

Gertboard Assembly Manual

Rev 1.1

The Gertboard is an add-on GPIO expansion board for the Raspberry Pi computer. It comes with a large variety of components, including buttons, LEDs, A/D converters, DACs, a motor controller, and an Atmel AVR microcontroller. This version is an assemble-it-yourself kit. You're going to be doing a great deal of soldering! If you are a beginner to soldering, we suggest that you practice on ordinary through-hole components before you tackle this board. Then when soldering SMD (Surface Mount Devices) parts start with R23, the big 0.1 Ohm resistor, then try the 10uF capacitors and then progress to the smaller components. As a word of comfort: all SMD components are resistors and capacitors. This means that it is very, very difficult, to overheat them when soldering.

Throughout building the board I suggest you check against the picture on the next page which shows a fully assembled board.

Working with Weller and element14 I have produced some instructional videos to help you. You can view these at www.element14.com/raspberrypi

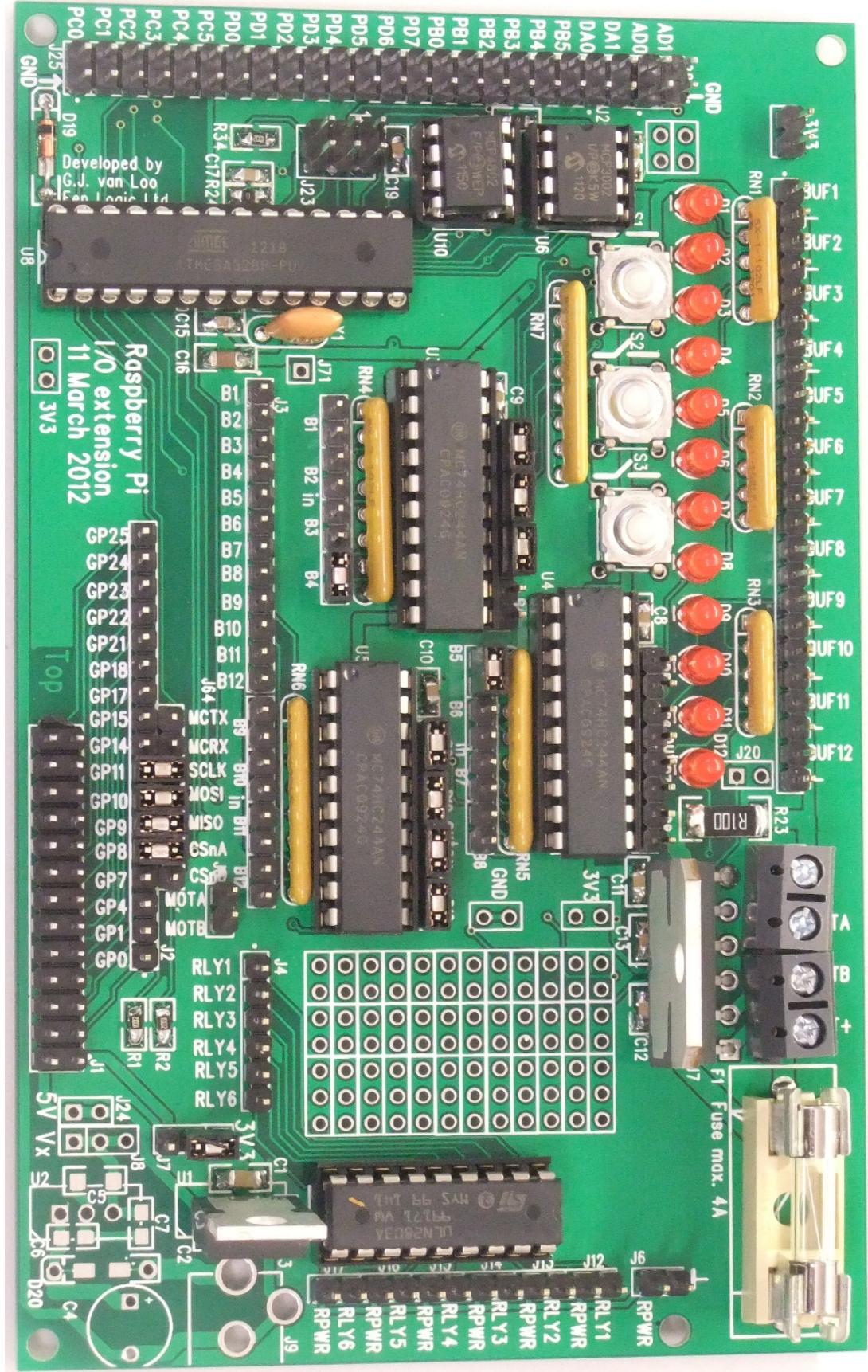


Fig.1 Fully assembled board including jumpers.

Introduction to soldering

To assemble the Gertboard, a few basic tools are going to be required. You might already have some of these in your tool kit, but if you are interested in electronics, they will be worth the investment for future projects:

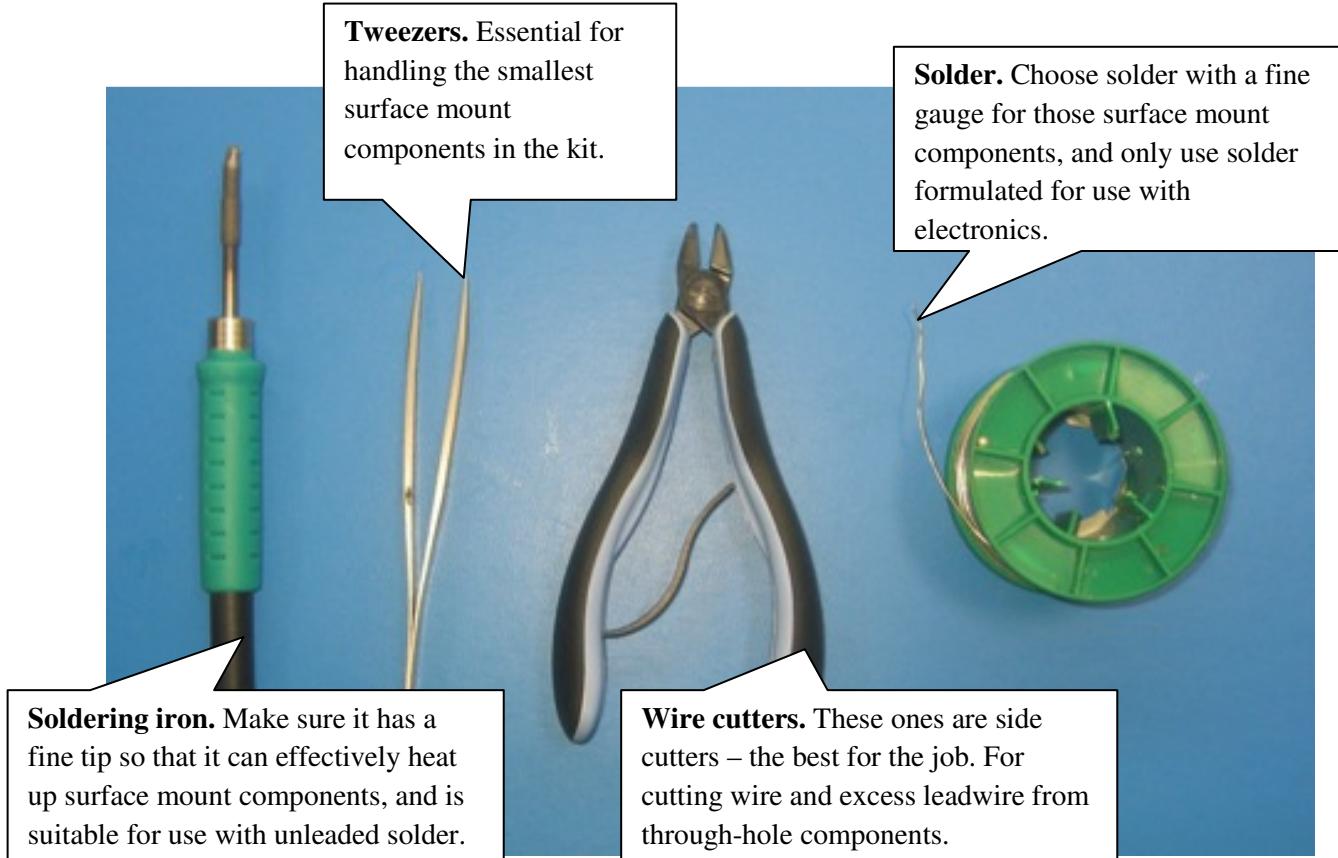


Fig.2: A good basics set of tools and materials to help assemble Gertboard.

It's worthwhile mentioning a few practical and safety tips at this point as well:

- Molten solder, and the soldering iron itself, are very hot! Even the best engineers occasionally come into contact with either, or both. Treat any such contact as a burn, and treat according to best first aid practice. Hold the burn under running cold water as soon as possible. If the burn is serious, seek medical help as soon as possible.
- Soldering should always be performed in a ventilated room. The fumes from molten solder, and the flux it contains, can be harmful if inhaled over a sustained period of time. Normal use however, is quite acceptable. Take sensible measures, and make sure the fumes are not inhaled, and the room is airy and ventilated.
- The workspace you choose to work in should be well lit, clean, and well organised, allowing you to work in a logical and methodical way.
- The golden rule of soldering: heat the component, then apply the solder to the joint, withdraw the solder, remove the heat.
- Wash your hands after handling solder.

Some Additional Items

The following items are very useful and I recommend them in the order of their usefulness:

A good knife

A sharp knife is useful to get SMD components out of their packaging. I have a very good scalpel (top). But a standard hobby knife (below) will do as well.

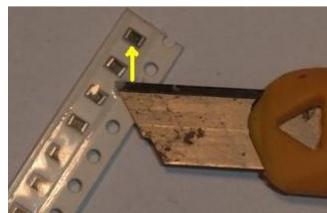


Fig. 3: Close up showing how a hobby knife is used to release a surface mount component from its tape package.

You slip the tip of the knife under the plastic which keeps the components in place. Then slide it up.

Sponges

Simple, standard kitchen sponges. They are very useful for keeping through-hole components in place as you turn the board over to solder them. (Watch the video!) First you put the components in their holes. Next you place the sponges on top. Hold it all together and turn your board (including the sponge) upside-down. You can now solder the components.



Fig.4: Sequence showing how a sponge stops components fall out of the printed circuit board as you turn it over for soldering.

Digital Multi-meter.

If you intend working with electronics in the future, a digital multi-meter is recommended. These days you can buy a good digital multi-meter at low cost. It allows you to check your circuit to give you the confidence that all is well before you apply power. It also helps you find errors when you find that something isn't working properly. You can also use it in daily life to check light bulbs are working, test the state of batteries, or find if a fuse is fine or has blown.



Fig. 5: Such great value today, and so essential, a DMM as a minimum allows you to quickly measure voltage, current and resistance.

Solder braid.

Solder braid is useful for removing solder when you realise you have made a mistake, and need to remove a component. To use solder braid, you push the copper wire on the excess solder with the soldering iron. When the solder melts the copper braid will absorb any excess solder. Be aware that you have to heat the solder braid as well as the circuit board. That may take a while. Just keep patient. What also helps is to cut-off any braid which has already been used. Then only the tip of the braid needs to be heated when you use it.

Caution! The braid can get very hot.



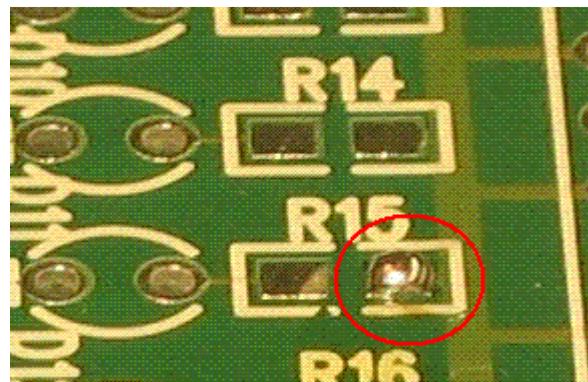
How to solder Surface Mount components.

Surface mount components look really challenging to place and to solder on to the board. However, it is not that difficult if you follow these steps. I will show you how to solder a SMD resistor down.

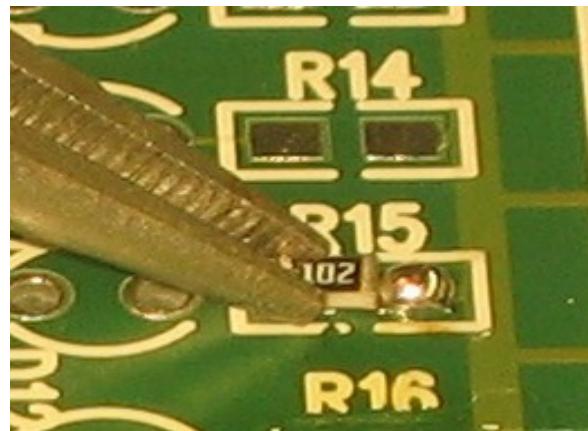
In this case, it is a 1K resistor in an 0805 package. (Note: The pictures are from an older version of the Gertboard). If you are interested in electronics and want to make your own, surface mount components cannot be avoided.

Start with putting a small amount of solder on one of the connections. This is called “tinning”. Here is a close up of the board where that has been done.

You see two locations on the board where a resistor is to be mounted. The top one (R14) has not been touched. The bottom one (R15) has a small additional amount of solder on the right hand side to form a slight dome.



Use tweezers to pick up the resistor. Pick it up so you have about half or 2/3 of it sticking out. Place the resistor just *adjacent* to the dome of solder. Do not push the resistor on the solder dome yet. If the right side has lifted give it a light tap with the soldering iron to make it lay flat again. (For resistors you normally have the black side up so you can read the text. But don't worry: it will work just as well if you solder it upside down).



Heat up the solder. The best way to do this is to keep the soldering iron as close to the edge of the pad as possible, while still touching the solder. Then, when the solder has melted push the resistor into the melted solder pool.

As you can see you do not need a small solder tip for the raspberry-Pi extension board as all the structures are rather large. The next step is to remove the solder iron *but keep your resistor in place*.

You have to wait till the solder has hardened. Only then can your tweezers be removed.

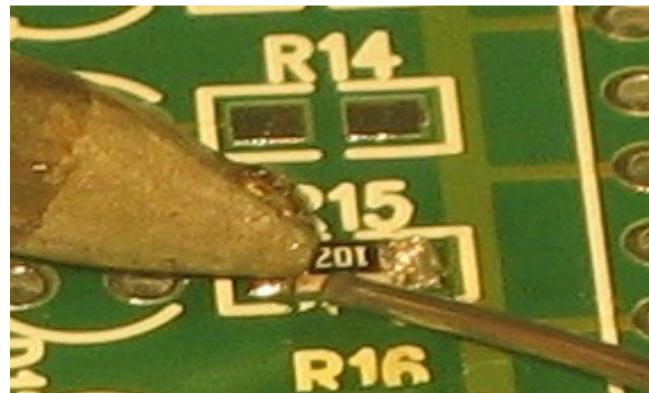
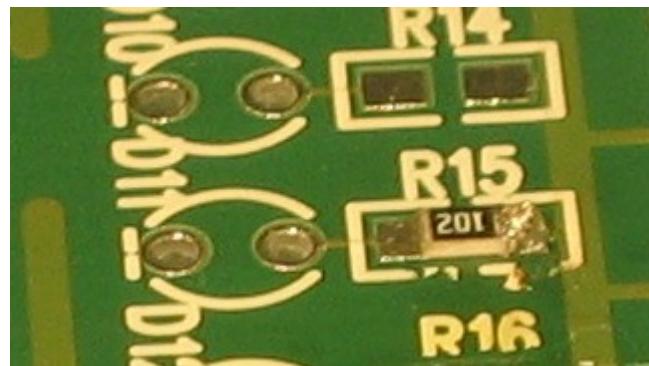


After you have done that, the board will look like this, with the resistor in this case soldered in place by its right hand connection.

The solder joint itself should be shiny and rounded, and should clearly make an even connection between the pad, and the metallic contact of the component. The joint shown here isn't perfect – try to aim for perfect!

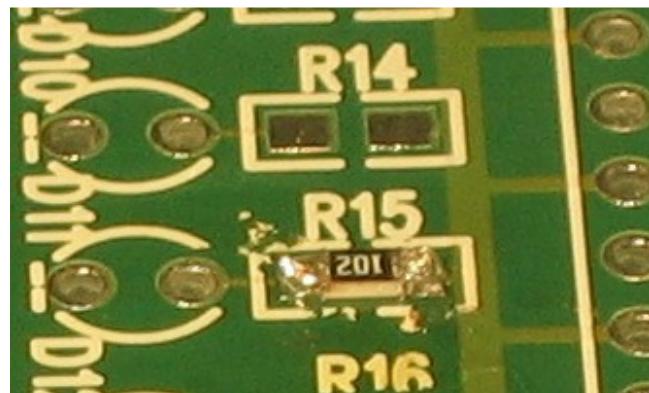
Now you have to solder the left hand side. For this you use the normal solder method:

- 1/ Solder iron in
- 2/ Solder in
- 3/ Solder out
- 4/ Solder iron out



The result, a fully soldered surface mount resistor.

In this case, it's not a perfect joint as already stated. Try to keep the actual soldering operation, quick, clean and clinical, and aim for the shiny rounded joints as said before.



Assembly.

There are many components on this board and finding the correct place to put any one in particular can be challenging. The assembly diagrams will help you find the right locations. For example, all the 100nF capacitors on the surface mount diagram below are marked with black rectangles.

Board orientation: When assembling, orientate the bare board as below:

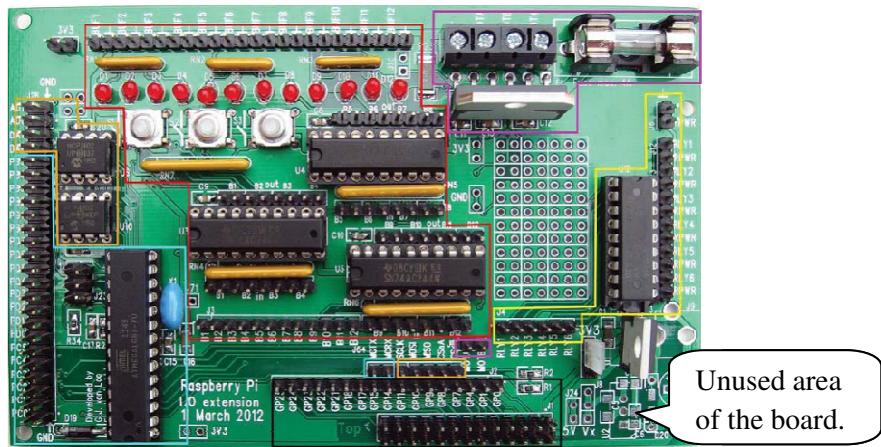


Fig 6: Proper orientation of the fully assembled Gertboard that will be used when describing locations on the board.

The fuse should be top right, and the marking “Raspberry Pi, I/O Extension, 11 March 2012” should be at the bottom of the board. In this guide, position indicators will refer to places like *top left*, but with respect to the board in *this orientation*. The position indicators are just that: *indicators*. They only give a direction of where to look.

Note: one corner of the board (the lower right) is not being used. Thus none of the following components should be installed: J8, J9, J24, C4, C5, C6, C7, D20, U2.

The easiest way to assemble the board is from the component with the lowest height to the component with the largest height. Start with all the surface mount components.

Components

First of all: some bags may have more components than required. This is just a result of the minimum packing size¹. Second: components can differ in appearance. What you see in the manual are typical representatives.

Most components are easy to recognize, for example the motor controller. Others are totally indistinguishable from each other. For the latter you have to refer to the label on the bag in which they

¹ Did you pay too much? Not really. Some parts are so terribly cheap that the biggest cost is in cutting them from a roll, putting them in a bag and adding a label. E.g. 0805 resistors cost 0.001. (Yes: 10 for a pence).

came. This also means that the **multiple component bags should not be unpacked** - because afterwards you will not be able to identify the components at all.



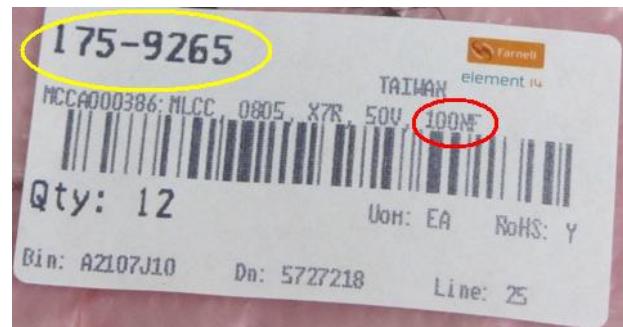
Fig. 7: Don't unpack multiple component bags! Here are two capacitors - one is 100nF, the other is 22nF. Can you tell the difference?

Each bag has a description of what its contents are:

For the more experienced among you: the number in the **RED** oval indicates that contents are capacitors with a value of 100nF.

The number in the **yellow** oval is in this case the Farnell element14 part number.

Going to the Farnell element14 website and specifying this number will give you a page showing all the details of this part, as shown below.



MULTICOMP - MCCA000386 - MLCC, 0805, X7R, 50V, 100nF



Manufacturer: MULTICOMP
Order Code: 1759265
Manufacturer Part No: MCCA000386
[Technical Data Sheet \(620.4KB\) EN](#)

*Image is for illustrative purposes only.
Please refer to product description.*

Product Information

| | |
|---------------------------------------|-----------------------|
| • MLCC, 0805, X7R, 50V, 100nF | |
| • Capacitance: | 0.1 μ F |
| • Capacitance Tolerance: | $\pm 10\%$ |
| • Dielectric Characteristic: | X7R |
| • Voltage Rating: | 50V |
| • Capacitor Case Style: | 0805 |
| • Operating Temperature Range: | -55°C to +125°C |
| • SVHC: | No SVHC (19-Dec-2011) |
| • Capacitor Mounting: | SMD |
| • External Depth: | 1.25mm |
| • External Width: | 2mm |
| • No. of Pins: | 2 |
| • Package / Case: | 0805 |
| • Series: | MLCC |
| • Termination Type: | SMD |

| | | |
|---|--|--|
| These are your 22nF capacitors: | | |
| 10uF capacitors: (Slightly bigger than the other capacitors) | | |
| 0 (zero) Ohm resistors: | | |
| 0.1 Ohm resistor (This one is clearly different from the other components) | | |
| 10K Ohm resistors | | |

Table 1: Description, label and physical appearance of the resistors and capacitors in the Gertboard kit.

SMD components

It is easiest if you start with the components which are low and then build up using components which are higher and higher. So we start with the SMD components.

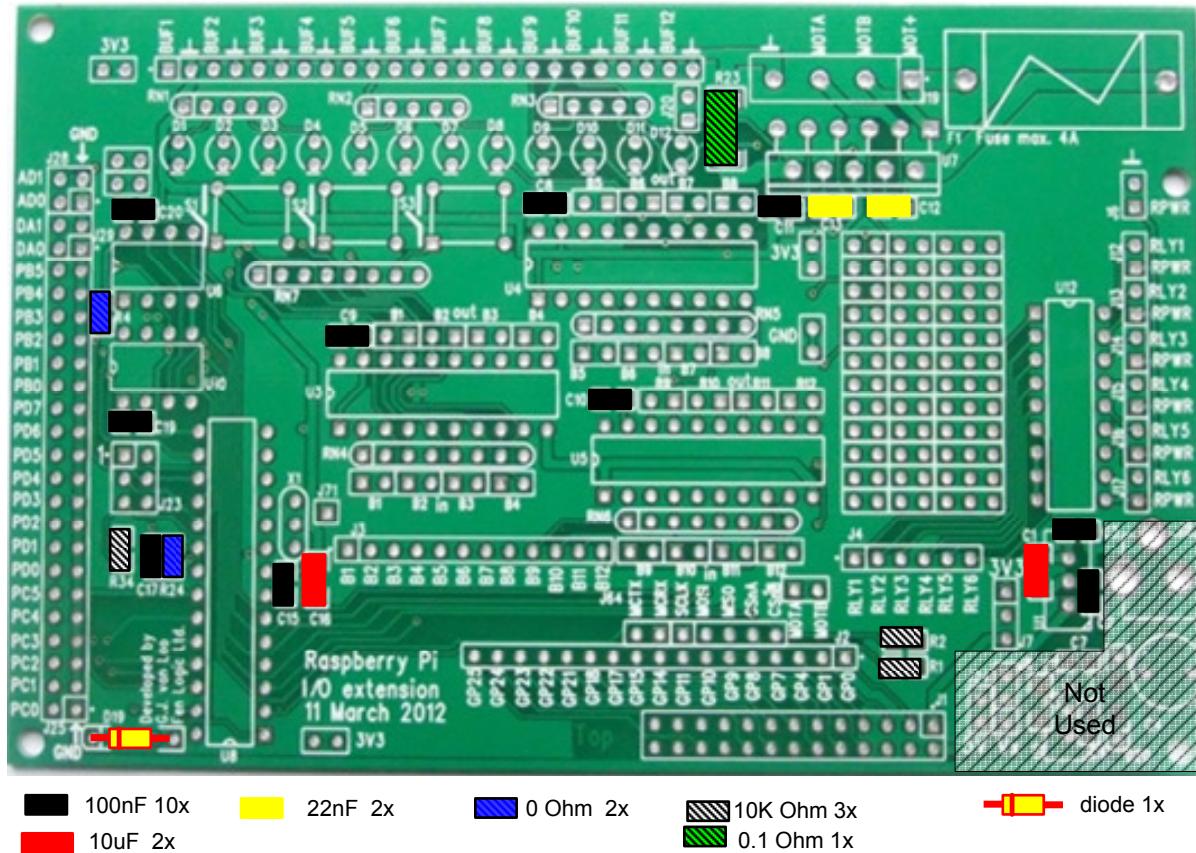


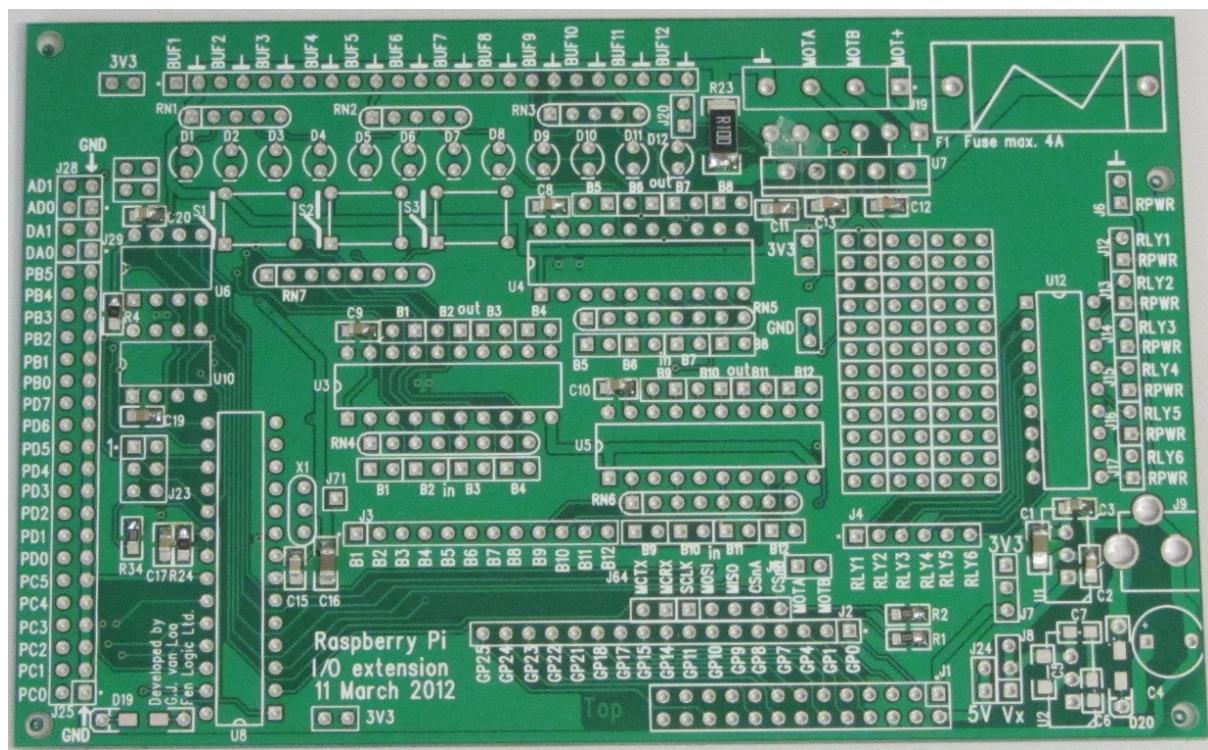
Diagram 1: surface mount components (plus diode)

All SMD components can be soldered in arbitrary direction: there is no special orientation.

The resistors have a top and bottom side. The top side is black with text on it. You can solder them upside down; it just does not look that great.

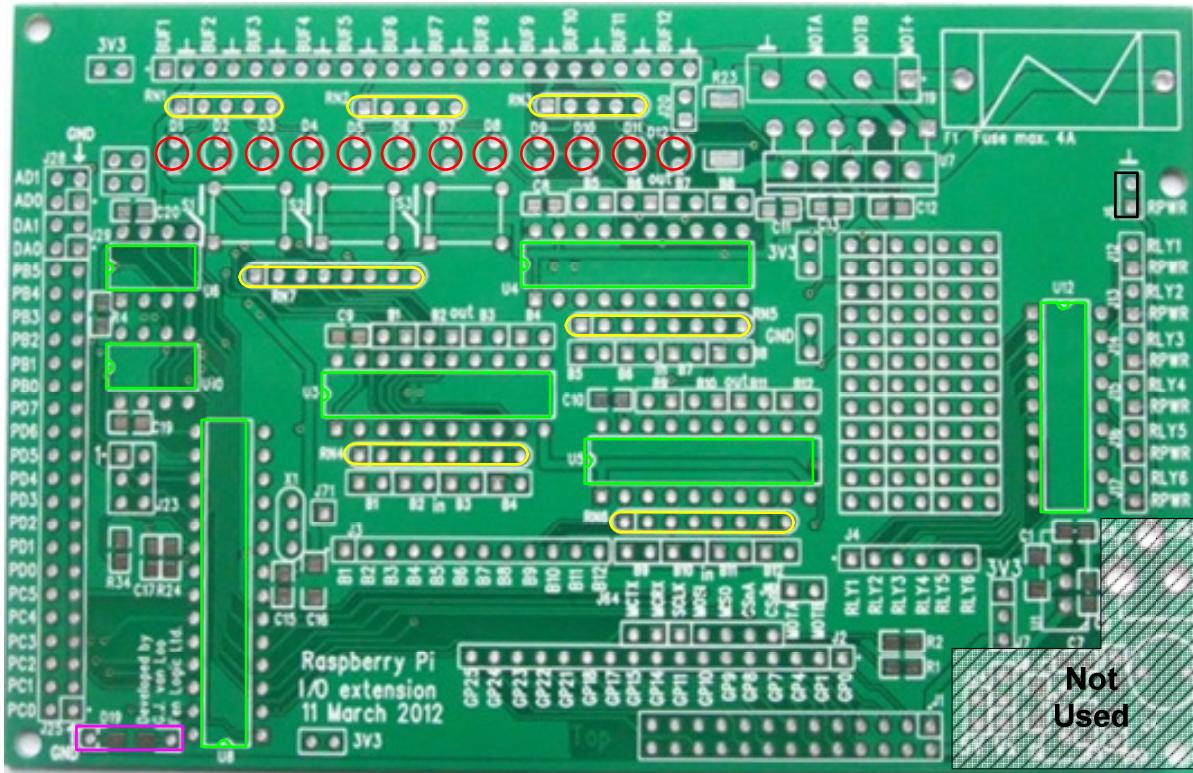
1. 100nF capacitors (Diagram 1: black rectangles). There are 10 of them:
C2, C3, C8, C9, C10, C11, C15, C17, C19, C20
2. 22nF capacitors (Diagram 1: yellow rectangles). There are two on the upper right:
C12, C13.
3. 10uF capacitors (Diagram 1: red rectangle). There are two – one on the bottom right: C1 and one on the bottom left: C16.
4. 10K Ohm resistor (Diagram 1: hatched white rectangle). There are three, one on the left and two on the bottom right. Try to get the black side up.
R1, R2, R34.
5. 0 Ohm resistor (Diagram 1: hatched blue rectangle). There are two on the left. Again the black side up.:
R4, R24
6. 0.1 Ohm resistor (Diagram 1: hatched green rectangle). There is one on the top, just right of the middle. Block (or green) side up:
R23

This is how your board should now look:



Board with SMD components only.

Small components:



- Integrated circuit socket, 8 pins (2x), 18 pins (1x), 20 pins (3x) & 28 pins (1x)
- Light Emitting Diode (LED) 12x
- Resistor array 5 pins (3x) & 8 pins (4x)
- Normal diode

Diagram 2: small components

1. Diode D19 (Diagram 2: purple rectangle). There is one on the bottom left.

This component has a special orientation: Make sure the stripe is pointing towards the left edge of the board



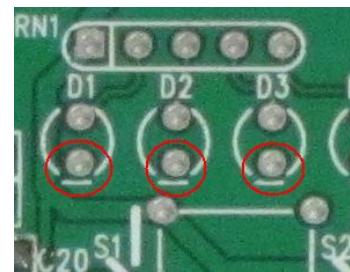
2. Light Emitting Diodes – LEDs (Diagram 2: red circles). These are near the top on the left.

This component has a special orientation: Make sure the **short** wire goes into the hole with the text Dn (e.g. D1, D2) next to it. So if we have the correct board orientation the long wire is at the bottom, and the short wire is at the top.

D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12.

The long wire
goes in the
bottom hole.

[If you want your board to look nice solder only one pin, then orient the LED so it sits ‘straight’ before soldering the second pin.]



3. 5 pin resistor arrays (Diagram 2: yellow round-end rectangles). These are just above the LEDs. *This component has a special orientation*: Make sure the text is towards the LEDs.

RN1, RN2, RN3 :



[Same as with the LEDs: For this resistor array and the 8 pin version below, if you want your board to look nice solder only one pin, then orient the component so it sits ‘straight’ before soldering the other pins.]

4. 8 pin resistor arrays (Diagram 2: yellow round-end rectangles). These are near the centre of the board. There is **no** special orientation

RN4, RN5, RN6, RN7.

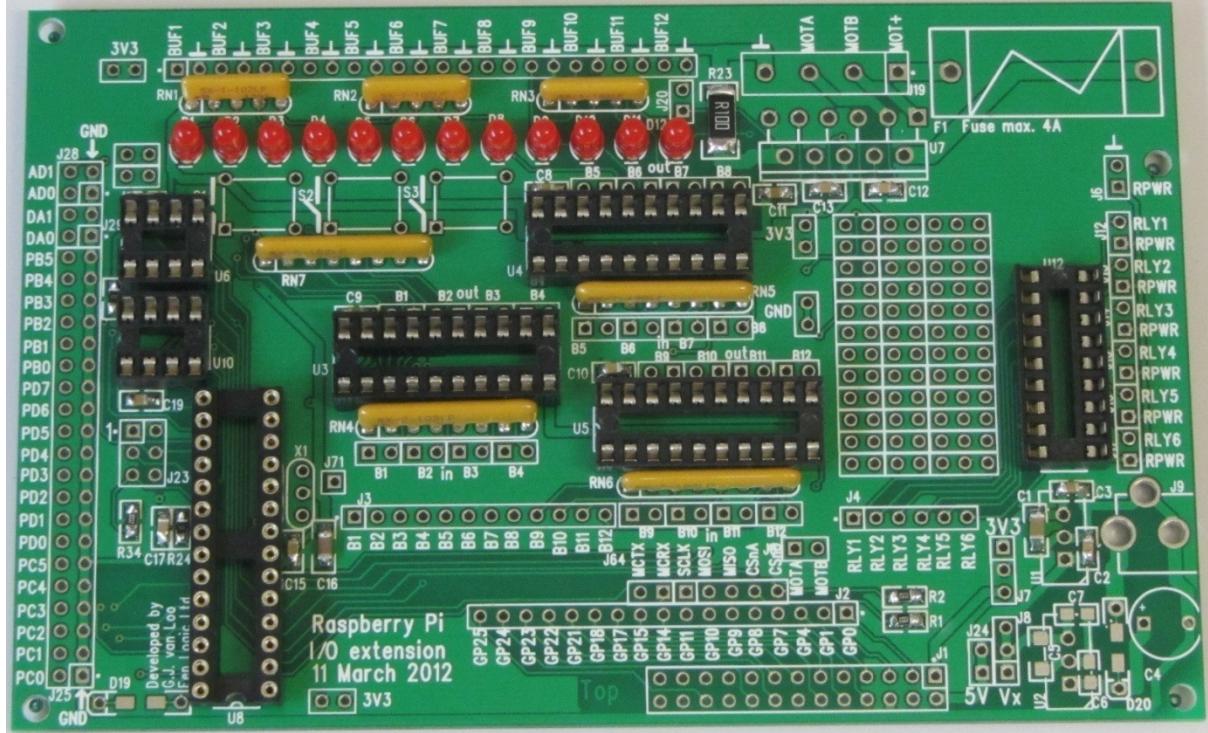


Beware to put them in the right holes! It is easy to slip up and put them in the holes of the headers instead!

IC sockets: (Diagram 2: light green rectangles).*These components have a special orientation*: the sockets have a small notch on one end. That should be above the notch indicator on the board.

- 28 pins:** U8 (bottom, Left)
- 20 pins:** U3, U4, U5 (middle)
- 18 pins:** U12 (right)
- 8 pins:** U6, U10 (top Left)

This is how your board should look now:



Larger components

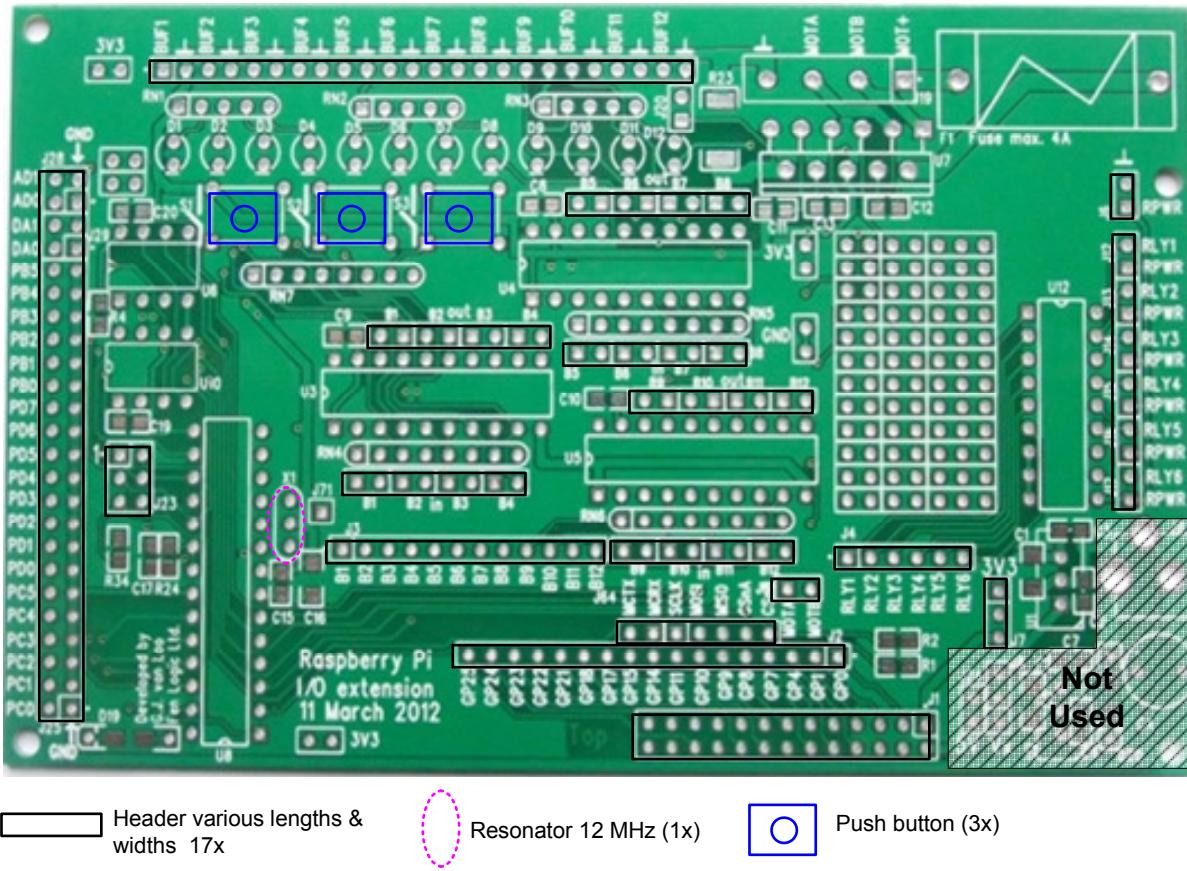


Diagram 3: Larger components

Resonator X1 (Diagram 3: dashed pink oval). Next to the 28 pin IC socket.

Switches/pushbuttons: (Diagram 3: blue rectangles with circles in the middle). Located just below the LEDs. Although the switches have a special orientation, they are very difficult to get in the wrong way as they occupy a rectangular space. (You may have to bend the pins about 0.5 mm to get them in the holes.)

S1, S2, S3

Headers (Diagram 3: long black rectangles).

The board has a large number of headers.

The headers may come in the right length or they may come in long strips of 36 pins.

[Again: If you want your board to look nice solder only one pin, then orient the component so it sits 'straight' before soldering the other pins.]

Two row headers:

J25, J28 and J29 can all be soldered as one big strip 24 pins long ($2 \times 24 = 48$ contacts), located on left edge of board)

J1 is 13 pins long ($2 \times 13 = 26$ contacts), located at bottom edge of board)

J23 is 3 pins long ($2 \times 3 = 6$ contacts), located just to the right of J25/28/29

Single row headers:

Make sure you count the right number of pins before cutting. It is not fatal if you make a mistake, as you can always solder a single header pin in. It is just more work and more difficult to line the pins up. If your kit comes with 4 strips with 36 pins each, here is how to

cut them to get the required header lengths:

Strip 1: cut in two part of 24+12

Strip 2: cut in three parts: 17+12+7

Strip 3: cut in six parts: 8+8+8+8+2+2

Strip 4: cut in five parts 8+8+6+3+2+2 which leaves a strip of 7 unused pins.

24 pins: At the top, above the LEDs (top, left-ish)

17 pins: J2 next to the “GPIO25,...,GPIO0” text (bottom)

12 pins: J12,...,J17 next to the “RLY1,...,PWR” text (right)

8 pins: There are six 8 pin headers all adjacent to the 20-pin IC sockets, one above and one below. The headers below the IC sockets are exactly adjacent the eight pin RN4, RN5, RN6 resistor arrays.

7 pins: J64 next to the “MCTX, MCRX,...,CSnA, CSnB” text (bottom)

6 pins: J4 next to the “RLY1,RLY2..RLY6” text (bottom right)

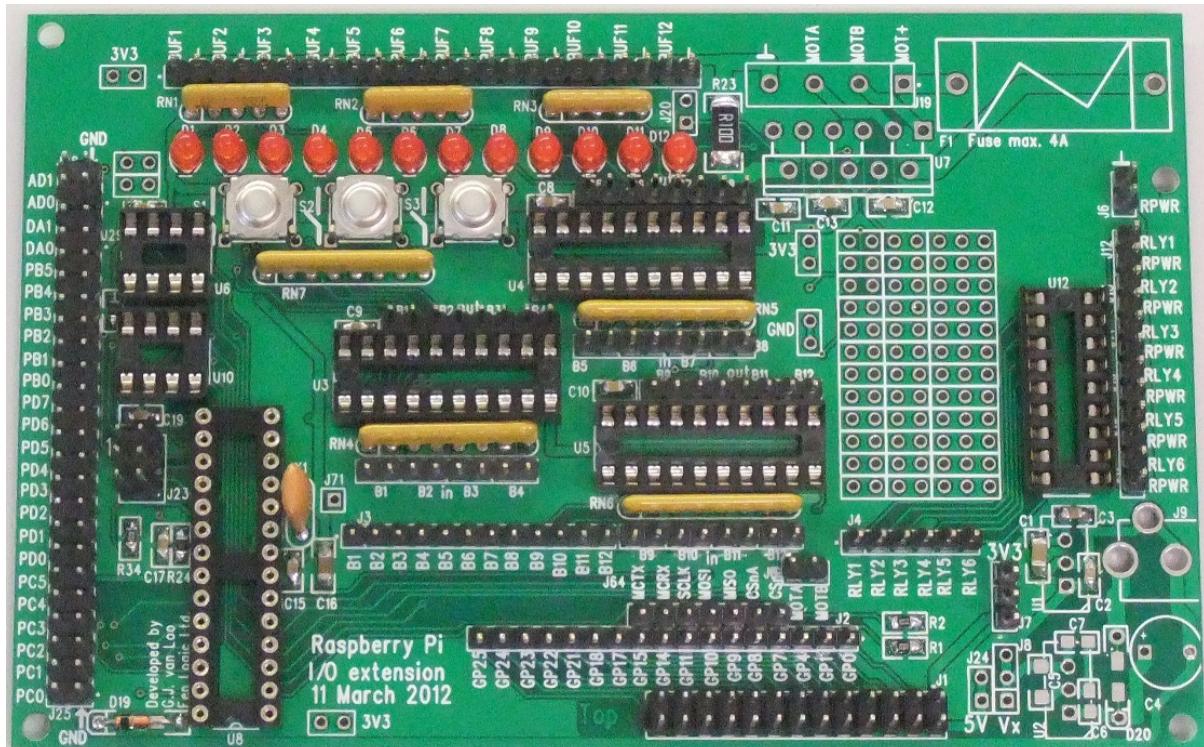
3 pins: J7 next to the “3V3” text (bottom right)

2 pins: J6 next to the mounting hole and the “RPWR” text (top right).

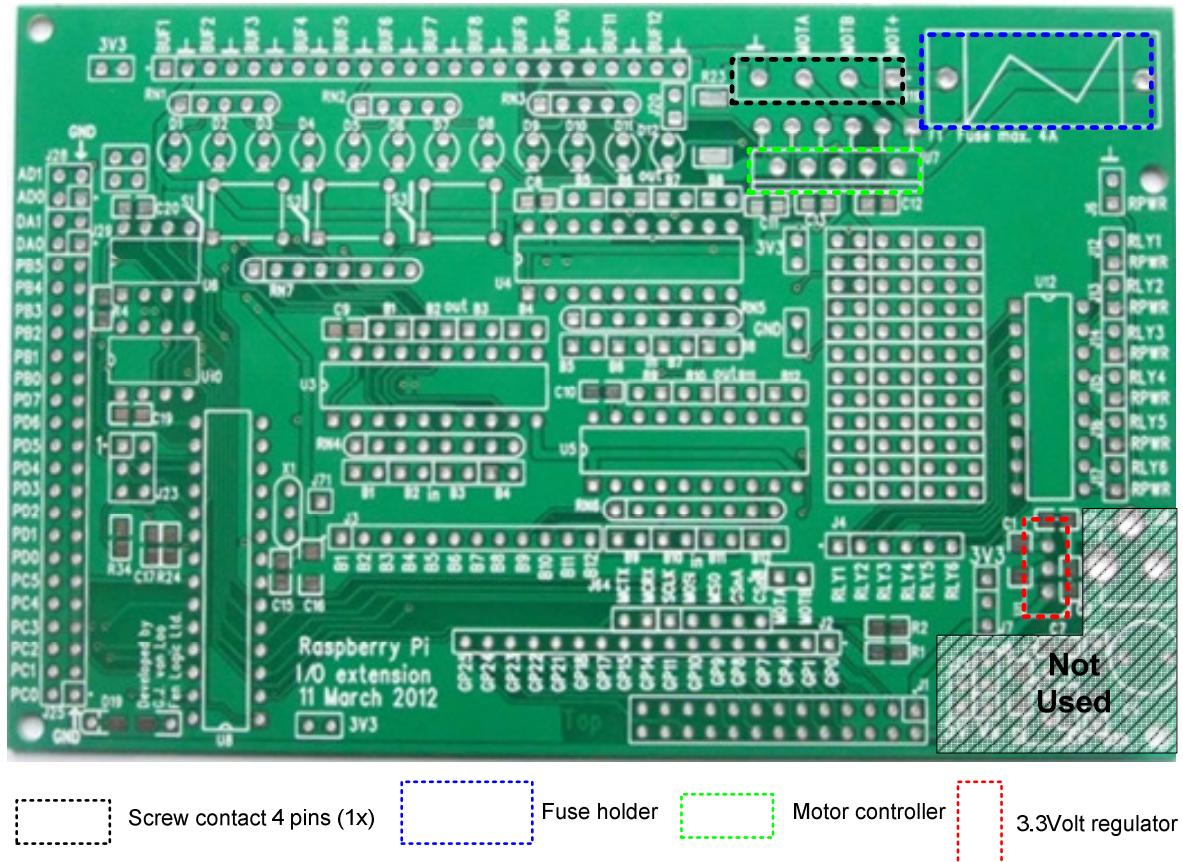
Next to the “MOTA, MOTB” text (near bottom right, below and to left of J4)

The board has a number of other locations for headers but they are not all used: J8, J24, and a number of 3V3 and GND headers. You can put a 2-pin header in the 3V3 upper left corner which is convenient to test the board.

This is how your board should look now:



High components:



J19: Screw connectors (Diagram 4: dashed dark blue rectangle). Located top right. Make sure you put the openings of the connectors facing the top of the board, otherwise they will be blocked when you install the motor controller. Also, some of the screw connector blocks included with the kits are quite large and cover up much of the text. Before you solder in the connectors, make sure you know which connection does what and mark the connector or board accordingly."

F1: Fuse holder (Diagram 4: dashed blue rectangle). Located top right.

U1: 3V3 regulator (Diagram 4: dashed red rectangle). Located bottom right. *This component has a special orientation.* Make sure the text is pointing outwards to the right edge of the board

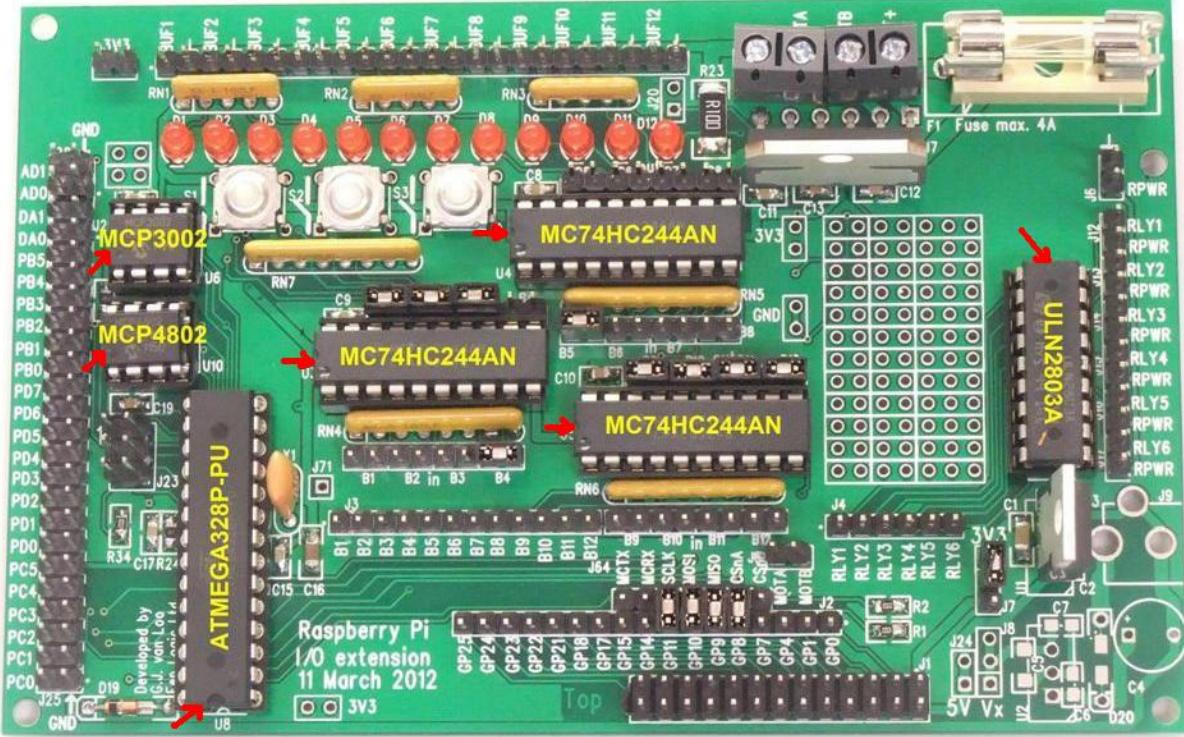
U7: Motor controller (Diagram 4: dashed light green rectangle). *This component has a special orientation,* but the pinout is such that it can be mounted in one way only.

The Fuse

At this point you can insert the fuse into the fuse holder.

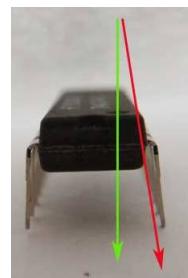
Inserting ICs into sockets:

The following diagram shows the finished board with the ICs in place. The red arrows point to the notch (Pin one indicator).



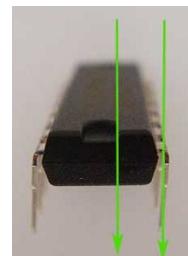
After all the soldering is done, put the ICs into their sockets. *The IC's have a special orientation, marked on the board: the notch shown on the board must align with the notch in the IC (and it is helpful if they line up with the notch in the IC socket).*

Be aware that the ICs may be marked with a number that is not exactly the same as shown above. This is fine, and within reason, components have been substituted into the kit for you.



Last step is inserting the IC's in their sockets. You will find that they do not fit! This is because the pins have been preformed with a certain angle with respect to the IC package. (See picture at the right). To fix that you have to bend them straight.

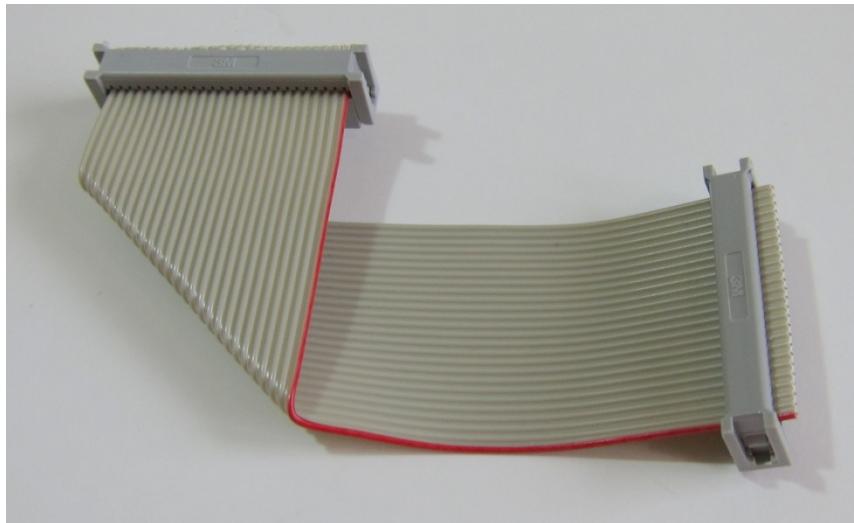
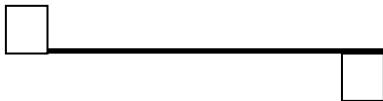
I do that as follows: Hold an IC between two fingers and push the pins down on a flat surface. Then put pressure on the pin slightly rotating the device.



When your IC looks like this you can put it in the socket:

You have to place 7 ICs. It is easiest to look at the diagram above and place the ICs accordingly.

Cable: The connection between the Pi and the Gertboard uses a 26-wire flat cable with press connectors. I found it easiest to fold the cable 90 Degrees and then use it to connect the two boards. To do that the two connectors should be pressed on opposite sides of the cable:



A good way to make these cables is with a vice. To attach a connector to one end of the ribbon cable, put the connector in the vice and tighten the vice *slightly* so the connector does not slip. Place the flat cable in the connector so that the pin one indicator on the connector (the triangle) is pointing to the red edge of the cable and the cable is at a 90 degree

angle to the connector. The cable profile should fit exactly in the header counter profile. Slowly tighten the vice making sure the cable stays in place. Make sure that you install the connectors so that the openings are on the underside when the cable is folded 90 degrees, as shown in the picture. To see how this is done have a look at youtube:

http://www.youtube.com/watch?v=sMiRoXY_oZg&feature=plcp

Watch the position of the red stripe in the picture above.

Testing:

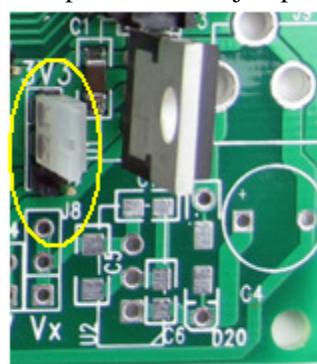
1. Connect the board to a Raspberry Pi. Make sure pin 1 of the Gertboard (marked with a dot) is connected to pin 1 on the Raspberry Pi (labelled P1).
2. Switch on the power of Raspberry Pi **which has a 1A supply!**
3. Check the Pi power LED is on.



4. Measure pin 1 of J7. J7 is next to the 3V3 regulator, which is near the bottom right of the board. Pin 1 is at the top of J7, and has the text “3V3” next to it. The other pin of the multi-meter can connect to any location marked as GND or has the \perp symbol. The multi-meter should show about 3.3 Volts. If not: check all your connections (Including the flat cable connector to the Pi) . Check also that the Pi power LED is still on.



If the meter shows the right value you can place the 3V3 jumper:



Your board is now ready to be used!