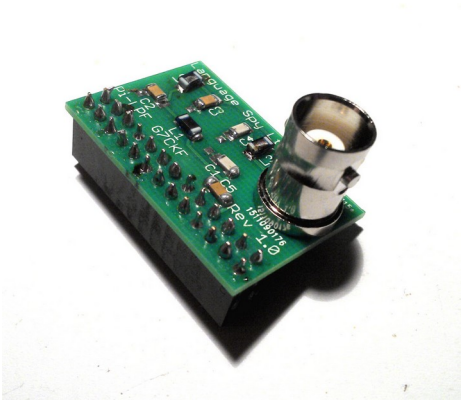
Pi-LPF kit instructions

1: Introduction



Thank you for purchasing a Pi-LPF low-pass filter kit for your Raspberry Pi. This kit once assembled allows you to use the Pi's internal clock generator as a simple low-power amateur radio transmitter with appropriate suppression of unwanted harmonics for legal usage. The Pi-LPF uses a 7-pole Chebyshev filter circuit, and is supplied with a set of filter components for the amateur radio band of your choice.

The Pi-LPF uses surface-mount components, which are soldered directly to the top of a circuit board rather than having wires pass through holes in the board and be soldered on the underside. Soldering surface mount components is not as easy as soldering through-hole components so this kit is not recommended for a complete novice solderer. Care has been taken to use surface mount devices that are not too small to work with and to place them with adequate space on the board, so this kit would be suitable for someone used to soldering through-hole who wishes to try a surface-mount kit.

All you will need to add to the kit once you've built it is a Raspberry Pi with appropriate software and an antenna suitable for transmission.

2: Building your Pi-LPF

2.1: You Will Need

A good light source. Surface-mount components are tiny, and easily lost. Plenty of light ensures you will be able to see them clearly. A good downward pointing desk lamp should suffice.

A clear high-contrast surface. Because surface-mount components can be difficult to see, it helps if they are manipulated over a bright white surface. A fresh sheet of white printer paper on a desk makes a suitable working area.

Good hands-free magnification. Unless you are fortunate enough to have amazing eyesight, you will need a good quality magnifier to work with surface-mount components. The “Helping hands” type on a stand is suitable, or perhaps the headband type.

A small flat-blade screwdriver. You will need to hold surface-mount components down while you solder them. If you have a set of jeweller's screwdrivers then usually one of the smaller ones will be suitable, below about 1.5mm in width.

A good-quality pair of precision tweezers. You will need these for picking up, manipulating, and turning over surface-mount devices. Metal tweezers are likely to be more useful than plastic ones, as they can be used on hot items during soldering.

A craft knife. Surface-mount components are packaged in a tape for use in automated board assembly machines. The tape has a thin plastic cover that needs to be carefully peeled back to reveal the components. This is best done over a well-lit surface under a magnifier using the tip of a craft knife. If the component falls out of the packaging onto the floor or a badly lit surface it is unlikely that it would be found.

A fine-tipped soldering iron. With care this kit can be assembled with a standard fine tipped iron suitable for use with conventional 0.1” pitch through-hole components. However the size of surface-mount components means that you will require a greater level of skill to build it using the larger screwdriver style iron tips. Thus the finer the tip, the better for assembling this kit. It is also recommended that you use a temperature controlled iron at a suitable temperature for your solder, if you have one.

Lead-free solder, with a flux core. This is an RoHS and WEEE compliant product, so to maintain that compliance it should be soldered with RoHS lead-free solder. Any decent quality flux cored solder designed for electronic use should be suitable for assembling this kit. Solder intended for plumbing may not be suitable.

Flux. Any decent quality non-acidic soldering flux should be suitable for use with this kit. Use liquid flux in a syringe designed for surface-mount assembly if you can afford it, otherwise flux paste applied with a cotton bud.

Desoldering braid. Decent quality desoldering braid is a must for surface-mount work, as some of the techniques involve an excess of solder which must be removed. You may also find a set of side cutters useful, for cutting off used braid.

Solvent cleaner. This is not essential, but it is desirable to remove excess flux from your board when you have finished construction. Which solvent cleaners you have available will depend on where you are in the world, however a good electronic parts supplier should carry suitable products. We use an electronic-grade aerosol cleaner and an old toothbrush to scrub away the flux.

You may also find a spring clamp designed for hand-soldering SMDs to be useful. This is the home-made clamp used to build our prototypes: https://hackaday.io/project/8605-spring-clamp-third-hand-for-hand-soldering-smds

2.2: How to solder SMDs

It is assumed that anyone embarking on this kit will already be familiar with soldering through-hole components as it is not a kit for the novice solderer. Thus this “How to solder...” section will not deal with the through-hole components in this kit, instead concentrating only on the surface-mount elements.

Surface-mount construction differs from through-hole in that the components are not automatically held in place by a hole in the board. Thus surface-mount components face a hazard through-hole solderers may not be used to: they are subject to the forces exerted by the surface tension of liquid solder as it solidifies. A surface mount-resistor for instance will rise up on end, so-called “tomb stoning” as the solder solidifies if it is soldered at one end without being held in place. Techniques for hand surface-mount soldering therefore differ from those for through-hole soldering in that the emphasis is on securing the component as well as soldering it.

It is worth recommending here a YouTube search for videos of SMD soldering techniques.

2.2.1: Chip capacitors

Before soldering a chip capacitor, ensure that the pads it is to go on are clean, flat, and ready tinned. The board included in this kit is already tinned, however this step is included here as general advice for surface-mount soldering. If tinning a pad leaves a domed blob of solder on it, remove the blob with some desoldering braid and your soldering iron.

Apply a thin layer of flux to both pads.

Carefully peel back the plastic tape on the top of the tape containing the chip to release it. It is suggested you do this immediately above the area of board onto which it is to be soldered, it is easy to lose a loose a small component. If the chip has landed the wrong way up, turn it over with your tweezers.

Carefully nudge the chip into place with the tip of your small screwdriver so that its conductive ends are centred on the pads.

Place the tip of the screwdriver on top of the chip and apply gentle pressure to hold it down while it is soldered.

While holding down the chip, pick up a small amount of solder on the end of your soldering iron, and solder one end of the chip to its pad. When the solder has solidified, test that the chip is soldered to the board by giving the chip a nudge with the screwdriver.

Solder the other end of the chip. Use as little solder as you can and use as little contact with the iron as you can, you need to avoid melting the joint at the first end of the chip.

If your chip has a large blob of solder at each end, remove them with some desoldering braid. Capillary action will have drawn enough solder underneath the ends of the chip to make a good contact without the need for a blob of solder.

2.2.2: Chip inductors

The wire-wound chip inductors supplied in the Language Spy filter component packs are very similar to the capacitors with the exception that the whole length of the top of the component is epoxy resin and the solderable connections are only on the lower half of each end. Thus soldering these components is a similar process to that for the capacitors, but with more care to apply the heat as close as possible to where the pad meets the connection on the inductor rather than to the whole end of the component. It is suggested that you use plenty of flux, and try to push a tiny blob of molten solder through the flux across the pad from its edge towards the end of the inductor.

2.3 Construction details

2.3.1: Identifying the components

The through-hole connectors supplied with this kit should be easy to identify. Some components will look identical to others with different values when they are out of their packaging, this section should help you tell them apart.

The surface-mount passive components will all be supplied in tape packaging or sealed bags with their value

written on the packaging to help identify them. Components common to all bands are loose in the bag containing the kit, while band-specific components are supplied in a bag of their own. These are tiny components that are easily lost, so we have included an extra one of each value in case that happens.

Chip capacitors. These are all “1206” size chips, 3.2mm x 1.6mm in size. They are a light brown or white colour and do not have a value written on them. Since they are very difficult to tell apart it is strongly recommended that you do not unpack more than one value at once. You should have three separate values. The DC blocking capacitor C5 has a value of 0.1uF, while values supplied for each frequency band can be found both in Appendix 1 and on the documentation for the accompanying LPF component kit.

Chip inductors. These are all “1206” size chips, 3.56mm x 2.16mm in size. The top of each inductor is encased in dark epoxy resin. They do not have a value written on them. Since they are very difficult to tell apart it is strongly recommended that you do not unpack more than one value at once. You should have two separate values. The values supplied for each frequency band can be found both in Appendix 1 and on the documentation for the accompanying LPF component kit.

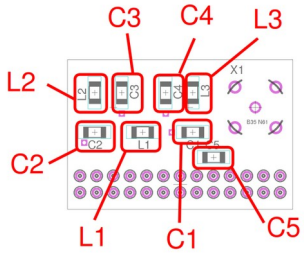
2.3.2: Pi-LPF construction step-by-step

You should now be ready to build your Pi-LPF. Here follows a step-by-step progression through the assembly process, in a recommended order. This order is not compulsory, however it has been chosen to ensure that smaller components are fitted before larger components that may make them difficult to reach for soldering.

It is **strongly recommended** that you only unpack one component at a time: that which you are currently installing.

Step 1: Chip components

Solder each component in a clockwise order round the board, starting with the 0.1uF DC blocking capacitor C5. So in order: C5, C1, L1, C2, L2, C3, C4, L3. Unpack only the component on which you are working at any one time, and take pains to ensure that you are unpacking the correct value.



Step 2: Connectors

Both the connectors are traditional through-hole types. It is suggested that you start with the 26-way Raspberry Pi connector, which goes on the underside of the board with the pins being soldered on top of the board. Take care to ensure it is flush with the board at all points before soldering pins at opposite corners. If it is at a slight angle you can desolder one corner to fit it flush with the board. When it is fixed in place at the corners you can solder all the rest of the pins. The BNC socket goes on the top of the board, with its pins being soldered to the underside. It will require a bit more heat than the other components to solder its earth pins, take care not to use too much solder.

2.4 Before you plug it in

VERY IMPORTANT! Before you plug your completed Pi-LPF into your Raspberry Pi, complete a close visual inspection of it under your magnifier. Pay close attention to any solder bridges that may remain across chip components, connector pins, or adjacent pads. Remove any surplus solder or solder bridges with desoldering braid.

This step is **very important** because your Pi can be damaged by short circuits or other mishaps on your board. **If that happens it is your responsibility as the builder of the board**. It is better to have to rework or desolder something than to damage your Pi with your work.

3: Using your Pi-LPF

The Pi-LPF is designed to work with all Raspberry Pi models at the time of writing that have the first 26 pins of the GPIO connector and the clock generator GPCLK0 on pin 7. It has been tested on original Pi model A and B boards, B+ boards, the Raspberry Pi 2, and the Pi Zero. It will not plug into the Compute Module development board, nor is it guaranteed to work with Raspberry Pi compatible boards from organisations other than the Raspberry Pi Foundation.

3.1 First run

If you are happy that your Pi-LPF is completed without solder bridges and has all parts correctly aligned, you are ready to go. Make sure your Raspberry Pi has SD card, keyboard, and mouse etc. but is disconnected from the power. **DO NOT plug or unplug your Pi-LPF on the GPIO connector while your Pi is powered up.**

Now carefully plug the Pi-LPF into the Pi's GPIO connector. If you have a Pi with the 40-pin GPIO connector such as the B+, Pi 2, or Pi Zero, the Pi-LPF should be plugged only into the first 26 pins that are compatible with the connector on older Pi boards. The Pi-LPF has been designed such that it does not foul the components on any of the Pi circuit boards, however you should take a look for yourself to ensure that this is not happening. If necessary cut a piece of thin card to act as an insulator between the bottom of the Pi-LPF and the Pi.

If you are happy with the step in the previous paragraph, power up your Pi. If all is well your Pi should start as normal. All you need now to use your Pi-LPF is a suitable antenna or dummy load to plug into the BNC socket, and appropriate software for the mode you wish to use it for.

3.2: Software

The Raspbian operating system used by most Raspberry Pi users does not come with any software to generate RF. If you wish to use the board you will usually have to download, install or compile some some software from other sources, or even write some yourself. Fortunately this is usually not a difficult process.

A few pieces of software that can use this board are listed below.

Freq_pi and PiVFO

https://github.com/JennyList/LanguageSpy/tree/master/RaspberryPi/rf/freq_pi
We have produced PiVFO, a simple graphical front-end for Jan Panteltje's command line frequency generator freq_pi. You can find both pieces of software on GitHub at the address above. Follow the instructions on the GitHub page to install, compile and run both packages on your Pi. You should install freq_pi first, then PiVFO. You will need to be able to type some commands on the Pi command line.

WsprryPi

https://github.com/JamesP6000/WsprryPi
This is a transmitter for the amateur radio WSPR protocol (http://wsprnet.org/drupal/), a beacon protocol designed to test and explore atmospheric radio propagation modes. Receiving stations around the world post their spots to the web site, and it is possible for a Raspberry Pi transmitter to be heard all around the globe given the right band and atmospheric conditions. This software requires an amateur radio licence for use.

Rpitx

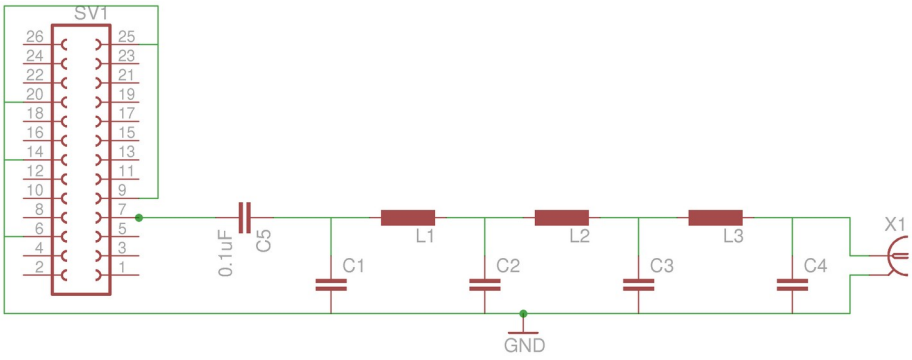
https://github.com/F5OEO/rpitx
This software from F5OEO is an exciting development for radio on the Raspberry Pi, using software defined radio techniques to generate AM, SSB, and SSTV modes. Instructions can be found on the GitHub page above. This software requires an amateur radio licence for use.

Appendix 1: Component values for different bands

Band	C1,C4	C2,C3	L1,L3	L2
60m	820pF	1.2nF	1uH	1.2uH
40m	620pF	820pF	820nH	1uH
30m	430pF	620pF	560nH	680nH
20m	390pF	510pF	470nH	560nH
17m	300pF	430pF	390nH	470nH

Version 2 filter component packs. More bands to come!

Appendix 2: Circuit diagram



Appendix 3: Declaration of conformity

Organisation: Language Spy Ltd, Neve's Croft, Godington, Bicester, OX27 9AF, UK
Product description: The Pi-LPF low-pass filter kit for the Raspberry Pi, a self-assembly kit of electronic parts.

This product has been designed to comply with the following directives:

Directive 2001/95/EC on general product safety
Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment

As a piece of electronic equipment requiring less than 50V DC it is not applicable under article 1 of directive 2014/35/EU on low voltage.

As a self-assembly kit for use by radio amateurs it is exempt from the following directives under the following clauses:
Annex 1 paragraph 1 of 2014/53/EU on radio & telecommunications equipment.
Article 1 paragraph 2(c) of 2004/108/EC on electromagnetic compatibility.
Article 2 paragraph 2(c) of 2014/30/EU on electromagnetic compatibility (When it becomes applicable).

Date: 2015-12-06

Jenny List, director