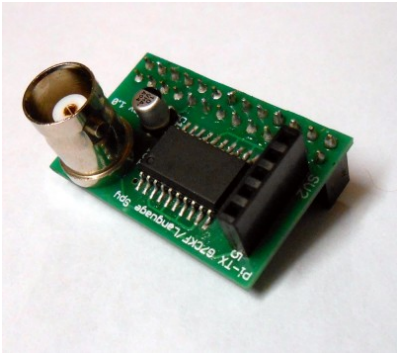
Pi-TX radio transmitter instructions

1: Introduction



Thank you for purchasing a Pi-TX radio transmitter kit for the Raspberry Pi, This kit once assembled provides an amplifier for the Pi's internal clock generator, allowing a licenced radio amateur to use it as a QRP transmitter with a higher power output than the Pi itself can provide. We measure its output at just below 150mW on the 10MHz band. It features a socket for a plug-in low-pass filter module to ensure the spectral purity of its RF output. You should have received a filter of your choice as a separate kit as part of your Pi-TX order.

The Pi-TX 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.

All you will need to add to the kit once you've built it is a Raspberry Pi with appropriate software.

1.1: How it works

At the heart of this kit is a 74ACT240 octal inverting buffer. One buffer performs the job of level translation to 5v from the Pi's 3.3v logic, and drives the further seven buffers which form the power amplifier. The TTL-compatible ACT version of the chip is used because it has an “on” threshold of 2V which is within the 3.3v range of the Pi's logic.

The output of the power amplifier passes through a DC blocking capacitor to a socket for a plug-in low-pass filter which is necessary to ensure an acceptable spectral purity for legal transmission. The output of this filter is taken to a BNC socket for the antenna.

The filter module is another Language Spy product, the Tiny-LPF. Your Pi-TX will have been supplied with a filter for the amateur band of your choice from our growing range which will have its own build instructions, and modules for further bands can be ordered separately.

2: Building your Pi-TX

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.

Finally, you should be aware of the possibility of damage to semiconductor devices from static electricity, and take care to use a suitable earthing arrangement if you think it may be necessary.

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 components

Before soldering a chip rcomponent, 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: Larger surface-mount components

This kit includes an electrolytic capacitor which is much larger than the chip capacitor, with much larger pads. Similar techniques are used to solder it, but it is much easier to handle and position.

As with a chip component, before soldering an electrolytic capacitor ensure that the pads it is to go on are clean, flat, and ready tinned.

Apply a thin layer of flux to both pads.

Peel back the plastic tape on the top of the tape containing the capacitor to release it. The electrolytic capacitor is large enough to pick up and place by hand.

Carefully place the capacitor on the board so that its connection tabs are centred on the pads. This component is polarised, so be sure to place it on the board the right way round. The angled corners should align with those on the outline printed on the board.

Hold the capacitor in place with the tip of your screwdriver.

While holding down the capacitor, pick up a small amount of solder on the end of your soldering iron, and solder one tab to its pad. When the solder has solidified, test that the capacitor is soldered to the board by giving it a gentle push with your finger

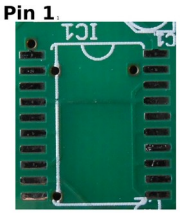
Solder the other tab. If the capacitor has a large blob of solder at each end, remove them with some desoldering braid.

2.2.3:Integrated circuits

This kit contains a single IC, with two rows of closely spaced pins. Soldering these pins individually would be a difficult task even for an extremely advanced solderer, so we will use a different technique of soldering multiple pins at once with an excess of solder which we will then remove with desoldering braid.

As with a chip component, before soldering an IC ensure that the pads it is to go on are clean, flat, and ready tinned.

Carefully peel back the plastic tape on the top of the tape containing the IC 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 IC has landed the wrong way up, turn it over with your tweezers.



Gently nudge the IC into place with the tip of your small screwdriver so that its pins are centred on their pads. Take particular care to ensure that the IC is on the board the right way round. The IC used in this kit will either have a recessed dot to denote pin 1 or it will have one bevelled edge on top, with the IC the right way up and the bevelled edge on the left pin 1 will be at the top left. The bevelled edge is marked on the board as a white line down the left hand side of the IC space, in addition pin 1 is marked with a white semicircle to represent the notch found at the top of older dual-in-line ICs. In the picture to the right, Pin 1 is at the top left hand corner.

Place the tip of the screwdriver on top of the IC and apply gentle pressure to hold it down while it is soldered. Take care to keep it steady so that its pins do not move off their pads.

While holding down the IC, pick up a small amount of solder on the end of your soldering iron, and solder one corner of the IC to its pads. It does not matter if you cover a couple of pins with a blob of solder, the aim is merely to fix it down at this point. When the solder has solidified, test that the IC is soldered to the board by giving it a gentle nudge with the screwdriver. Inspect the IC to ensure that its pins are still correctly aligned with their pads. If it has moved you will need to very carefully melt the solder you have just applied and nudge the IC into place with your screwdriver.

Apply a thin layer of flux to each row of pins.

Solder the other side of the IC from that whose corner you have just soldered. Your aim is to hold a blob of molten solder on the end of your iron and run it down the row of pins in one fluid movement. Starting at one end melting the end of your solder wire over the IC pins you should be able to draw the resulting molten solder across the row. The flux will ensure that a good joint is made, and any surplus solder or solder bridges between pins will be later removed with desoldering braid.

Solder the first side of the IC in the same way as above.

Your IC should now be securely fixed to the board, but will certainly have an excess of solder and will probably have some solder bridges between pins. Carefully remove this excess with desoldering braid. Capillary action will have drawn enough solder underneath the IC pins to make a good contact without the need for a blob of solder.

2.2.4: After soldering

After soldering surface-mount devices using these techniques it is quite likely your board will be rather a mess with a lot of surplus flux on its surface. When you have completed all the surface mount soldering it is therefore worth removing all this flux with solvent cleaner. It won't stop the kit from working, but it looks unsightly.

2.3 Construction details

2.3.1: Identifying the components

The larger through-hole components such as the connectors should be easy to identify. The surface-mount passive components will all be supplied in tape packaging and the chip capacitor will have its value written on

the tape to help identify it.

C1 is a 10uF electrolytic capacitor. It is a silver cylindrical can with a plastic base and small connection tabs. It can be identified by its value in microfarads in the first line of writing on its top: “10” for C1.

C2 is a 0.1uF “1206” size chip, 3.2mm x 1.6mm in size. It is a light brown colour and does not have a value written on it. One extra of this component has been included: small components are easy to lose.

IC1 is a 74ACT240 octal buffer in a 20-pin SOIC package. The top of the IC has a recessed dot to denote pin 1, or a bevelled edge along the row of pins containing pin 1, with the bevelled edge facing you pin 1 will be on the leftmost end of the row in front of you. The second line of text etched on the top of IC1 is the truncated part number: “ACT240”

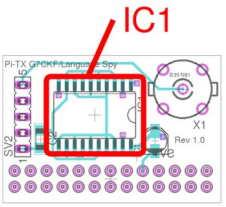
2.3.2: Pi-TX construction step-by-step

You should now be ready to build your Pi-TX. 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 the connectors 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.

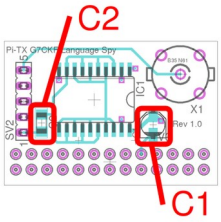
Step 1: IC1

First to be installed is IC1. Take care to identify pin 1, and to ensure that it is aligned with the end identified by the half-circle and the line printed on the board.



Step 2: C1 and C2

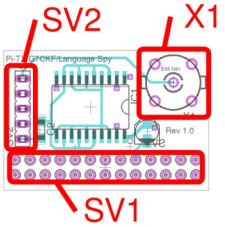
Now install the electrolytic capacitor C1, and the DC blocking capacitor C2. Take care to observe the polarity of C1, and to ensure that it is installed in the correct orientation on the board.



Step 3: Now would be a good time to remove any surplus flux with solvent cleaner.

Step 4: Through-hole components

The connectors are all traditional through-hole components. It is recommended that you start with the LPF connector SV2, which goes on the top of the board with its pins being soldered on the underside.



Then solder Raspberry Pi connector SV1, 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.

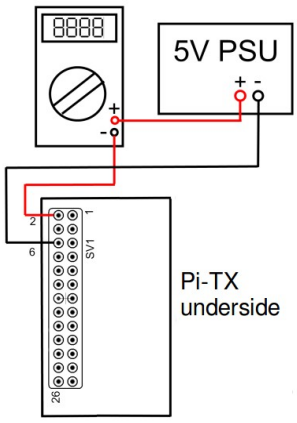
Finally solder the BNC socket X1, which will require a bit more heat than the other components to solder its earth pins, take care not to use too much solder.

If the steps above have gone according to plan, you should now have a completed Pi-TX. Congratulations!

2.4 Before you plug it in

VERY IMPORTANT! Before you plug your completed Pi-TX into your Raspberry Pi, complete a close visual inspection of it under your magnifier. Pay close attention to any solder bridges that may remain between IC pins, across chip components or adjacent pads, the orientation of the IC to ensure pin 1 is in the correct place, and the orientation of the electrolytic capacitor. Remove any surplus solder or solder bridges with desoldering braid.

If you have a 5 volt bench power supply and a multimeter that can measure current, you can measure the standing current consumed by the Pi-TX before you plug it into your Pi. Ensure the power supply voltage is exactly 5V, and set the multimeter to a current range. Now connect the power supply negative to pin 6 of SV1 and the positive via the multimeter to pin 2. A correctly assembled Pi-TX should consume about 1mA when not processing any RF.



These steps are **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-TX

The Pi-TX 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.

Since the Pi-TX draws power from the Raspberry Pi's 5 volt line, it is recommended that you use a decent quality PSU with spare capacity to supply at least an extra 200mW over the power consumed by your Pi.

3.1 First run

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

Now carefully plug the Pi-TX into the Pi's GPIO connector. If you have a Pi with the 40-pin GPIO connector such as the B+ or Pi 2, the Pi-TX should be plugged only into the first 26 pins that are compatible with the connector on older Pi boards. The Pi-TX 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-TX and the Pi.

Plug the completed filter module into the Pi-TX. You should refer to the documentation supplied with the accompanying filter for construction details. It is suggested that you go for the straight set of pins, and mount them on the bottom of the filter PCB.

Connect a suitable antenna or dummy load to X1, and power up your Pi. **Important! Do not run your Pi-TX without a filter, an antenna, or a dummy load: this might damage it.**

If all is well your Pi should start as normal. To use the Pi-TX, all you now need is some suitable software.

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. **Please note:** This software is not produced by Language Spy Ltd, and any support queries on software should be addressed to that software's developer.

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.

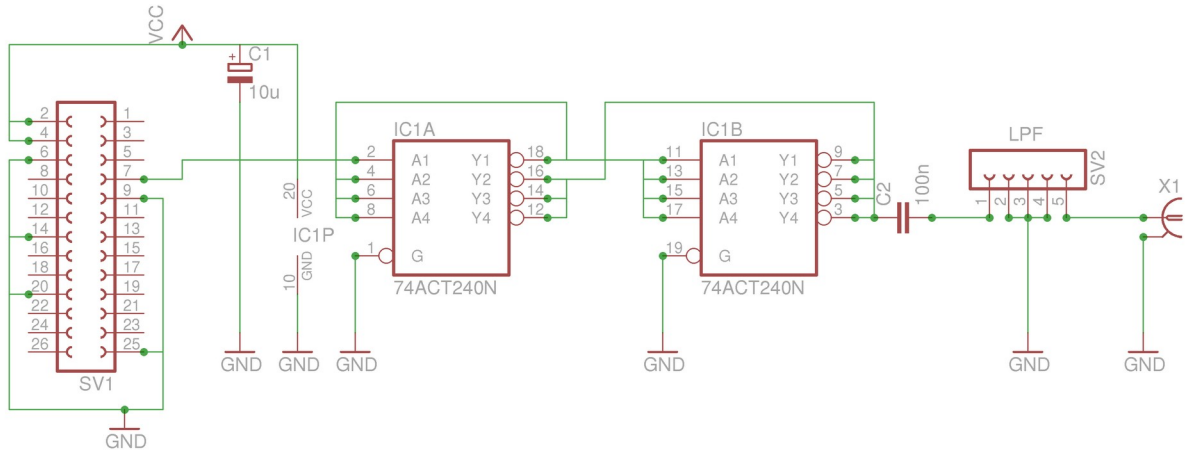
Rpitx

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.

PiCW

https://github.com/JamesP6000/PiCW
PiCW is a simple Morse (CW) transmitter for the Raspberry Pi. Instructions can be found on the GitHub page above. This software requires an amateur radio licence for use.

Appendix 1: Circuit Diagram



Appendix 2: Declaration of conformity

Organisation: Language Spy Ltd, Neve's Croft, Godington, Bicester, OX27 9AF, UK
Product description: The Pi-TX transmitter 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 applicable).

Date: 2016-02-21

Jenny List, director