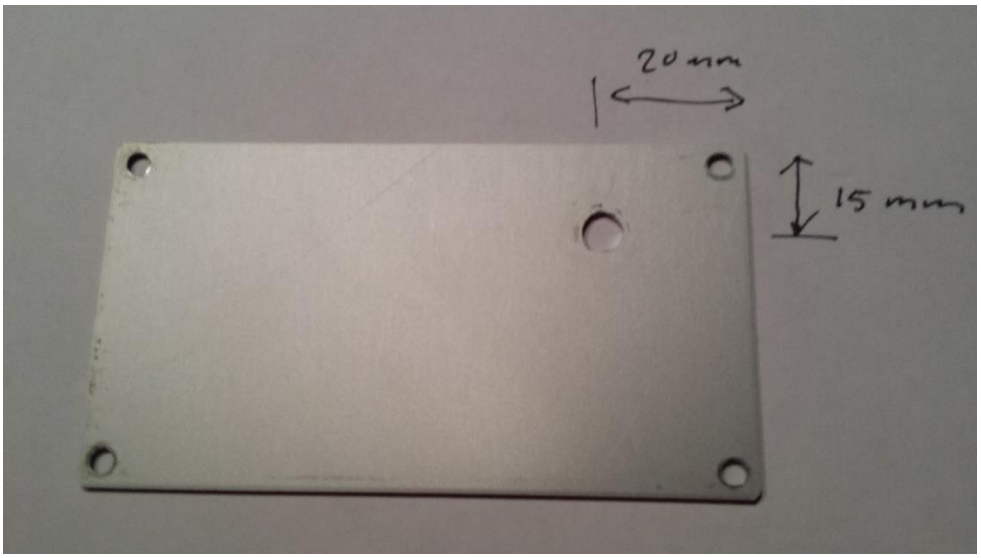
DC connector

Solder the power wire to the DC connector. There are three pins, looking from the backside the left pin is connected to the inside pin (this is PLUS), so solder the RED wire to it. The mid pin is power ground, connect to the BLACK wire.

Connect the power lines to the board, black is GND, red is VIN.

Casing

Drill a 6mm hole in one of the end panels of the casing. This is the place where the antenna is mounted. The hole should be 15 mm from the upper side and at least 10 mm from both the ends.

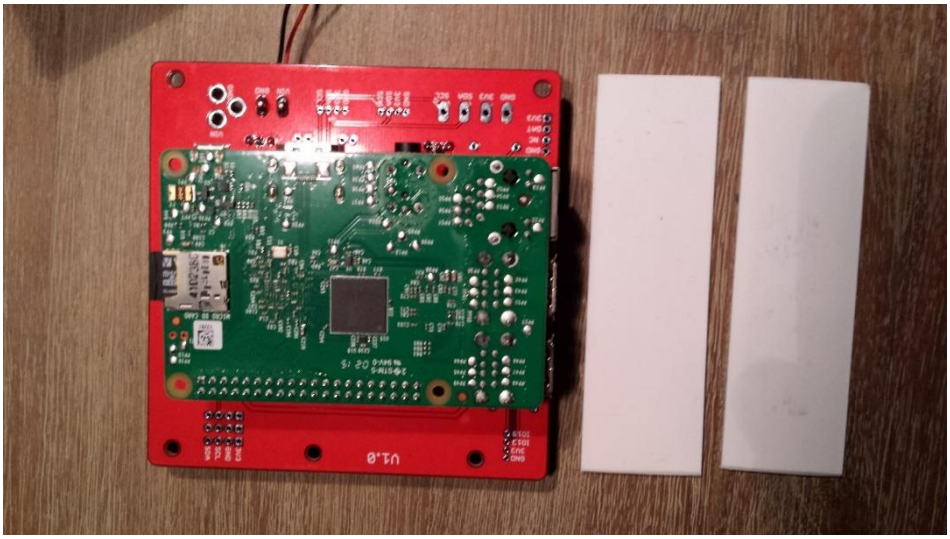


Drill an 8mm hole in the other panel on the upper left corner 15mm from the left and 15 mm from the top.

There are two options for this panel. Just add another 8mm hole at the bottom and open it open it up so the Ethernet cable can go through. Or you can make a bigger square opening for all the connectors (USB an Ethernet) to access from the outside.

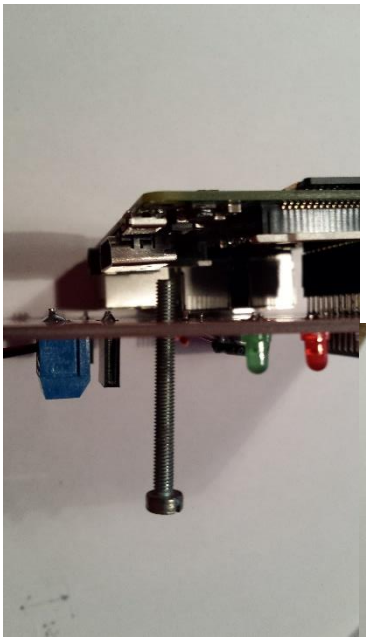
Adjust the length of the wires to the power connector and mount the connector to the panel.

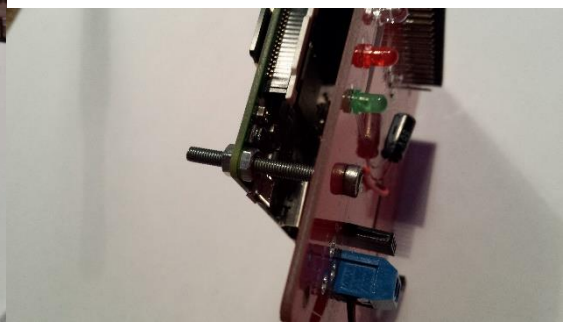
Saw to pieces of 30x100mm plastic 2mm thick. Both ends should be filed to get them a little smaller (1,6 mm).



Mount the Raspberry PI to the underside of the board. Just after the software test we will mount the ic880a board.

Drive a nut through the hole near the terminal block. M3 size will only fit if it is turned into it firmly. Put a bolt on the other side and finally when it reaches the PI also at the end.

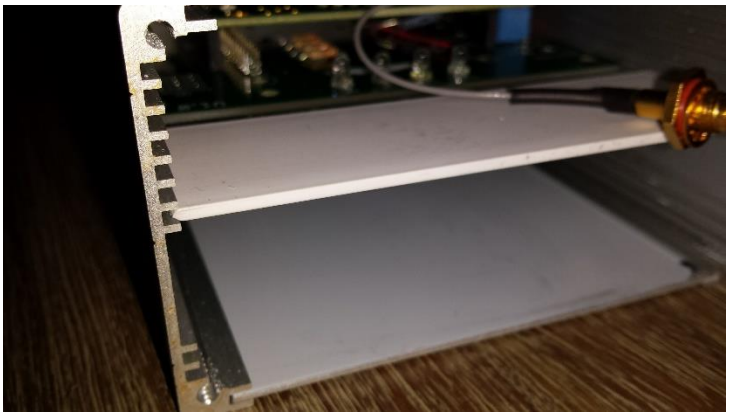




Mount the pig tail in the panel

Mount one end part (antenna side) of the casing with the four screws. The two side panels should have the rails on the upside.

Shift in the white plate, the PCB and again a plate into the casing.



Shift in the bottom plate. We will leave the upside open for the moment.

Mount the power connector in the other panel. Close the casing on the other side. Power connector on the upside

After building en testing the software we will finish the casing with the following steps

Mount the ic880a board. Be careful! This is a very EMD sensitive (and expensive) board. So ‘discharge’ yourself or even better use ESD equipment. Place the board onto the three connectors. Check visual if you mounted it the right way!

Mount the pig tail to the antenna connector. Look at the picture to identify the right connector. Near pin 20 is another connector, this one is for the future GPS extension and we will not use this one, but the one near the 12 drilled holes. The connector is very small and can break easily.

The casing can be mounted together.

Software

Download and install the Raspbian OS

- Download latest Raspbian Jessie Lite
  https://www.raspberrypi.org/downloads/raspbian/

Prepare the SD card and write the image software to the SD card

- Use win32diskimager
  https://sourceforge.net/projects/win32diskimager/files/latest/download?source=files
- Or ApplePi-Baker on MacOS
  http://www.tweaking4all.com/software/macosx-software/macosx-apple-pi-baker/

Power-up and log-in to RaspberryPi

- Remove the SD card and plug it gentle into the Raspberry Pi.
- Connect the Raspberry Pi with an Ethernet cable to your switch or router (or set up Wi-Fi later).
- Power Up the Raspberry Pi

- If you have a console directly connected to the Pi you can login with default user:

username: `pi`

password: `raspberry`

Configure Wi-Fi

- Configure the wifi credentials (check here for additional details)
- Open the `wpa-supplicant` configuration file in nano:

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

- Go the bottom of the file (use the down arrows to move the cursor) and add the following text, replacing SSID and password to match your network:

```
network={
    ssid="The_SSID_of_your_wifi"
    psk="Your_wifi_password"
   }
```

- Now save the file by pressing `Ctrl+X` (Exit) then `Y` (Yes), then finally press `Enter`. At this point, `wpa-supplicant` will normally notice a change has occurred within a few seconds, and it will try and connect to the network.
- If it does not, either manually restart the interface with `sudo ifdown wlan0` and `sudo ifup wlan0`
- or reboot your Raspberry Pi with `sudo reboot`
- You can verify if it has successfully connected using `ifconfig wlan0`. If the `inet addr` field has an address beside it, the Pi has connected to the network. If not, check your password and ESSID are correct.

Check and set ip address

- Any device connected to a Local Area Network is assigned an IP address. As it is eventually useful to be able to access your RaspberryPi over the network from another machine using SSH or VNC. To do this you need to know the Pi's IP address, whether it is connected with Wi-Fi or with an Ethernet Cable. This is easy if you have a display connected, and there are a number of methods for finding it remotely from another machine on the network.

- If the RaspberryPi has a display you can find out it's IP address by typing in:

```
hostname -i
```

- If the network router gives a DHCP address it is good practice to enter the router settings to manually assign an IP address for your RaspberryPi . With a manually assigned IP address it will be easier to connect remotely to the RaspberryPi using SSH from another computer, laptop or mobile connected to the same network using the IP address of the RaspberryPi to connect)

- If the RaspberryPi does not have a display attached (headless) you can find out it's IP address by using one of the following methods described in more detail here.

Install an SSH tool on your computer, laptop or another RaspberryPi

- Use an SSH tool to connect to the RaspberryPi from a computer connected on the same network.
- Putty is the most well-known for Windows
  http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html
- From a Linux computer or Mac (or from another Raspberry Pi) you can use the terminal (which can usually be found in the Utilities folder on a Mac), without needing to install additional software.
  https://www.raspberrypi.org/documentation/remote-access/ssh/unix.md

https://github.com/ttn-zh/ic880a-gateway/wiki

Connect using SSH to the Raspberry Pi

- When you can connect to your Raspberry Pi via SSH via another computer on the same network you will be able to disconnect the Raspberry Pi from the display, keyboard and mouse and continue to set it up remotely.
- Raspian comes with the SSH daemon software installed, you just need to enable it in the settings of the Raspberry Pi by typing:

```
sudo raspi-config
```

- Then in the Raspberry Pi Configuration Tool select advance options (9) and then SSH (A4) to enable it.

- In the SSH client or Terminal application on your computer you can then type

```
ssh pi@nnn.nnn.nnn.nnn
```

(where nnn.nnn.nnn.nnn is the ip address of the Raspberry Pi)

- On a Mac you will see a security warning that the destination is unknown/untrusted, you will need to accept by typing `Yes` *then enter* to connect and the Mac will generate and remember a new SSH key.
- Note: If you have trouble connecting this could be caused by SSH Keys being remembered by the Mac in which case you will first need to type:

```
ssh-keygen -R nnn.nnn.nnn.nnn
```
then
```
ssh pi@nnn.nnn.nnn.nnn
```

@@
@ WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED! @
@@
IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
Someone could be eavesdropping on you right now (man-in-the-middle attack)!
It is also possible that a host key has just been changed.

- You may to do this, any time you use a different boot image at the same IP address, or a different Raspberry Pi at the same IP address on a Mac.

Additional setting for the Raspberry Pi

- Once connected to the raspberry Pi via SSH you can log in using the default name and password

username: `pi`
password: `raspberry`

- Return to the raspi-config utility to enable SPI
- and also expand the filesystem

```
sudo raspi-config
```
select to enable `SPI` (9 Advanced options: A6 SPI or A5 SPI for v3)
select to expand `filesystem` (1 Expand Filesystem)

- The Raspberry Pi system will automatically reboot
  - Configure locales and time zone:

```
$ sudo dpkg-reconfigure locales
```

- Select OK, en_GB.UTF8-8 (default) select OK, OK

```
$ sudo dpkg-reconfigure tzdata
```

- Select your time zone (Europe, Amsterdam)
- Make sure you have an updated installation and install git (confirm 2x [Y]):

```
$ sudo apt-get update
$ sudo apt-get upgrade select Y
```

- You may then see this message below, if so press q to quit

```
* The 20161018 release has introduced a /etc/sudoers.d/010_pi-
nopasswd file. The file is installed even if the "pi ALL=(ALL)
NOPASSWD: ALL" entry has been previously removed from /etc/sudoers by
the user. If you do not want the entry to exist, please comment out
or remove 010_pi-nopasswd. If upgrading to 20161018+3 from a version
earlier than 20161018, the line in 010_pi-nopasswd is automatically
commented out if the entry doesn't exist in sudoers. See
https://github.com/RPi-Distro/raspberrypi-sys-mods/issues/6
 -- Serge Schneider <serge@raspberrypi.org>
(q to quit)
```

- Then Install git (confirm [Y]):

```
sudo apt-get install git select Y
```

- Create new user for TTN and add it to sudoers. Give the user a password. Full Name, Room, Phone, Other: default / none.

```
$ sudo adduser ttn
$ sudo adduser ttn sudo
```

- To prevent the system asking root password regularly, add TTN user in sudoers file

```
$ sudo visudo
```

- Add the line: ttn ALL=(ALL) NOPASSWD: ALL
- Save with CTRL-X, Y[es] and ENTER

⚠ Beware this allows a connected console with the ttn user to issue any commands on your system, without any password control. This step is completely optional and remains your decision.

- Logout and login as ttn and remove the default pi user

```
$ sudo userdel -rf pi
```

- The libbcm2835 is needed because of the LEDs on the board. Get it and install it:

```
$ wget
https://drfasching.com/public/data/libbcm2835_1.50_armhf.deb
$ sudo dpkg -i libbcm2835_1.50_armhf.deb
```

- Clone the installer and start the installation

```
$ git clone -b spi https://github.com/galagaking/ic880a-gateway.git

$ cd ~/ic880a-gateway
```

- Without the ic880a board installed we can run a little LED test. This test will blink the four on board LEDS one after another and if connected also the 5 connections of the ic880a board (pin 13..17 of the ic880a board). If there is any failure, check your soldering!

```
$ gcc -o kitt kitt.c -l bcm2835
```

```
$ sudo ./kitt
```

- All the LEDs should be blinking. If not: check your soldering and the bridge for CE0 / ic880a!
- `$ sudo shutdown -h now`
- power off and reinstall the ic880A board if you removed it for the LED test.
- Power on again

- Now it is time for the big installation script:

```
$ sudo ./install.sh spi
```

- If you want to use the remote configuration option, please make sure you have created a JSON file named as your gateway EUI (e.g. B827EBFFFE7B80CD.json) in the Gateway Remote Config repository.
- If not, answer No to the remote settings file
- Change the Host name in to a more personal one (ttn-gateway-frank)
- Change the descriptive name in to a more personal one (ttn-ic880a-frank)
- Enter your contact email. Not used yet, but in the future you can be contacted if your gateway is down.
- Get the address of the final destination of the gateway. Get the coordinates from http://www.gps-coordinates.net/, with Get Altitude an estimation of the Altitude will be calculated.
- Enter Latitude, Longitude and Altitude.
- System will copy and create packages. Confirm with [Y]
- After installation, system will reboot. You can remove the Ethernet Cable if you use Wifi.
- Unplug the Ethernet cable and close the enclosure
- **Big Success!** You should now have a running gateway in front of you!

Meaning of the LEDs

- Blue (IO4): heartbeat: will blink in 1Hz frequency
- White (IO18): Downlink server: sent package to TTN network
- RED (IO23): Bad packet received: CRC error, frequency error etc.
- GREEN(IO24): packet received

You can change the LED definition in the local_conf.json file, by changing the port numbers (4, 18, 23, 24).

Typical local_conf.json file

```
{
 "gateway_conf": {
       "gateway_ID": "FB10EBFFFEDD216C",
       "servers": [ { "server_address":
"router.eu.thethings.network", "serv_port_up": 1700,
"serv_port_down": 1700, "serv_enabled": true } ],
       "ref_latitude": 51.234567,
       "ref_longitude": 5.678901,
       "ref_altitude": 11,
       "contact_email": "",
       "description": "ttn-ic880a" ,
       "led_heartbeat":4,
```

```
            "led_down":18,
            "led_error":23,
            "led_packet":24
        }
    }
```

Average power usage 0,8A /4W

Test your gateway status

Test your gateway is working:

```
$ cd /var/log
$ sudo tail -f syslog
```

If you want to look at node traffic:

```
$ sudo tail -f /var/log/syslog | grep "\[\#"
```

To check if your gateway is connected to TTN visit this site:

https://staging.thethingsnetwork.org/gatewaystatus/

Common problems

- SPI bus not enabled in RASPI-CONFIG
- CE880 bridge not soldered
- SD Card problems: use good quality SD card (class 10), reinstall card if you have still problems here

Antenna

For test usage you can use the small inside antenna. You can connect outside antenna's like:

- http://webshop.ideetron.nl/GP901C
- http://webshop.ideetron.nl/SD868L

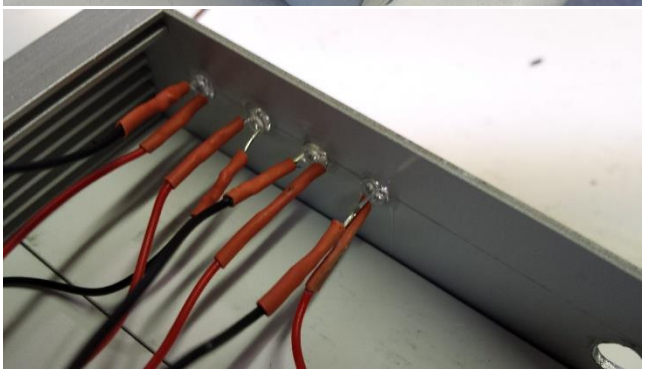
You can connect the antenna with a SMA connector or use an adapter like this:

Using the appropriate cabling.

More info on the gateway, the software and antenna's you can find on
https://www.thethingsnetwork.org/forum/

Outside LED status

If you want to have a look on the LEDs if the box is closed, you can drill four holes in the box, extend the LEDs with some wire and put them in these 3mm holes.



You can use the gateway as ‘Wifi’ connected, but preferably you will connect with Ethernet. This also will not disturb any signals by the Wifi signal.