Dedicated To

My Family

Who supported me thick and thinPreface

First, Congratulations on investing your hard-earned money on this book. Who should read this book past this page?? A Techie by heart, A Hobbyist by nature & A Hacker by chance. Someone looking forward to having a rocking time with this magical box, labelled Raspberry Pi.

The Author was as excited as you are right now to begin his hacking spree, but it was when I faced numerous challenges (both on Hardware and Software level), that I decided to capture my daily learning’s in the form of simple notes on notepad. And then, it all started, with my collection of simple notes to capture new learning’s, which has now taken the shape of a book.

The basic idea behind publishing this book, is to cut short the plethora of information available on various websites on how-to build System Image for Raspberry-Pi, and to help readers quickly jump to the practical stuff that matters, without wasting time and energy on.

Everything said and done, I would personally love to hear from you, your suggestions to make this book even better.

Regards,

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# About the Author

Sudhanshu Gupta (Founder – Softwares Unleashed), is a Bachelors in Electronics & Tele-Communications & M.S. in Softwares Systems and has been associated with Telecom domain and Embedded Software development since 2004.

He had worked with Major Industry giant(s), LG, Infineon, Intel, NXP to name a few. Sudhanshu during his stint with the corporate world, has contributed to numerous success stories of Big OEMs (LG, Samsung, Nokia) …cutting short the list.

He is now on a fast track to take his passion forward, i.e. Embedded Systems Application Development and sharing his Technical Knowledge for the benefit of others.

# Before we start

Hope my work would be helpful to most of you reading this book, and enjoy working on the demo projects as much as I loved it creating them.

So without any further ado, let’s get started…

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# About Raspberry Pi

The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. Now over four years old, the Raspberry Pi, a cheap credit card sized computer, has taken the computing and DIY world by storm.

The original model became far more popular than anticipated, selling outside of its target market for uses such as robotics.

Per the Raspberry Pi Foundation, over 5 million Raspberry-Pi(s) have been sold before February 2015, making it the best-selling British computer.

#### Overview

Several generations of Raspberry-Pi(s) have been released. The first generation (Raspberry Pi 1 Model B) was released in February 2012. It was followed by a simpler and inexpensive model Model-A. In 2014, the foundation released a board with an improved design in Raspberry Pi 1 Model B+. The model laid the current "mainline" form-factor. Improved A+ and B+ models were released a year later. A cut down "compute module" was released in April 2014, and a Raspberry Pi Zero with smaller size and limited input/output (I/O) and general-purpose input/output (GPIO) abilities was released in November 2015 for US$5. The Raspberry Pi 2, which added more RAM, was released in February 2015. Raspberry Pi 3 Model B released in February 2016 is bundled with on-board Wi-Fi and Bluetooth. As of December 2016, Raspberry Pi 3 Model B is the newest mainline Raspberry Pi. These boards are priced between US$5–35.

All models feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit (CPU) and an on-chip graphics-processing unit (GPU, a Video Core IV). CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on-board memory range from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either the SDHC or MicroSD sizes. Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm phone jack for audio. Lower level output is provided by several GPIO pins which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 has on board Wi-Fi 802.11n and Bluetooth.

The Foundation provides Raspbian, a Debian-based Linux distribution for download, as well as third party Ubuntu, Windows 10 IOT Core, RISC OS, and specialized media centre distributions. [8] It promotes Python and Scratch as the main programming language, with support for many other languages. The default firmware is closed source, while an unofficial open source is available.

# Support Repo – RPI\_IOT\_KERNEL

This guide comes equipped with support material to speed up and enhance your learning experience, by collating all the necessary tools, kernel, scripts at a single repo. Just in case we missed it, you need to have an account created on [www.github.com](http://www.github.com) to access this support repo.

Git Repo Link: <https://github.com/softwaresunleashed/rpi_iot_kernel.git>

Create an empty folder and type in following command on shell prompt (and wait for few mins):

$ git clone --recursive https://github.com/softwaresunleashed/rpi\_iot\_kernel.git

Note: GIT is a pre-requisite to this step, hence, if GIT isn’t installed yet on your environment, execute the following command to install GIT on your system

$ sudo apt-get install git

This repo contains the following sections:

1. Firmware
2. Linux
3. Tools
4. Support

## FIRMWARE

Official RPi GPU / Firmware (bootloader) are part of this folder.

## LINUX

Based on Official RPi Linux 4.9.x kernel. This kernel includes kernel modifications, scripts, drivers etc. done for learning concepts which are detailed throughout this book.

## TOOLS

Based on Official RPi toolchain package. This toolchain shall be helpful in compiling code or generating RPi understandable binary format.

## SUPPORT

All the support files, misc. scripts, that will assist you throughout this book are added in this folder.

# Preparing Raspberry Pi for First Boot

## Hardware Requirements

1. Raspberry Pi (of course absolute yes!!)
2. Power adapter (your micro USB phone charger will do).
3. Memory Card (MMCSD Class 10 preferred)
4. Wi-Fi dongle (USB) (good to have)
5. Ethernet Cable to connect to network. (If you don’t have a Wi-Fi dongle)
6. USB Keyboard (optional)
7. HDMI Monitor (optional)

You could hook your Raspberry Pi up to a keyboard and monitor and set things up that way, or you can connect to your Pi over SSH and run every step from the comfort of your laptop. Although my personal favourite is SSH method, which is much easier than begging your friend for a random monitor.

## Install Raspbian on Your Pi and Connect to It Over SSH

For the first time ever, you need to insert or flash (as developers like to call it) a Pre-Built on to a SD (Rpi2) / MicroSD card (Rpi3) and insert it in into the designated slots on our magic machine.

You’ll need to choose from one of the following options to flash onto your Raspberry Pi.

Two versions of Pre-Built (and more reliable) OS images for RPi.

1. NOOBS / NOOBS Lite [ <https://www.raspberrypi.org/downloads/noobs/>]
2. Raspbian Lite / Pixel [ <https://www.raspberrypi.org/downloads/raspbian/> ]

On a newly installed Rasbian image (This is what I have been using most of my time), try connecting to RPI board via the following default credentials:

Username: pi (Default)

Password: raspberry (Default)

Note: You would need keyboard + HDMI monitor for first time login, since SSH is *not* enabled by default.

Lately, there have been substantial development on OS front, and several Third-party vendors have also come up with charming Linux distros apart from Noobs and Raspbian. In case you are in a mood to experiment, choose one variant that suits your taste buds from the section that follows on Third Party OS Images.

## Third Party Operating System Images

You may be interested in trying the following distros for Raspberry Pi, in addition to the ones mentioned above:

1. Ubuntu Mate [ <https://ubuntu-mate.org/raspberry-pi/> ]
2. Snappy Ubuntu Core [ <https://developer.ubuntu.com/core/get-started/raspberry-pi-2-3> ]
3. Windows 10 IOT Core [ <https://developer.microsoft.com/en-us/windows/iot/getstarted> ]
4. OSMC – Open Source Media Center [ <https://osmc.tv/> ]
5. LibreELEC [ <https://libreelec.tv/> ]
6. PiNet – Centralized Raspberry Pi Classroom [ <http://pinet.org.uk/> ]
7. RISC OS [ <https://www.riscosopen.org/content/downloads/raspberry-pi> ]
8. RPi Weather Station [ <https://downloads.raspberrypi.org/weather_station/images/weather_station-2016-03-24/> ]

## Image Flashing Softwares

To flash / burn above OS images to memory card, we need certain specialized software(s) that takes OS Image file as input, converts them into a format that is understandable by target board, and finally copy the contents onto the memory card.

Following are the list of various software(s) that can be used to burn RPi OS images onto memory card.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Flashing Software Name** | **Windows** | **Linux** | **OSX** | **Link** |
| Etcher | Y | Y | Y | <https://etcher.io/> |
| Raspberry Pi Imager |  |  |  | <https://www.raspberrypi.org/downloads/> |

## Setting Wi-Fi Up via Command Line

[https://www.raspberrypi.org/documentation/configuration/wireless/wireless-cli.md]

This method is suitable if you don't have access to the graphical user interface normally used to set up Wi-Fi on the Raspberry Pi. It is particularly suitable for use with a serial console cable if you don't have access to a screen or wired Ethernet network. Note also that no additional software is required; everything you need is already included on the Raspberry Pi.

### GETTING WIFI NETWORK DETAILS

To scan for Wi-Fi networks, use the command

$ sudo iwlist wlan0 scan.

This will list all available Wi-Fi networks, along with other useful information.

Look out for:

1. ' ESSID:"testing" ' is the name of the Wi-Fi network.
2. 'IE: IEEE 802.11i/WPA2 Version 1' is the authentication used. WPA2, the newer and more secure wireless standard which replaces WPA. This guide should work for WPA or WPA2 but may not work for WPA2 enterprise. You'll also need the password for the wireless network. The ESSID (ssid) for the examples below is ‘testing’ and the password (psk) is ‘testingPassword’.

### ADDING THE NETWORK DETAILS TO THE RASPBERRY PI

Open the wpa-supplicant configuration file in Nano:

$ sudo nano /etc/wpa\_supplicant/wpa\_supplicant.conf

Go to the bottom of the file and add the following:

network={

ssid="testing"

psk="testingPassword"

}

The password can be configured either as the ASCII representation, in quotes as per the example above, or as a pre-encrypted 32-byte hexadecimal number. You can use the **wpa\_passphrase** utility to generate an encrypted PSK. This takes the SSID and the password and generates the encrypted PSK. With the example from above, you can generate the PSK with

$ wpa\_passphrase "testing" "testingPassword.

The output is as follows.

network={

ssid="testing"

#psk="testingPassword"

psk=131e1e221f6e06e3911a2d11ff2fac9182665c004de85300f9cac208a6a80531

}

Note that the plain text version of the code is present but commented out. You should delete this line from the final wpa\_suplicant file for extra security.

### UNSECURED NETWORKS

If the network you are connecting to does not use a password, the wpa\_supplicant entry for the network will need to include the correct key\_mgmt entry. e.g.

network={

ssid="testing"

key\_mgmt=NONE

}

### HIDDEN NETWORKS

If you are using a hidden network, an extra option in the wpa\_supplicant file, scan\_ssid, may help connection.

network={

ssid="yourHiddenSSID"

scan\_ssid=1

psk="Your\_wifi\_password"

}

You can verify whether it has successfully connected using

$ ifconfig wlan0.

If the inet addr field has an address beside it, the Raspberry Pi has connected to the network. If not, check your password and ESSID are correct.

### ADDING MULTIPLE WIRELESS NETWORK CONFIGURATIONS

On recent versions of Raspbian, it is possible to set up multiple configurations for wireless networking. For example, you could set up one for home and one for school.

For example, if you have two networks in range, you can add the priority option to choose between them. The network in range, with the highest priority, will be the one that is connected.

network={

ssid="HomeOneSSID"

psk="passwordOne"

priority=1

id\_str="homeOne"

}

network={

ssid="HomeTwoSSID"

psk="passwordTwo"

priority=2

id\_str="homeTwo"

}

## Enable SSH (with Keyboard and Monitor attached)

[ <https://www.raspberrypi.org/documentation/remote-access/ssh/> ]

SSH can be enabled manually from the desktop:

1. Launch Raspberry Pi Configuration from the Preferences menu
2. Navigate to the Interfaces tab
3. Select Enabled next to SSH
4. Click OK

Alternatively, **raspi-config** can be used:

1. Enter **sudo raspi-config** in a terminal window
2. Select **Interfacing** Options
3. Navigate to and select **SSH**
4. Choose **Yes**
5. Select **Ok**
6. Choose **Finish**

## Enable SSH on a Headless Raspberry Pi

[ <https://www.raspberrypi.org/documentation/remote-access/ssh/> ]

For headless setup, SSH can be enabled by placing a file named **ssh**, without any extension, onto the boot partition (/boot) of the SD card. The file can be added by offloading the memory card from RPi and mounting it on Host Machine (Windows / Mac).

When the Pi boots, it looks for the ssh file. If it is found, SSH is enabled, and the file is deleted.

The content of the file does not matter: it could contain text, or nothing at all.

## Safely Shutting down RPi

Don’t mess with the wires / accessories while RPi is still powered on. Shutdown the Pi and wait for any blinking LEDs to stop and disconnect power before trying to connect / disconnect wires.

You can use either of the commands:

$ sudo shutdown -h now

Or

$ sudo halt

# Step by Step Guide (Building Custom Linux Kernel)

Building the system image for raspberry pie is easier than as depicted on various websites. This step-by-step guide will get your brand-new Raspberry Pi box up and running in no time (minus the complex jargon involved). RPi development is best done on an Ubuntu (Debian distro) with access to root privileges on shell. The guide assumes you have access to a shell with root privileges on an Ubuntu laptop / desktop.

NOTE: MAC OSX users may install Virtual Box with the latest Ubuntu distro installed. Then follow the instructions in the subsequent pages. Link to Virtual Box for MAC (<https://www.virtualbox.org/wiki/Downloads>). Also, install the extension pack provided on the website. Extension packs provide a bridge between your host environment (MAC OSX) and the guest environment (Linux Ubuntu)

## 1) Get the kernel source

First things first, we need to pull Linux Kernel source from WWW and store it locally on our hard drive.

~ # mkdir rpi\_4\_x\_xx

~ # cd rpi\_4\_x\_xx

~/rpi\_4\_x\_xx # git clone git://github.com/raspberrypi/linux.git

where x & xx are the major and minor release numbers for Raspberry-Pi Linux kernel. Latest RPI Linux Kernel version as of this writing was 4.9.y.

**Quick Repo Sync Tip:**

If you wish to save some time and download just the latest and greatest Linux Kernel available as of date, append “--depth=1” to the git clone command above. Believe me, it saves a lot of download time (and your broadband data cost), since most of the branching information is redundant to a hobbyist. However, if you are one of those geeky minds who would like to dwell into each commit that has ever been done on the repo, feel free to omit “—depth=1”.

## 2) Get the cross-compiler

Since, we shall be building Raspberry Pi system image on a machine, which would be running a CPU with different architecture, we would require downloading a Cross-Compiler. A Cross-Compiler is a program that generates code for a target device (Raspberry Pi in this case), although it is executing on a completely different machine with completely different architecture.

Cross compiling from Linux (pre-built bmc2708\_armv6kz compiler)

~ # mkdir rpi\_tools

~ # cd rpi\_tools

~/rpi\_tools # git clone git://github.com/raspberrypi/tools.git <enter>

NOTE: Install git command if not already installed via the following command

# apt-get install git

## 3) Install necessary packages

* On Ubuntu shell execute the following command (requires root privileges)

# apt-get install gcc-arm-linux-gnueabi make ncurses-dev

* Some Editors are handful, if not already installed

# apt-get install vim-gnome

* For compiling 32bit kernel on 64-bit VM (e.g. Virtual Box), following library needs to be installed.

# apt-get install lib32z1-dev

* Installing QT libs for using Graphical Interface to select Kernel config options ($ make xconfig)

# apt-get install qt4-dev-tools libqt4-dev libqt4-core libqt4-gui

# apt-get install qtlib4\*

* Starting with RPi kernel 4.19.y, following packages were needed to be installed (if not already installed)

# apt-get install bison

# apt-get install flex

# apt-get install libssl-dev

## 4) Code Compilation

#### 1#. Go to the build directory on PC

# cd <path\_to\_kernel\_source\_directory>/linux/

#### 2#. Firstly, ensure your build directory is clean:

<path\_to\_kernel\_source\_directory>/linux/ # make mrproper

#### 3#. Define Cross-Compiler & Processor Architecture

From this point on, if you are cross-compiling, please substitute <your\_compiler> with your compiler binary prefix (e.g. <your\_compiler>=arm-bcm2708hardfp-linux-gnueabi- or arm-linux-gnueabihf-) as each compiler will be named slightly differently. Check your toolchain folder for the compiler you wish to use to compile Linux Kernel for RPi.

Debug Note: Do *not* forget the hyphen (-) at the end of the compiler name. This has caused lots of time wasted and errors resulting in “xxxxxxxxx command not found”.

If you are building on the RPi (although we won’t recommend that as build process would be quite slow), remove ARCH=arm CROSS\_COMPILE=<your\_compiler> from each command.

#### 4#. Kernel Config File

You will want to get a working kernel configuration (.config) to start from.

If you are one of those lucky few, who got RPi with a pre-installed image loaded on the memory card, you can get the config file by executing following command on the shell (on the RPi):

/raspberryPi\_root\_folder # zcat /proc/config.gz > .config

& then copy .config file to your build directory (on PC).

PS: /proc/config.gz isn’t available on Raspbian Jessi distro. Support is available on Wheezy Raspbian distro only.

OR

**Alternatively**, the default configuration is available in the downloaded kernel source in <path\_to\_kernel\_src\_dir>/linux/arch/arm/configs/bcmrpi\_defconfig.

Copy (& rename) bcmrpi\_defconfig to .config in the build directory

OR

**Alternatively**, execute the following command on shell

<kernel\_src\_dir> $ export ARCH=arm

<kernel\_src\_dir> $ export CROSS \_COMPILE=arm-bcm2708hardfp-linux-gnueabi-

<kernel\_src\_dir> $ make bcmrpi\_defconfig

#### 5#. Setting Build Environment

Ensure that your configuration file is up-to-date by executing the following command...Textual, Sequential access to configuration parameters. (**Quite tedious)**

# make ARCH=arm CROSS\_COMPILE=<your\_compiler> oldconfig

OR

Optionally, if you want to tweak the configuration Graphically & more Organized -- **Better**), run this command on shell:

# make ARCH=arm CROSS\_COMPILE=<your\_compiler> <config\_targets>

Use any one of the following <config\_targets>:

config :- Update config using a Line-oriented program

nconfig :- Update config using a ncurses menu-based program

menuconfig :- Update config using a menu-based program

**xconfig :- Update config using a QT based front-end**

gconfig :- Update config using a GTK based front-end

NOTE: The configuration info is stored in ".config" file on exit from the configuration menu.

The file is in the "build artifacts folder" (if mentioned explicitly by the macro KBUILD\_OUTPUT)

e.g. In the build script we can mention the build output folder as

export KBUILD\_OUTPUT=\_build\_output\_folder

#### 6#. Let the Build Begin

Once you have made necessary changes in the Linux Kernel of RPi, you can trigger the build with the following command and have a cup of coffee or your lunch. This shall take time for the first fresh build. Incremental builds there-after shall be much less time consuming.

# make –j<N> ARCH=arm CROSS\_COMPILE=<your\_compiler>

If you are on a multi-core machine, you can make the build faster by appending -j<N> to the build command above. Where ‘N’ is the number of cores on your system plus one.

Quick Tip: Don’t bother to clean object files, in case changes are made only in source files…A change in header file, deserves a cleaner build with object files and library files deleted manually.

## 5) Preparing the SYSTEM IMAGE

Once your linux kernel is successfully built, you need to pack the kernel such that Raspberry Pi likes to have it. Follow the steps below…

#### 1#. Get Build Tools

Because of the way, the memory addresses are arranged in the Broadcom SoC (The CPU used on Raspberry Pi), you will need to prepare the compiled image, before uploading it to Memory Card.

If you haven't got the tools directory from the GIT repo, do so now:

# cd ~/rpi\_tools/compiler/tools

~/rpi\_tools/compiler/tools # git clone git://github.com/raspberrypi/tools.git

OR

DOWNLOAD\_FROM\_LINK\_TO\_TAR\_BALL:

https://github.com/raspberrypi/tools/

#### 2#. Make Image

In the toolchain set, there is a folder called mkimage. Enter this directory, and then run the following:

$ cd ~/rpi\_iot\_kernel/tools

$ ./mkimage/imagetool-uncompressed.py <kernel\_build\_dir>/arch/arm/boot/zImage

Update for Latest Raspberry Pi Kernel Versions :

With recent RPi Kernels, the process of creating the image has changed as below

$ cd ~/rpi\_iot\_kernel/linux

$ ./scripts/mkknlimg ./arch/arm/boot/zImage kernel.img

Location of "kernel.img”:

Above command will output a file called "kernel.img" (in the same folder where the python script "imagetool-uncompressed.py" is located.)

Quick Tip [1]: Above python script expects boot-uncompressed.txt file to be present in the same folder as the imagetool-uncompressed.py script. Hence, to get rid of any errors, we need to be execute the python script from the “mkimage” folder, so that boot-uncompressed.txt is available to the python script.

Quick Tip [2]: If you get error regarding "python2" not available, try creating a soft link to python2 as follows: (not sure why this is needed, but it worked for me)

# ln -s /usr/bin/python2.6 /usr/bin/python2

## 6) Transfer the Kernel Image

Copy your new kernel.img file into the RPi boot partition, though preferably as a new file (such as kernel\_new.img) just in case it doesn't work. If you're building on the RPi, just copy the file to /boot.

If you use a different filename, edit **config.txt** change the kernel line:

---

# Comment out the below line

#kernel=kernel.img

# Add this new line in /boot/config.txt

kernel=kernel\_new.img

---

## 7) Copy Device Tree Blobs (Recent Kernels Only)

For relatively newer RPi kernels, copy Device Tree blobs onto the SD Card.

$ sudo cp arch/arm/boot/dts/\*.dtb /boot

$ sudo cp arch/arm/boot/dts/overlays/\*.dtb\* /boot/overlays

$ sudo cp arch/arm/boot/dts/overlays/README /boot/overlays

## 8) Building the Device Drivers (Modules)

Now you need to transfer the Device Drivers (aka Modules).

In the build directory, run the following (substituting <modules\_path> for a folder somewhere (e.g. ~/modules):

<path\_to\_kernel\_source\_directory>/linux/ # make ARCH=arm CROSS\_COMPILE=<your\_compiler> modules\_install INSTALL\_MOD\_PATH=<modules\_path>

The contents of this directory should then be copied into the RPi root directory.

NOTE: If you have rebuilt the new kernel with exactly the same version as the one that's running, you'll need to remove the old modules first. Ideally this should be done offline by mounting the SD card on another system.

## 9) Updating the GPU (Graphics Processing Unit) firmware

Your RPi should now be ready to boot the new kernel. However, at this point it's recommended (not necessary) that you update your GPU firmware and libraries. This is required if you've just moved from 3.2 to 3.6 as the firmware interface has changed.

The "firmware" and "boot files" should be updated at the same time to ensure that your new kernel works properly

"master" - This is the version of firmware currently used in Raspbian (i.e. it works with the 3.2 kernel).

"next" - This is a development branch which provides a newer GPU firmware to work with the updated drivers in the 3.6 kernel.

For the "master" branch:

<path\_to\_folder\_where\_firmware\_is\_to\_be\_stored> # git clone git://github.com/raspberrypi/firmware.git

For the "next" branch:

<path\_to\_folder\_where\_firmware\_is\_to\_be\_stored> # git fetch git://github.com/raspberrypi/firmware.git next:refs/remotes/origin/next

## 10) Transfer the firmware

In case you are using a Virtual Box setup on Windows / Mac environment, take a pause to refer the section “Transferring files between VirtualBox and Host OS” , before continuing with the following section.

a) Firstly, update the required boot files in the RPi boot directory with those you've downloaded. These are:

-1- bootcode.bin

-2- fixup.dat

-3- start.elf

Next, you need to copy the VC libraries over.

There are two copies of this: one for **hard float** and one for **soft float**.

To find the correct one that you should be using, run the following command (substituting the program name for your compiler binary as required):

# arm-none-linux-gnueabi-gcc -v 2>&1 | grep hard

If something prints out, and you can see **--with-float=hard**, you need the hard float ones.

NOTE: The current version of Raspbian uses hard float.

b) Remove the /opt/vc directory from the RPi root, then:

For hard float, copy vc from the hardfp/opt directory into /opt in the RPi root directory

Otherwise copy vc from the top-level opt directory into /opt in the RPi root directory.

# Understanding Device Tree

[ <https://www.raspberrypi.org/documentation/configuration/device-tree.md> ]

Raspberry Pi's latest kernels and firmware, including Raspbian and NOOBS releases, now use a Device Tree (DT) to manage some resource allocation and module loading by default. This was implemented to ease the problem of multiple drivers contending for system resources, and to allow HAT modules to be auto-configured.

The current implementation is not a pure Device Tree system – there is still some board support code that creates some platform devices – but the external interfaces (I2C, I2S, SPI), and the audio devices that use them, must now be instantiated using a Device Tree Blob (DTB) passed to the kernel by the loader (start.elf).

The main impact of using Device Tree is to change from "everything on", relying on module blacklisting to manage contention, to "everything off unless requested by the DTB". To continue to use external interfaces and the peripherals that attach to them, you will need to add some new settings to your config.txt.

Here are few examples :

===============================

# Uncomment some or all these lines to enable the optional hardware interfaces

#dtparam=i2c\_arm=on

#dtparam=i2s=on

#dtparam=spi=on

# Uncomment one of these lines to enable an audio interface

#dtoverlay=hifiberry-amp

#dtoverlay=hifiberry-dac

#dtoverlay=hifiberry-dacplus

#dtoverlay=hifiberry-digi

#dtoverlay=iqaudio-dac

#dtoverlay=iqaudio-dacplus

#dtoverlay=audioinjector-wm8731-audio

# Uncomment this to enable the lirc-rpi module

#dtoverlay=lirc-rpi

# Uncomment this to override the defaults for the lirc-rpi module

#dtparam=gpio\_out\_pin=16

#dtparam=gpio\_in\_pin=17

#dtparam=gpio\_in\_pull=down

===============================

## DEVICE TREES

A Device Tree (DT) is a description of the hardware in a system. It should include the name of the base CPU, its memory configuration, and any peripherals (internal and external). A DT should not be used to describe the software, although by listing the hardware modules it does usually cause driver modules to be loaded. It helps to remember that DTs are supposed to be OS-neutral, so anything which is Linux-specific probably shouldn't be there.

A Device Tree represents the hardware configuration as a hierarchy of nodes. Each node may contain properties and sub nodes. Properties are named arrays of bytes, which may contain strings, numbers (big-endian), arbitrary sequences of bytes, and any combination thereof. By analogy to a filesystem, nodes are directories and properties are files. The locations of nodes and properties within the tree can be described using a path, with slashes as separators and a single slash (/) to indicate the root.

### 1.1: BASIC DTS SYNTAX

Device Trees are usually written in a textual form known as Device Tree Source (DTS) and stored in files with a .dts suffix. DTS syntax is C-like, with braces for grouping and semicolons at the end of each line. Note that DTS requires semicolons after closing braces: think of C structs rather than functions. The compiled binary format is referred to as Flattened Device Tree (FDT) or Device Tree Blob (DTB) and is stored in DTB files.

The following is a simple tree in DTS format:

/dts-v1/;

/include/ "common.dtsi";

/ {

node1 {

a-string-property = "A string";

a-string-list-property = "first string", "second string";

a-byte-data-property = [0x01 0x23 0x34 0x56];

cousin: child-node1 {

first-child-property;

second-child-property = <1>;

a-string-property = "Hello, world";

};

child-node2 {

};

};

node2 {

an-empty-property;

a-cell-property = <1 2 3 4>; /\* each number (cell) is a uint32 \*/

child-node1 {

my-cousin = <&cousin>;

};

};

};

/node2 {

another-property-for-node2;

};

This tree contains:

* a required header: /dts-v1/.
* The inclusion of another DTS file, conventionally named \*.dtsi and analogous to a .h header file in C.
* a single root node: /
* a couple of child nodes: node1 and node2.
* some children for node1: child-node1 and child-node2.
* a label (cousin) and a reference to that label (&cousin): see Labels and References below.
* several properties scattered through the tree.
* a repeated node (/node2).

**Properties** are simple key-value pairs where the value can either be empty or contain an arbitrary byte stream. While data types are not encoded in the data structure, there are a few fundamental data representations that can be expressed in a Device Tree source file.

Text strings (NULL-terminated) are indicated with double quotes:

string-property = "a string";

Cells are 32-bit unsigned integers delimited by angle brackets:

cell-property = <0xbeef 123 0xabcd1234>;

Arbitrary byte data is delimited with square brackets, and entered in hex:

binary-property = [01 23 45 67 89 ab cd ef];

Data of differing representations can be concatenated using a comma:

mixed-property = "a string", [01 23 45 67], <0x12345678>;

Commas are also used to create lists of strings:

string-list = "red fish", "blue fish";

### 1.2: AN ASIDE ABOUT /INCLUDE/

The **/include/** directive results in simple textual inclusion, much like C's **#include** directive, but a feature of the Device Tree compiler leads to different usage patterns. Given that nodes are named, potentially with absolute paths, it is possible for the same node to appear twice in a DTS file (and its inclusions). When this happens, the nodes and properties are combined, interleaving and overwriting properties as required (later values override earlier ones).

# Transferring files between VirtualBox and Host OS

Like multiple users, you may be using Virtual Box VM (running Ubuntu on top of it), to build Kernel images. Once Kernel image is built, you may have to transfer the image and firmware to memory card, before it can be deployed onto RPi.

To do this there are couple of methods :

1. Shared Folder between Host & Guest OS
2. Mapping Card Reader to Virtual SD Card (. vmdk)
3. Secure copy between Host & Guest OS.
4. Using a USB card reader

## Shared Folder between Host & Guest OS

[ https://ryansechrest.com/2012/10/permanently-share-a-folder-between-host-mac-and-guest-linux-os-using-virtualbox/]

### Step 1: Share a folder on the host OS

1. In VirtualBox, click your OS on the left and click on **Settings**.
2. Click on the **Shared Folders** tab.
3. Click on the **folder with the plus** on the right.
4. **Browse to a folder** of your choice in the folder path.
5. **Enter a folder name** with no spaces e.g. “Share”.
6. Check **Auto-mount** and **Make Permanent**, if available.
7. Click on **OK**.

### Step 2: Mount the folder in the guest OS

1. **Create a folder** in your guest OS that you want to share.
2. **Open a Terminal**.
3. **Type in** id and press ENTER— remember that ID.
4. **Switch to the** root **user** using sudo su and enter your password.
5. **Browse to the** etc **folder** using cd /etc.
6. **Edit the** rc.local **file** using vi rc.local.
7. Move your **cursor right above** exit 0 and **press the letter “i”** on your keyboard to insert text.
8. **Type in the following command on shell**:  sudo mount -t vboxsf -o uid=1000,gid=1000 Share /home/username/Documents/Share
   * 1000 should match the ID you noted down earlier.
   * Share should match the folder name from step 1.
   * username should match your Linux username.
   * /Documents/Share should be the absolute path of the new folder you created.
9. **Now hit “ESC”**, type :wq! and hit ENTER to save and quit the file editing.

After you restart the guest OS, your shared folder will be automatically mounted.

## Secure Copy (SCP) between Host & Guest OS.

This is my favourite method (and easiest too). Works like a charm for me every time. In a Linux environment, for both security and ease of use, ssh is the best way to go. SSH, SSHFS, SCP, and SFTP as you list are all just different services built on top of the SSH protocol.

SCP is very easy to use, it works just like “cp” command in shell, but you can provide user and machine names in the path.

So, we might do a CP like cp ~/rpi\_iot\_kernel/ ~/rpi\_iot\_kernel\_backup/, but we could just as easily do

$ scp ~/rpi\_iot\_kernel/linux/kernel.img [user@host\_pc:~/temp/kernel.img](mailto:user@host_pc:~/temp/kernel.img)

to send it to the host computer (on which your Virtual Box Guest OS is running).

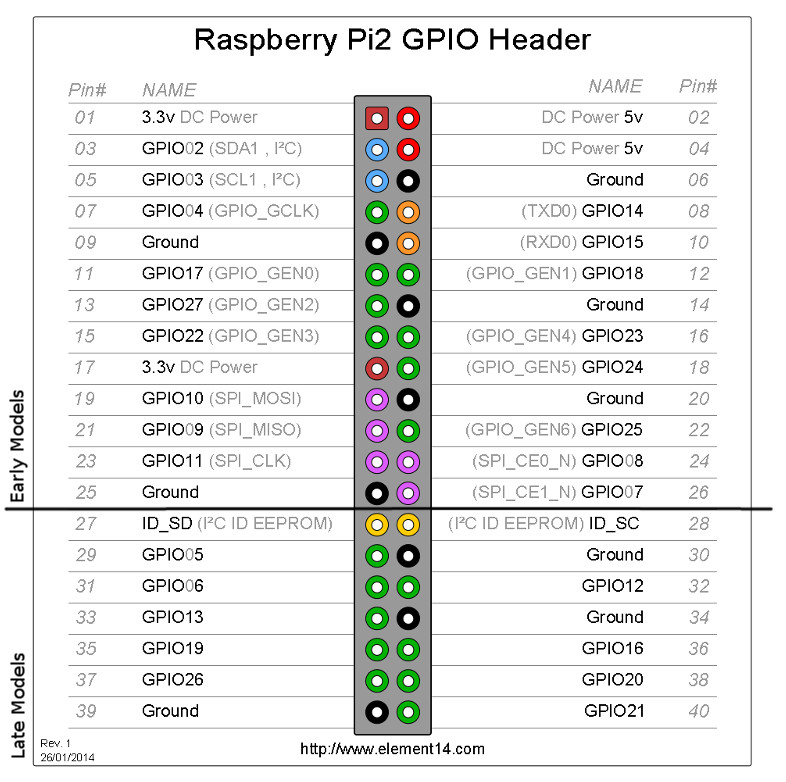
That's it - we don't need to set anything up. You'll be prompted for the account password on the other machine if you don't have certificate or some other authentication set up (scp shares those settings with ssh, of course).

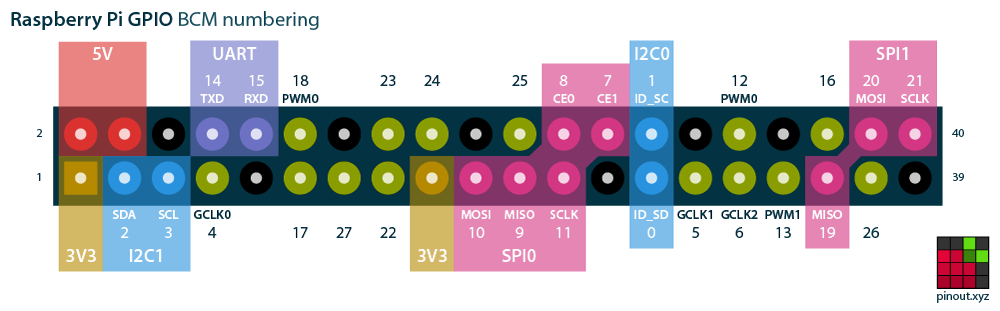
## Using a USB card reader

Another one of my favourite. Simply insert a USB Card Reader with SD Card, it is auto mounted in Guest OS (e.g. Ubuntu running inside Virtual Box). Once SD Card shows in Guest OS, we can simply exchange file(s) using any in-built file explorer.

# GPIO Pinout on Raspberry Pi

Following figures depicts the GPIO pins & their respective functionality. Rpi models below v3 had 26pin GPIO header. RPi3 onwards, GPIO header has been expanded to 40 pins (adding more GPIOs for interfacing), keeping the new header configuration backward compatible with older RPi models.





# CSCOPE & VIM Integration

## Integrating CSCOPE and VIM

When you are working with a large code base, you need a powerful tool to navigate through the code seamlessly . There are many paid tools put there that does this efficiently and for the open source enthusiast in you, you have [Cscope](http://cscope.sourceforge.net/) that provides a command line interface to code navigation.

In my project where I had to make changes to parts of code that includes thousands of file that pours in from teams across geographies, I found it difficult to open up Cscope each time I had to find the reference to a variable or search for a definition.

With Cscope integrated vim (and some getting used to), code navigation is easier, faster and all the more interesting. We shall now see, how to integrate vim and Cscope in quick steps and provide some shell functions that will make your life easier.

NOTE: It goes without saying that this is all applicable for non-GUI code editors like me who prefer to use FOS tools for your day to day activities

STEP 1:

Install vim and cscope .

STEP 2:

Download the cscope vim map from

[ <http://cscope.sourceforge.net/cscope_maps.vim>]

and copy it to your ~/.vim/plugin folder or somewhere where this file can be “sourced” from.

I had to move the “set nocscopeverbose” line from the end of CSCOPE\_DB addition branch to the beginning of the branch to avoid some prints at vim start-up . (from line 49 to above line 33 in the 2002/3/7 version of the map file).

STEP 3:

Add the following functions to your ~/.profile (or ~/.bashrc) file

function build\_cscope\_db\_func()

{

find $PWD -name \*.c \

-o -name \*.h \

-o -name \*.mk \

-o -name \*.xml\

-o -name \*.cfg\

-o -name \*.ini\

-o -name \*.dat\

-o -name \*.cpp > $PWD/cscope.files

cscope -RCbk

export CSCOPE\_DB=$PWD/cscope.out

}

alias csbuild=build\_cscope\_db\_func

function cscope\_export\_db\_func()

{

export CSCOPE\_DB=$PWD/cscope.out

}

alias csexport=cscope\_export\_db\_func

Once this is in place , save the file and import it into your environment by executing “. ~/.profile” .

NOTE: you can alter the type of files to be included in cscope parsing in the above function to suite your needs

STEP 4:

Now go to the root folder of your code and execute “csbuild”. This operation might take some time depending on your code size and type of files included in the csbuild function. This operation is valid until there is code change to be parsed.

STEP 5:

Now open vim and you are ready to navigate your mighty code base.

To start with , supose you want to find the file main.c, issue the vim command ” :cs f f main.c ” [i.e. cscope find files of name main.c]

Another command that can be issued ” :cs f s main  ” to find all references to the symbol “main”. List of all commands will be listed on issuing ” :cs h ” to vim.

Once a file is open, to perform the operations (like “s” to find all references to a symbol under the cursor), while in vim command mode, do a ” ctrl + \    s”. Same goes for other commands (like f to open a file with name under the cursor)

**cscope commands**:

add : Add a new database (Usage: add file|dir [pre-path] [flags])

find : Query for a pattern (Usage: find a|c|d|e|f|g|i|s|t name)

a: Find assignments to this symbol

c: Find functions calling this function

d: Find functions called by this function

e: Find this egrep pattern

f: Find this file

g: Find this definition

i: Find files #including this file

s: Find this C symbol

t: Find this text string

STEP 6:

Once a cscope database is built (using csbuild), its link to vim is valid only until the session is active (since it is controlled using an environment variable). Once you open a new session, you have to go to the location of the cscope.out file (root folder of your code) and do a csexport.

This is also valid when you want to switch between projects (code bases). csbuild can be executed on all project roots and csexport can be used to switch between projects

## Source Code Navigation in CSCOPE + VIM

Cscope answers these questions from a symbol database that it builds the first time it is used on the source files.

Where is this symbol used?

Where is it defined?

Where did this variable get its value?

What is this global symbol's definition?

Where is this function in the source files?

What functions call this function?

What functions are called by this function?

Where does the message "out of space" come from?

Where is this source file in the directory structure?

What files include this header file?

When cscope is normally invoked, you will get a full-screen selection screen allowing you to make a query for one of the above questions.

However, once a match is found to your query and you have entered your text editor to edit the source file containing match, you cannot simply jump from tag to tag as you normally would with vi's Ctrl-] or :tag

Cscope related commands

**add : Add a new cscope database/connection**.

USAGE :cs add {file|dir} [pre-path] [flags]

[pre-path] is the pathname used with the -P command to cscope.

[flags] are any additional flags you want to pass to cscope.

EXAMPLES

:cscope add /usr/local/cdb/cscope.out

:cscope add /projects/vim/cscope.out /usr/local/vim

:cscope add cscope.out /usr/local/vim -C

**find : Query cscope. All cscope query options are available**

**except option #5 ("Change this grep pattern").**

USAGE :cs find {querytype} {name}

{querytype} corresponds to the actual cscope line

interface numbers as well as default nvi commands:

0 or s: Find this C symbol

1 or g: Find this definition

2 or d: Find functions called by this function

3 or c: Find functions calling this function

4 or t: Find this text string

6 or e: Find this egrep pattern

7 or f: Find this file

8 or i: Find files #including this file

9 or a: Find places where this symbol is assigned a value

For all types, except 4 and 6, leading white space for {name} is

removed. For 4 and 6 there is exactly one space between {querytype}

and {name}. Further white space is included in {name}.

EXAMPLES

:cscope find c vim\_free

:cscope find 3 vim\_free

These two examples perform the same query: functions calling

"vim\_free".

:cscope find t initOnce

:cscope find t initOnce

The first one searches for the text "initOnce", the second one for

" initOnce".

:cscope find 0 DEFAULT\_TERM

Executing this example on the source code for Vim 5.1 produces the

following output:

Cscope tag: DEFAULT\_TERM

# line filename / context / line

1 1009 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"amiga"

2 1013 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"win32"

3 1017 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"pcterm"

4 1021 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"ansi"

5 1025 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"vt52"

6 1029 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"os2ansi"

7 1033 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"ansi"

8 1037 vim-5.1-gtk/src/term.c <<GLOBAL>>

# undef DEFAULT\_TERM

9 1038 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"beos-ansi"

10 1042 vim-5.1-gtk/src/term.c <<GLOBAL>>

#define DEFAULT\_TERM (char\_u \*)"mac-ansi"

11 1335 vim-5.1-gtk/src/term.c <<set\_termname>>

term = DEFAULT\_TERM;

12 1459 vim-5.1-gtk/src/term.c <<set\_termname>>

if (STRCMP(term, DEFAULT\_TERM))

13 1826 vim-5.1-gtk/src/term.c <<termcapinit>>

term = DEFAULT\_TERM;

14 1833 vim-5.1-gtk/src/term.c <<termcapinit>>

term = DEFAULT\_TERM;

15 3635 vim-5.1-gtk/src/term.c <<update\_tcap>>

p = find\_builtin\_term(DEFAULT\_TERM);

Enter nr of choice (<CR> to abort):

The output shows several pieces of information:

1. The tag number (there are 15 in this example).

2. The line number where the tag occurs.

3. The filename where the tag occurs.

4. The context of the tag (e.g., global, or the function name).

5. The line from the file itself.

**kill : Kill a cscope connection (or kill all cscope connections).**

USAGE :cs kill {num|partial\_name}

To kill a cscope connection, the connection number or a partial

name must be specified. The partial name is simply any part of

the pathname of the cscope database. Kill a cscope connection

using the partial name with caution!

If the specified connection number is -1, then \_ALL\_ cscope

connections will be killed.

**reset : Reinit all cscope connections.**

USAGE :cs reset

**show : Show cscope connections.**

USAGE :cs show

# Deep-Dive References

Someone wise once said, “Little Knowledge is dangerous”. While this may be true in most of the scenarios, refer this section to get a deep-dive into various sections discussed throughout this book.

## Creating Bash Aliases

Do you often find yourself typing a long command on the command line or searching the bash history for a previously typed command? If your answer to any of those questions is yes, then you will find bash aliases handy. Bash aliases allow you to set a memorable shortcut command for a longer command.

Bash aliases are essentially shortcuts that can save you from having to remember long commands and eliminate a great deal of typing when you are working on the command line.

For example, you could set the alias tgz to be a shortcut for the tar -xvfz command.

This article explains how to create bash aliases so you can be more productive on the command line.

### Creating Bash Aliases without Arguments

Creating aliases in bash is very straight forward. The syntax is as follows:

$ alias alias\_name="command\_to\_run"

An alias declaration starts with the alias keyword followed by the alias name, an equal sign and the command you want to run when you type the alias. The command needs to be enclosed in quotes and with no spacing around the equal sign. Each alias needs to be declared on a new line.

The ls command is probably one of the most used commands on the Linux command line. I usually use this command with the -la switch to list out all files and directories, including the hidden ones in long list format.

Let’s create a simple bash alias named ll which will be a shortcut for the ls -la command. To do so type open a terminal window and type:

$ alias ll="ls -la"

Now, if you type ll in your terminal, you’ll get the same output as you would by typing ls -la.

The ll alias will be available only in the current shell session. If you exit the session or open a new session from another terminal, the alias will not be available.

To make the alias persistent you need to declare it in the ~/.bash\_profile or ~/.bashrc file.

Open the ~/.bashrc in your text editor:

$ vi ~/.bashrc

and add your aliases:

|  |
| --- |
| ~/.bashrc |
| # Aliases  # alias alias\_name="command\_to\_run"  # Long format list  alias ll="ls -la"  # Print my public IP  alias myip='curl ipinfo.io/ip' |

The aliases should be named in a way that is easy to remember. It is also recommended to add a comment for future reference.

Once done, save and close the file. Make the aliases available in your current session by typing:

$ source ~/.bashrc

As you can see, creating simple bash aliases is quick and very easy.

If you want to make your .bashrc more modular you can store your aliases in a separate file. Some distributions like Ubuntu and Debian include a .bash\_aliases file, which is sourced from the ~/.bashrc.

### Creating Bash Aliases with Arguments (Bash Functions)

Sometimes you may need to create an alias that accepts one or more arguments. That’s where bash functions come in handy.

The syntax for creating a bash function is very easy. They can be declared in two different formats:

function\_name () {

[commands]

}

or

function function\_name {

[commands]

}

To pass any number of arguments to the bash function simply, put them right after the function’s name, separated by a space. The passed parameters are $1, $2, $3, etc., corresponding to the position of the parameter after the function’s name. The $0 variable is reserved for the function name.

Let’s create a simple bash function which will create a directory and then navigate into it:

|  |
| --- |
| ~/.bashrc |
| mkcd ()  {  mkdir -p -- "$1" && cd -P -- "$1"  } |

Same as with aliases, add the function to your ~/.bashrc file and run “source ~/.bash\_profile” to reload the file.

Now instead of using mkdir to create a new directory and then cd to move into that directory, you can simply type:

$ mkcd new\_directory

If you wonder what are -- and && here is a short explanation.

--

- makes sure you’re not accidentally passing an extra argument to the command. For example, if you try to create a directory that starts with - (dash) without using -- the directory name will be interpreted as a command argument.

&&

- ensures that the second command runs only if the first command is successful.

## SCP Command to Securely Transfer Files

SCP (secure copy) is a command-line utility that allows you to securely copy files and directories between two locations.

With scp, you can copy a file or directory:

* From your local system to a remote system.
* From a remote system to your local system.
* Between two remote systems from your local system.

When transferring data with scp, both the files and password are encrypted, so that anyone snooping on the traffic doesn’t get anything sensitive.

### SCP Command Syntax

Before going into how to use the scp command, let’s start by reviewing the basic syntax.

The scp command syntax take the following form:

$ scp [OPTION] [user@]SRC\_HOST:]file1 [user@]DEST\_HOST:]file2

* OPTION - scp options such as cipher, ssh configuration, ssh port, limit, recursive copy …etc.
* [user@]SRC\_HOST:]file1 - Source file.
* [user@]DEST\_HOST:]file2 - Destination file

Local files should be specified using an absolute or relative path while remote file names should include a user and host specification.

SCP provides a number of options that control every aspect of its behaviour. The most widely used options are:

-P Specifies the remote host ssh port.

-p Preserves files modification and access times.

-q Use this option if you want to suppress the progress meter and non-

error messages.

-C This option will force scp to compresses the data as it is sent to the

destination machine.

-r This option will tell scp to copy directories recursively.

### Before you Begin

The scp command relies on ssh for data transfer, so it requires an ssh key or password to authenticate on the remote systems. (Refer to SSH section for details).

The colon (:) is how scp distinguish between local and remote locations.

To be able to copy files you must have at least read permissions on the source file and write permission on the target system.

Be careful when copying files that share the same name and location on both systems, scp will overwrite files without warning.

When transferring large files, it is recommended to run the scp command inside a “screen” or “tmux” session.

### Copy a Local File to a Remote System

To copy a file from a local to a remote system run the following command:

$ scp file.txt remote\_username@10.10.0.2:/remote/directory

Where, file.txt is the name of the file we want to copy, remote\_username is the user on the remote server, 10.10.0.2 is the server IP address. The /remote/directory is the path to the directory you want to copy the file to. If you don’t specify a remote directory, the file will be copied to the remote user home directory.

You will be prompted to enter the user password, and the transfer process will start.

Omitting the filename from the destination location copies the file with the original name. If you want to save the file under a different name, you need to specify the new file name:

$ scp file.txt remote\_username@10.10.0.2:/remote/directory/newfilename.txt

If SSH on the remote host is listening on a port other than the default 22 then you can specify the port using the -P argument:

$ scp -P 2322 file.txt remote\_username@10.10.0.2:/remote/directory

The command to copy a directory is much like as when copying files. The only difference is that you need to use the -r flag for recursive.

To copy a directory from a local to remote system, use the -r option:

$ scp -r /local/directory remote\_username@10.10.0.2:/remote/directory

### Copy a Remote File to a Local System

To copy a file from a remote to a local system, use the remote location as a source and local location as the destination.

For example to copy a file named file.txt from a remote server with IP 10.10.0.2 run the following command:

$ scp remote\_username@10.10.0.2:/remote/file.txt /local/directory

If you haven’t set a password-less SSH login (checkout section on Setup Password-less SSH Login ) to the remote machine, you will be asked to enter the user password.

### Copy a File Between Two Remote Systems

When using scp you don’t have to log in to one of the servers to transfer files from one to another remote machine.

The following command will copy the file /files/file.txt from the remote host host1.com to the directory /files on the remote host host2.com.

$ scp user1@host1.com:/files/file.txt user2@host2.com:/files

You will be prompted to enter the passwords for both remote accounts. The data will be transfer directly from one remote host to the other.

## Setup Password-less SSH Login

You may also want to set up an SSH key-based authentication and connect to your Linux servers without entering a password.

Secure Shell (SSH) is a cryptographic network protocol used for secure connection between a client and a server and supports various authentication mechanisms. The two most popular mechanisms are passwords based authentication and public key based authentication.

In this tutorial, we will show you how to setup an SSH key-based authentication as well how to connect to your Linux server without entering a password.

### Setup SSH Password-less Login

To set up a password less SSH login in Linux all you need to do is to generate a public authentication key and append it to the remote hosts **~/.ssh/authorized\_keys** file.

The following steps will describe the process for configuring password less SSH login:

#### Check for existing SSH key pair.

Before generating a new SSH key pair first check if you already have an SSH

key on your client machine because you don’t want to overwrite your existing

keys.

Run the following ls command to see if existing SSH keys are present:

$ ls -al ~/.ssh/id\_\*.pub

If there are existing keys, you can either use those and skip the next step or

backup up the old keys and generate a new one.

If you see No such file or directory or no matches found it means that you do

not have an SSH key and you can proceed with the next step and generate a

new one.

#### Generate a new SSH key pair.

The following command will generate a new 4096 bits SSH key pair with your

email address as a comment:

$ ssh-keygen -t rsa -b 4096 -C "your\_email@domain.com"

Press Enter to accept the default file location and file name:

Enter file in which to save the key (/home/yourusername/.ssh/id\_rsa):

Next, the ssh-keygen tool will ask you to type a secure passphrase. Whether

you want to use passphrase it’s up to you, if you choose to use passphrase you

will get an extra layer of security. In most cases, developers and system

administrators use SSH without a passphrase because they are useful for fully

automated processes. If you don’t want to use passphrase just press Enter

Enter passphrase (empty for no passphrase):

The whole interaction looks like this:

A screenshot of a cell phone

Description automatically generated

To be sure that the SSH keys are generated you can list your new private and

public keys with:

$ ls ~/.ssh/id\_\*

Output :

/home/yourusername/.ssh/id\_rsa /home/yourusername/.ssh/id\_rsa.pub

#### Copy the public key

Now that you have generated an SSH key pair, in order to be able to login to

your server without a password you need to copy the public key to the server

you want to manage.

The easiest way to copy your public key to your server is to use a command

called ssh-copy-id. On your local machine terminal type:

$ ssh-copy-id remote\_username@server\_ip\_address

You will be prompted to enter the remote\_username password:

Output :

remote\_username@server\_ip\_address's password:

Once the user is authenticated, the public key will be appended to the remote

user authorized\_keys file and connection will be closed.

If for some reason the ssh-copy-id utility is not available on your local computer you can use the following command to copy the public key:

$ cat ~/.ssh/id\_rsa.pub | ssh remote\_username@server\_ip\_address "mkdir -p

#### Login to your server using SSH keys

After completing the steps above you should be able log in to the remote

server without being prompted for a password.

To test it just try to login to your server via SSH:

$ ssh remote\_username@server\_ip\_address

If everything went well, you will be logged in immediately.

### Disabling SSH Password Authentication

To add an extra layer of security to your server you can disable the password authentication for SSH.

**Caution :** Before disabling the SSH password authentication make sure you can log in to your server without a password and the user you are logging in with has sudo privileges.

Let’s now see, how to configure sudo access:

1. Log into your remote server with SSH keys, either as a user with sudo privileges or root:

$ ssh sudo\_user@server\_ip\_address

1. Open the SSH configuration file /etc/ssh/sshd\_config, search for the following directives and modify as it follows:

|  |
| --- |
| /etc/ssh/sshd\_config |
| PasswordAuthentication no  ChallengeResponseAuthentication no  UsePAM no |

Once you are done save the file and restart the SSH service. On Ubuntu or

Debian servers, run the following command:

$ sudo systemctl restart ssh

## Change the SSH Port

By default, SSH listens on port 22. Changing the default SSH port adds an extra layer of security to your server by reducing the risk of automated attacks.

Instead of changing the port is much simpler and secure to configure your firewall to allow access to port 22 only from specific hosts.

### Changing the SSH Port

Follow the steps below to change the SSH Port on your Linux system:

**1. Choosing a New Port Number**

In Linux, port numbers below 1024 are reserved for well-known services and can only be bound to by root. Although you can use a port within 1-1024 range for the SSH service to avoid issues with port allocation in the future it is recommended to choose a port above 1024.

In this example will change the SSH port to 5522, you can choose any port you like.

**2. Adjusting Firewall**

Before changing the SSH port, first you’ll need to adjust your firewall to allow traffic on the new SSH port.

If you are using UFW, the default firewall configuration tool for Ubuntu run the following command to open the new SSH port:

$ sudo ufw allow 5522/tcp

If you are using iptables as your firewall, the following command will open the new SSH port:

$ sudo iptables -A INPUT -p tcp --dport 5522 -m conntrack –ctstate NEW,ESTABLISHED -j ACCEPT

**3. Configuring SSH**

Open the SSH configuration file /etc/ssh/sshd\_config with your text editor:

$ sudo vi /etc/ssh/sshd\_config

Search for the line starting with Port 22. In most cases, this line will start with a hash #. Remove the hash # and enter your new SSH port number that will be used instead of the standard SSH port 22.

|  |
| --- |
| /etc/ssh/sshd\_config |
| Port 5522 |

Be extra careful when modifying the SSH configuration file. The incorrect configuration may cause the SSH service to fail to start.

Once you are done save the file and restart the SSH service to apply the changes:

$ sudo systemctl restart ssh

To verify that SSH daemon is listening on the new port 5522 type:

$ ss -an | grep 5522

The output should look something like this:

tcp LISTEN 0 128 0.0.0.0:5522 0.0.0.0:\*

tcp ESTAB 0 0 192.168.121.108:5522 192.168.121.1:57638

tcp LISTEN 0 128 [::]:5522 [::]:\*

### Using the New SSH Port

Now that you changed the SSH port when login to the remote machine you’ll need to specify the new port.

Run the ssh followed by the -p <port\_number> option to specify the port:

$ ssh -p 5522 username@remote\_host\_or\_ip

## Using the SSH Config File

If you are regularly connecting to the same systems, you can simplify your workflow by defining all of your connections in the SSH config file. If you are regularly connecting to multiple remote systems over SSHs, you’ll find that remembering all of the remote IP addresses, different usernames, non-standard ports, and various command-line options is difficult, if not impossible.

One option would be to create a bash alias (see section Creating Bash Aliases) for each remote server connection. However, there is another, much better, and simpler solution to this problem. OpenSSH allows you to set up a per-user configuration file where you can store different SSH options for each remote machine you connect to.

### Prerequisites

A Linux or a MacOS system with OpenSSH client installed.

### SSH Config File Location

OpenSSH client-side configuration file is named config, and it is stored in .ssh directory under user’s home directory.

The ~/.ssh directory is automatically created when the user runs the ssh command for the first time. If the directory doesn’t exist on your system, create it using the command below:

$ mkdir -p ~/.ssh && chmod 700 ~/.ssh

By default the SSH configuration file may not exist so you may need to create it using the “touch” command:

$ touch ~/.ssh/config

This file must be readable and writable only by the user, and not accessible by others:

$ chmod 600 ~/.ssh/config

### SSH Config File Structure and Patterns

The SSH Config File takes the following structure:

Host hostname1

SSH\_OPTION value

SSH\_OPTION value

Host hostname2

SSH\_OPTION value

Host \*

SSH\_OPTION value

The contents of the SSH client config file is organized into stanzas (sections). Each stanza starts with the Host directive and contains specific SSH options that are used when establishing a connection with the remote SSH server.

Indentation (use tabs and not spaces) is not required but is recommended since it makes the file easier to read.

The Host directive can contain one pattern or a whitespace-separated list of patterns. Each pattern can contain zero or more non-whitespace character or one of the following pattern specifiers:

\* - Matches zero or more characters.

e.g. Host \* matches all hosts, while 192.168.0.\* matches hosts in the 192.168.0.0/24 subnet.

? - Matches exactly one character.

e.g. The pattern, Host 10.10.0.? matches all hosts in 10.10.0.[0-9] range.

! - When used at the start of a pattern, it negates the match.

e.g. Host 10.10.0.\* !10.10.0.5 matches any host in the 10.10.0.0/24 subnet except 10.10.0.5.

The SSH client reads the configuration file stanza by stanza, and if more than one patterns match, the options from the first matching stanza take precedence. Therefore more host-specific declarations should be given at the beginning of the file, and more general overrides at the end of the file.

You can find a full list of available ssh options by typing “man ssh\_config” in your terminal.

The SSH config file is also read by other programs such as scp, sftp, and rsync.

### SSH Config File Example

Now that we’ve covered the basic of the SSH configuration file, let’s look at the following example.

Typically, when connecting to a remote server via SSH you would specify the remote user name, hostname, and port. For example, to log in as a user named john to a host called dev.example.com on port 2322 from the command line, you would type:

$ ssh john@dev.example.com -p 2322

To connect to the server using the same options as provided in the command above simply by typing ssh dev, put the following lines to your "~/.ssh/config file:

|  |
| --- |
| ~/.ssh/config |
| Host dev  HostName dev.example.com  User john  Port 2322 |

Now when you type ssh dev, the ssh client will read the configuration file and use the connection details that are specified for the dev host:

$ ssh dev

### Shared SSH Config File Example

This example gives more detailed information about the host patterns and option precedence.

Let’s take the following example file:

Host targaryen

HostName 192.168.1.10

User daenerys

Port 7654

IdentityFile ~/.ssh/targaryen.key

Host tyrell

HostName 192.168.10.20

Host martell

HostName 192.168.10.50

Host \*ell

user oberyn

Host \* !martell

LogLevel INFO

Host \*

User root

Compression yes

When you type ssh targaryen, the ssh client reads the file and apply the options from the first match, which is Host targaryen. Then it checks the next stanzas one by one for a matching pattern. The next matching one is Host \* !martell (meaning all hosts except martell), and it will apply the connection option from this stanza. The last definition Host \* also matches, but the ssh client will take only the Compression option because the User option is already defined in the Host targaryen stanza.

The full list of options used when you type ssh targaryen is as follows:

HostName 192.168.1.10

User daenerys

Port 7654

IdentityFile ~/.ssh/targaryen.key

LogLevel INFO

Compression yes

When running ssh tyrell the matching host patterns are:

Host tyrell, Host \*ell, Host \* !martell and Host \*.

The options used in this case are:

HostName 192.168.10.20

User oberyn

LogLevel INFO

Compression yes

If you run ssh martell, the matching host patterns are:

Host martell, Host \*ell and Host \*.

The options used in this case are:

HostName 192.168.10.50

User oberyn

Compression yes

For all other connections, the ssh client will use the options specified in the Host \* !martell and Host \* sections.

### Override SSH Config File Option

The ssh client reads its configuration in the following precedence order:

1. Options specified from the command line
2. Options defined in the ~/.ssh/config
3. Options defined in the /etc/ssh/ssh\_config

If you want to override a single option, you can specify it on the command line. For example, if you have the following definition:

Host dev

HostName dev.example.com

User john

Port 2322

And you want to use all other options but to connect as user root instead of john simply specify the user on the command line:

$ ssh -o "User=root" dev

The -F (configfile) option allows you to specify an alternative per-user configuration file.

To tell the ssh client to ignore all of the options specified in the ssh configuration file, use:

$ ssh -F /dev/null user@example.com

## Screen Command

Have you ever faced the situation where you perform a long-running task on a remote machine, and suddenly your connection drops, the SSH session is terminated, and your work is lost. Well, it has happened to all of us at some point, hasn’t it? Luckily, there is a utility called screen that allows us to resume the sessions.

### Introduction to Screen

Screen or GNU Screen is a terminal multiplexer. In other words, it means that you can start a screen session and then open any number of windows (virtual terminals) inside that session. Processes running in Screen will continue to run when their window is not visible even if you get disconnected.

### Install Linux GNU Screen

The screen package is pre-installed on most Linux distros nowadays. You can check if it is installed on your system by typing:

$ screen --version

Output :

Screen version 4.06.02 (GNU) 23-Oct-17

If you don’t have screen installed on your system, you can easily install it using the package manager of your distro.

**Install Linux Screen on Ubuntu and Debian**

$ sudo apt install screen

### Starting Linux Screen

To start a screen session, simply type screen in your console:

$ screen

This will open a screen session, create a new window, and start a shell in that window.

Now that you have opened a screen session, you can get a list of commands by typing:

Ctrl+a ?

### Starting Named Session

Named sessions are useful when you run multiple screen sessions. To create a named session, run the screen command with the following arguments:

$ screen -S session\_name

It’s always a good idea to choose a descriptive session name.

### Working with Linux Screen Windows

When you start a new screen session, it creates a single window with a shell in it.

You can have multiple windows inside a Screen session.

To create a new window with shell type Ctrl+a c, the first available number from the range 0...9 will be assigned to it.

### Common Screen Commands

Below are some most common commands for managing Linux Screen Windows:

|  |  |  |
| --- | --- | --- |
| Prefix | Option | Remark |
| Ctrl + a | c | Create a new window (with shell) |
| Ctrl + a | “ | List all window |
| Ctrl + a | 0 | Switch to window 0 (by number ) |
| Ctrl + a | A | Rename the current window |
| Ctrl + a | S | Split current region horizontally into two regions |
| Ctrl + a | | | Split current region vertically into two regions |
| Ctrl + a | tab | Switch the input focus to the next region |
| Ctrl + a | Ctrl + a | Toggle between the current and previous region |
| Ctrl + a | Q | Close all regions but the current one |
| Ctrl + a | X | Close the current region |

### Detach from Linux Screen Session

You can detach from the screen session at any time by typing:

$ Ctrl+a d

The program running in the screen session will continue to run after you detach from the session.

### Reattach to a Linux Screen

To resume your screen session use the following command:

$ screen -r

In case you have multiple screen sessions running on your machine, you will need to append the screen session ID after the r switch.

To find the session ID list of the current running screen sessions, type :

$ screen -ls

Output :

There are screens on:

10835.pts-0.linuxize-desktop (Detached)

10366.pts-0.linuxize-desktop (Detached)

If you want to restore screen 10835.pts-0, then type the following command:

$ screen -r 10835

### Customize Linux Screen

When screen is started, it reads its configuration parameters from /etc/screenrc and ~/.screenrc if the file is present. We can modify the default Screen settings according to our preferences using the .screenrc file.

Here is a sample ~/.screenrc configuration with customized status line and few additional options:

|  |
| --- |
| ~/.screenrc |
| # Turn off the welcome message  startup\_message off  # Disable visual bell  vbell off  # Set scrollback buffer to 10000  defscrollback 10000  # Customize the status line  hardstatus alwayslastline  hardstatus string '%{= kG}[ %{G}%H %{g}][%= %{= kw}%?%-Lw%?%{r}(%{W}%n\*%f%t%?(%u)%?%{r})%{w}%?%+Lw%?%?%= %{g}][%{B} %m-%d %{W}%c %{g}]' |

### Basic Linux Screen Usage

Below are the most basic steps for getting started with screen:

* On the command prompt, type “screen”.
* Run the desired program.
* Use the key sequence Ctrl-a + Ctrl-d to detach from the screen session.
* Reattach to the screen session by typing “screen -r”.

## Tmux Command

### What is tmux?

Tmux is a terminal multiplexer an alternative to GNU Screen. In other words, it means that you can start a Tmux session and then open multiple windows inside that session. Each window occupies the entire screen and can be split into rectangular panes.

With Tmux you can easily switch between multiple programs in one terminal, detach them and reattach them to a different terminal.

Tmux sessions are persistent, which means that programs running in Tmux will continue to run even if you get disconnected.

All commands in Tmux start with a prefix, which by default is ctrl+b.

### Installing Tmux

You can easily install Tmux using the package manager of your distro.

**Installing Tmux on Ubuntu and Debian**

$ sudo apt install tmux

**Installing Tmux on macOS**

$ brew install tmux

### Starting Your First Tmux Session

To start your first Tmux session, simply type tmux in your console:

$ tmux

This will open a new session, create a new window, and start a shell in that window.

Once you are in Tmux you’ll notice a status line at the bottom of the screen which shows information about the current session.

You can now run your first Tmux command. For example, to get a list of all commands, you would type:

$ Ctrl+b ?

### Creating Named Tmux Sessions

By default, Tmux sessions are named numerically. Named sessions are useful when you run multiple Tmux sessions. To create a new named session, run the tmux command with the following arguments:

$ tmux new -s session\_name

It’s always a good idea to choose a descriptive session name.

### Detaching from Tmux Session

You can detach from the Tmux session and return to your normal shell by typing:

Ctrl+b d

The program running in the Tmux session will continue to run after you detach from the session.

### Re-attaching to Tmux Session

To attach to a session first, you need to find the name of the session. To get a list of the currently running sessions type:

$ tmux ls

The name of the session is the first column of the output :

0: 1 windows (created Sat Sep 15 09:38:43 2019) [158x35]

my\_named\_session: 1 windows (created Sat Sep 15 10:13:11 2019) [78x35]

As you can see from the output, there are two running Tmux sessions. The first one is named 0 and the second one my\_named\_session.

For example, to attach to session 0, you would type:

$ tmux attach-session -t 0

### Working with Tmux Windows and Panes

When you start a new Tmux session, by default, it creates a single window with a shell in it. To create a new window with shell type Ctrl+b c, the first available number from the range 0...9 will be assigned to it.

A list of all windows is shown on the status line at the bottom of the screen.

Below are some most common commands for managing Tmux windows and panes:

|  |  |  |
| --- | --- | --- |
| Prefix | Option | Remark |
| Ctrl + b | c | Create a new window (with shell) |
| Ctrl + b | w | Choose window from a list |
| Ctrl + b | 0 | Switch to window 0 (by number ) |
| Ctrl + b | , | Rename the current window |
| Ctrl + b | % | Split current pane horizontally into two panes |
| Ctrl + b | “ | Split current pane vertically into two panes |
| Ctrl + b | o | Go to the next pane |
| Ctrl + b | ; | Toggle between the current and previous pane |
| Ctrl + b | x | Close the current pane |

### Customizing Tmux

When Tmux is started, it reads its configuration parameters from ~/.tmux.conf if the file is present.

Here is a sample ~/.tmux.conf configuration with customized status line and few additional options:

|  |
| --- |
| ~/.tmux.conf |
| # Improve colors  set -g default-terminal 'screen-256color'  # Set scrollback buffer to 10000  set -g history-limit 10000  # Customize the status line  set -g status-fg green  set -g status-bg black |

### Basic Tmux Usage

Below are the most basic steps for getting started with Tmux:

1. On the command prompt, type “tmux new -s my\_session”.
2. Run the desired program.
3. Use the key sequence Ctrl-b + d to detach from the session.
4. Reattach to the Tmux session by typing “tmux attach-session -t my\_session”.

There’s lots more to learn about Tmux at Tmux User’s Manual page.

<https://man.openbsd.org/OpenBSD-current/man1/tmux.1>

# IoT & Raspberry Pi

This section contains IoT based fun (and serious) projects. The projects described below touch upon all the major aspects used by hobbyist, engineers, scientists, hackers in the past and till date. Knowledge of these Hardware & Software components

## 1) Remote Temperature Monitor using ESP8266 MCU Node & RPi

[ <https://openhomeautomation.net/connect-esp8266-raspberry-pi> ]

Have you ever dreamt of controlling your home’s cooling/heating equipment, just to make that perfect ambience by the time you reach your home? All this and more, without you clicking a single button.

Monitoring the temperature of your home remotely, and that too without your intervention could be a bliss, not to forget the optimized communication between various IoT enabled devices, that help minimize your electricity bills.

Following pages will take you through a step by step procedure of setting up the various IoT devices involved and getting them to interact.

### Summary

We will connect a Temperature sensor (Dallas DS18B20) to an ESP8266 board and access the data via Wi-Fi. However, here, we are going to grab that data from a Raspberry Pi and make RPi display the data on a simple graphical interface.

To do so, we will run a simple web server on the ESP8266 chip. The Raspberry Pi will then access this data via Wi-Fi and display it graphically. The wonderful thing is that you can make the Raspberry Pi the ‘hub’ of your home, with several ESP8266-based devices connected to it.

### Hardware Requirements

1. Temperature Sensor (Dallas DS18B20)
2. ESP8266 chip (which makes Temperature sensor IoT enabled)
3. Raspberry Pi board
4. Bread board (Optional)
5. Jumper wires

### Software Requirements

1. Arduino IDE (Latest version)

[ <https://www.arduino.cc/en/Main/Software> ]

1. Raspbian operating system installed on RPi board
2. Dallas Temperature library

You can install it from the Arduino library manager, that you can access from **Sketch > Include Library > Manage Libraries** inside the Arduino IDE…Search for “**DALLAS**” & “**OneWire**”

1. Node.js on RPi (refer to section – “Installing node.js on Raspberry Pi” for more details)

### Hardware Configuration

Once Software installation is complete, we can now go ahead with connecting ESP8266 with Temperature sensor. (Refer to Temperature Sensor Datasheet for correct pin configurations - Dallas DS18B20 – used in this instance).

|  |  |
| --- | --- |
| ESP8266 MCU Node | Dallas DS18B20 Breakout Board |
|  | |

=== Dallas Temperature Sensor Datasheet ===

<https://github.com/softwaresunleashed/rpi_iot_kernel/blob/devel/documents/Datasheets/TemperatureSensor/Dallas/DS18B20.pdf>

===

=== LoLin ESP8266 Wi-Fi Board Setup ===

Refer to Datasheet – Chapter THREE for setting up LoLin ESP8266 Wi-Fi module (used by author for this project) in Arduino IDE. In case you are using any other ESP8266 module in your project, you can skip this section and can refer to the corresponding datasheet.

<https://github.com/softwaresunleashed/rpi_iot_kernel/blob/devel/documents/Datasheets/ESP8266/esp8266-V10.pdf>

OR

Refer to section – “**Installing LoLin ESP8266 Board Configs in Arduino IDE**” in this book.

===

|  |  |
| --- | --- |
| **ESP8266 Chip** | **Temperature Sensor** |
| 3.3V | Vcc pin (Right) |
| GND | GND (Left) |
| GPIO5 (D1) | Data Out pin (Middle) |

Make sure that you connected everything according to the instructions above, or you won’t be able to continue.

### Testing the Sensor – Dallas DS18B20

We will now test the sensor. Again, remember that we are using the Arduino IDE, so we can code just like we would do using an Arduino board. Here, we will simply print the value of the temperature inside the Serial monitor of the Arduino IDE.

Remember to Install “**DALLAS**” Temperature Library & “**OneWire**” Library (if not already done). Refer to snapshot below.

**Dallas Library**



**One Wire**



**Complete code for this part:**

// Code for testing Temperature Sensor over Serial Port

#include <OneWire.h>

#include <DallasTemperature.h>

// Data wire is plugged into pin 2 on the ESP8266 MCU Node

// ‘5’ refers to GPIO05 which is pin 2(refer to ESP8266 pinout

// snapshot above

#define ONE\_WIRE\_BUS 5

// Setup a oneWire instance to communicate with any OneWire

// devices (not just lcMaxim/Dallas temperature ICs)

OneWire oneWire(ONE\_WIRE\_BUS);

// Pass our oneWire reference to Dallas Temperature.

DallasTemperature sensors(&oneWire);

void setup(void)

{

// start serial port

Serial.begin(115200);

Serial.println("Dallas Temperature IC Control Library Demo");

// Start up the library

sensors.begin();

}

void loop(void)

{

// call sensors.requestTemperatures() to issue a global temperature

// request to all devices on the bus

Serial.print(" Requesting temperatures...");

// Send the command to get temperatures

sensors.requestTemperatures();

Serial.println("DONE");

Serial.print("Temperature for Device 1 is: ");

Serial.print(sensors.getTempCByIndex(0));

// You can have more than one IC on the same bus.

// 0 refers to the first IC on the wire

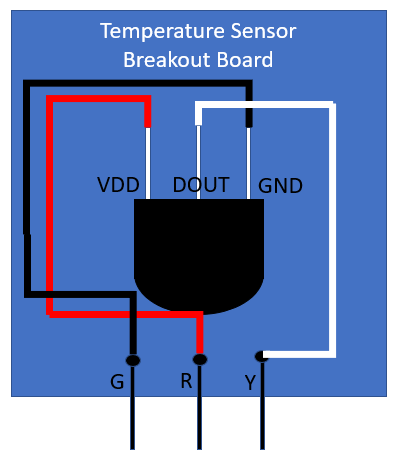
delay(2000);

}

You can see that all the measurement part is contained inside the loop() function, which makes the code inside it repeats every 2 seconds. Then, we read data from the Dallas DS18B20 sensor, print the value of the temperature on the Serial port.

**Trouble Shoot**

If you are not getting some valid (Deg Celsius) temperature, refer to Troubleshooting section – “Temperature sensor reporting invalid or constant temperature”. Refer to block diagram below for Temperature Sensor IC to Header mapping.



There are few temperature sensor breakout boards available in the market, like the one used in IoT projects section.

Here the mapping between Temp IC and Headers may not be straight forward. You must ensure the IC pins to external header’s mapping using “Continuity” feature on any standard multimeter.

If “Continuity” feature isn’t available on your multimeter, you can check for resistance between IC pins and header pins. The two pins that are connected shall show minimal (close to Zero) resistance.

### Accessing the Sensor via Wi-Fi

At this point, we are sure that the sensor is working, and that data can be read by the ESP8266 chip. Now, we are going to build the sketch that will connect to your Wi-Fi network, and then make the measurements accessible by the Raspberry Pi.

As this sketch is quite long, I will only detail the most important parts here. Complete code can be found on GIT repo or end of this section.

It starts by including the required libraries for this project:

**#include <ESP8266WiFi.h>**

**#include <ESP8266WebServer.h>**

**#include <aREST.h>**

**#include <OneWire.h>**

**#include <DallasTemperature.h>**

Then, you need to set up your own Wi-Fi network name & password in the code:

**const** **char**\* ssid = "your\_wifi\_network\_name";

**const** **char**\* password = "your\_wifi\_network\_password";

We also declare the aREST API, that will help us control the board remotely from the Raspberry Pi:

aREST rest = aREST();

Now, we also declare one variable that will contain the measurements made by the sensor:

**int** temperature;

After that, we create a web server on port 80:

WiFiServer **server**(80);

Then, inside the setup() function of the sketch, we connect the ESP8266 to the Wi-Fi network:

WiFi.begin(ssid, password);

**while** (WiFi.status() != WL\_CONNECTED) {

delay(500);

Serial.print(".");

}

Serial.println("");

Serial.println("WiFi connected");

Then, we expose the two measurement variables to the aREST API, so they can be access from the outside:

rest.variable("temperature", &temperature);

After that, we set the name & ID of the board:

rest.set\_id("1");

rest.set\_name("sensor\_module");

Then, we start the server, and print the IP address on the Serial port:

*// Start the server*

server.begin();

Serial.println("Server started");

*// Print the IP address*

Serial.println(WiFi.localIP());

Inside the loop() function of the sketch, we check if a client is connected to the ESP8266, and handle the request:

WiFiClient client = server.available();

**if** (!client) {

return;

}

**while**(!client.available()){

delay(1);

}

rest.handle(client);

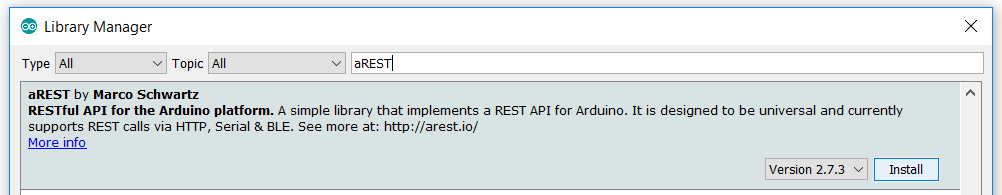
Then, we read data from the sensor:

// Send the command to get temperatures

temperature = sensors.getTempCByIndex(0);

Follow the instructions we saw in the previous section to upload the code to the board. Then, open the Serial monitor to get the IP address of the board, you will need it soon.

You would need to install “aREST” library to compile the code shown in next section.



**Complete code for this part:**

// Code for testing Temperature Sensor over Web Interface

#include <ESP8266WiFi.h>

#include <ESP8266WebServer.h>

#include <aREST.h>

#include <OneWire.h>

#include <DallasTemperature.h>

//------------------------------------------

//WIFI

const char\* ssid = "your\_wifi\_network\_name";

const char\* password = "your\_wifi\_network\_password";

aREST rest = aREST();

int temperature;

//------------------------------------------

//HTTP

// The port to listen for incoming TCP connections

#define LISTEN\_PORT 80

// Create an instance of the server

WiFiServer server(LISTEN\_PORT);

// Data wire is plugged into pin 2 on the ESP8266 MCU Node

// ‘5’ refers to GPIO05 which is pin 2(refer to ESP8266 pinout)

#define ONE\_WIRE\_BUS 5

// Setup a oneWire instance to communicate with any OneWire devices

// (not just lcMaxim/Dallas temperature ICs)

OneWire oneWire(ONE\_WIRE\_BUS);

// Pass our oneWire reference to Dallas Temperature.

DallasTemperature sensors(&oneWire);

void setup(void)

{

// start serial port

Serial.begin(115200);

Serial.println("Dallas Temperature IC Control Library Demo");

Serial.println("");

// trigger wi-fi connection

WiFi.begin(ssid, password);

// wait for Wi-Fi connection to complete.

Serial.print("Connecting to SSID -- " + ssid);

while (WiFi.status() != WL\_CONNECTED) {

delay(500);

Serial.print(".");

}

Serial.println("");

Serial.println("Wi-Fi connected");

// expose the two-measurement variable(temperature) to the aREST API

// so, they can be accessed from outside

rest.variable("temperature",&temperature);

// set the name & ID of the board:

rest.set\_id("1");

rest.set\_name("sensor\_module");

// Start the server

server.begin();

Serial.println("Server started");

// Print the IP address

Serial.println(WiFi.localIP());

// Start up the temperature sensor library

sensors.begin();

}

void loop(void)

{

// call sensors.requestTemperatures() to issue a global temperature

// request to all devices on the bus

sensors.requestTemperatures();

// Send the command to get temperatures

temperature = sensors.getTempCByIndex(0);

// check if a client is connected to the ESP8266, and handle the request

WiFiClient client = server.available();

if (!client) {

return;

}

while(!client.available()){

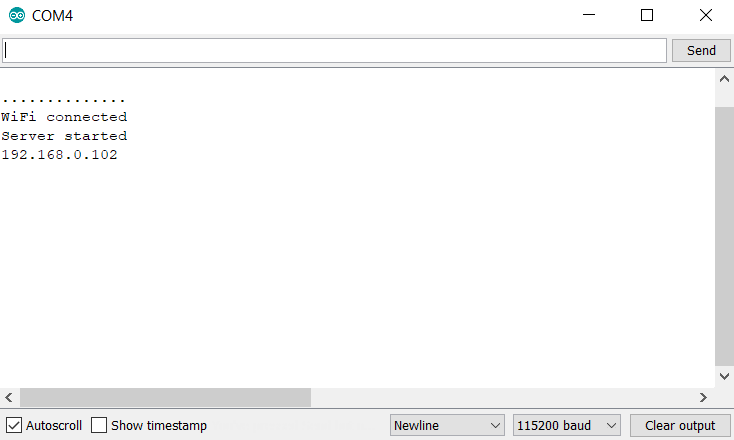
delay(1);

}

rest.handle(client);

}

**Snapshot of Server Listening for Temperature Requests from Clients**



### Connecting the Board to Your Raspberry Pi over Air Interface

We shall now see how to connect the ESP8266 board to your Raspberry Pi, so it can display the data in a nice graphical interface.

Download and place all the files into a folder on your Pi,

$ mkdir -p iot\_projects/remote\_temp\_monitor

$ cd iot\_projects/remote\_temp\_monitor/

$ wget <https://github.com/softwaresunleashed/rpi_iot_kernel/raw/devel/iot_projects_src_code/01_iot_based_temp_monitor/RPI/web_interface.tar.gz>

After you have downloaded the above compressed archive from Git Repo, navigate to this folder with a terminal, and type:

$ sudo npm install express jade arest

**Troubleshoot:**

If “npm” package isn’t installed on RPi, then you will get following error message.

sudo: npm: command not found

This error can be fixed by installing NPM package on RPi by executing following command on RPi shell

$ sudo apt-get update

$ sudo apt-get dist-upgrade

$ sudo apt-get install npm

**Be patient, these steps can take a while**. After that, type:

$ sudo node app.js

This will start the application on your Raspberry Pi. Then, navigate to the URL of your Raspberry Pi on port 3000, for example:

http://192.168.0.100:3000

You should immediately see the interface showing the temperature readings made by the ESP8266 board:

<Add Image of Web server running on Raspberry Pi showing Temperature - HERE>

The only thing that you need to change to run this interface is the IP address of your ESP8266 board inside the app.js file:

// Replace 192.168.0.100 with IP address of ESP8266 board

rest.addDevice('http','192.168.0.100');

## 2) RaspberryPi and NXP PN7150 NFC Controller

### Brief Introduction to RFID & NFC

[ <https://blog.atlasrfidstore.com/rfid-vs-nfc> ]

If you follow developments in the tech industry on a semi-regular basis, you’re likely familiar with the terms near-field communication (NFC) and radio frequency identification (RFID). Recently, you may have seen RFID in the news, or you may have been told that your cell phone is an NFC device. In any case, this article will answer a few questions you may have about RFID and NFC.

### Differences between NFC and RFID

**Short Answer:** RFID is the process by which items are uniquely identified using radio waves, and NFC is a specialized subset within the family of RFID technology. Specifically, NFC is a branch of High-Frequency (HF) RFID, and both operate at the 13.56 MHz frequency. NFC is designed to be a secure form of data exchange, and an NFC device is capable of being both an NFC reader and an [NFC tag](http://www.atlasrfidstore.com/near-field-communication/). This unique feature allows NFC devices to communicate peer-to-peer.

**Long Answer:** By definition, RFID is the method of uniquely identifying items using radio waves. At a minimum, an RFID system comprises [a tag](http://www.atlasrfidstore.com/rfid-tags/), [a reader](http://www.atlasrfidstore.com/rfid-readers/), and [an antenna](http://www.atlasrfidstore.com/rfid-antennas/). The reader sends an interrogating signal to the tag via the antenna, and the tag responds with its unique information. RFID tags are either[Active or Passive](http://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid).

Active RFID tags contain their own power source giving them the ability to broadcast with a read range of up to 100 meters. Their long read range makes active RFID tags ideal for many industries where asset location and other improvements in logistics are important.

[Passive RFID tags](http://www.atlasrfidstore.com/rfid-tags/) do not have their own power source. Instead, they are powered by the electromagnetic energy transmitted from the RFID reader. Because the radio waves must be strong enough to power the tags, passive RFID tags have a read range from near contact and up to 25 meters.

Passive RFID tags primarily operate at three frequency ranges:

* Low Frequency (LF) 125 -134 kHz
* High Frequency (HF)13.56 MHz
* Ultra-High Frequency (UHF) 856 MHz to 960 MHz

Near-field communication devices operate at the same frequency (13.56 MHz) as HF RFID readers and tags. The standards and protocols of the NFC format is based on RFID standards outlined in ISO/IEC 14443, FeliCa, and the basis for parts of ISO/IEC 18092. These standards deal with the use of RFID in proximity cards.

As a finely-honed version of HF RFID, near-field communication devices have taken advantage of the short-read range limitations of its radio frequency. Because NFC devices must be in close proximity to each other, usually no more than a few centimetres, it has become a popular choice for secure communication between consumer devices such as smartphones.

Peer-to-peer communication is a feature that sets NFC apart from typical RFID devices. An NFC device is able to act both as a reader and as a tag. This unique ability has made NFC a popular choice for contactless payment, a key driver in the decision by influential players in the mobile industry to include NFC in newer smartphones. Also, NFC smartphones pass along information from one smartphone to the other by [tapping the two devices together](http://blog.atlasrfidstore.com/how-to-use-nfc-tags-in-marketing), which turns sharing data such as contact info or photographs into a simple task. Recently, you may have seen advertising campaigns that used [smart posters](http://blog.atlasrfidstore.com/nfc-smart-posters) to pass information along to the consumers.

Also, NFC devices can read passive NFC tags, and some NFC devices are able to read passive HF RFID tags that are compliant with ISO 15693. The data on these tags can contain commands for the device such as opening a specific mobile application. You may start seeing HF RFID tags and NFC tags more frequently in advertisements, posters, and signs as it’s an efficient method to pass along information to consumers.

At the end of the day, NFC builds upon the standards of HF RFID and turns the limitations of its operating frequency into a unique feature of near-field communication.

### PN7150 NXP NFC Controller - General Description

PN7150 datasheet could be found at the following location - <https://github.com/softwaresunleashed/rpi_iot_kernel/raw/devel/documents/Datasheets/NFC/NXP_PN7150/PN7150.pdf>

Best plug n play and high-performance full NFC solution. PN7150 is a full NFC controller solution with integrated firmware and NCI interface designed for contactless communication at 13.56 MHz It is compatible with NFC forum requirements.

PN7150 is designed based on learnings from previous NXP NFC device generation. It is the ideal solution for rapidly integrating NFC technology in any application, especially those running O/S environment like Linux and Android, reducing Bill of Material (BOM) size and cost, thanks to:

• Full NFC forum compliancy with small form factor antenna

• Embedded NFC firmware providing all NFC protocols as pre-integrated

feature

• Direct connection to the main host or microcontroller, by I2C-bus

physical and NCI protocol.

• Ultra-low power consumption in polling loop mode.

• Highly efficient integrated power management unit (PMU) allowing

direct supply from a battery.

### Installation instructions

The following instructions assume the driver being installed under the drivers/misc kernel source sub-folder. Below instructions may have to be adapted accordingly in case another path is chosen for the driver installation.

### Getting the drivers

Clone the nxp-pn5xx repository into the kernel directory:

$ cd drivers/misc

$ git clone https://github.com/NXPNFCLinux/nxp-pn5xx.git

This will create the sub-folder nxp-pn5xx containing the following files:

• pn5xx\_i2c.c: driver implementation

• pn5xx\_i2c.h: driver interface definition

• README.md: repository comments

• Makefile: driver related makefile

• Kconfig: driver related config file

• LICENSE: driver licensing terms

• sample\_devicetree.txt: example of device tree definition

### Including the driver to the kernel

Include the driver to the compilation by adding below line to the heading makefile (drivers/misc/Makefile).

obj-y += nxp-pn5xx/

Include the driver config by adding below line to the heading configuration file (drivers/misc/Kconfig).

source "drivers/misc/nxp-pn5xx/Kconfig"

### Creating the device node

Two methods are supported for the creation of the /dev/pn544 device node: device tree and platform data. Any of the two methods can be used, but of course the I2C address (0x28 in the below examples) and GPIO assignments must be adapted to the hardware integration in the platform.

#### Device tree

Below is an example of definition to be added to the platform device tree file (.dts file located for instance under arch/arm/boot/dts kernel sub-folder for ARM based platform). For ARM64 based platform the dts files to be modified could be found in arch/arm64/boot/dts kernel sub-folder.

&i2c{

status = "okay";

pn547: pn547@28 {

compatible = "nxp,pn547";

reg = <0x28>;

clock-frequency = <400000>;

interrupt-gpios = <&gpio2 17 0>;

enable-gpios = <&gpio4 21 0>;

};

};

#### Platform data

Below is an example of definition to be added to the platform definition file. The structure pn544\_i2c\_platform\_data being defined in the driver interface header file, pn5xx\_i2c.h must be included in the platform definition file, and pn5xx\_i2c.h file must be copied to include/linux kernel source sub-folder.

static struct pn544\_i2c\_platform\_data nfc\_pdata = {

.irq\_gpio = GPIO\_TO\_PIN(1,29),

.ven\_gpio = GPIO\_TO\_PIN(0,30),

.firm\_gpio = GPIO\_UNUSED

.clkreq\_gpio = GPIO\_UNUSED

};

static struct i2c\_board\_info \_\_initdata nfc\_board\_info[] = {

{

I2C\_BOARD\_INFO("pn547", 0x28),

.platform\_data = &nfc\_pdata,

},

};

Then the declared nfc\_board\_info structure must be added to the platform using dedicated procedure (platform specific).

### Building the driver

Through menuconfig procedure include the driver to the build, as built-in (<\*>) or modularizes features (<M>):

Device Drivers --->

Misc devices --->

< > NXP PN5XX based driver

If <M> option is selected, build the driver and install the generated pn5xx\_i2c.ko module. Otherwise if built-in, build the complete kernel, the driver will be included in the kernel.

If the device tree method was used in previous step, build the platform related device tree and install generated dtb file.

## 3) Controlling Raspberry Pi LED from cloud

[ <https://arest.io/control-raspberry-pi-anywhere-arest> ]

### Summary

The Raspberry Pi is an amazing board that can be used for a wide range of applications, from being used as the hub of a home automation system to be controlling a mobile robot. It’s also a great board to build Internet of Things (IoT) projects, as it easy to connect to the Internet & can be interfaced with a lot of other components.

However, it can sometimes be intimidating to configure your Raspberry Pi and then connect it to an Internet of Things platform. In this project, we are going to see how to use the aREST framework on the Raspberry Pi, so you can easily control your board from anywhere in the world. Let’s start!

### Hardware Requirements

1. Raspberry Pi board
2. 5mm LED
3. 220 Ohm Resistor
4. Breadboard
5. Jumper wires

|  |  |
| --- | --- |
| Raspberry Pi (Any Model) |  |

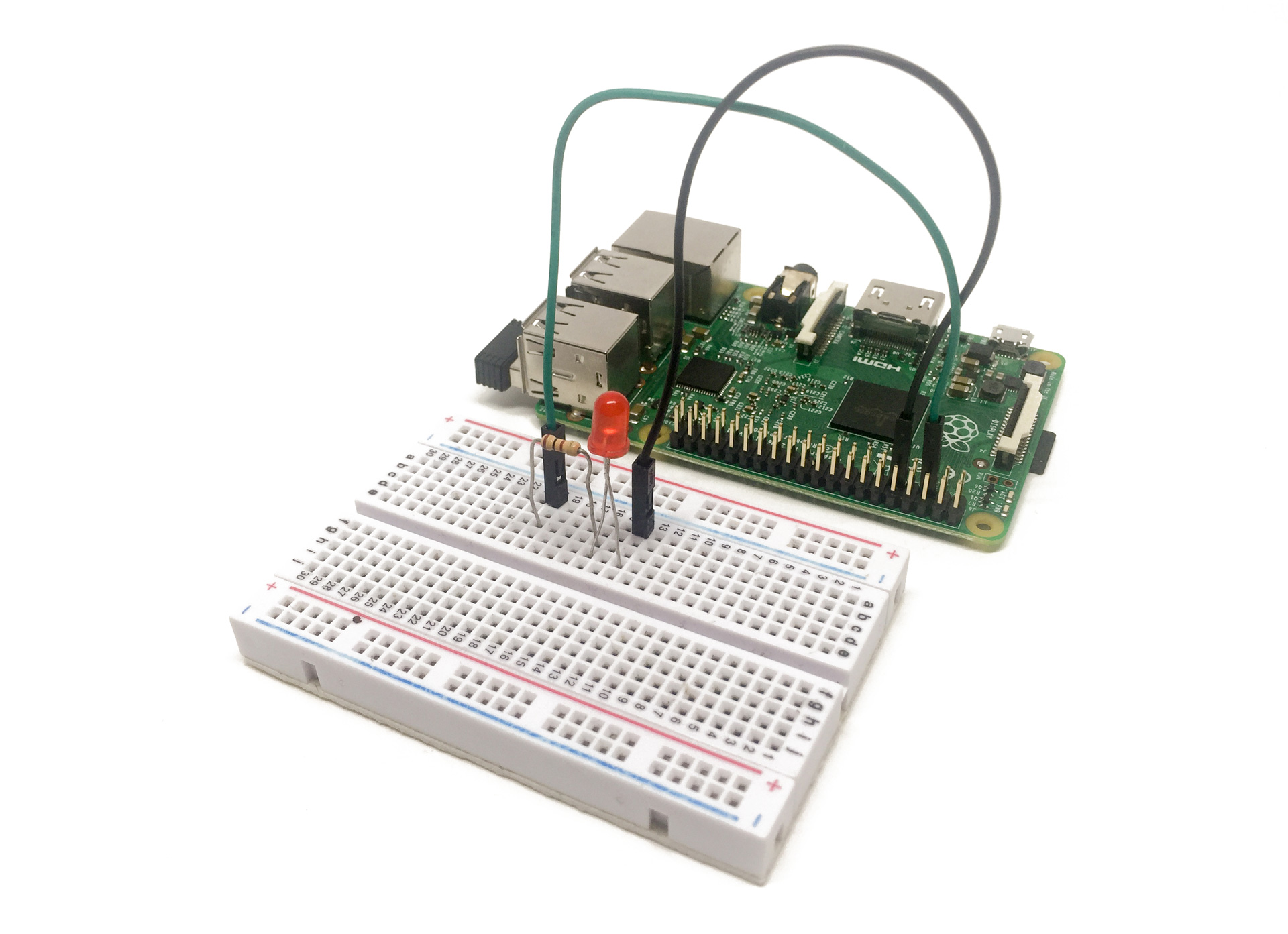
### Software Requirements

1. Node.js installed on RPi board (refer to section – “Installing node.js on Raspberry Pi” for more details)

### Hardware Configuration

Let’s now see how to configure the project. As we’ll only connect an LED to the Pi, it will be quite simple. First, place the LED in series with the resistor on the breadboard, with the longest pin of the LED connected to the resistor. Then, connect the other end of the resistor to GPIO3 of the Pi (pin 5), and the other end of the LED to one Ground pin of the Pi. Refer to RPi GPIO pinout in section - GPIO Pinout on Raspberry Pi.

This is the final result:



Once this is done, make sure your Raspberry Pi is also connected to the Internet, via Wi-Fi or Ethernet.

### Connecting Your Raspberry Pi to the aREST Cloud

We are now going to configure the Raspberry Pi so it connects to the aREST cloud server, that will allow you to control it from anywhere in the world. This is the complete code for this project:

*// cloud.js*

*// Code for controlling LED connected to RPi board via Cloud*

**var** express = require('express');

**var** app = express();

**var** piREST = require('pi-arest')(app);

piREST.set\_id('rpi\_led');

piREST.set\_name('pi\_cloud');

piREST.set\_mode('bcm');

*// Connect to cloud.aREST.io*

piREST.connect();

*// Start server*

**var** server = app.listen(80, **function**() {

console.log('Listening on port %d',server.address().port);

});

Or download it from - <https://github.com/softwaresunleashed/rpi_iot_kernel/blob/devel/iot_projects_src_code/03_control_rpi_led_from_cloud/cloud.js>

Make sure to modify the ID of the board in the set\_id() function: this is what will identify the board on the server. Then, place the code inside a file called cloud.js on your Raspberry Pi.

Inside the same folder, type the following command inside a terminal:

$ sudo npm install pi-arest express

This will install the required modules for the project. Then, start the software with:

$ sudo node cloud.js

You Raspberry Pi should then be connected to the aREST cloud server.

## 4) Raspberry Pi talking to ESP8266 using MQTT protocol

[ <https://www.hackster.io/ruchir1674/raspberry-pi-talking-to-esp8266-using-mqtt-ed9037> ]

## 5) Home Automation - IoT meets Alexa

[ <https://www.hackster.io/mjrobot/when-iot-meets-ai-home-automation-with-alexa-and-nodemcu-56e5cd#_=_> ]

## 6) Nokia LCD Interfacing with RPi ( cpushow )

[ <https://learn.adafruit.com/nokia-5110-3310-lcd-python-library/overview> ]

[ <https://www.raspberrypi.org/forums/viewtopic.php?t=191554> ]

### Summary

We will be using **wiringPi** library in this project, to display current system usage (Uptime, CPU load, RAM, Processes running).

|  |  |
| --- | --- |
|  |  |
|  | |

### Hardware Requirements

1. Raspberry Pi board
2. Nokia 5110 LCD daughter board

[ <https://robu.in/product/mini-1-6-inch-rpi-pcd8544-shield-v3-0-cpu-info-pixel-matrix-lcd-with-backlight-for-raspberry-pi-3-84x48-resolution/> ]

### Software Requirements

1. Raspbian operating system installed on RPi board
2. Install GIT
3. Install other software libraries as described below
   * wiringPi library
   * cpushow source

### Hardware Configuration

Nokia 5110 LCD (PCD8544 controller) vs RPi GPIO connections

|  |  |  |
| --- | --- | --- |
| **PCD8544 LCD** | **🡨🡪** | **RPi Pin – GPIO #** |
| LCD2 – VCC |  | P01 - 3.3V |
| LCD3 - CLK |  | P11 - GPIO0 |
| LCD4 – Din |  | P12 - GPIO1 |
| LCD5 - D/C |  | P13 - GPIO2 |
| LCD6 - CS |  | P15 - GPIO3 |
| LCD7 - RST |  | P16 - GPIO4 |
| LCD8 - LED |  | P01 - 3.3V |

// Pin Setup (LCD pins to RPi GPIO pins mapping)

int \_din = 1; // GPIO1

int \_sclk = 0; // GPIO0

int \_dc = 2; // GPIO2

int \_rst = 4; // GPIO4

int \_cs = 3; // GPIO3

### Setting up the environment

Following steps needs to be executed once on

1. Enable SPI drivers using **raspi-config** utility.
2. Ensure that SPI drivers are enabled and loaded, as follows

pi@raspberrypi: ~ $ **lsmod | grep spi**

spidev 7188 0

spi\_bcm2835 7489 0

### Software Interface LCD to RPI

1. Get wiringPi library source code

$ cd ~

$ git clone git://git.drogon.net/wiringPi

$ cd wiringPi

1. Build wiringPi library

$ ./build

1. Create a working directory

$ cd ~

$ git clone https://github.com/paradigmic/cpushow.git

$ cd cpushow

*pi@raspberrypi:~/iot\_projects/cpushow $ ls -al*

*total 52*

*drwxr-xr-x 3 pi pi 4096 Oct 14 02:44 .*

*drwxr-xr-x 7 pi pi 4096 Oct 13 15:40 ..*

*drwxr-xr-x 8 pi pi 4096 Oct 13 15:40 .git*

*-rw-r--r-- 1 pi pi 12 Oct 13 15:40 .gitignore*

*-rw-r--r-- 1 pi pi 237 Oct 13 15:40 Makefile*

*-rw-r--r-- 1 pi pi 23568 Oct 13 15:40 PCD8544.c*

*-rw-r--r-- 1 pi pi 3101 Oct 13 15:40 PCD8544.h*

*-rw-r--r-- 1 pi pi 3718 Oct 13 15:51 pcd8544\_rpi.c*

1. Compile C code linking wiringPi library (Source Code shared below for reference)

$ cc -o cpushow pcd8544\_rpi.c PCD8544.c -L/usr/locallib -lwiringPi

1. Execute the CPU Show program to display CPU parameters via following command.

$ sudo ./cpushow

### Source Code

*// Makefile*

*//*

*cpushow: PCD8544.o pcd8544\_rpi.o*

*gcc -o cpushow PCD8544.o pcd8544\_rpi.o -L/usr/local/lib -lwiringPi*

*PCD8544.o: PCD8544.c PCD8544.h*

*gcc -c PCD8544.c*

*pcd8544\_rpi.o: pcd8544\_rpi.c PCD8544.h*

*gcc -c pcd8544\_rpi.c*

*clean:*

*rm \*.o cpushow*

*// PCD8544.h*

*//*

*/\**

*=================================================================================*

*Name : PCD8544.h*

*Version : 0.1*

*Copyright (C) 2010 Limor Fried, Adafruit Industries*

*CORTEX-M3 version by Le Dang Dung, 2011 LeeDangDung@gmail.com (tested on LPC1769)*

*Raspberry Pi version by Andre Wussow, 2012, desk@binerry.de*

*Description : PCD8544 LCD library!*

*================================================================================*

*This library is free software; you can redistribute it and/or*

*modify it under the terms of the GNU Lesser General Public*

*License as published by the Free Software Foundation; either*

*version 2.1 of the License, or (at your option) any later version.*

*This library is distributed in the hope that it will be useful,*

*but WITHOUT ANY WARRANTY; without even the implied warranty of*

*MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU*

*Lesser General Public License for more details.*

*================================================================================*

*\*/*

*#include <stdint.h>*

*#define BLACK 1*

*#define WHITE 0*

*#define LCDWIDTH 84*

*#define LCDHEIGHT 48*

*#define PCD8544\_POWERDOWN 0x04*

*#define PCD8544\_ENTRYMODE 0x02*

*#define PCD8544\_EXTENDEDINSTRUCTION 0x01*

*#define PCD8544\_DISPLAYBLANK 0x0*

*#define PCD8544\_DISPLAYNORMAL 0x4*

*#define PCD8544\_DISPLAYALLON 0x1*

*#define PCD8544\_DISPLAYINVERTED 0x5*

*// H = 0*

*#define PCD8544\_FUNCTIONSET 0x20*

*#define PCD8544\_DISPLAYCONTROL 0x08*

*#define PCD8544\_SETYADDR 0x40*

*#define PCD8544\_SETXADDR 0x80*

*// H = 1*

*#define PCD8544\_SETTEMP 0x04*

*#define PCD8544\_SETBIAS 0x10*

*#define PCD8544\_SETVOP 0x80*

*#define swap(a, b) { uint8\_t t = a; a = b; b = t; }*

*// calibrate clock constants*

*#define CLKCONST\_1 8000*

*#define CLKCONST\_2 400 // 400 is a good tested value for Raspberry Pi*

*// keywords*

*#define LSBFIRST 0*

*#define MSBFIRST 1*

*void LCDInit(uint8\_t SCLK, uint8\_t DIN, uint8\_t DC, uint8\_t*

*CS, uint8\_t RST, uint8\_t contrast);*

*void LCDcommand(uint8\_t c);*

*void LCDdata(uint8\_t c);*

*void LCDsetContrast(uint8\_t val);*

*void LCDclear();*

*void LCDdisplay();*

*void LCDsetPixel(uint8\_t x, uint8\_t y, uint8\_t color);*

*uint8\_t LCDgetPixel(uint8\_t x, uint8\_t y);*

*void LCDfillcircle(uint8\_t x0, uint8\_t y0, uint8\_t r,uint8\_t*

*color);*

*void LCDdrawcircle(uint8\_t x0, uint8\_t y0, uint8\_t r,uint8\_t*

*color);*

*void LCDdrawrect(uint8\_t x, uint8\_t y, uint8\_t w, uint8\_t*

*h,uint8\_t color);*

*void LCDfillrect(uint8\_t x, uint8\_t y, uint8\_t w, uint8\_t*

*h,uint8\_t color);*

*void LCDdrawline(uint8\_t x0, uint8\_t y0, uint8\_t x1, uint8\_t*

*y1, uint8\_t color);*

*void LCDsetCursor(uint8\_t x, uint8\_t y);*

*void LCDsetTextSize(uint8\_t s);*

*void LCDsetTextColor(uint8\_t c);*

*void LCDwrite(uint8\_t c);*

*void LCDshowLogo();*

*void LCDdrawchar(uint8\_t x, uint8\_t line, char c);*

*void LCDdrawstring(uint8\_t x, uint8\_t line, char \*c);*

*void LCDdrawstring\_P(uint8\_t x, uint8\_t line, const char \*c);*

*void LCDdrawbitmap(uint8\_t x, uint8\_t y, const uint8\_t*

*\*bitmap, uint8\_t w, uint8\_t h, uint8\_t color);*

*void LCDspiwrite(uint8\_t c);*

*void shiftOut(uint8\_t dataPin, uint8\_t clockPin, uint8\_t*

*bitOrder, uint8\_t val);*

*void \_delay\_ms(uint32\_t t);*

*// PCD8544.c*

*//*

*/\**

*=================================================================================*

*Name : PCD8544.c*

*Version : 0.1*

*Copyright (C) 2010 Limor Fried, Adafruit Industries*

*CORTEX-M3 version by Le Dang Dung, 2011 LeeDangDung@gmail.com (tested on LPC1769)*

*Raspberry Pi version by Andre Wussow, 2012, desk@binerry.de*

*Description :*

*A simple PCD8544 LCD (Nokia3310/5110) driver. Target board is Raspberry Pi.*

*This driver uses 5 GPIOs on target board with a bit-bang SPI implementation*

*(hence, may not be as fast).*

*Makes use of WiringPI-library of Gordon Henderson (https://projects.drogon.net/raspberry-pi/wiringpi/)*

*Recommended connection (http://www.raspberrypi.org/archives/384):*

*LCD pins Raspberry Pi*

*LCD1 - GND P06 - GND*

*LCD2 - VCC P01 - 3.3V*

*LCD3 - CLK P11 - GPIO0*

*LCD4 - Din P12 - GPIO1*

*LCD5 - D/C P13 - GPIO2*

*LCD6 - CS P15 - GPIO3*

*LCD7 - RST P16 - GPIO4*

*LCD8 - LED P01 - 3.3V*

*References :*

*http://www.arduino.cc/playground/Code/PCD8544*

*http://ladyada.net/products/nokia5110/*

*http://code.google.com/p/meshphone/*

*================================================================================*

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*================================================================================*

*\*/*

*#include <wiringPi.h>*

*#include "PCD8544.h"*

*// An abs() :)*

*#define abs(a) (((a) < 0) ? -(a) : (a))*

*// bit set*

*#define \_BV(bit) (0x1 << (bit))*

*// LCD port variables*

*static uint8\_t cursor\_x, cursor\_y, textsize, textcolor;*

*static int8\_t \_din, \_sclk, \_dc, \_rst, \_cs;*

*// font bitmap*

*static unsigned char font[] = {*

*0x00, 0x00, 0x00, 0x00, 0x00,*

*0x3E, 0x5B, 0x4F, 0x5B, 0x3E,*

*0x3E, 0x6B, 0x4F, 0x6B, 0x3E,*

*0x1C, 0x3E, 0x7C, 0x3E, 0x1C,*

*0x18, 0x3C, 0x7E, 0x3C, 0x18,*

*0x1C, 0x57, 0x7D, 0x57, 0x1C,*

*0x1C, 0x5E, 0x7F, 0x5E, 0x1C,*

*0x00, 0x18, 0x3C, 0x18, 0x00,*

*0xFF, 0xE7, 0xC3, 0xE7, 0xFF,*

*0x00, 0x18, 0x24, 0x18, 0x00,*

*0xFF, 0xE7, 0xDB, 0xE7, 0xFF,*

*0x30, 0x48, 0x3A, 0x06, 0x0E,*

*0x26, 0x29, 0x79, 0x29, 0x26,*

*0x40, 0x7F, 0x05, 0x05, 0x07,*

*0x40, 0x7F, 0x05, 0x25, 0x3F,*

*0x5A, 0x3C, 0xE7, 0x3C, 0x5A,*

*0x7F, 0x3E, 0x1C, 0x1C, 0x08,*

*0x08, 0x1C, 0x1C, 0x3E, 0x7F,*

*0x14, 0x22, 0x7F, 0x22, 0x14,*

*0x5F, 0x5F, 0x00, 0x5F, 0x5F,*

*0x06, 0x09, 0x7F, 0x01, 0x7F,*

*0x00, 0x66, 0x89, 0x95, 0x6A,*

*0x60, 0x60, 0x60, 0x60, 0x60,*

*0x94, 0xA2, 0xFF, 0xA2, 0x94,*

*0x08, 0x04, 0x7E, 0x04, 0x08,*

*0x10, 0x20, 0x7E, 0x20, 0x10,*

*0x08, 0x08, 0x2A, 0x1C, 0x08,*

*0x08, 0x1C, 0x2A, 0x08, 0x08,*

*0x1E, 0x10, 0x10, 0x10, 0x10,*

*0x0C, 0x1E, 0x0C, 0x1E, 0x0C,*

*0x30, 0x38, 0x3E, 0x38, 0x30,*

*0x06, 0x0E, 0x3E, 0x0E, 0x06,*

*0x00, 0x00, 0x00, 0x00, 0x00,*

*0x00, 0x00, 0x5F, 0x00, 0x00,*

*0x00, 0x07, 0x00, 0x07, 0x00,*

*0x14, 0x7F, 0x14, 0x7F, 0x14,*

*0x24, 0x2A, 0x7F, 0x2A, 0x12,*

*0x23, 0x13, 0x08, 0x64, 0x62,*

*0x36, 0x49, 0x56, 0x20, 0x50,*

*0x00, 0x08, 0x07, 0x03, 0x00,*

*0x00, 0x1C, 0x22, 0x41, 0x00,*

*0x00, 0x41, 0x22, 0x1C, 0x00,*

*0x2A, 0x1C, 0x7F, 0x1C, 0x2A,*

*0x08, 0x08, 0x3E, 0x08, 0x08,*

*0x00, 0x80, 0x70, 0x30, 0x00,*

*0x08, 0x08, 0x08, 0x08, 0x08,*

*0x00, 0x00, 0x60, 0x60, 0x00,*

*0x20, 0x10, 0x08, 0x04, 0x02,*

*0x3E, 0x51, 0x49, 0x45, 0x3E,*

*0x00, 0x42, 0x7F, 0x40, 0x00,*

*0x72, 0x49, 0x49, 0x49, 0x46,*

*0x21, 0x41, 0x49, 0x4D, 0x33,*

*0x18, 0x14, 0x12, 0x7F, 0x10,*

*0x27, 0x45, 0x45, 0x45, 0x39,*

*0x3C, 0x4A, 0x49, 0x49, 0x31,*

*0x41, 0x21, 0x11, 0x09, 0x07,*

*0x36, 0x49, 0x49, 0x49, 0x36,*

*0x46, 0x49, 0x49, 0x29, 0x1E,*

*0x00, 0x00, 0x14, 0x00, 0x00,*

*0x00, 0x40, 0x34, 0x00, 0x00,*

*0x00, 0x08, 0x14, 0x22, 0x41,*

*0x14, 0x14, 0x14, 0x14, 0x14,*

*0x00, 0x41, 0x22, 0x14, 0x08,*

*0x02, 0x01, 0x59, 0x09, 0x06,*

*0x3E, 0x41, 0x5D, 0x59, 0x4E,*

*0x7C, 0x12, 0x11, 0x12, 0x7C,*

*0x7F, 0x49, 0x49, 0x49, 0x36,*

*0x3E, 0x41, 0x41, 0x41, 0x22,*

*0x7F, 0x41, 0x41, 0x41, 0x3E,*

*0x7F, 0x49, 0x49, 0x49, 0x41,*

*0x7F, 0x09, 0x09, 0x09, 0x01,*

*0x3E, 0x41, 0x41, 0x51, 0x73,*

*0x7F, 0x08, 0x08, 0x08, 0x7F,*

*0x00, 0x41, 0x7F, 0x41, 0x00,*

*0x20, 0x40, 0x41, 0x3F, 0x01,*

*0x7F, 0x08, 0x14, 0x22, 0x41,*

*0x7F, 0x40, 0x40, 0x40, 0x40,*

*0x7F, 0x02, 0x1C, 0x02, 0x7F,*

*0x7F, 0x04, 0x08, 0x10, 0x7F,*

*0x3E, 0x41, 0x41, 0x41, 0x3E,*

*0x7F, 0x09, 0x09, 0x09, 0x06,*

*0x3E, 0x41, 0x51, 0x21, 0x5E,*

*0x7F, 0x09, 0x19, 0x29, 0x46,*

*0x26, 0x49, 0x49, 0x49, 0x32,*

*0x03, 0x01, 0x7F, 0x01, 0x03,*

*0x3F, 0x40, 0x40, 0x40, 0x3F,*

*0x1F, 0x20, 0x40, 0x20, 0x1F,*

*0x3F, 0x40, 0x38, 0x40, 0x3F,*

*0x63, 0x14, 0x08, 0x14, 0x63,*

*0x03, 0x04, 0x78, 0x04, 0x03,*

*0x61, 0x59, 0x49, 0x4D, 0x43,*

*0x00, 0x7F, 0x41, 0x41, 0x41,*

*0x02, 0x04, 0x08, 0x10, 0x20,*

*0x00, 0x41, 0x41, 0x41, 0x7F,*

*0x04, 0x02, 0x01, 0x02, 0x04,*

*0x40, 0x40, 0x40, 0x40, 0x40,*

*0x00, 0x03, 0x07, 0x08, 0x00,*

*0x20, 0x54, 0x54, 0x78, 0x40,*

*0x7F, 0x28, 0x44, 0x44, 0x38,*

*0x38, 0x44, 0x44, 0x44, 0x28,*

*0x38, 0x44, 0x44, 0x28, 0x7F,*

*0x38, 0x54, 0x54, 0x54, 0x18,*

*0x00, 0x08, 0x7E, 0x09, 0x02,*

*0x18, 0xA4, 0xA4, 0x9C, 0x78,*

*0x7F, 0x08, 0x04, 0x04, 0x78,*

*0x00, 0x44, 0x7D, 0x40, 0x00,*

*0x20, 0x40, 0x40, 0x3D, 0x00,*

*0x7F, 0x10, 0x28, 0x44, 0x00,*

*0x00, 0x41, 0x7F, 0x40, 0x00,*

*0x7C, 0x04, 0x78, 0x04, 0x78,*

*0x7C, 0x08, 0x04, 0x04, 0x78,*

*0x38, 0x44, 0x44, 0x44, 0x38,*

*0xFC, 0x18, 0x24, 0x24, 0x18,*

*0x18, 0x24, 0x24, 0x18, 0xFC,*

*0x7C, 0x08, 0x04, 0x04, 0x08,*

*0x48, 0x54, 0x54, 0x54, 0x24,*

*0x04, 0x04, 0x3F, 0x44, 0x24,*

*0x3C, 0x40, 0x40, 0x20, 0x7C,*

*0x1C, 0x20, 0x40, 0x20, 0x1C,*

*0x3C, 0x40, 0x30, 0x40, 0x3C,*

*0x44, 0x28, 0x10, 0x28, 0x44,*

*0x4C, 0x90, 0x90, 0x90, 0x7C,*

*0x44, 0x64, 0x54, 0x4C, 0x44,*

*0x00, 0x08, 0x36, 0x41, 0x00,*

*0x00, 0x00, 0x77, 0x00, 0x00,*

*0x00, 0x41, 0x36, 0x08, 0x00,*

*0x02, 0x01, 0x02, 0x04, 0x02,*

*0x3C, 0x26, 0x23, 0x26, 0x3C,*

*0x1E, 0xA1, 0xA1, 0x61, 0x12,*

*0x3A, 0x40, 0x40, 0x20, 0x7A,*

*0x38, 0x54, 0x54, 0x55, 0x59,*

*0x21, 0x55, 0x55, 0x79, 0x41,*

*0x21, 0x54, 0x54, 0x78, 0x41,*

*0x21, 0x55, 0x54, 0x78, 0x40,*

*0x20, 0x54, 0x55, 0x79, 0x40,*

*0x0C, 0x1E, 0x52, 0x72, 0x12,*

*0x39, 0x55, 0x55, 0x55, 0x59,*

*0x39, 0x54, 0x54, 0x54, 0x59,*

*0x39, 0x55, 0x54, 0x54, 0x58,*

*0x00, 0x00, 0x45, 0x7C, 0x41,*

*0x00, 0x02, 0x45, 0x7D, 0x42,*

*0x00, 0x01, 0x45, 0x7C, 0x40,*

*0xF0, 0x29, 0x24, 0x29, 0xF0,*

*0xF0, 0x28, 0x25, 0x28, 0xF0,*

*0x7C, 0x54, 0x55, 0x45, 0x00,*

*0x20, 0x54, 0x54, 0x7C, 0x54,*

*0x7C, 0x0A, 0x09, 0x7F, 0x49,*

*0x32, 0x49, 0x49, 0x49, 0x32,*

*0x32, 0x48, 0x48, 0x48, 0x32,*

*0x32, 0x4A, 0x48, 0x48, 0x30,*

*0x3A, 0x41, 0x41, 0x21, 0x7A,*

*0x3A, 0x42, 0x40, 0x20, 0x78,*

*0x00, 0x9D, 0xA0, 0xA0, 0x7D,*

*0x39, 0x44, 0x44, 0x44, 0x39,*

*0x3D, 0x40, 0x40, 0x40, 0x3D,*

*0x3C, 0x24, 0xFF, 0x24, 0x24,*

*0x48, 0x7E, 0x49, 0x43, 0x66,*

*0x2B, 0x2F, 0xFC, 0x2F, 0x2B,*

*0xFF, 0x09, 0x29, 0xF6, 0x20,*

*0xC0, 0x88, 0x7E, 0x09, 0x03,*

*0x20, 0x54, 0x54, 0x79, 0x41,*

*0x00, 0x00, 0x44, 0x7D, 0x41,*

*0x30, 0x48, 0x48, 0x4A, 0x32,*

*0x38, 0x40, 0x40, 0x22, 0x7A,*

*0x00, 0x7A, 0x0A, 0x0A, 0x72,*

*0x7D, 0x0D, 0x19, 0x31, 0x7D,*

*0x26, 0x29, 0x29, 0x2F, 0x28,*

*0x26, 0x29, 0x29, 0x29, 0x26,*

*0x30, 0x48, 0x4D, 0x40, 0x20,*

*0x38, 0x08, 0x08, 0x08, 0x08,*

*0x08, 0x08, 0x08, 0x08, 0x38,*

*0x2F, 0x10, 0xC8, 0xAC, 0xBA,*

*0x2F, 0x10, 0x28, 0x34, 0xFA,*

*0x00, 0x00, 0x7B, 0x00, 0x00,*

*0x08, 0x14, 0x2A, 0x14, 0x22,*

*0x22, 0x14, 0x2A, 0x14, 0x08,*

*0xAA, 0x00, 0x55, 0x00, 0xAA,*

*0xAA, 0x55, 0xAA, 0x55, 0xAA,*

*0x00, 0x00, 0x00, 0xFF, 0x00,*

*0x10, 0x10, 0x10, 0xFF, 0x00,*

*0x14, 0x14, 0x14, 0xFF, 0x00,*

*0x10, 0x10, 0xFF, 0x00, 0xFF,*

*0x10, 0x10, 0xF0, 0x10, 0xF0,*

*0x14, 0x14, 0x14, 0xFC, 0x00,*

*0x14, 0x14, 0xF7, 0x00, 0xFF,*

*0x00, 0x00, 0xFF, 0x00, 0xFF,*

*0x14, 0x14, 0xF4, 0x04, 0xFC,*

*0x14, 0x14, 0x17, 0x10, 0x1F,*

*0x10, 0x10, 0x1F, 0x10, 0x1F,*

*0x14, 0x14, 0x14, 0x1F, 0x00,*

*0x10, 0x10, 0x10, 0xF0, 0x00,*

*0x00, 0x00, 0x00, 0x1F, 0x10,*

*0x10, 0x10, 0x10, 0x1F, 0x10,*

*0x10, 0x10, 0x10, 0xF0, 0x10,*

*0x00, 0x00, 0x00, 0xFF, 0x10,*

*0x10, 0x10, 0x10, 0x10, 0x10,*

*0x10, 0x10, 0x10, 0xFF, 0x10,*

*0x00, 0x00, 0x00, 0xFF, 0x14,*

*0x00, 0x00, 0xFF, 0x00, 0xFF,*

*0x00, 0x00, 0x1F, 0x10, 0x17,*

*0x00, 0x00, 0xFC, 0x04, 0xF4,*

*0x14, 0x14, 0x17, 0x10, 0x17,*

*0x14, 0x14, 0xF4, 0x04, 0xF4,*

*0x00, 0x00, 0xFF, 0x00, 0xF7,*

*0x14, 0x14, 0x14, 0x14, 0x14,*

*0x14, 0x14, 0xF7, 0x00, 0xF7,*

*0x14, 0x14, 0x14, 0x17, 0x14,*

*0x10, 0x10, 0x1F, 0x10, 0x1F,*

*0x14, 0x14, 0x14, 0xF4, 0x14,*

*0x10, 0x10, 0xF0, 0x10, 0xF0,*

*0x00, 0x00, 0x1F, 0x10, 0x1F,*

*0x00, 0x00, 0x00, 0x1F, 0x14,*

*0x00, 0x00, 0x00, 0xFC, 0x14,*

*0x00, 0x00, 0xF0, 0x10, 0xF0,*

*0x10, 0x10, 0xFF, 0x10, 0xFF,*

*0x14, 0x14, 0x14, 0xFF, 0x14,*

*0x10, 0x10, 0x10, 0x1F, 0x00,*

*0x00, 0x00, 0x00, 0xF0, 0x10,*

*0xFF, 0xFF, 0xFF, 0xFF, 0xFF,*

*0xF0, 0xF0, 0xF0, 0xF0, 0xF0,*

*0xFF, 0xFF, 0xFF, 0x00, 0x00,*

*0x00, 0x00, 0x00, 0xFF, 0xFF,*

*0x0F, 0x0F, 0x0F, 0x0F, 0x0F,*

*0x38, 0x44, 0x44, 0x38, 0x44,*

*0x7C, 0x2A, 0x2A, 0x3E, 0x14,*

*0x7E, 0x02, 0x02, 0x06, 0x06,*

*0x02, 0x7E, 0x02, 0x7E, 0x02,*

*0x63, 0x55, 0x49, 0x41, 0x63,*

*0x38, 0x44, 0x44, 0x3C, 0x04,*

*0x40, 0x7E, 0x20, 0x1E, 0x20,*

*0x06, 0x02, 0x7E, 0x02, 0x02,*

*0x99, 0xA5, 0xE7, 0xA5, 0x99,*

*0x1C, 0x2A, 0x49, 0x2A, 0x1C,*

*0x4C, 0x72, 0x01, 0x72, 0x4C,*

*0x30, 0x4A, 0x4D, 0x4D, 0x30,*

*0x30, 0x48, 0x78, 0x48, 0x30,*

*0xBC, 0x62, 0x5A, 0x46, 0x3D,*

*0x3E, 0x49, 0x49, 0x49, 0x00,*

*0x7E, 0x01, 0x01, 0x01, 0x7E,*

*0x2A, 0x2A, 0x2A, 0x2A, 0x2A,*

*0x44, 0x44, 0x5F, 0x44, 0x44,*

*0x40, 0x51, 0x4A, 0x44, 0x40,*

*0x40, 0x44, 0x4A, 0x51, 0x40,*

*0x00, 0x00, 0xFF, 0x01, 0x03,*

*0xE0, 0x80, 0xFF, 0x00, 0x00,*

*0x08, 0x08, 0x6B, 0x6B, 0x08,*

*0x36, 0x12, 0x36, 0x24, 0x36,*

*0x06, 0x0F, 0x09, 0x0F, 0x06,*

*0x00, 0x00, 0x18, 0x18, 0x00,*

*0x00, 0x00, 0x10, 0x10, 0x00,*

*0x30, 0x40, 0xFF, 0x01, 0x01,*

*0x00, 0x1F, 0x01, 0x01, 0x1E,*

*0x00, 0x19, 0x1D, 0x17, 0x12,*

*0x00, 0x3C, 0x3C, 0x3C, 0x3C,*

*0x00, 0x00, 0x00, 0x00, 0x00,*

*};*

*// the memory buffer for the LCD*

*uint8\_t pcd8544\_buffer[LCDWIDTH \* LCDHEIGHT / 8] = {0,};*

*// Le: get the bitmap assistance here! : http://en.radzio.dxp.pl/bitmap\_converter/*

*// Andre: or here! : http://www.henningkarlsen.com/electronics/t\_imageconverter\_mono.php*

*const uint8\_t pi\_logo [] = {*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0010 (16) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xF8, 0xF8, 0xFC, 0xAE, 0x0E, 0x0E, 0x06, 0x0E, 0x06, // 0x0020 (32) pixels*

*0xCE, 0x86, 0x8E, 0x0E, 0x0E, 0x1C, 0xB8, 0xF0, 0xF8, 0x78, 0x38, 0x1E, 0x0E, 0x8E, 0x8E, 0xC6, // 0x0030 (48) pixels*

*0x0E, 0x06, 0x0E, 0x06, 0x0E, 0x9E, 0xFE, 0xFC, 0xF8, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0040 (64) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0050 (80) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0060 (96) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x03, 0x0F, 0x0F, 0xFE, // 0x0070 (112) pixels*

*0xF8, 0xF0, 0x60, 0x60, 0xE0, 0xE1, 0xE3, 0xF7, 0x7E, 0x3E, 0x1E, 0x1F, 0x1F, 0x1F, 0x3E, 0x7E, // 0x0080 (128) pixels*

*0xFB, 0xF3, 0xE1, 0xE0, 0x60, 0x70, 0xF0, 0xF8, 0xBE, 0x1F, 0x0F, 0x07, 0x00, 0x00, 0x00, 0x00, // 0x0090 (144) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x00A0 (160) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x00B0 (176) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x80, 0xC0, // 0x00C0 (192) pixels*

*0xE0, 0xFC, 0xFE, 0xFF, 0xF3, 0x38, 0x38, 0x0C, 0x0E, 0x0F, 0x0F, 0x0F, 0x0E, 0x3C, 0x38, 0xF8, // 0x00D0 (208) pixels*

*0xF8, 0x38, 0x3C, 0x0E, 0x0F, 0x0F, 0x0F, 0x0E, 0x0C, 0x38, 0x38, 0xF3, 0xFF, 0xFF, 0xF8, 0xE0, // 0x00E0 (224) pixels*

*0x80, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x00F0 (240) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0100 (256) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0110 (272) pixels*

*0x00, 0x7F, 0xFF, 0xE7, 0xC3, 0xC1, 0xE0, 0xFF, 0xFF, 0x78, 0xE0, 0xC0, 0xC0, 0xC0, 0xC0, 0xE0, // 0x0120 (288) pixels*

*0x60, 0x78, 0x38, 0x3F, 0x3F, 0x38, 0x38, 0x60, 0x60, 0xC0, 0xC0, 0xC0, 0xC0, 0xE0, 0xF8, 0x7F, // 0x0130 (304) pixels*

*0xFF, 0xE0, 0xC1, 0xC3, 0xE7, 0x7F, 0x3E, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0140 (320) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0150 (336) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0160 (352) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x03, 0x0F, 0x7F, 0xFF, 0xF1, 0xE0, 0xC0, 0x80, 0x01, // 0x0170 (368) pixels*

*0x03, 0x9F, 0xFF, 0xF0, 0xE0, 0xE0, 0xC0, 0xC0, 0xC0, 0xC0, 0xC0, 0xE0, 0xE0, 0xF0, 0xFF, 0x9F, // 0x0180 (384) pixels*

*0x03, 0x01, 0x80, 0xC0, 0xE0, 0xF1, 0x7F, 0x1F, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x0190 (400) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x01A0 (416) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x01B0 (432) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, // 0x01C0 (448) pixels*

*0x03, 0x03, 0x07, 0x07, 0x0F, 0x1F, 0x1F, 0x3F, 0x3B, 0x71, 0x60, 0x60, 0x60, 0x60, 0x60, 0x71, // 0x01D0 (464) pixels*

*0x3B, 0x1F, 0x0F, 0x0F, 0x0F, 0x07, 0x03, 0x03, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x01E0 (480) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // 0x01F0 (496) pixels*

*0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,*

*};*

*// reduces how much is refreshed, which speeds it up!*

*// originally derived from Steve Evans/JCW's mod but cleaned up and optimized*

*//#define enablePartialUpdate*

*static void my\_setpixel(uint8\_t x, uint8\_t y, uint8\_t color)*

*{*

*if ((x >= LCDWIDTH) || (y >= LCDHEIGHT))*

*return;*

*// x is which column*

*if (color)*

*pcd8544\_buffer[x+ (y/8)\*LCDWIDTH] |= \_BV(y%8);*

*else*

*pcd8544\_buffer[x+ (y/8)\*LCDWIDTH] &= ~\_BV(y%8);*

*}*

*void LCDshowLogo()*

*{*

*uint32\_t i;*

*for (i = 0; i < LCDWIDTH \* LCDHEIGHT / 8; i++ )*

*{*

*pcd8544\_buffer[i] = pi\_logo[i];*

*}*

*LCDdisplay();*

*}*

*#ifdef enablePartialUpdate*

*static uint8\_t xUpdateMin, xUpdateMax, yUpdateMin, yUpdateMax;*

*#endif*

*static void updateBoundingBox(uint8\_t xmin, uint8\_t ymin, uint8\_t xmax, uint8\_t ymax) {*

*#ifdef enablePartialUpdate*

*if (xmin < xUpdateMin) xUpdateMin = xmin;*

*if (xmax > xUpdateMax) xUpdateMax = xmax;*

*if (ymin < yUpdateMin) yUpdateMin = ymin;*

*if (ymax > yUpdateMax) yUpdateMax = ymax;*

*#endif*

*}*

*void LCDInit(uint8\_t SCLK, uint8\_t DIN, uint8\_t DC, uint8\_t CS, uint8\_t RST, uint8\_t contrast)*

*{*

*\_din = DIN;*

*\_sclk = SCLK;*

*\_dc = DC;*

*\_rst = RST;*

*\_cs = CS;*

*cursor\_x = cursor\_y = 0;*

*textsize = 1;*

*textcolor = BLACK;*

*// set pin directions*

*pinMode(\_din, OUTPUT);*

*pinMode(\_sclk, OUTPUT);*

*pinMode(\_dc, OUTPUT);*

*pinMode(\_rst, OUTPUT);*

*pinMode(\_cs, OUTPUT);*

*// toggle RST low to reset; CS low so it'll listen to us*

*if (\_cs > 0)*

*digitalWrite(\_cs, LOW);*

*digitalWrite(\_rst, LOW);*

*\_delay\_ms(500);*

*digitalWrite(\_rst, HIGH);*

*// get into the EXTENDED mode!*

*LCDcommand(PCD8544\_FUNCTIONSET | PCD8544\_EXTENDEDINSTRUCTION );*

*// LCD bias select (4 is optimal?)*

*LCDcommand(PCD8544\_SETBIAS | 0x4);*

*// set VOP*

*if (contrast > 0x7f)*

*contrast = 0x7f;*

*LCDcommand( PCD8544\_SETVOP | contrast); // Experimentally determined*

*// normal mode*

*LCDcommand(PCD8544\_FUNCTIONSET);*

*// Set display to Normal*

*LCDcommand(PCD8544\_DISPLAYCONTROL | PCD8544\_DISPLAYNORMAL);*

*// set up a bounding box for screen updates*

*updateBoundingBox(0, 0, LCDWIDTH-1, LCDHEIGHT-1);*

*}*

*void LCDdrawbitmap(uint8\_t x, uint8\_t y,const uint8\_t \*bitmap, uint8\_t w, uint8\_t h,uint8\_t color)*

*{*

*uint8\_t j,i;*

*for ( j=0; j<h; j++)*

*{*

*for ( i=0; i<w; i++ )*

*{*

*if (\*(bitmap + i + (j/8)\*w) & \_BV(j%8))*

*{*

*my\_setpixel(x+i, y+j, color);*

*}*

*}*

*}*

*updateBoundingBox(x, y, x+w, y+h);*

*}*

*void LCDdrawstring(uint8\_t x, uint8\_t y, char \*c)*

*{*

*cursor\_x = x;*

*cursor\_y = y;*

*while (\*c)*

*{*

*LCDwrite(\*c++);*

*}*

*}*

*void LCDdrawstring\_P(uint8\_t x, uint8\_t y, const char \*str)*

*{*

*cursor\_x = x;*

*cursor\_y = y;*

*while (1)*

*{*

*char c = (\*str++);*

*if (! c)*

*return;*

*LCDwrite(c);*

*}*

*}*

*void LCDdrawchar(uint8\_t x, uint8\_t y, char c)*

*{*

*if (y >= LCDHEIGHT) return;*

*if ((x+5) >= LCDWIDTH) return;*

*uint8\_t i,j;*

*for ( i =0; i<5; i++ )*

*{*

*uint8\_t d = \*(font+(c\*5)+i);*

*uint8\_t j;*

*for (j = 0; j<8; j++)*

*{*

*if (d & \_BV(j))*

*{*

*my\_setpixel(x+i, y+j, textcolor);*

*}*

*else*

*{*

*my\_setpixel(x+i, y+j, !textcolor);*

*}*

*}*

*}*

*for ( j = 0; j<8; j++)*

*{*

*my\_setpixel(x+5, y+j, !textcolor);*

*}*

*updateBoundingBox(x, y, x+5, y + 8);*

*}*

*void LCDwrite(uint8\_t c)*

*{*

*if (c == '\n')*

*{*

*cursor\_y += textsize\*8;*

*cursor\_x = 0;*

*}*

*else if (c == '\r')*

*{*

*// skip em*

*}*

*else*

*{*

*LCDdrawchar(cursor\_x, cursor\_y, c);*

*cursor\_x += textsize\*6;*

*if (cursor\_x >= (LCDWIDTH-5))*

*{*

*cursor\_x = 0;*

*cursor\_y+=8;*

*}*

*if (cursor\_y >= LCDHEIGHT)*

*cursor\_y = 0;*

*}*

*}*

*void LCDsetCursor(uint8\_t x, uint8\_t y)*

*{*

*cursor\_x = x;*

*cursor\_y = y;*

*}*

*// bresenham's algorithm - thx wikpedia*

*void LCDdrawline(uint8\_t x0, uint8\_t y0, uint8\_t x1, uint8\_t y1, uint8\_t color)*

*{*

*uint8\_t steep = abs(y1 - y0) > abs(x1 - x0);*

*if (steep)*

*{*

*swap(x0, y0);*

*swap(x1, y1);*

*}*

*if (x0 > x1)*

*{*

*swap(x0, x1);*

*swap(y0, y1);*

*}*

*// much faster to put the test here, since we've already sorted the points*

*updateBoundingBox(x0, y0, x1, y1);*

*uint8\_t dx, dy;*

*dx = x1 - x0;*

*dy = abs(y1 - y0);*

*int8\_t err = dx / 2;*

*int8\_t ystep;*

*if (y0 < y1)*

*{*

*ystep = 1;*

*} else*

*{*

*ystep = -1;*

*}*

*for (; x0<=x1; x0++)*

*{*

*if (steep)*

*{*

*my\_setpixel(y0, x0, color);*

*}*

*else*

*{*

*my\_setpixel(x0, y0, color);*

*}*

*err -= dy;*

*if (err < 0)*

*{*

*y0 += ystep;*

*err += dx;*

*}*

*}*

*}*

*// filled rectangle*

*void LCDfillrect(uint8\_t x, uint8\_t y, uint8\_t w, uint8\_t h, uint8\_t color)*

*{*

*// stupidest version - just pixels - but fast with internal buffer!*

*uint8\_t i,j;*

*for ( i=x; i<x+w; i++)*

*{*

*for ( j=y; j<y+h; j++)*

*{*

*my\_setpixel(i, j, color);*

*}*

*}*

*updateBoundingBox(x, y, x+w, y+h);*

*}*

*// draw a rectangle*

*void LCDdrawrect(uint8\_t x, uint8\_t y, uint8\_t w, uint8\_t h, uint8\_t color)*

*{*

*// stupidest version - just pixels - but fast with internal buffer!*

*uint8\_t i;*

*for ( i=x; i<x+w; i++) {*

*my\_setpixel(i, y, color);*

*my\_setpixel(i, y+h-1, color);*

*}*

*for ( i=y; i<y+h; i++) {*

*my\_setpixel(x, i, color);*

*my\_setpixel(x+w-1, i, color);*

*}*

*updateBoundingBox(x, y, x+w, y+h);*

*}*

*// draw a circle outline*

*void LCDdrawcircle(uint8\_t x0, uint8\_t y0, uint8\_t r, uint8\_t color)*

*{*

*updateBoundingBox(x0-r, y0-r, x0+r, y0+r);*

*int8\_t f = 1 - r;*

*int8\_t ddF\_x = 1;*

*int8\_t ddF\_y = -2 \* r;*

*int8\_t x = 0;*

*int8\_t y = r;*

*my\_setpixel(x0, y0+r, color);*

*my\_setpixel(x0, y0-r, color);*

*my\_setpixel(x0+r, y0, color);*

*my\_setpixel(x0-r, y0, color);*

*while (x<y)*

*{*

*if (f >= 0)*

*{*

*y--;*

*ddF\_y += 2;*

*f += ddF\_y;*

*}*

*x++;*

*ddF\_x += 2;*

*f += ddF\_x;*

*my\_setpixel(x0 + x, y0 + y, color);*

*my\_setpixel(x0 - x, y0 + y, color);*

*my\_setpixel(x0 + x, y0 - y, color);*

*my\_setpixel(x0 - x, y0 - y, color);*

*my\_setpixel(x0 + y, y0 + x, color);*

*my\_setpixel(x0 - y, y0 + x, color);*

*my\_setpixel(x0 + y, y0 - x, color);*

*my\_setpixel(x0 - y, y0 - x, color);*

*}*

*}*

*void LCDfillcircle(uint8\_t x0, uint8\_t y0, uint8\_t r, uint8\_t color)*

*{*

*updateBoundingBox(x0-r, y0-r, x0+r, y0+r);*

*int8\_t f = 1 - r;*

*int8\_t ddF\_x = 1;*

*int8\_t ddF\_y = -2 \* r;*

*int8\_t x = 0;*

*int8\_t y = r;*

*uint8\_t i;*

*for (i=y0-r; i<=y0+r; i++)*

*{*

*my\_setpixel(x0, i, color);*

*}*

*while (x<y)*

*{*

*if (f >= 0)*

*{*

*y--;*

*ddF\_y += 2;*

*f += ddF\_y;*

*}*

*x++;*

*ddF\_x += 2;*

*f += ddF\_x;*

*for ( i=y0-y; i<=y0+y; i++)*

*{*

*my\_setpixel(x0+x, i, color);*

*my\_setpixel(x0-x, i, color);*

*}*

*for ( i=y0-x; i<=y0+x; i++)*

*{*

*my\_setpixel(x0+y, i, color);*

*my\_setpixel(x0-y, i, color);*

*}*

*}*

*}*

*// the most basic function, set a single pixel*

*void LCDsetPixel(uint8\_t x, uint8\_t y, uint8\_t color)*

*{*

*if ((x >= LCDWIDTH) || (y >= LCDHEIGHT))*

*return;*

*// x is which column*

*if (color)*

*pcd8544\_buffer[x+ (y/8)\*LCDWIDTH] |= \_BV(y%8);*

*else*

*pcd8544\_buffer[x+ (y/8)\*LCDWIDTH] &= ~\_BV(y%8);*

*updateBoundingBox(x,y,x,y);*

*}*

*// the most basic function, get a single pixel*

*uint8\_t LCDgetPixel(uint8\_t x, uint8\_t y)*

*{*

*if ((x >= LCDWIDTH) || (y >= LCDHEIGHT))*

*return 0;*

*return (pcd8544\_buffer[x+ (y/8)\*LCDWIDTH] >> (7-(y%8))) & 0x1;*

*}*

*void LCDspiwrite(uint8\_t c)*

*{*

*digitalWrite(\_cs, LOW); //bugfix*

*shiftOut(\_din, \_sclk, MSBFIRST, c);*

*digitalWrite(\_cs, HIGH); //bugfix*

*}*

*void LCDcommand(uint8\_t c)*

*{*

*digitalWrite( \_dc, LOW);*

*LCDspiwrite(c);*

*}*

*void LCDdata(uint8\_t c)*

*{*

*digitalWrite(\_dc, HIGH);*

*LCDspiwrite(c);*

*}*

*void LCDsetContrast(uint8\_t val)*

*{*

*if (val > 0x7f) {*

*val = 0x7f;*

*}*

*LCDcommand(PCD8544\_FUNCTIONSET | PCD8544\_EXTENDEDINSTRUCTION );*

*LCDcommand( PCD8544\_SETVOP | val);*

*LCDcommand(PCD8544\_FUNCTIONSET);*

*}*

*void LCDdisplay(void)*

*{*

*uint8\_t col, maxcol, p;*

*for(p = 0; p < 6; p++)*

*{*

*#ifdef enablePartialUpdate*

*// check if this page is part of update*

*if ( yUpdateMin >= ((p+1)\*8) )*

*{*

*continue; // nope, skip it!*

*}*

*if (yUpdateMax < p\*8)*

*{*

*break;*

*}*

*#endif*

*LCDcommand(PCD8544\_SETYADDR | p);*

*#ifdef enablePartialUpdate*

*col = xUpdateMin;*

*maxcol = xUpdateMax;*

*#else*

*// start at the beginning of the row*

*col = 0;*

*maxcol = LCDWIDTH-1;*

*#endif*

*LCDcommand(PCD8544\_SETXADDR | col);*

*for(; col <= maxcol; col++) {*

*//uart\_putw\_dec(col);*

*//uart\_putchar(' ');*

*LCDdata(pcd8544\_buffer[(LCDWIDTH\*p)+col]);*

*}*

*}*

*LCDcommand(PCD8544\_SETYADDR ); // no idea why this is necessary but it is to finish the last byte?*

*#ifdef enablePartialUpdate*

*xUpdateMin = LCDWIDTH - 1;*

*xUpdateMax = 0;*

*yUpdateMin = LCDHEIGHT-1;*

*yUpdateMax = 0;*

*#endif*

*}*

*// clear everything*

*void LCDclear(void) {*

*//memset(pcd8544\_buffer, 0, LCDWIDTH\*LCDHEIGHT/8);*

*uint32\_t i;*

*for ( i = 0; i < LCDWIDTH\*LCDHEIGHT/8 ; i++)*

*pcd8544\_buffer[i] = 0;*

*updateBoundingBox(0, 0, LCDWIDTH-1, LCDHEIGHT-1);*

*cursor\_y = cursor\_x = 0;*

*}*

*// bitbang serial shift out on select GPIO pin. Data rate is defined by CPU clk speed and CLKCONST\_2.*

*// Calibrate these value for your need on target platform.*

*void shiftOut(uint8\_t dataPin, uint8\_t clockPin, uint8\_t bitOrder, uint8\_t val)*

*{*

*uint8\_t i;*

*uint32\_t j;*

*for (i = 0; i < 8; i++) {*

*if (bitOrder == LSBFIRST)*

*digitalWrite(dataPin, !!(val & (1 << i)));*

*else*

*digitalWrite(dataPin, !!(val & (1 << (7 - i))));*

*digitalWrite(clockPin, HIGH);*

*for (j = CLKCONST\_2; j > 0; j--); // clock speed, anyone? (LCD Max CLK input: 4MHz)*

*digitalWrite(clockPin, LOW);*

*}*

*}*

*// roughly calibrated spin delay*

*void \_delay\_ms(uint32\_t t)*

*{*

*uint32\_t nCount = 0;*

*while (t != 0)*

*{*

*nCount = CLKCONST\_1;*

*while(nCount != 0)*

*nCount--;*

*t--;*

*}*

*}*

*// pcd8544\_rpi.c*

*//*

*/\**

*=================================================================================*

*Name : pcd8544\_rpi.c*

*Version : 0.1*

*Copyright (C) 2012 by Andre Wussow, 2012, desk@binerry.de*

*Description :*

*A simple PCD8544 LCD (Nokia3310/5110) for Raspberry Pi for displaying some system informations.*

*Makes use of WiringPI-library of Gordon Henderson (https://projects.drogon.net/raspberry-pi/wiringpi/)*

*Recommended connection (http://www.raspberrypi.org/archives/384):*

*LCD pins Raspberry Pi*

*LCD1 - GND P06 - GND*

*LCD2 - VCC P01 - 3.3V*

*LCD3 - CLK P11 - GPIO0*

*LCD4 - Din P12 - GPIO1*

*LCD5 - D/C P13 - GPIO2*

*LCD6 - CS P15 - GPIO3*

*LCD7 - RST P16 - GPIO4*

*LCD8 - LED P01 - 3.3V*

*================================================================================*

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*================================================================================*

*\*/*

*#include <wiringPi.h>*

*#include <stdint.h>*

*#include <stdio.h>*

*#include <stdlib.h>*

*#include <string.h>*

*#include <sys/sysinfo.h>*

*#include "PCD8544.h"*

*// pin setup*

*int \_din = 1;*

*int \_sclk = 0;*

*int \_dc = 2;*

*int \_rst = 4;*

*int \_cs = 3;*

*// lcd contrast*

*//may be need modify to fit your screen! normal: 30- 90 ,default is:45 !!!maybe modify this value!*

*int contrast = 60;*

*int main (void)*

*{*

*// print infos*

*printf("Raspberry Pi PCD8544 sysinfo display\n");*

*printf("========================================\n");*

*// check wiringPi setup*

*if (wiringPiSetup() == -1)*

*{*

*printf("wiringPi-Error\n");*

*exit(1);*

*}*

*// init and clear lcd*

*LCDInit(\_sclk, \_din, \_dc, \_cs, \_rst, contrast);*

*LCDclear();*

*// show logo*

*LCDshowLogo();*

*delay(5000);*

*for (;;)*

*{*

*// clear lcd*

*LCDclear();*

*// get system usage / info*

*struct sysinfo sys\_info;*

*if(sysinfo(&sys\_info) != 0)*

*{*

*printf("sysinfo-Error\n");*

*}*

*// uptime*

*char uptimeInfo1[15];*

*char uptimeInfo2[15];*

*unsigned long uptime = sys\_info.uptime / 60;*

*unsigned long days = uptime / 60 / 24;*

*unsigned long hours = (uptime / 60) % 60 % 24;*

*unsigned long minutes = uptime % 60;*

*snprintf(uptimeInfo1, sizeof(uptimeInfo1),*

*"Uptime %03ld dys", days);*

*snprintf(uptimeInfo2, sizeof(uptimeInfo2),*

*"%02ld hrs %02ld mns", hours, minutes);*

*// cpu info*

*char cpuInfo[15];*

*snprintf(cpuInfo, sizeof(cpuInfo),*

*"CPU load %.2f", ((float)sys\_info.loads[0])/(1<<SI\_LOAD\_SHIFT));*

*// ram info*

*char ramInfo[15];*

*unsigned long totalRam = sys\_info.freeram / 1024 / 1024;*

*snprintf(ramInfo, sizeof(ramInfo),*

*"RAM %ld MB", totalRam);*

*// other*

*char other[15];*

*snprintf(other, sizeof(other),*

*"Procs %ld", sys\_info.procs);*

*// build screen*

*LCDdrawstring(0, 0, uptimeInfo1);*

*LCDdrawstring(0, 8, uptimeInfo2);*

*LCDdrawstring(0, 16, cpuInfo);*

*LCDdrawstring(0, 24, ramInfo);*

*LCDdrawstring(0, 32, other);*

*LCDdrawstring(0, 40, "");*

*LCDdisplay();*

*delay(1000);*

*}*

*return 0;*

*}*

### Output of cpushow executable binary



### LCD Contrast Adaptation

If LCD display seems to be very bright or dark, the contrast of the LCD screen has to be adjusted in code file - pcd8544\_rpi.c, and then recompile and execute the compiled binary ( ./cpushow ) to see the effects of the changes made!

$ vi pcd8544\_rpi.c

// LCD contrast variable

// Normal: 30- 90, default is:45!!!

int contrast = 45;

// Change this value here, default is 45

// If it’s too dark, go down a little, 5 is a good step index.

// If it’s too light, an increase of 5

### Running script / executable on bootup

[ <https://www.raspberrypi.org/forums/viewtopic.php?t=191554> ]

To run **cpushow** executable binary at every bootup & given that you appear to need to run it as root (and I'm taking your word for that), you can put it in the root crontab file by using the command:

**$ sudo crontab -e**

Prefix your command (absolute path to where cpushow executable is kept) with "@reboot".

There should be a line in the file that says:

@reboot mycommand

i.e. something like this:

**@reboot /home/pi/iot\_projects/wiringPi/cpushow/cpushow**

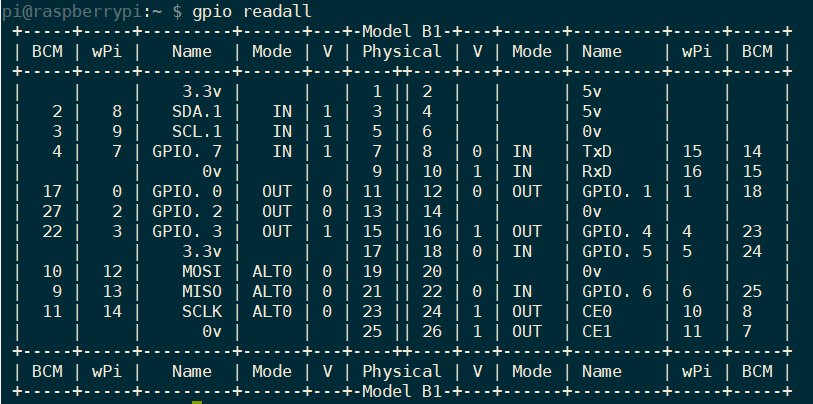
No sudo required because everything that gets run from that file is run as root.

Note that when something is run from cron, the normal (i.e. login) environment variables are not set. So, unless all paths are given as absolute paths and you don't need anything set, it's better to wrap the command in a shell script that sets anything you need, like paths or display ID.

### Reading current GPIO pin status

Once **wiringpi** is installed, it is possible to test it with the following command:

pi@raspberrypi:~ $ gpio readall



# Trouble Shooting Guide

There would be times, when our friendly device RPi is distressed and may give you tough time going around. Following section provides real life problems encountered and Tips & Tricks on how they were fixed.

Priceless!!!

## Troubleshooting Power Problems

[ [http://elinux.org/R-Pi\_Troubleshooting - Troubleshooting\_power\_problems](http://elinux.org/R-Pi_Troubleshooting#Troubleshooting_power_problems) ]

If you think you have a problem with your power supply, it is a promising idea to check the actual voltage on the Raspberry Pi circuit board. Two test points labelled TP1 and TP2 are provided on the circuit board to facilitate voltage measurements.

Use a multimeter which is set to the range 20 volts DC (or 20v =). You should see a voltage between 4.75 and 5.25 volts. Anything outside this range indicates that you have a problem with your power supply or your power cable.

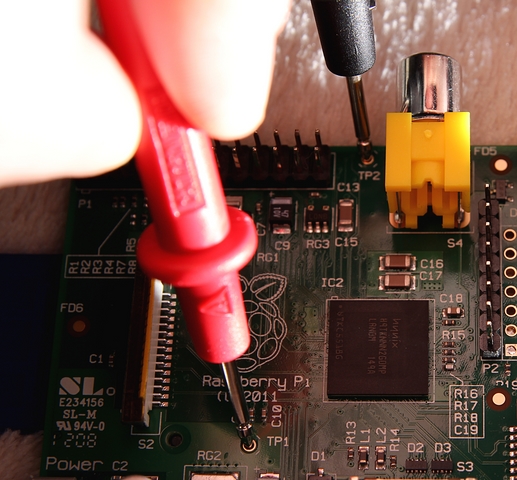
Note: Even if the multimeter shows the correct voltage, you may have some power supply problems. A multimeter only displays the average voltage. If there are very short-lived dips or spikes in the voltage, these will not be shown by the multimeter. It is best to measure voltage when Pi is busy.

If your voltage is low, it could be:

* The power supply produces too low a voltage
* The power supply cannot supply enough current, which results in a voltage drop. Make sure Power supply is labelled as at least 700mA. (Some cheap power supplies don't deliver what is labelled).
* The Micro USB power cable is low quality. Some Micro USB cables have very thin conductors, resulting in enough voltage drop for RPi to fail even if the power supply itself is fine.
* Attached USB devices want too much power. The Pi is only designed for up to 100mA USB devices. A USB device wanting more than that will cause a voltage drop.
* The F3 Polyfuse could be blown or bad, see below for how to test.

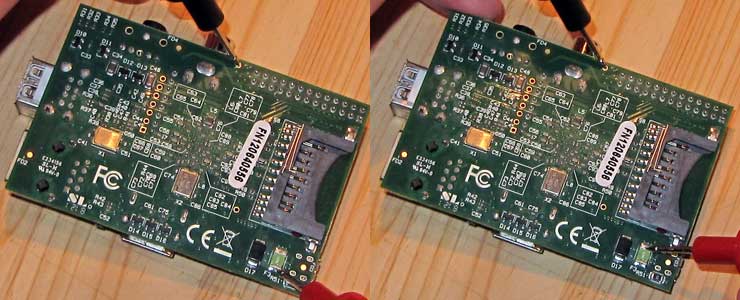
Note: keyboards with LCD displays, built in USB hubs, backlights, etc. are likely to be problematic. Try to use a basic one. Wi-Fi dongles are also unlikely to work when directly connected. Connect high powered USB devices to a powered USB hub.

Try booting without HDMI, Ethernet or USB device plugged in, and see if the voltage improves.

## How to test the F3 polyfuse

1. Remove all the things plugged into your Raspberry Pi, including SD card.
2. Locate the TP2 test point on the top of the board.
3. Turn your board over and find the TP2 test point on the bottom of the board. One lead of your multi-meter will always be on the TP2 point on the bottom of the board for all tests.
4. Plug your power supply into the micro USB port and power your board.
5. Place one lead of your multi-meter on the TP2 point on the bottom of the board and one lead on the side of the F3 fuse closest to the edge of the board. Note the voltage. This is the voltage coming into your RPi from your power supply.
6. Keeping one lead on TP2, move the other lead to the side of F3 closest to the SD card slot. This is the voltage coming out of the F3 fuse.



If the voltage is different by more than about 0.3v you probably have an issue with the F3 fuse.

When polyfuses "blow" their resistance increases dramatically, thereby limiting the voltage that can pass through them. If your power problem suddenly appeared after your board was known to be working fine, it is probable the fuse is just "blown" and will return to normal. Polyfuses recover from the tripped state to near their normal value in a few minutes but do take some hours to fully recover so leave it unpowered and check it again in a little while. If your power problem has been since the first time you plugged in your board, the fuse was probably bad when it arrived and should be returned to place you purchased it.

Also, on a related issue, do note that if you do not power the PI in the "official manner", that is through its micro-USB port, but use any alternative way (such as through the GPIO header, the test points TP1 and TP2), but also by back-powering it, you are bypassing the PI's input polyfuse protection device! This can have extreme consequences if ever you manage to put more than 6V on the PI, even for a very short period. As this causes the overvoltage device D17 on the PI to trigger and short the 5V supply! Without the polyfuse limiting the current through D17, it will burn out, probably melting the PI's enclosure with it, (if you have any) and possibly causing a fire-hazard. It will probably also create a permanent short of the 5V supply! So be warned, and if you use back power make sure your hub or its PSU has a fuse to prevent this from happening. If not, add your own fuse.

## Red power LED is on, green LED does not flash, nothing on display

[ [http://elinux.org/R-Pi\_Troubleshooting - Red\_power\_LED\_is\_on.2C\_green\_LED\_does\_not\_flash.2C\_nothing\_on\_display](http://elinux.org/R-Pi_Troubleshooting#Red_power_LED_is_on.2C_green_LED_does_not_flash.2C_nothing_on_display) ]

A faintly glowing steady green LED means **no boot code has ever been executed**, as almost the first thing the boot code does is to turn the faint glow off! When flashing/blinking, the green LED should be as bright as the red LED.

There is a difference between the quad core Pi 2 (BCM2836) and the other models if there is no SD card inserted, or the SD card is improperly formatted. The former will have both red and green lights on bright and steady. The latter will have only the red light on.

This indicates:

* The Raspberry Pi cannot find a valid image on the SD card. Turn the board over to check that the card is inserted correctly; the insertion force is much larger than for some laptops.
* Check that you have correctly written a Raspberry Pi image to the card by using a MAC or PC and browse for the following files:
  + bootcode.bin
  + fixup.dat
  + start.elf amongst others
* Did you have admin rights when you used the SD-card writer software? Without it the software might go through the motions without doing anything!
* Older images do not load boot code for revB boards with the Hynix chip. Use release 2013-02-09 (?) or later. (I observe a single blip on the green activity LED)
* It is also possible that the image you are writing to the card is corrupt, as downloads do occasionally end up corrupted or truncated. You can check with a checksum utility to verify the integrity of the download.
* The SD card may itself have an issue. (This one I faced myself, my RPi board dint boot up due to the broken MicroSD converter).
* Try with no cables connected except the USB power lead, and SD card inserted. You should see flashing of the OK light for ~20 seconds. If that helps, plug in cables one at a time to identify which is interfering with boot.
* Confirm the USB cable is properly seated in the power slot. The red power LED does not necessarily mean it is fully connected.
* Look at the SD card holder on the Raspberry Pi carefully. At first glance it may look fine, but the contacts must be springy, and they must protrude at least 2mm as measured from the lower edge of the holder to the top of the contact bulge. This happens due to the solder process and the type of holder used. Some of the solder residue falls into the contact cavity restricting the springiness and the height that the contact protrudes. You can fix this yourself but remember you can void your warranty. The contacts are delicate so be careful. Insert a needle pin under the contact bulge and pull lightly up until the one end of the contact unclips. Clean the cavity where the contact unclipped from of any solder or other residue by blowing into the cavity. Clip the contact back into the cavity by lightly pushing it into the cavity. Do this for all the contacts.
* Ensure that when your SD Card is fully inserted that the longer metal spring contacts (one clearly visible on the end of the slot, and one hidden in the side nearest the power connector) are closed. These are used to detect the presence of an SD Card therefore if no contact is made then the Raspberry Pi won't attempt to access the card.
* Check carefully for any cracks or damage to the SD Card slot, if the sides are damaged then the card may not be making proper contact with the pins (can usually confirm this if your Raspberry Pi boots if you manually hold the SD Card in position).
* The voltage is too low (below 5 V), try a different power supply and/or cable. The R-Pi needs a supply rated for 700 mA or more. Some supplies labelled as such cannot provide their rated current while maintaining 5V.
* If for whatever reason the main polyfuse F3 has been overheated previously it may happen that it hasn't completely recovered, in which case, if you turn the PI on, a considerable amount of energy from the power supply is lost in the fuse and doesn't reach the PI. Try if the polyfuse seems hot.
* Some problems have been reported if the ambient temperature is low that might be related to micro-fractures, fissures in solder or other issues. Try warming the Raspberry Pi with a hair dryer for just a few seconds (do not use excessive heat or you may cause irreversible damage!) and reconnect the power.

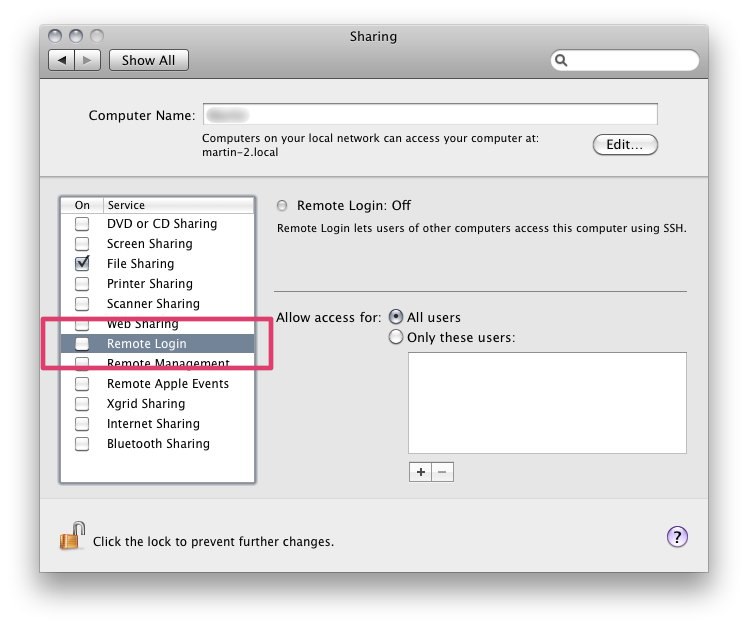
## [How to Allow Incoming SSH (SCP) connections on MAC OS?](https://apple.stackexchange.com/questions/2419/how-can-i-allow-incoming-ssh-scp-connections)

## Connection refused error when trying to SCP

Mac OS

To allow SSH incoming connections to your Mac, you need to enable Remote Login in Sharing Preferences pane. See image below.

Here’s a picture:



## Custom Kernel Image Doesn’t Boot

[ <https://www.raspberrypi.org/forums/viewtopic.php?t=103087&p=713260> ]

Check the ELF headers of your custom kernel using the following command:

$ file kernel.img

If you get something like “kernel.img : data”, this could mean that your image creation method isn’t compatible with the latest kernel formats (Of course, this was the format used by earlier RPi kernel versions).

Follow the steps below, to generate a compatible kernel image with latest kernel version.

With recent RPi Kernels, the process of creating the kernel image has changed as described below.

$ cd ~/rpi\_iot\_kernel/linux

$ ./scripts/mkknlimg ./arch/arm/boot/zImage kernel\_new.img

$ file kernel\_image\_new.img

The above command, checks the ELF headers of newly generated kernel image

Expected Result :

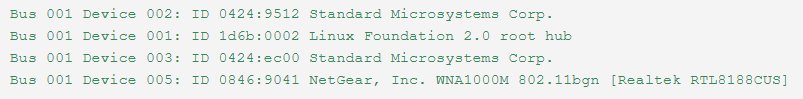
kernel\_new.img: Linux kernel ARM boot executable zImage (little-endian)

Finally, Copy the kernel\_new.img generated above, to /boot folder on Raspberry Pi and reboot. Remember to change /boot/config.txt to boot from the newly created kernel.img

## Wi-Fi Dongle Issues – Doesn’t camp to Wi-Fi Network

[ <https://www.raspberrypi.org/forums/viewtopic.php?f=28&t=44044> ]

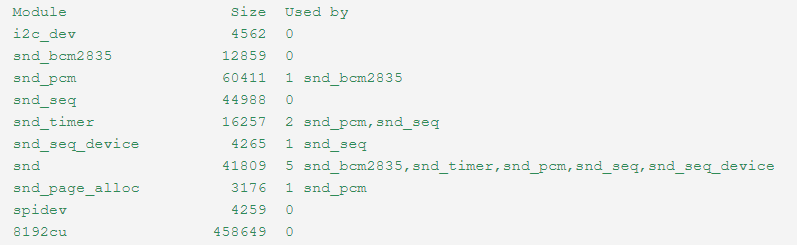
1. **Check whether the Wi-Fi stick is being picked up at all**  
   Run a 'lsusb' in a terminal and you should see your Wi-Fi stick in the output of the command.



Possible Outcomes:

* + If you can see it, it means that at least the stick is most likely working.
  + If you can't see it, then the stick is not being picked up.
  + If you're using a powered hub, try the stick in another computer
  + If you're NOT using a powered hub, try a powered hub first.

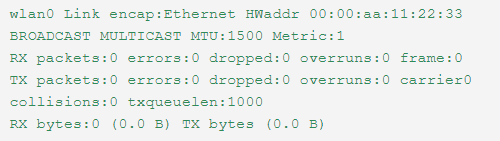
1. **Check whether the modules loaded**Run a ‘lsmod’ and see if the module for the stick is loaded. The module name will change depending on the stick that is being used. For example, if you have the above RTL8188CUS Wi-Fi adapter, then lsmod will show the following output (notice the 8192cu module is loaded):



Possible Outcomes:

* For RT5370 sticks, you'll see a rt2800usb module in there instead. If the module is there, then the drivers are being loaded correctly.
* If NOT, ensure that you copied the Modules (/lib/modules) folder that were generated while building the RPi Kernel.

1. **Check the Wi-Fi NIC**  
   Since the stick is there and drivers are loaded, check to make sure the stick is being picked up  
     
   Run an **ifconfig -a** and check the output. You should see a 'wlan0' in the output.



Possible Outcomes:

* If you do not see this note, then you may be missing some firmware for your device.
* The firmware packages for the more common devices are as follows:  
  **firmware-ralink** for Ralink devices (RT5370/RT3070/etc.)  
  **firmware-realtek** for Realtek devices (RTL8188CUS/etc.)  
  **firmware-atheros** for Atheros devices.
* **apt-get install <firmware-package>** will install the firmware on Raspbian.

Once you've installed the firmware, unplug and plug the stick back

in to see if **ifconfig -a** can see it now.

1. If not, try a reboot as well.
2. **Check the Wi-Fi configuration**

If you can see wlan0 when you run ifconfig -a but you can't get online, you'll need to make sure the adapter is getting an IP address, and is connected to a Wi-Fi Network.

For Raspbian:  
Check /etc/network/interfaces and ensure that you have the Wi-Fi details configured.

This can be done in either the interfaces file, or it can be linked to another file via the wpa-roam or wpa-conf parameters in /etc/network/interfaces

Verify the details for the network are correct, SSID and PSK need to be exactly right for the Wi-Fi NIC to connect to a network.

If you have changed the details, run **sudo ifdown wlan0 && sudo ifup wlan0** to use the new settings.  
  
These settings will be applied when the Wi-Fi starts up.

**4a) Wi-Fi Not Connecting on Startup**  
If the Wi-Fi works when you run ifup wlan0, but doesn't come up when you reboot the Pi, we'll need to check the file /etc/network/interfaces again.

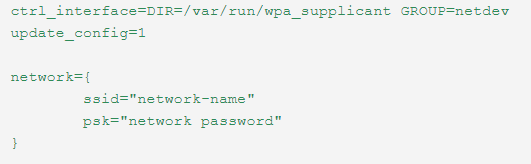
Look for any lines that have auto at the beginning and see if you see one that has 'auto wlan0'.

If not, then add that line in. This line directs the Pi to connect to bring up the Wi-Fi NIC automatically, which in turns triggers the Wi-Fi NIC to connect to the Wi-Fi network.

**4b) How do I configure the Wi-Fi Settings**  
By default, Raspbian has in /etc/network/interfaces this line:



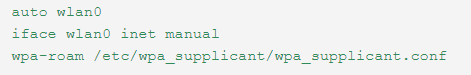
The contents of the file should look something like this:



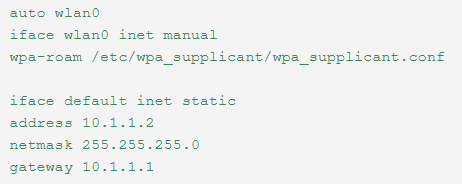
If it doesn't, or if it has the wrong details, updating the details here will let the Wi-Fi Adapter connect.

**4c) How do I configure Wi-Fi to use a Static IP address**

In /etc/network/interfaces, there should be these lines



To make it use a static IP address, we need to add a few lines, and change dhcp to static, and then it should look like this:



That block will bring up wlan0 on startup, connect to the Wi-Fi network that's detailed in wpa\_supplicant.conf, and set an address of 10.1.1.2

**4d) Make Sure the Wi-Fi Network Can Be Detected**

If the Pi still won't connect, make sure the Pi can see the Wi-Fi Network  
  
This can be done with the wpa\_cli command, but this needs to be run as root



That should show a list of available Wi-Fi networks, and if yours isn't on the list, then you may need to adjust the location of the Pi or the Wi-Fi router.

## USB Stick not detected on RPI

There have been times, when the Memory Stick (Pen Drive or any other fancy name you call it by), isn’t mounted on RPI board. This happens despite the number of times you format the pen drive on your Windows or Mac machine. Of course, there is mostly no trouble observed if you are using a Linux machine to format the media.

Solution:

* 1. Insert the pen drive in RPI USB slot
  2. Boot to RPI shell prompt
  3. If memory stick is functioning (working one), the device would be seen under /dev/sd[x]
  4. Confirm [x] via typing following command

**$ dmesg | grep sd**

Let’s say only one USB storage is connected, so you may see something like **/dev/sda**

* 1. Let’s now make a filesystem on previously identified pen drive

$ mkfs.msdos -I /dev/sda

* 1. Mount the device using following command

$ mount -t vfat /dev/sda /mnt

* 1. Pen drive contents are now available under /mnt folder

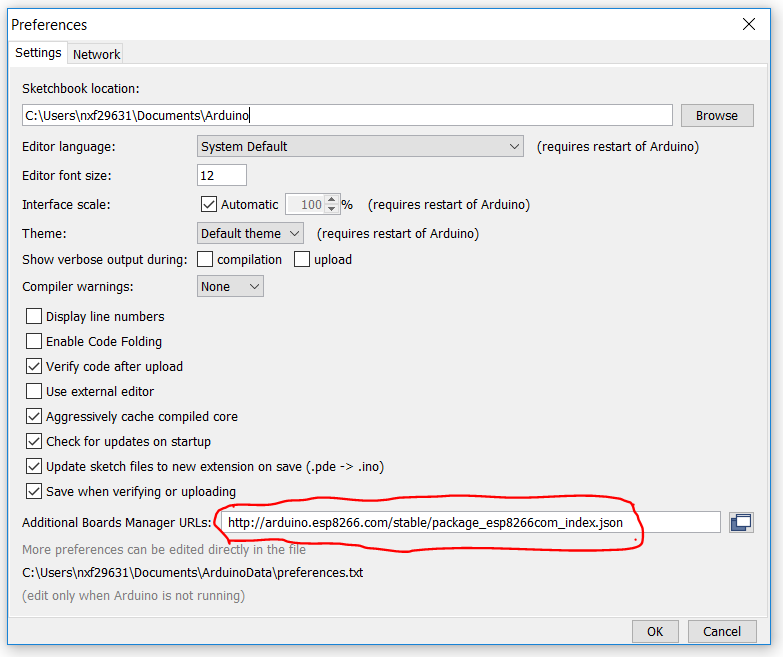
## Installing LoLin ESP8266 Board Configs in Arduino IDE

Follow below step(s) to install ESP8266 library to work in Arduino IDE environment.

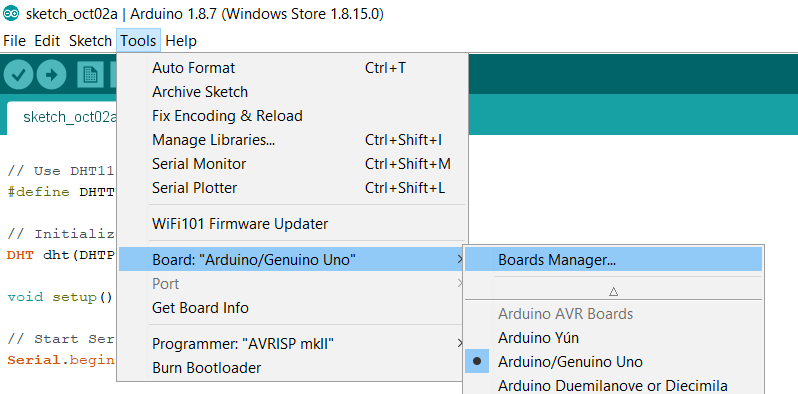
1. Install the latest version of Arduino IDE. <https://www.arduino.cc/en/Main/Software>

2. Install the ESP8266 Board Package

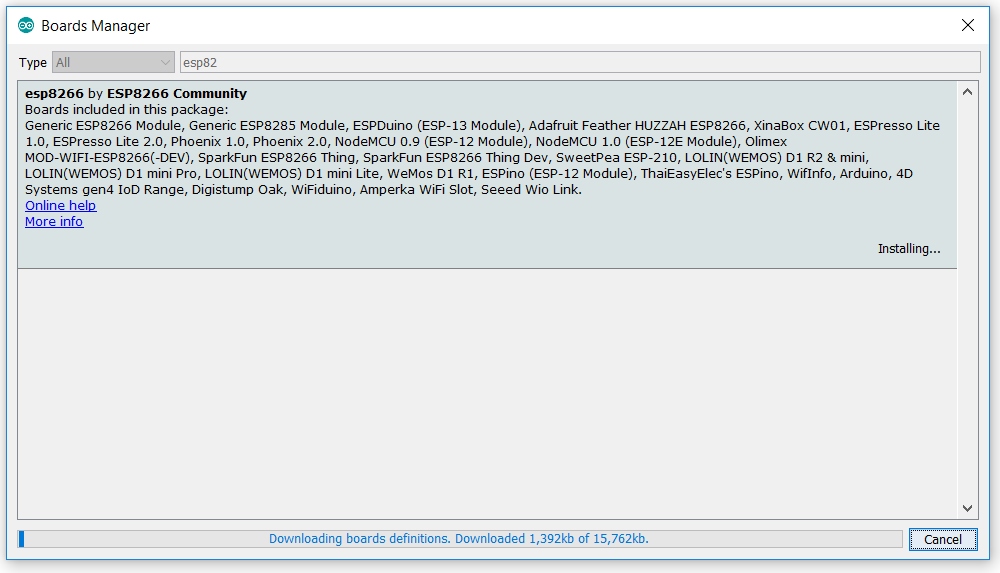
Enter **http://arduino.esp8266.com/stable/package\_esp8266com\_index.json** into Additional Board Manager URLs field in the Arduino IDE preferences.

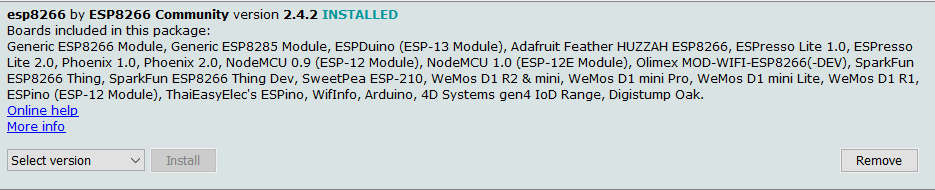


3. Next, use the Board manager to install the ESP8266 package.



4. Search for “esp8266”, and install **“esp8266” by ESP8266 Community**



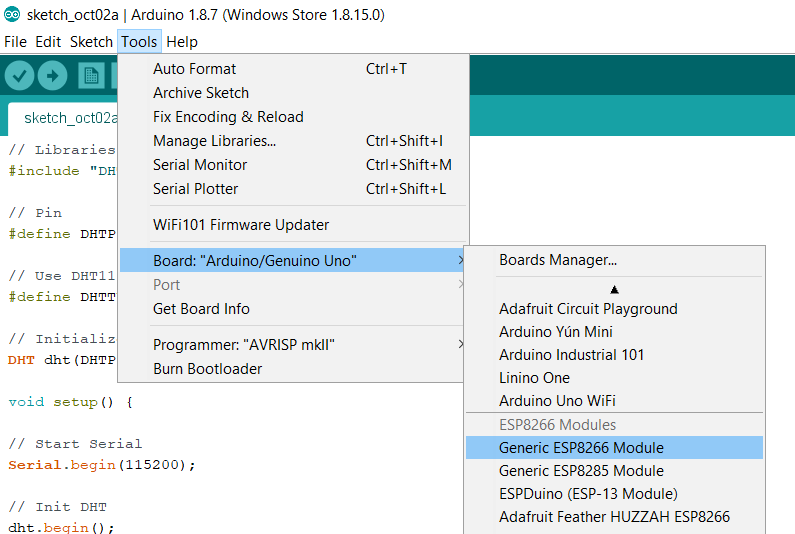


**Precautionary Note:**

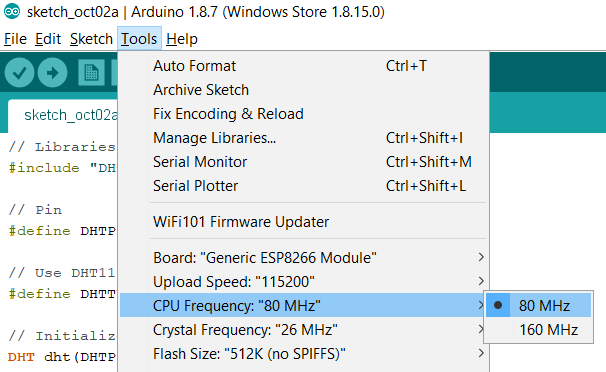
If the you don’t see any search results OR the download doesn’t start for some time, ensure that you are not behind an Office Firewall or VPN connection. (I had to close down my Cisco VPN, before the download started for me.)

5. Restart Arduino IDE.

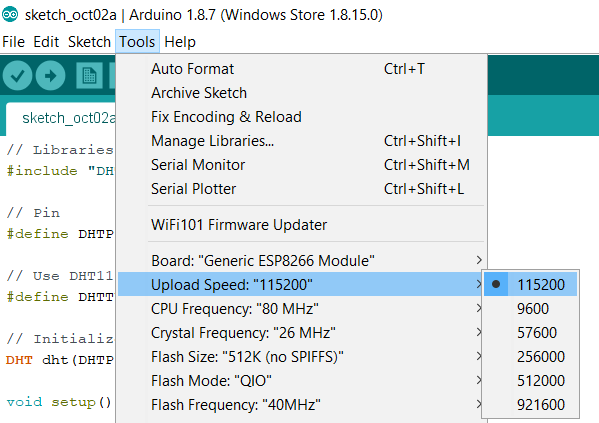
When you've restarted Arduino IDE, select ‘**Generic ESP8266 Module**’ from the ‘Tools’ -> ‘Board:’ dropdown menu.

****

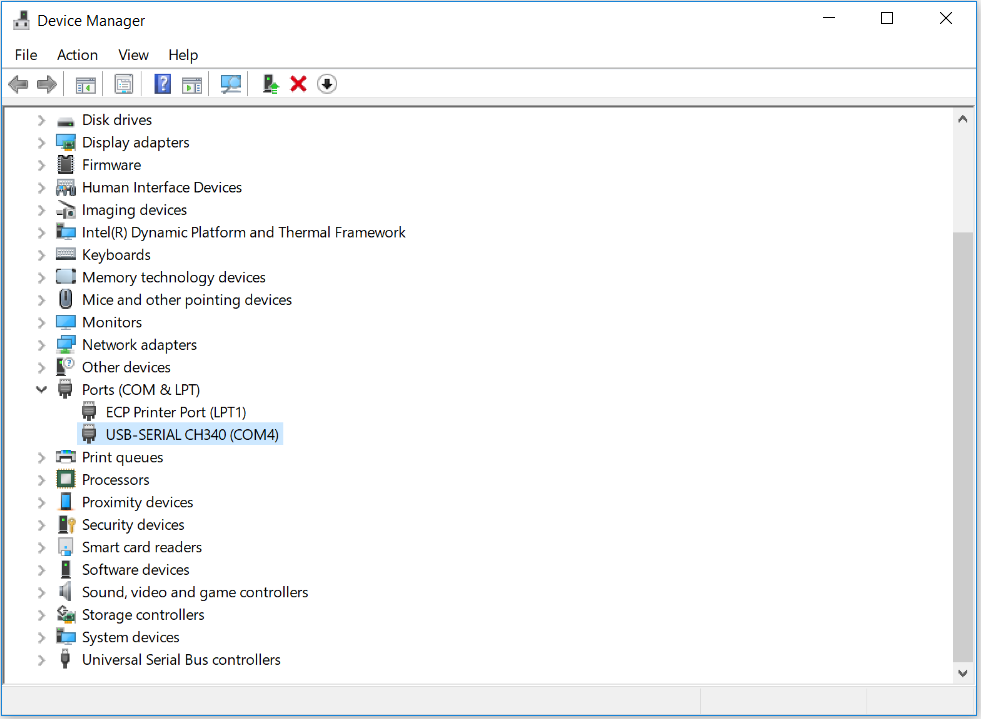
**6.** Select 80 MHz as the CPU frequency (you can try 160 MHz overclock later)

****

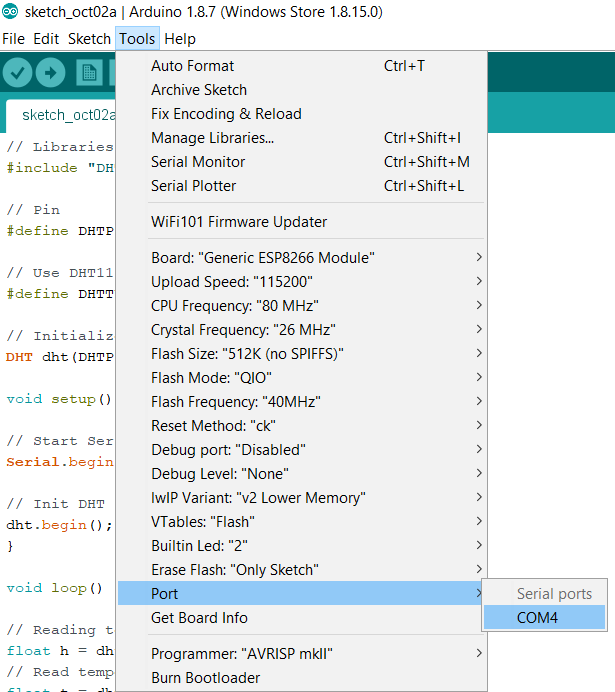
**7.** Select ‘115200’ baud upload speed is a good place to start - later you can try higher speeds

****

**8.** Go to your Windows ‘Device Manager’ to find out which Com Port ‘USB-Serial CH340’ is assigned to.



**9.** Select the matching COM/serial port for your CH340 USB-Serial interface.

****

Note:

If this is your first time using CH340 “**USB-to-Serial**” interface, please install the driver first before proceeding with the above Com Port setting.

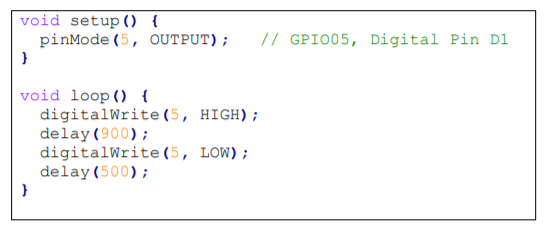
The CH340 driver can be download from the below site:

<https://github.com/softwaresunleashed/rpi_iot_kernel/tree/devel/documents/Datasheets/ESP8266/drivers>

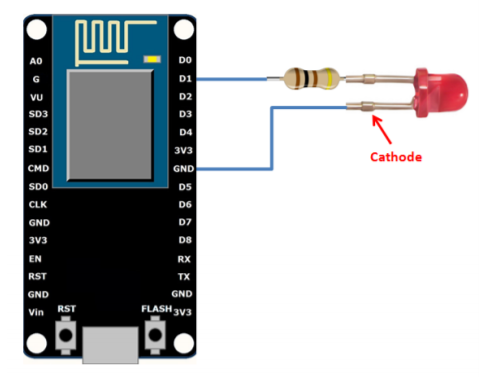
## Flash Sketch Code (LED Blink Test) in ESP8266 using Arduino IDE

Following section explains how to upload a sketch / code to Arduino based ESP8266 MCU Node.

Enter this code into the sketch window. A sketch window is where you type in your Arduino based code.



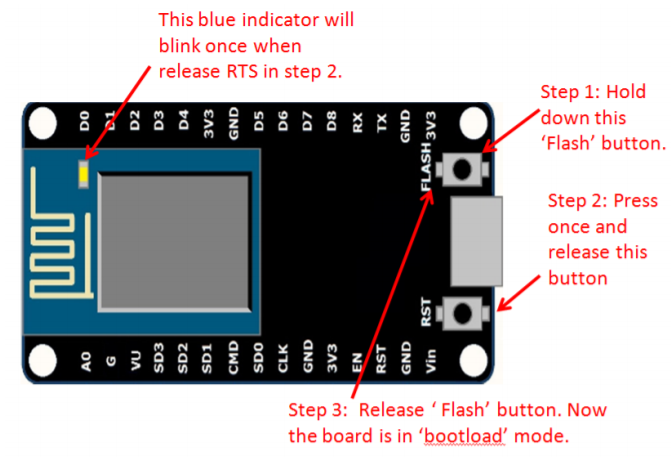
**Connect a LED as shown in Figure.**



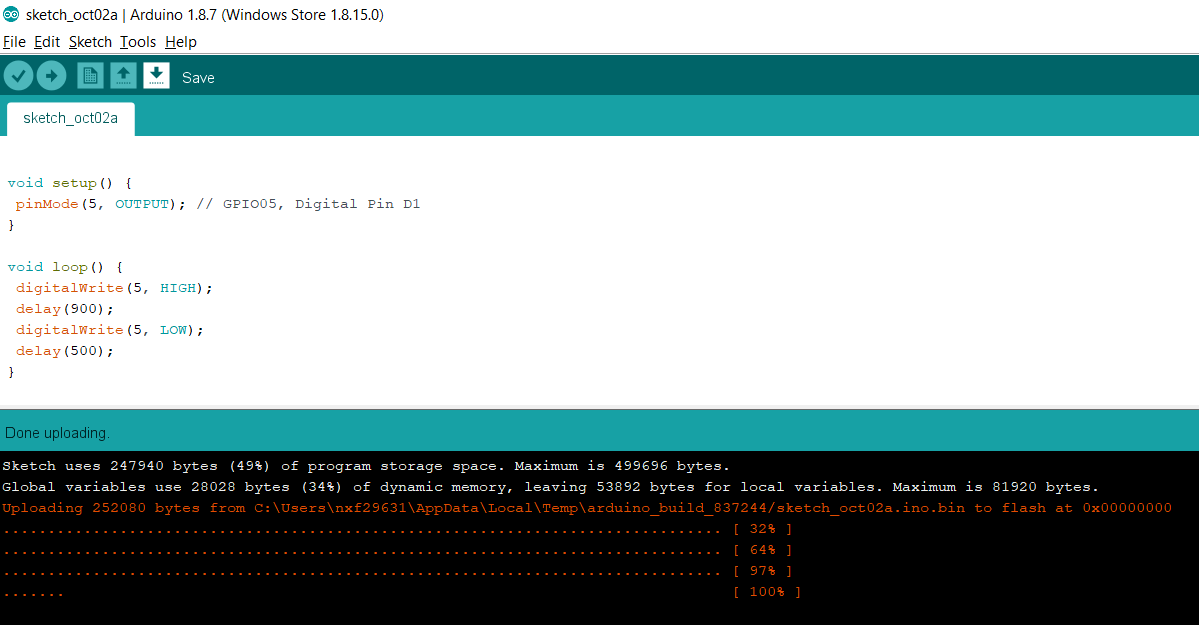
**Steps to upload code:**

Put the board into bootload mode. You'll have to do this before each upload. There is no timeout for bootload mode, so you don't have to rush!

1. Hold down the ‘Flash’ button.
2. While holding down ‘ Flash’, press the ‘RST’ button.
3. Release ‘RST’, then release ‘Flash’
4. When you release the ‘RST’ button, the blue indication will blink once, this means its ready to bootload.



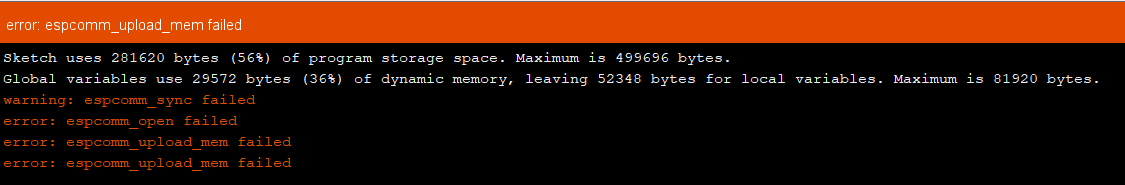
**Successful Flash Snapshot**



## Error While Flashing on Arduino / ESP8266 Wi-Fi Node MCU

**Problem:**

While flashing code on Arduino / ESP8266, if we are continuously getting the following error.



**Solution:**

Check the following –

* 1. Serial console or any other application is not currently using the COM port where Arduino based ESP8266 is connected.
  2. There is no active connection to ESP8266 board, i.e. no slave device is connected to the board which may interfere in download process.
  3. Isolate ESP8266 board and then Unplug and Plug power cable (USB cable) to ESP8266 board and try flashing code again.

## Temperature sensor reporting invalid or constant temperature

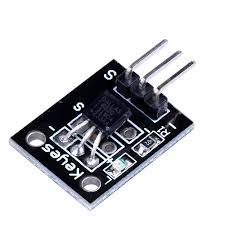
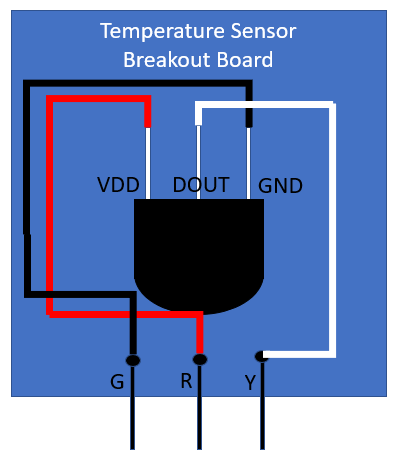
If temperature sensor is not reporting valid temperature on serial port, following could be the possible reason(s). Check if :

1. Power (Voltage / Current) is applied as per required values mentioned in the Temperature sensor datasheet. Typically, the voltage requirement is 3.3V to 5V.
2. Connections are proper. There are few temperature sensor breakout boards available in the market, like the one used in IoT projects section (snapshot below).

Here the mapping between Temp IC and Headers may not be straight forward. You must ensure the IC pins to external header’s mapping using “Continuity” feature on any standard multimeter.

If “Continuity” feature isn’t available on your multimeter, you can check for resistance between IC pins and header pins. The two pins that are connected shall show minimal (close to Zero) resistance.

Refer to block diagram below for mapping

## sudo: npm: command not found

If “npm” package isn’t installed on RPi, then you will get following error message. This error can be fixed by installing NPM package on RPi by executing following command(s) on RPi shell.

$ sudo apt-get update

$ sudo apt-get dist-upgrade

$ sudo apt-get install npm

Be patient, these steps can take a while to finish.

## Installing node.js on Raspberry Pi

[ http://node-arm.herokuapp.com/ ]

Steps to install NodeJS on RPi:

1. Open the link in web browser - <https://nodejs.org/dist/latest/>
2. Note down the latest version of NodeJS at this link. If you are running Linux on older models of RPi, choose the file (or select otherwise) -- node-vXX.XX.X-linux-armvXX.tar.gz
3. wget <https://nodejs.org/dist/latest/node-vXX.XX.X-linux-armvXX.tar.gz>
4. tar -xvf node-vXX.XX.X-linux-armvXX.tar.gz
5. cd node-vXX.XX.XX-linux-armvXX
6. sudo cp -R \* /usr/local/

To check Node.js is properly installed and you have the right version, run the command

$ node -v

and it should return the currently installed version – v10.12.0 (as of this writing)

## Can not write Images to corrupted SD Card

There were times when Etcher failed to write images onto corrupted SDCards. Then came Raspberry Pi’s Official Imager software to rescue. It even formatted the card seamlessly (which I was struggling to format on my MacBook).

Use **Raspberry Pi Imager** for an easy way to install Raspbian and other operating systems to an SD card ready to use with your Raspberry Pi:

Download Links :

<https://downloads.raspberrypi.org/imager/imager.exe> [ Windows ]

<https://downloads.raspberrypi.org/imager/imager.dmg> [ Mac ]

<https://downloads.raspberrypi.org/imager/imager_amd64.deb> [ Ubuntu ]

Snapshots :

A screenshot of a cell phone

Description automatically generated with medium confidenceA screenshot of a cell phone

Description automatically generated with medium confidence

A screenshot of a cell phone

Description automatically generated with medium confidenceA screenshot of a cell phone

Description automatically generated with medium confidence

## Installing Linux Headers on Raspberry Pi

For Linux Device drivers development, it is necessary to install Linux headers, be it cross-compilation on host machine or directly on target device (Raspberry Pi in our case).

**Easy Way**

If you have cloned the entire kernel from github, the headers are already included in the source tree. If you don't need all the extra files, it is possible to install only the kernel headers from the Raspbian repo.

**$ sudo apt install raspberrypi-kernel-headers**

Note that it can take quite a while for this command to complete, as it installs a lot of small files. There is no progress indicator.

On Debian, Ubuntu and their derivatives, all kernel header files can be found under /usr/src directory. You can check if the matching kernel headers for your kernel version are already installed on your system using the following command.

**$ ls -l /usr/src/linux-headers-$(uname -r)**

**Alternate Way**

Before you can install the appropriate kernel headers, update your packages index, in order to grab information about the latest package releases, using the following command.

$ sudo apt-get update

Then run the following command that follows to install the Linux Kernel headers package for your kernel version.

$ sudo apt-get install linux-headers-$(uname -r)

Ensure if Linux headers are installed properly, re-run following command and see if the output is non-empty.

$ ls -l /usr/src/linux-headers-$(uname -r)

If you still don’t see linux headers installed, follow along :

Check the Source.list file to contain the repository entries.

$ sudo vi /etc/apt/sources.list

Uncomment line below

#deb-src http://raspbian.raspberrypi.org/raspbian/ buster main contrib non-free rpi

And then 'apt-get update' to enable 'apt-get source'

$ sudo apt-get update

$ sudo apt-get source

## Virtual Box VM could not connect to network

Internet works perfectly on host (Mac OS 64-bit, fully updated) but cannot connect to internet on Guest OS Ubuntu 18.04 (under VirtualBox).

Here are the steps I took to solve my problem:

1. Open **VirtualBox Manager**

A screenshot of a cell phone

Description automatically generated

1. Select the machine you cannot get internet on in the left pane
2. Click the **Settings** button in the top menu
3. Click **Network** in the left pane in the settings window
4. Switched to **Bridged Adapter** in the **Attached to** drop-down menu
5. Select the name of the network adapter you are currently using on your host machine. I am using wireless, so I chose en1 which is my wireless network adapter. You can check which adapter you are currently using by opening the terminal (CTRL+ALT+T by default) and running ifconfig / ipconfig. It will probably be the en’x’ adapter that shows an inet addr and shows data transfer next to RX bytes.
6. Under **Advanced**, make sure the machine is using the **Desktop Adapter Type**
7. Under **Advanced**, make sure **Promiscuous Mode** is set to **Allow VMs**
8. Under **Advanced**, make sure **Cable connected** is checked on
9. Hit **OK** to save your changes (check snapshot below).
10. Restart your VM.

A screenshot of a social media post

Description automatically generated

## Couldn’t SSH to Ubuntu running on Virtual Box VM

The SSH server is not installed by default on Ubuntu desktop systems but it can be easily installed from the standard Ubuntu repositories.

To install and enable SSH on your Ubuntu system complete the following steps:

1. Open your terminal either by using the Ctrl+Alt+T keyboard shortcut or by clicking on the terminal icon and install the openssh-server package by typing:

$ a

$ sudo apt install openssh-server

Enter the password when prompted and enter Y to continue with the

installation.

A screenshot of a cell phone

Description automatically generated

1. Once the installation is completed, the SSH service will start automatically.
2. To verify that the installation was successful and SSH service is running type the following command which will print the SSH server status:

$ a

You should see something like Active: active (running) :

A screenshot of a cell phone

Description automatically generated

Press q to get back to the command line prompt.

Ubuntu comes with a firewall configuration tool called UFW. If the firewall is enabled on your system, make sure to open the SSH port:

$ sudo ufw allow ssh

A picture containing drawing

Description automatically generated

Now that SSH is installed and running on your Ubuntu system you can connect to it via SSH from any remote machine.

## Increasing VDI disk size in Virtual Box

In Virtual Box, we have the luxury to create dynamic disks. By dynamic disk we refer to disks that have a physical size and a virtual size. Dynamic disks start with minimum virtual size and can expand till the max size, as and when user keeps installing new apps or source code. This certainly has an advantage of saving host machine’s disk space till the time you don’t need it. (as opposed to fixed-size virtual box disk image .VDI ).

Now, times can come when even this dynamic size disk may need to be upgraded to bigger sizes. Recently, I had to do this as 50GB was not sufficient for Building Ubuntu Kernel’s Source Code, since I had many more packages already installed.

**Caution** : Keep a copy of your VDI file before trying out following steps. In case today isn’t your best day, you may revert back to backup copy.

This section describes the procedure on how to do so :

1. Shutdown VM and quit **VirtualBox**.
2. Open the terminal and go to the below path of VirtualBox installation on your MacOS (default location). From here you can run the command to resize the **VDI** file.

$ cd /Applications/VirtualBox.app/Contents/Resources/VirtualBoxVM.app/Contents/MacOS

1. Locate location of VDI file that we need to increase size of , and execute the following command :

$ pwd

/Applications/VirtualBox.app/Contents/Resources/VirtualBoxVM.app/Contents/MacOS

$ VBoxManage modifyhd --resize 25600 /Users/sudhanshu/VirtualBox\ VMs/ UbuntuHDD /UbuntuHDD.vdi

0%...10%...20%...30%...40%...50%...60%...70%...80%...90%...100%

1. Now, when you’ll check the size, execute following command :

$ VBoxManage showhdinfo /Users/sudhanshu/VirtualBox\ VMs/UbuntuHDD/UbuntuHDD.vdi

UUID: 3b334533-31c4-45d7-bd6c-af4cd0f93bb3

Parent UUID: base

State: locked write

Type: normal (base)

Location: /Users/sudhanshu/VirtualBox VMs/UbuntuHDD/UbuntuHDD.vdi

Storage format: VDI

Format variant: dynamic default

Capacity: 102400 Mbytes **<< From 50GB to 100 GB**

Size on disk: 46042 MBytes

Encryption: disabled

In use by VMs: UbuntuHDD (UUID: 8c04f9aa-f896-438a-a3f4-0c9319b2449c)

1. And It’s done. Just open the VirtualBox and start VM using the same
2. Now, to allocate Additional Space Size In Virtual Machine Guest OS (Ubuntu Machine), Use Ubuntu Disks Utility Tool as described below :

* Start and login into Ubuntu OS (in VirtualBox VM).
* Then search keyword disk in Show Applications area ( Click the bottom left icon in ubuntu desktop to show applications).



* Click the Disks utility tool to open it. Click the VBOX hard disk in left, then you can find the unallocated disk space ( Free Space ) in right.
* Click the **Additional partition options** icon ( the third icon ) at Volumes bottom. Then click **Resize…** menu item to open the **Resize Volume** popup dialog. You can change the disk volume space size in it.

1. If everything works well for you, then you can delete the backup VDI we made in the beginning of the section.

# Further Reading

|  |
| --- |
| Reference Links |
| <http://elinux.org/RPi_Kernel_Compilation> |
| <http://elinux.org/RPiconfig> |
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| <https://www.raspberrypi.org/> |
| <https://www.raspberrypi.org/resources/learn/> |
| <https://www.raspberrypi.org/documentation/linux/kernel/building.md> |
| <https://www.raspberrypi.org/documentation/remote-access/ssh/> |
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| <http://www.howtogeek.com/276468/how-to-use-a-raspberry-pi-as-a-networked-time-machine-drive-for-your-mac/> |
| <http://www.howtogeek.com/138281/the-htg-guide-to-getting-started-with-raspberry-pi/all/> |
|  |
|  |
| <https://superuser.com/questions/326211/best-way-to-transfer-files-over-a-lan-between-two-linux-computers> |
|  |
| How to resize a VirtualBox VDI file on Mac OS  <http://www.nilinfobin.com/misc/how-to-resize-a-virtualbox-vdi-file-on-mac-os/> |
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# Legends

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|  |  |
| RPi | Raspberry Pi |
| SoC | System on Chip |
| VC | Video Core |
| NFC | Near Field Communication |
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# Revision History

|  |  |  |
| --- | --- | --- |
| Date | Version | Remarks |
|  |  |  |
| 03 Apr 2020 | 1.5 | Added section on increasing VDI disk size for VirtualBox |
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