Ultimate LPF kit: Relay-switched LPF kit

PCB Revision 5

1. Introduction

Thank you for purchasing the QRP Labs relay-switched low-pass filter (LPF) kit. Note that this kit can also be used with the QRP Labs Band Pass Filter (BPF) kits.

This kit is designed to complement the Ultimate3 QRSS/WSPR kit but could also be used on its own at the output of a homebrew QRP transmitter. The kit consists of a PCB that switches one of five LPF's between the transmitter output and the antenna (the kit's "RF output"). This kit does not include the LPF's, it is designed to accept the plug-in LPF filter kit, which is available separately (for bands 2200m, 600m, ten HF bands 160m – 10m, and 6m band).

Note that when used with the Ultimate3 QRSS/WSPR kit, the relay-switched LPF kit provides up to six bands, each with its own relay-switched LPF. This is because the Ultimate3 kit contains space on its PCB for fitting Relay 0 (band 0). Combined with the 5 LPF's on the relay-switched LPF kit PCB (band 1 to 5) this allows for six LPF's.

Important note: This Rev 5 PCB is designed so that one LPF is always in circuit – this should be the highest frequency LPF plugged in to the board, which should always be plugged in to position "1". The jumpers on the board can also be used to configure other options, including NOT always having the "1" LPF always in circuit. This could be useful for example if you wish to use the relay board to select one of 5 Band Pass Filter (BPF) kits. There are other jumper options for having separate antenna outputs. These will be covered in separate documents.

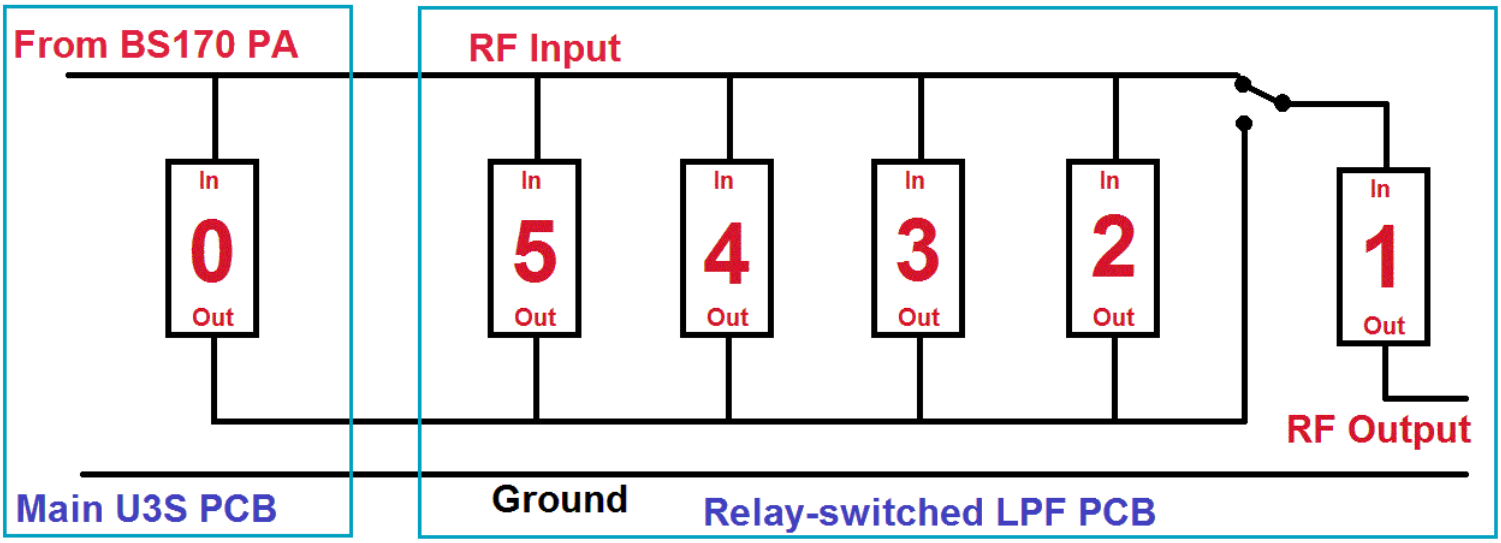
This document covers the most common assembly option for the Ultimate3S Output Filters.

2. Parts List

Please inventory the parts to make sure everything is present.

RL1-RL5	Panasonic TX2-5V relays. Six are supplied (five are installed on the LPF kit PCB, one is provided for the installation on the Ultimate3 kit PCB)
D1-D5	1N4148 diode. Six are supplied (five are installed on the LPF kit PCB, one is provided for the installation on the Ultimate3 kit PCB)
10 of	4-way female header sockets
1 of	10-way (2 x 5) female header socket
1 of	10-way (2 x 5) male header plug, extended (tall) size
4 of	25mm nylon hex spacers
1 of	Printed circuit board, 80 x 37mm size

3. Design



In the above block diagram, each block represents a Low Pass Filter (LPF) module and a relay. The relay is a DPDT type (dual pole, dual throw). When the relay is un-energised, the resting position is for both input and output of the corresponding LPF to be shorted to ground. When the relay is energised, the LPF is connected between the “RF Input” bus and the common LPF output bus.

In use, only one relay should be energised at once time, to switch in the desired LPF. The Ultimate3S firmware automatically ensures that only one relay is energised at any one time.

In the above diagram, the relay switches are not shown, except for the final relay, for the LPF in position “1”. This LPF must always be the highest frequency, and it is always in circuit. The relay for this LPF switches its input when energised, to the RF Input bus (from the Ultimate3S PA output). When un-energised, the common output of the other LPFs is routed to the input of this final LPF in position “1”.

As an example, imagine you are using bands 80, 40, 30, 20, 15 and 10m. The highest frequency is 10m (28MHz) so insert this in socket “1”. Even when transmitting on one of the other bands 80..15m, the signal will still also pass through the 10m LPF. This provides a significant improvement in attenuation of the VHF harmonics. It is necessary to ensure that you configure the transmissions in the Ultimate3S to be on the correct band for the LPF plugged into the numbered slots 1..5, and slot 0 on the main U3S PCB.

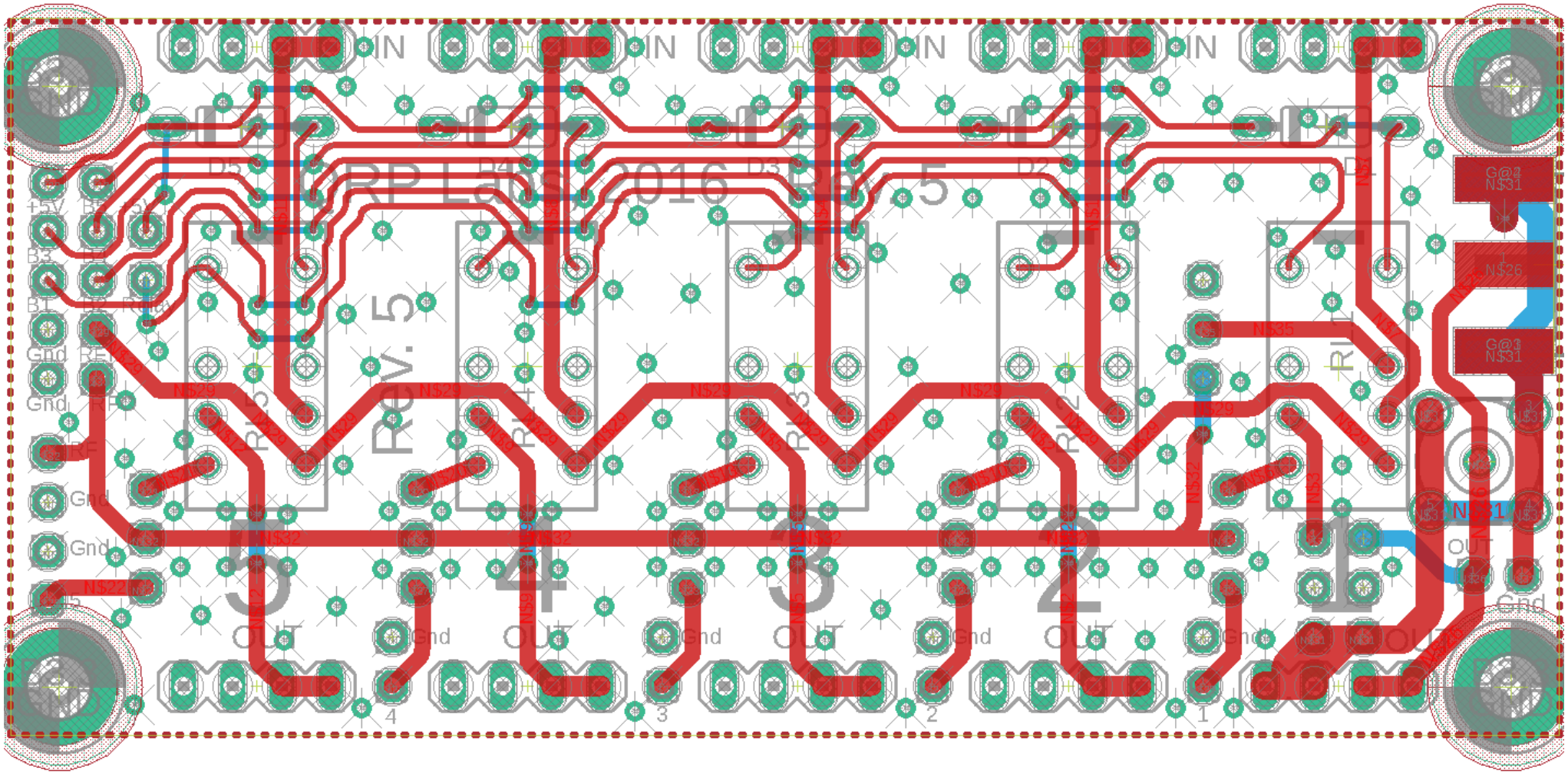
Note that the ground connection to the final output pads is NOT connected by default, to the groundplane of the relay-switched LPF PCB. This is so that the ground current also flows through the final LPF in position “1”. It improves harmonic attenuation because it prevents leakage past the LPF.

The relays are miniature Panasonic RX2-5V types. With a height of only 8.5mm, they are small enough to fit underneath the plug-in LPF boards. The coil current is only 28mA and it can therefore be driven directly by an AVR microcontroller output pin. A 1N4148 diode is installed across the coil of each relay, to prevent high switching voltages from damaging the microcontroller output.

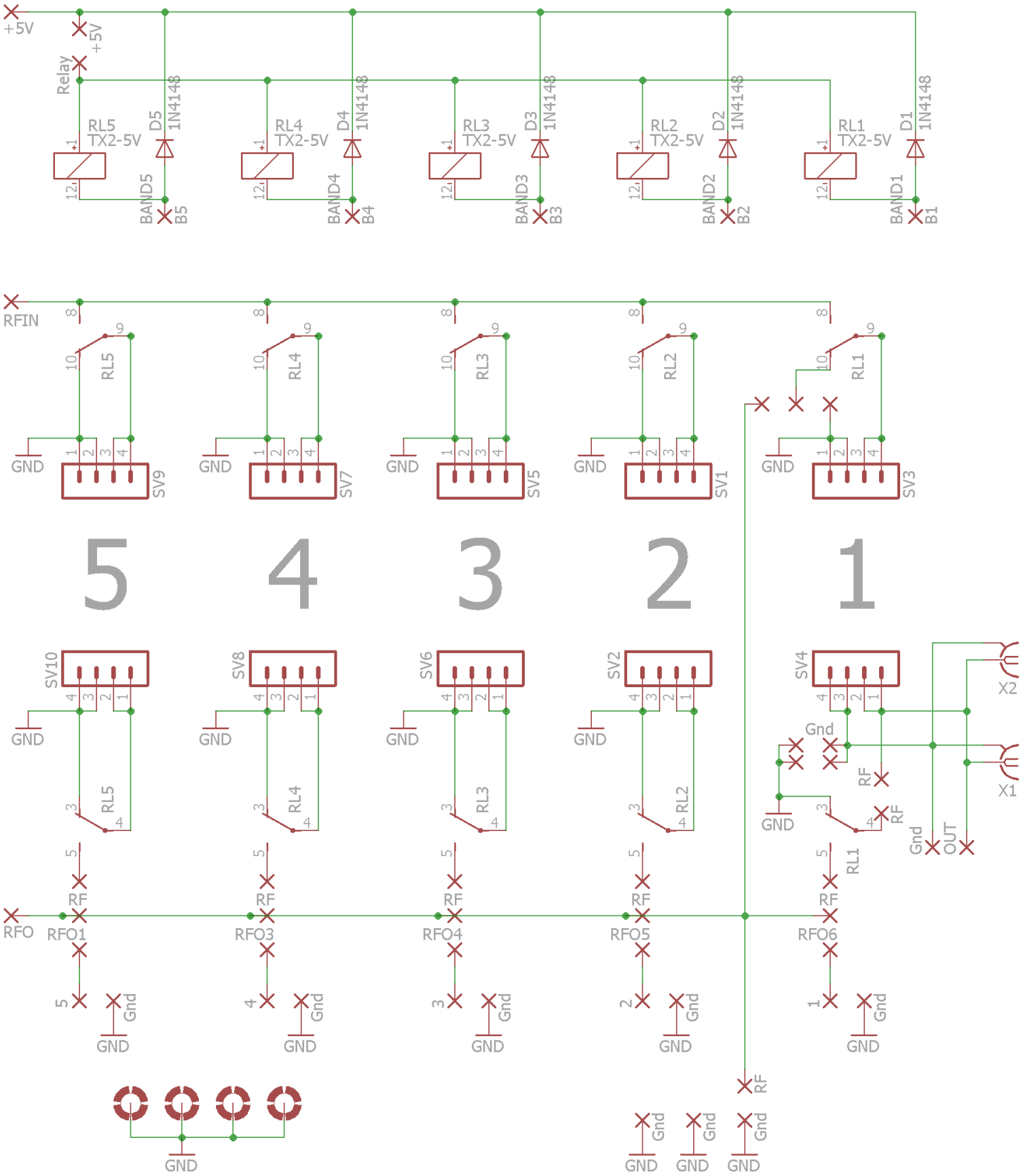
The relay-switched LPF kit can be used in your homebrew QRP transceiver project too. One side of the relay coils are connected to +5V. So to switch a relay, the appropriate band 1 to 5 input should be driven to a low voltage to energise the relay coil. A transistor could also be used to switch each relay coil.

Note that the PCB allows the output side of each LPF / relay-switch to be connected either to the common RF Output signal, or to individual connection pads. In this way, you can use either a single antenna, or connect different antennas for each band. The choice is arranged by wire jumpers, described in a separate document.

The following page shows the trace diagram of the relay-switched LPF kit PCB. Red traces are on the top side of the PCB, blue traces are on the bottom. There are extensive ground planes both sides (not shown).


IN
IN
IN
IN
OUT
OUT
OUT
OUT
Gnd
Gnd
Gnd
Gnd
+5V
B3
B2
B1
B0
RPLab 2016
Rev. 5
5
4
3
2
1
N$29
N$32
N$31
N$35
N$26
N$22

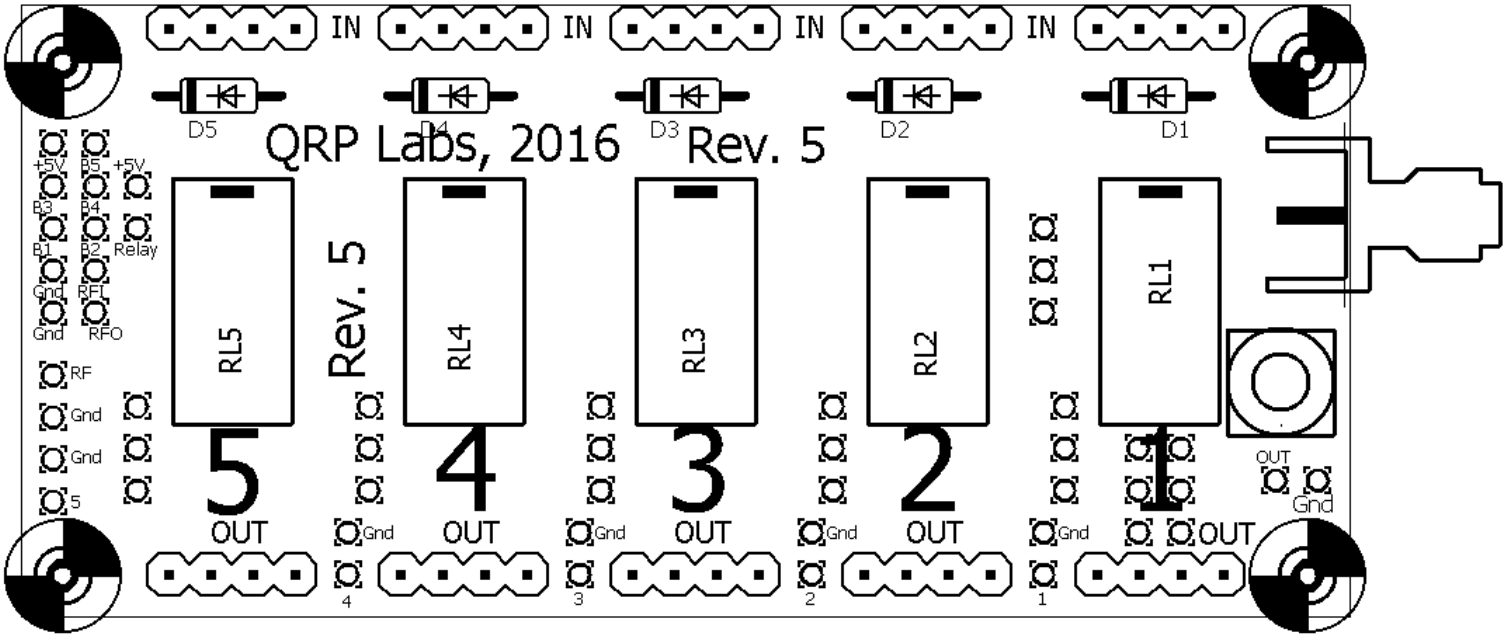
This circuit diagram shows all the jumper options. This document describes only the jumper configuration that will most usually be used with an Ultimate3S transmitter. Other jumper options will be described in separate documents.



The RF output of this relay-switched LPF kit are at the right-hand side of the PCB (opposite end to the 2 x 5-pin header connection). There are three possible outputs, they are in parallel; these are: a vertical mounting SMA pad footprint; an edge-mounting SMA connector footprint, and a pair of 0.1-inch spaced holes. Note that the vertical SMA may interfere with the LPF in position “1”. In practice where the relay-switched LPF is installed in an enclosure such as the QRP Labs Ultimate3S case, a short length of coaxial cable to the BNC socket on the rear panel does a good job; the ends of the cable can easily be soldered into the vertical SMA pads.

4. Construction

Please refer to the parts placement diagram below.

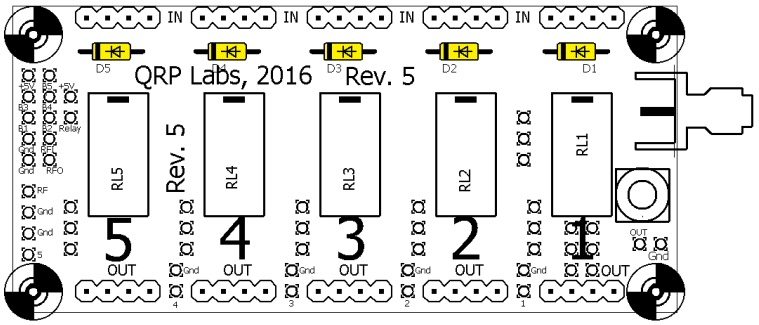


The order of construction is not important but a good principle to follow is to install the smaller components first, so that the larger ones do not prevent easy access.

One suggested order of construction is described in the following sections.

1) Diodes

Solder in the five diodes D1-D5 shown in this diagram coloured yellow. Pay attention to align the diodes correctly, according to the stripe on the diode and the silk-screen of the PCB.



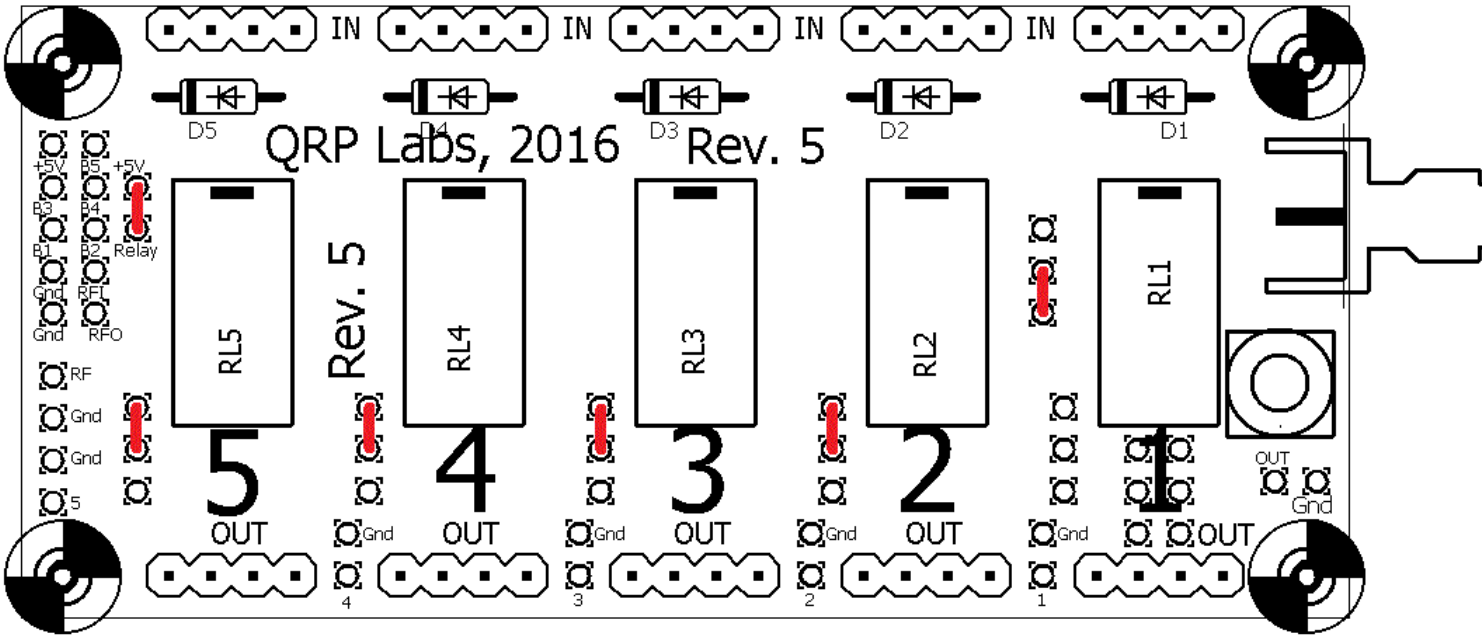
1) Jumper wires

Remember that this document describes the most common configuration that will be used with the Ultimate3S transmitter kit. The jumpers provide a lot of flexibility in how this kit is used – this will be described in separate documents.

The jumper configuration described here routes the incoming RF signal from the PA output, to the RF output at the right side of the board. The signal always passes through the far right relay (in the “1” position).

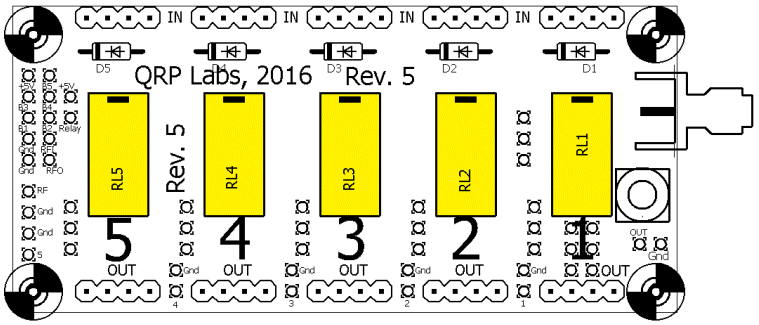
Fit 6 jumper wires as shown in RED in this diagram. The jumper wires can be made from off-cuts of the diodes.

It is important to install these jumpers correctly now, because they are difficult to reach once the relays are installed!



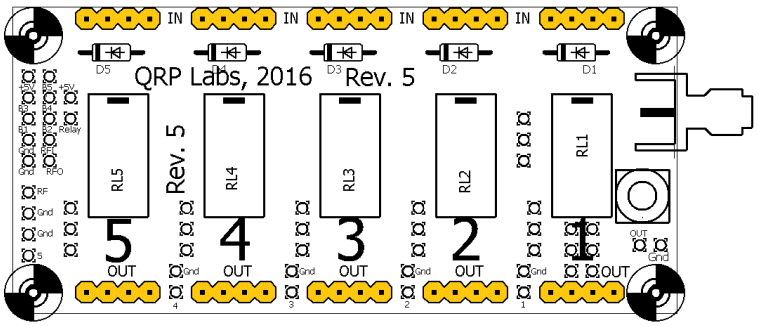
2) Relays

Fit and solder the five relays. Ensure that the relay pins are carefully straightened before inserting into the PCB, as the pins are delicate and some may have become slightly bent.

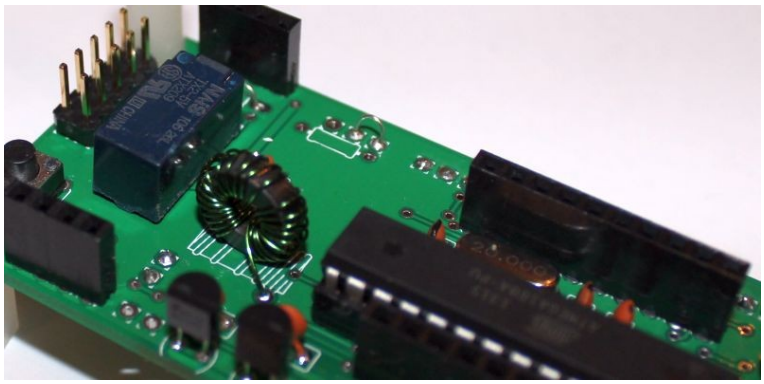


3) LPF sockets

Fit and solder the ten 4-way sockets for the LPF's. Ensure that they are pushed in properly into the PCB, and at right-angles to the PCB. One way to do this, is to plug in a constructed LPF to ensure correct orientation of the sockets, then solder them to the PCB.

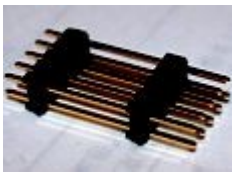


4) Relay/diode on U3S PCB

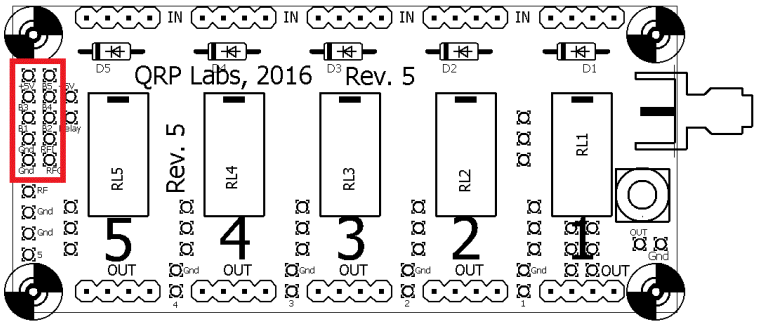


If using the LPF board with the Ultimate3 QRSS/WSPR kit, solder the 6th diode and relay (for band 0) in place under the plug-in LPF on the main Ultimate3 PCB. Note that if you have previously fitted wire jumpers at W0-W1 and W2-W3 on the main Ultimate3 PCB (for standalone use WITHOUT the relay-switched LPF board), then you need to remove these wire jumpers now.

5) Tall 5 x 2-pin header



Fit the tall 10-way (5 x 2) pin header connector, pictured to the right, to the Ultimate3S PCB. The board photo (above right) shows the old (pre 6-Feb-2014 shipped kits) board interconnect method, using the standard-height header. Insert the tall header (right), with the short pins into the PCB, and the tall pins sticking up next to the relay.



Fit the 10-way (5 x 2) socket to the BOTTOM side of the relay kit PCB (tracks side, not the components side). This will mate with the long pins of the tall header fitted to the U3 PCB.

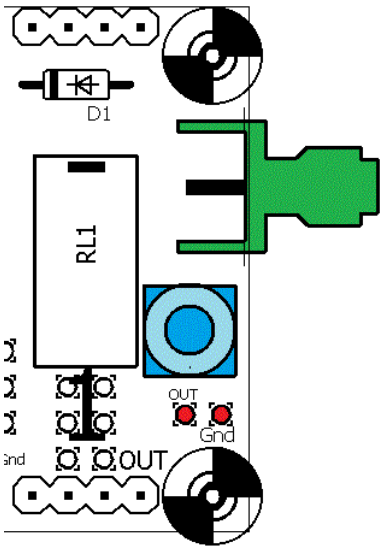
Be sure to solder the 5 x 2 socket on the BOTTOM side of the relay kit PCB! The opposite side to the relays and diodes! It's an easy mistake to make – and you wouldn't be the first – but difficult to fix!

The easiest way to ensure that the plug and socket are perfectly aligned is to assemble the U3 and the relay PCB in their final configuration, bolting the PCB's together using the 25-mm hex spacers, but WITHOUT soldering yet. This will ensure correct orientation of all the connectors.

It will still help to temporarily remove the LCD from the U3, so that you can access the U3-side header with your soldering iron.

When the two boards are bolted together and the connectors perfectly aligned, you can solder the 10-way connectors.

6) RF Output



The RF Output may be taken using the vertical SMA socket (blue), horizontal edge connecting SMA socket (green), or the 0.1-inch spaced holes (red).

When using the vertical SMA socket the SMA connector may not allow the LPF module in position 1 to fit properly.

Usually a short length of coax soldered to the vertical SMA pads (blue) and routed to an RF connector on the enclosure rear panel is best.

5. Operation

Be sure to install the LPF modules correctly! The “In” and “Out” legends on the relay board PCB silkscreen should match the text printed on the LPF modules!

When used with the Ultimate3 kit, firmware version v3.02 or above is required. Please refer to the appropriate operation manual for your firmware version, for details.

The relay-switched LPF kit may also be used with the QRP Labs Arduino shield kit.

REMEMBER! Always install the highest frequency band LPF in socket “1”. Configure your Ultimate3S accordingly – make sure to always transmit the highest frequency to band 1].

6. Resources

Please see the kit page http://qrp-labs.com /ultimatelpf for information on latest updates and issues.

Please join the Yahoo forum http://groups.yahoo.com/neo/groups/QRPLabs/info for discussion and updates on all the kits!

7. Version History

1 14-Jan-2014

- Initial version

2 06-Feb-2014

- Modified PCB interconnection method, to use single tall-header plug on the U3 side, and single 10-way socket on the relay board side.

3 28-Mar-2014

- PCB Rev 2: adds the jumper wire connections to allow connection of each relay output to either the common RF output, or an individual band output pad.

4 16-Feb-2015

- Added page numbering

5 01-Jul-2015

- PCB Rev 4: adds pads for SMA connectors on right of PCB

6 09-Nov-2015

- Note about the few mm too long headers supplied in some Rev 4 kits.

7 02-Nov-2016

- Changes and simplification, for Rev 5 PCB

8 06-Jan-2022

- Added PCB trace diagram