

Headless Raspberry Pi Server (plus project guides)

This is a guide on how to do a pi completely headless - no screen or keyboard attached! (requires networking of course)

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Base Headless Pi Setup

This page describes how to get a Pi to a base level headless configuration (ie, SSH & networking enabled, all packages up to date)

- *Minimum sd card size is 4GB*

WARNING: Old method of Pi SD card setup NO LONGER WORKS!

Used to be that you could just write the Raspbian image to a card, add the `ssh` file in the `/boot` partition, and ssh into the pi, but the normal `pi` user was removed in new OS versions. Instead, the [Pi Imager](#) tool must be used.

Install the imaging software and write the SD card

1. install the imaging software. On arch:

```
sudo pacman -S rpi-imager
```

(On other OS's, the package manager is different, but the package name should be the same or similar.)

2. Plug in the SD card that will go into the pi
3. Open the "Raspberry Pi Imager" software and choose an image ("Choose OS" button --> Raspberry Pi OS (other) --> OS Lite)
4. Hit the gear icon to change these settings:
 - hostname
 - enable ssh
 - username/password
 - wifi (if the pi has wifi)
 - Locale (time zone/keyboard layout)
5. Choose the SD card as the Storage device
6. Click the "Write" button

Boot the Pi and login

1. Insert the SD card into the Pi
2. plug in ethernet to the Pi if not using wifi (most USB ethernet adapters are supported)
3. Apply power to the Pi
4. wait for it to come online and log in via SSH (check local DHCP server logs for Pi's IP)

Post-install steps (after logging in):

1. run `sudo raspi-config` to finish SD card setup:
 - 6 Advanced Options --> A1 Expand File System
2. reboot the Pi
3. update packages with `sudo apt update && sudo apt upgrade`

The Pi can now be used for it's intended project.

Add SSH Keys

To allow login from Yubikey or other private key, public keys should be added to `authorized_keys` file in the Pi user's home directory. Downloading keys requires internet connection:

1. `mkdir ~/.ssh`
2. `curl https://github.com/your-github-username.keys > ~/.ssh/authorized_keys`
3. `chmod 700 ~/.ssh`
4. `chmod 600 ~/.ssh/authorized_keys`
5. (Optional) disable password login: edit `/etc/ssh/sshd_config` and add/modify the password auth lines to:

```
PasswordAuthentication no
PermitEmptyPasswords no
```

Reboot Pi after changing SSH config.

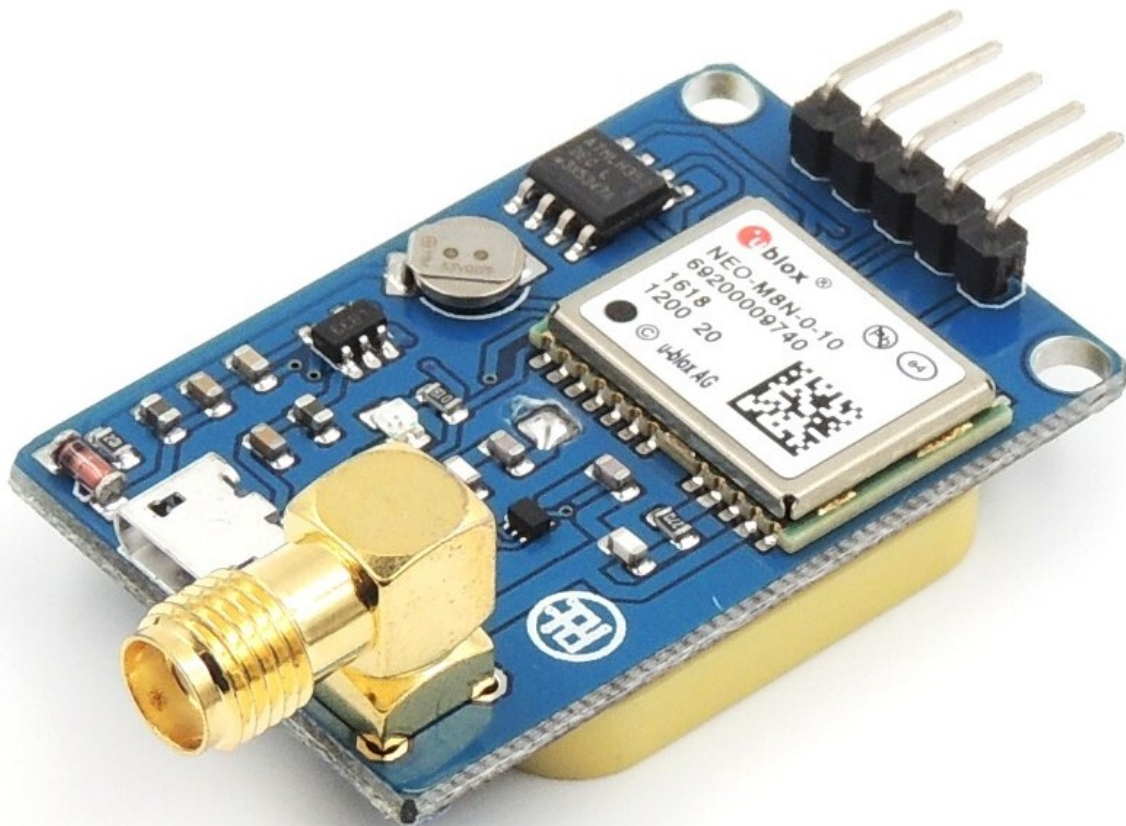
Project 1: GPS-based NTP server

Source: [Microsecond accurate NTP with a Raspberry Pi and PPS GPS](#)

Info

This page describes setting up a GPS module with a Pi to act as a Stratum 1 NTP server.

The GPS module I purchased is from the NEO-xM line (6M, 7M, 8M). The board looks similar to this:



Things of note: GPIO header, USB, included antenna module, and external antenna port:

- The GPIO header should have the pins labelled on one side of the board, preferably in the same order as the pins on the Pi, so the GPS board can plug directly into it.
- The module can be connected to a PC via USB, but that is not covered in this guide.
- The large white and tan ceramic block on the bottom of the module is a GPS receiver antenna. It can be used, but then the module must be placed remotely from the Pi, which can cause timing issues with the PPS line.
- An external GPS antenna is recommended, which plugs into the SMA port. The on-board antenna is disabled in this case.

PPS = Pulse Per Second. While the serial/USB data from the GPS module contains the actual time & date information required for the NTP server, the PPS input is required to keep sub-millisecond accuracy. the PPS output sends a signal pulse at the start of each second, +/- a few nanoseconds. The time keeping software uses this second input to keep precise time.

Setup:

1. Install packages:

```
sudo apt install pps-tools gpsd gpsd-clients gpsd-tools chrony
```

('pps/gpsd' packages are for interpreting GPS data, chrony is the actual NTP server)

2. Add these lines to the end of `/boot/config.txt`

```
# the next 3 lines are for GPS & PPS signals
dtoverlay=pps-gpio,gpiopin=18
enable_uart=1
init_uart_baud=9600
```

These lines initialise pins on the Pi's GPIO header to enable the serial port, and set the PPS pin as an input.

3. Add this text to the end of `/etc/modules` to enable the PPS module:

```
pps-gpio
```

4. disable system handling of the COM port (allows the GPS software to keep control of the port):

```
sudo systemctl mask serial-getty@ttyS0.service
```

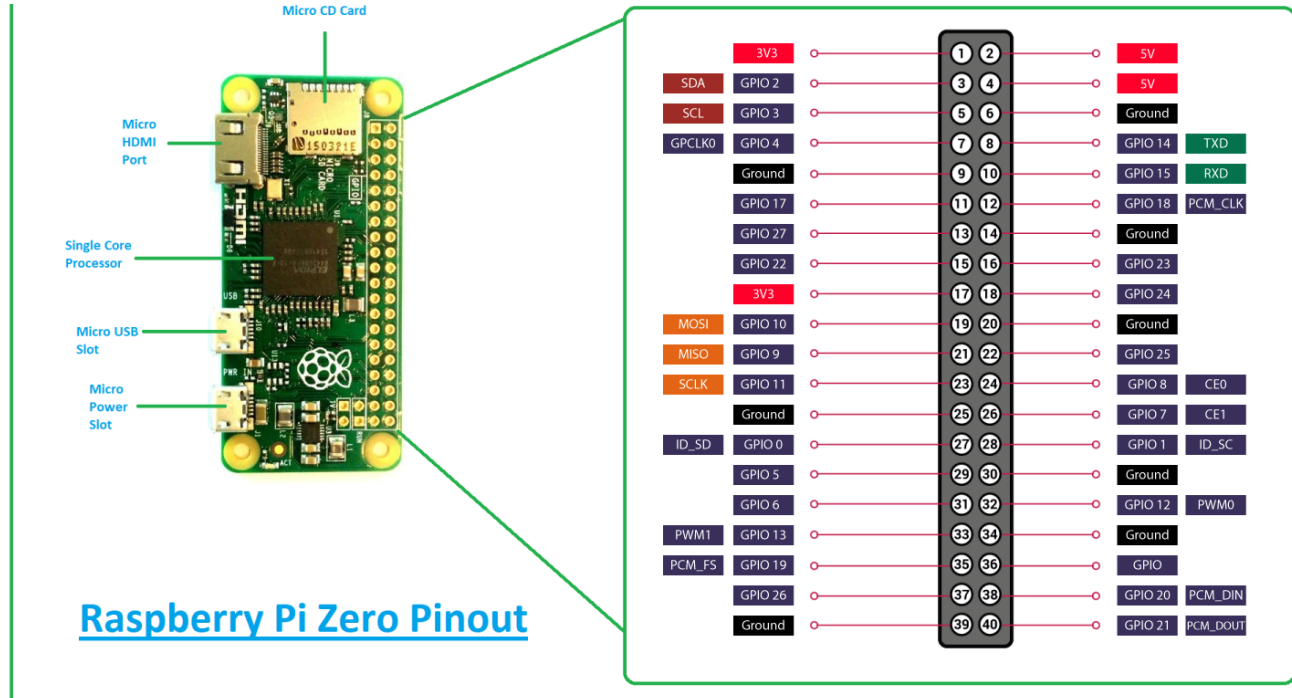
Check this command worked after rebooting the Pi: `/dev/ttyS0` should be owned by `root: dialout` and have permissions `crw-rw----`.

Wire up the GPS module:

Pinout:

1. GPS VIN to RPi pin 2 or 4 (+5Vbus)
2. GPS GND to RPi pin 6 (GND)
3. GPS RX to RPi pin 8 (Pi TX)
4. GPS TX to RPi pin 10 (Pi RX)
5. GPS PPS to RPi pin 12 (GPIO 18)

Picture reference (all Pi's have the same header):



Note that all the required pins on the Pi header are sequential. Most GPS modules with headers are pin-compatible with the Pi, however some swap the positions of the TX and RX pins (The 'TX' of the GPS module must go to the 'RX' pin on the header, and vice-versa.) If the GPS is not detected when you plug it into the header, try extending the header with jumper wires and crossing over the TX/RX pins.

Check GPS functionality

With the GPS module powered via the Pi, The on-board LED will light a solid color. The LED will start blinking once it has a GPS lock, and will start sending GPS data (called "NMEA" data) via the serial lines. Once the Pi has booted, check that the GPS module is working:

1. Check that the pps service is running:

```
lsmod | grep pps
```

Should return the service `pps_core`, and sometimes other services as well, they can be ignored.

2. Check the PPS input for good pulses (after GPS has a lock, ie the indicator light is blinking):

```
sudo ppstest /dev/pps0
```

Example output:

```
trying PPS source "/dev/pps0"
found PPS source "/dev/pps0"
ok, found 1 source(s), now start fetching data...
source 0 - assert 1655253832.999996389, sequence: 966 - clear 0.000000000, sequence:
0
source 0 - assert 1655253834.000004254, sequence: 967 - clear 0.000000000, sequence:
0
source 0 - assert 1655253835.000001120, sequence: 968 - clear 0.000000000, sequence:
0
source 0 - assert 1655253836.000000985, sequence: 969 - clear 0.000000000, sequence:
0
source 0 - assert 1655253836.999996852, sequence: 970 - clear 0.000000000, sequence:
0
source 0 - assert 1655253838.000001719, sequence: 971 - clear 0.000000000, sequence:
0
source 0 - assert 1655253839.000002586, sequence: 972 - clear 0.000000000, sequence:
0
source 0 - assert 1655253840.000001453, sequence: 973 - clear 0.000000000, sequence:
0
### ...etc
```

If there is a timeout, then there is likely not a good GPS lock yet.

Set up software:

Enable the GPS decoder software and the NTP server:

1. Edit `/etc/default/gpsd`:
 - change `GPSD_OPTIONS=""` to `GPSD_OPTIONS="-n"`
 - change `START_DAEMON="false"` to `START_DAEMON="true"`
 - change `DEVICES=""` to `DEVICES="/dev/ttyS0 /dev/pps0"`
2. Edit `/etc/chrony/chrony.conf` file, add this block of code to the top:

```

### GPS TIME SYNC INFO
# GPS reference defines and adjustments:
refclock SHM 0 delay 0.1 offset 0.1165 refid NMEA
refclock PPS /dev/pps0 refid PPS

# Allow all LAN IP Ranges so NTP server is network-agnostic (can be used on any LAN):
allow 10.0.0.0/8
allow 192.168.0.0/16
allow 172.16.0.0/12

### END GPS TIME SYNC INFO

```

Notes:

- 'delay 0.1' describes the accuracy of the serial time source, in seconds. Larger numbers deprioritizes the source (sources with smaller delays have higher priority). NMEA Source needs a non-zero delay, else chrony refuses to use it. Leave this number alone.
- 'offset 0.1165' adjusts the fixed offset delay, in seconds, on the NMEA source. Edit this offset to align GPS and PPS timing, for higher accuracy.

3. Due to an inconsistency with the Pi Zero, the `gpsd` service often starts in an "active (disabled)" state. This can be solved by forcing the service to start later in the boot process. Edit the "[Install]" section of the `gpsd` service file, `/lib/systemd/system/gpsd.service`:

```

[Unit]
Description=GPS (Global Positioning System) Daemon
After=sysinit.target

[Service]
Type=forking
EnvironmentFile=- /etc/default/gpsd
ExecStart=/usr/sbin/gpsd $GPSD_OPTIONS $OPTIONS $DEVICES

[Install]
WantedBy=multi-user.target
Also=gpsd.socket
# add this line to force gpsd to wait until chrony starts before running:
WantedBy=chronyd.service

```

4. Re-enable the 'gpsd' service: `sudo systemctl disable gpsd && sudo systemctl enable gpsd`

5. Reboot the Pi.

6. Check NMEA function: after rebooting, run the program `gpsmon`, it may sit on a blank screen for up to 60 seconds, but afterwards will display a window similar to this:

```
tcp://localhost:2947          u-blox>

Ch PRN  Az  El S/N Flag U  ECEF Pos: +13[redacted].90m -4[redacted].49m +4[redacted]1.88m
0   8 321  6  8 0304 ECEF Vel:  +0.07m/s      -0.02m/s      -0.02m/s
1  10 305 48 35 070d Y LTP Pos:  44.[redacted]° -73.[redacted]° 93.17m
2  13 59  7  0 010c LTP Vel:   0.00m/s    0.0°    0.00m/s
3  14 23  1  0 0104
4  15 65 41 30 070d Y
5  18 187 41 10 040d Y
6  22 245  2  0 0104
7  23 347 81 25 040d Y
8  24 112 62 22 040d Y
9  27 284 11 17 040d Y
10 32 252 22 26 040d Y
11 120 114 14  0 0110
12 133 213 33  0 0110
13 138 224 28  0 0110
14 194  0 -91  0 0110
15 195  0 -91  0 0110

Time: 3 01:17:16.00
Time GPS: 2214+263836.000      Day: 3

Est Pos Err 21.43m Est Vel Err 0.00m/s
PRNs: 6 PDOP: 2.7 Fix 0x03 Flags 0xdd
NAV_SOL

DOP [H] 1.3 [V] 2.0 [P] 2.4 [T] 1.4 [G] 2.8
NAV_DOP

TOFF: 0.115322286 PPS: -0.0000002683
NAV_SVINFO
```

This confirms that the software is decoding the GPS info properly.

7. Check Chrony is selecting GPS as a time source; run `chronyc sources`

Output:

| MS Name/IP address | Stratum | Poll | Reach | LastRx | Last sample |
|--------------------------|---------|------|-------|--------|-----------------------------|
| ===== | | | | | |
| #- NMEA | 0 | 4 | 377 | 15 | +3794us[+3794us] +/- 470us |
| #* PPS | 0 | 4 | 377 | 16 | +351ns[+515ns] +/- 3000ns |
| ^- time.cloudflare.com | 3 | 6 | 377 | 70 | -2009us[-2008us] +/- 16ms |
| ^- smtp.us.naz.com | 2 | 6 | 377 | 2 | -26ms[-26ms] +/- 105ms |
| ^- hc-007-ntp1.weber.edu | 2 | 6 | 377 | 5 | +3131us[+3131us] +/- 72ms |
| ^- dns2.kcweb.net | 2 | 6 | 377 | 6 | +1296us[+1296us] +/- 88ms |

[More info here](#) under the header 'Time Sources'. TLDR: 'PPS' should have a '*' next to it, indicating it is the primary time source (may take up to 5 minutes to update the primary source after GPS is locked), and the [bracketed] time in the 'NMEA' row should be less than ~5msec. [change the 'offset' value \(step 2\) in the `chrony.conf` file](#) to adjust this bracketed value, and restart chrony with the command `sudo systemctl restart chrony`. A "Reach" of '377' indicates source was polled successfully all 8 of the last 8 tries, a higher reach value for a source marks it as more trustworthy, and ups the source's priority. Lower numbers mean polls have been missed, and the source is marked as less reliable.

Set up other machines to use the Pi as an NTP server (Linux):

1. Install `ntp` package on the machine
2. Edit `/etc/ntp.conf` and add `server [pi.local.ip] true` to the list of servers
3. start the ntp service (on Arch: `sudo systemctl start ntpd`)
4. Check the NTP sources with `ntpq -p`:

| remote | refid | st | t | when | poll | reach | delay | offset | jitter |
|------------------|---------------|----|---|------|------|-------|---------|---------|--------|
| ===== | | | | | | | | | |
| *192.168.1.137 | .PPS. | 1 | u | 35 | 64 | 1 | 1.851 | +144501 | 0.001 |
| +time.walb.tech | 50.205.244.21 | 3 | u | 34 | 64 | 1 | 82.802 | +144501 | 0.001 |
| -li1187-193.memb | 132.163.96.3 | 2 | u | 30 | 64 | 1 | 179.522 | +144501 | 0.001 |
| +time-dfw.0xt.ca | 68.166.61.255 | 2 | u | 33 | 64 | 1 | 106.817 | +144501 | 0.001 |
| +LAX.CALTICK.NET | 17.253.26.253 | 2 | u | 32 | 64 | 1 | 118.527 | +144501 | 0.001 |

Check back in about 20 minutes, after which one source should have a '*' next to it to indicate that server is the chosen server. Remove default NTP servers and restart the ntp service if the pi is not selected. Note: `true` added after the pi's IP in the config indicates it is more "trustworthy" than other sources, and is more likely to be picked.

5. If NTP source is registered correctly, and you are ready to use NTP, enable the ntp service (on Arch: `sudo systemctl enable ntpd`)

Set up other machines to use the Pi as an NTP server (Windows):

Change the system's time server settings to the Pi's local IP address, or install your NTP sync program of choice (one options is [Dimension 4.](#))

Project 2 [WIP]: Pi-Hole DNS level blocker with sync and recursive DNS

Sources:

1. [Craft Computing Video](#)
2. [Unbound recursive DNS setup](#)
3. [gravity-sync script to sync pi-holes](#)
4. [Ultimage Guide on systemd on Raspberry Pi](#) (reference only, nothing in this guide is required to make pi-hole work)

Project 3 [WIP]: Lenny Troll (phone anti-scammer bot)

Sources:

1. <https://lennytroll.com/>
2. DIY guide highly recommends [U.S. Robotics USR5637](#) USB Modem
 - Modem Requirements:
 - On-board hardware controlled modem, "softmodems"/winmodems not supported.
 - Must have voice capability (TAD/TAM capability)
 - Another modem option: [StarTech USB56KEMH2 USB Modem](#), uses [Conexant CX93010-21Z chipset](#) (not verified).

Check out USB info before installing lenny:

- Is the USB modem a serial device (eg, `/dev/ttyUSB0` or `/dev/ttyACM0`)? Should "just work" with Linux.
- [Sending AT commands to serial modem in linux](#) (test that the modem works before installing Lenny)
- `lenny_service.txt` (systemd service file) will have to be edited to point to the correct directory housing Lenny Troll.