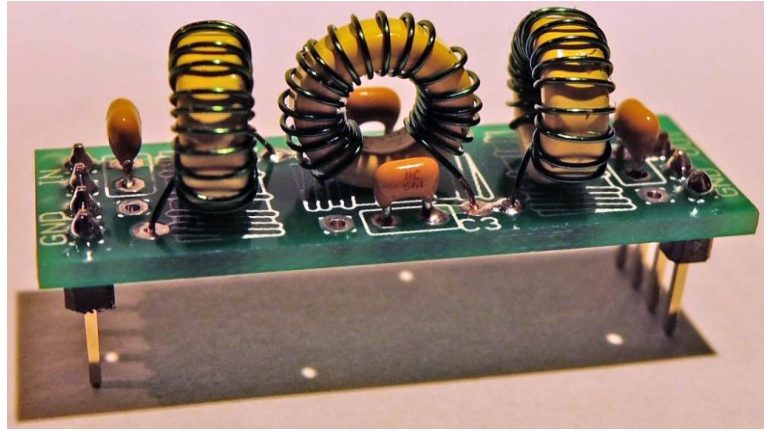


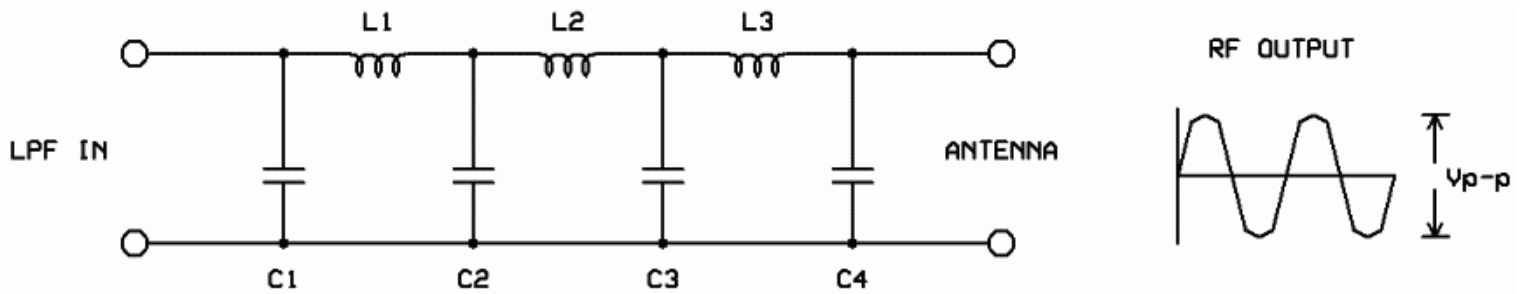
Low Pass Filter Kit

1. Introduction

A low pass filter (LPF) is required following the power amplifier of a transmitter to attenuate unwanted emissions on harmonic frequencies. This 7-element Low Pass Filter kit is based on the G-QRP technical notes, a design by Ed Wetherhold W3NQN.



2. Design



The design uses four capacitors and three inductors wound on toroids, and has 50-ohm input and output impedance. The small PCB has a 4-pin plug at its input and output. It is designed to fit onto the "Ultimate2" multi-mode QRSS/WSPR transmitter kit, but may of course be used as a LPF for other QRP transmitter designs. It also fits the relay-switched LPF kit.

Note that the kit is supplied with high-quality low-loss class-1 dielectric (CC4) RF ceramic capacitors of the C0G type (NP0, meaning near-zero temperature drift).

3. Parts List

Please refer to the parts list below, for your band. Capacitor values are in picofarads (pf) except where indicated (600m and 2200m LF band values are in nanofarads) and the inductors L1-3 specify the number of turns to wind on the toroid. L1 and L3 are the same. L2 has the higher number of turns. The inductor value is indicated in brackets after the number of turns.

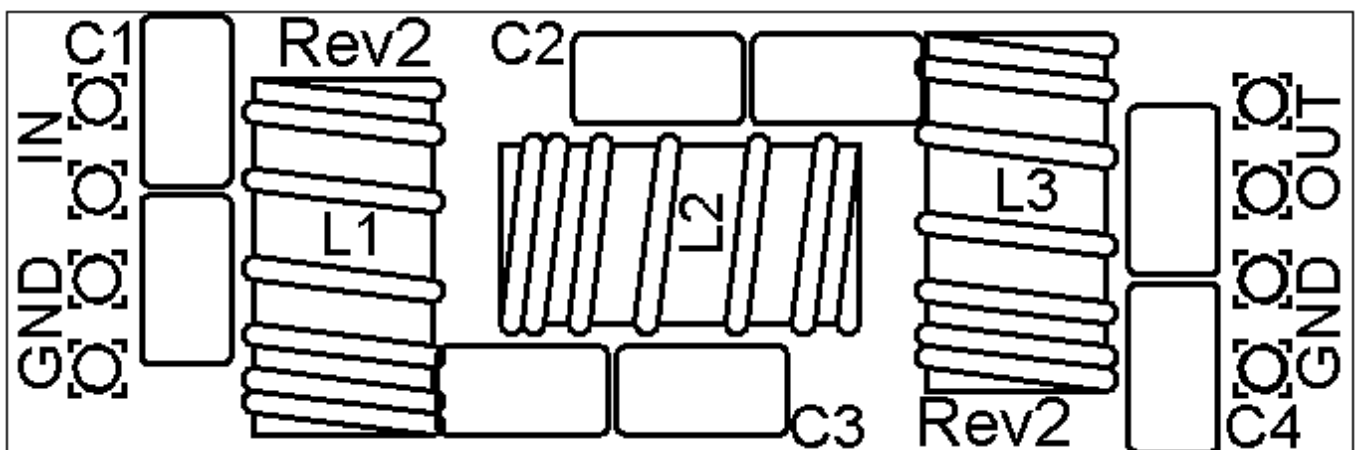
| Band | C1 | C2 | C3 | C4 | L1/L3 | L2 | Toroid |
|-------|------------|-----------|-----------|------------|-------------|-------------|----------------|
| 2200m | 2.2n//10n | 4.7n//22n | 4.7n//22n | 2.2n//10n | 105 (54uH) | 105 (54uH) | T50-2 (red) |
| 600m | 2.2n//2.2n | 10n | 10n | 2.2n//2.2n | 64 (20uH) | 70 (24uH) | T50-2 (red) |
| 160m | 820 | 2200 | 2200 | 820 | 30 (4.44uH) | 34 (5.61uH) | T50-2 (red) |
| 80m | 470 | 1200 | 1200 | 470 | 25 (2.42uH) | 27 (3.01uH) | T37-2 (red) |
| 60m | 680 | 1200 | 1200 | 680 | 23 (2.12uH) | 24 (2.30uH) | T37-2 (red) |
| 40m | 270 | 680 | 680 | 270 | 21 (1.38uH) | 24 (1.70uH) | T37-6 (yellow) |
| 30m | 270 | 560 | 560 | 270 | 19 (1.09uH) | 20 (1.26uH) | T37-6 (yellow) |
| 20m | 180 | 390 | 390 | 180 | 16 (773nH) | 17 (904nH) | T37-6 (yellow) |
| 17m | 100 | 270 | 270 | 100 | 13 (548nH) | 15 (668nH) | T37-6 (yellow) |
| 15m | 82 | 220 | 220 | 82 | 12 (444nH) | 14 (561nH) | T37-6 (yellow) |
| 12m | 100 | 220 | 220 | 100 | 12 (438nH) | 13 (515nH) | T37-6 (yellow) |
| 10m | 56 | 150 | 150 | 56 | 10 (303nH) | 11 (382nH) | T37-6 (yellow) |
| 6m | 22 | 82 | 82 | 22 | 7 (165nH) | 9 (265nH) | T37-6 (yellow) |

The following table is the same but shows the capacitor marking. The capacitor markings usually use a three digit code, where the first two digits are the value and the 3rd digit is the number of zeroes of the capacitance in pico-farads. So for example, “560” = 56pF, “271” = 270pF and “472” = 4700pF (4.7nF). You may need a magnifying glass or jeweller's loupe to view the marked value clearly. The inductor value is indicated in brackets after the number of turns.

| Band | C1 | C2 | C3 | C4 | L1/L3 | L2 | Toroid |
|-------|---------|---------|---------|---------|-------------|-------------|----------------|
| 2200m | 222+103 | 472+223 | 472+223 | 222+103 | 105 (54uH) | 105 (54uH) | T50-2 (red) |
| 600m | 222+222 | 103 | 103 | 222+222 | 64 (20uH) | 70 (24uH) | T50-2 (red) |
| 160m | 821 | 222 | 222 | 821 | 30 (4.44uH) | 34 (5.61uH) | T50-2 (red) |
| 80m | 471 | 122 | 122 | 471 | 25 (2.42uH) | 27 (3.01uH) | T37-2 (red) |
| 60m | 681 | 122 | 122 | 681 | 23 (2.12uH) | 24 (2.30uH) | T37-2 (red) |
| 40m | 271 | 681 | 681 | 271 | 21 (1.38uH) | 24 (1.70uH) | T37-6 (yellow) |
| 30m | 271 | 561 | 561 | 271 | 19 (1.09uH) | 20 (1.26uH) | T37-6 (yellow) |
| 20m | 181 | 391 | 391 | 181 | 16 (773nH) | 17 (904nH) | T37-6 (yellow) |
| 17m | 101 | 271 | 271 | 101 | 13 (548nH) | 15 (668nH) | T37-6 (yellow) |
| 15m | 820 | 221 | 221 | 820 | 12 (444nH) | 14 (561nH) | T37-6 (yellow) |
| 12m | 101 | 221 | 221 | 101 | 12 (438nH) | 13 (515nH) | T37-6 (yellow) |
| 10m | 560 | 151 | 151 | 560 | 10 (303nH) | 11 (382nH) | T37-6 (yellow) |
| 6m | 220 | 820 | 820 | 220 | 7 (165nH) | 9 (265nH) | T37-6 (yellow) |

4. Construction

Parts placement is defined by the printed legend on the PCB. Please refer to the parts placement diagram below. Note that all capacitor positions have space for 2 capacitors which are connected in parallel, this is to accommodate the required capacitance values for the LF Bands (600m and 2200m), which require two capacitors paralleled to make the right value.



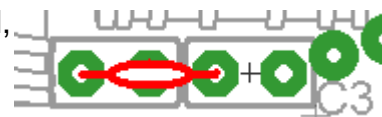
The PCB is quite small and the parts are close together. You are recommended to use a low wattage iron with a fine tip, and fine solder e.g. 1mm diameter or less. Take care not to overheat the PCB and risk damaging it. A well-lit area and magnifying glass may assist. Be careful not to bridge solder across closely-packed connections. I recommend checking with a DVM to make sure no solder bridges have been inadvertently created. Take care to ensure correct alignment of the 4-pin plugs.

Winding the toroids is quite straightforward, and the supplied wire should be enough for all three toroids, just divide it into three pieces. Remember that each time the wire goes through the centre of the toroid

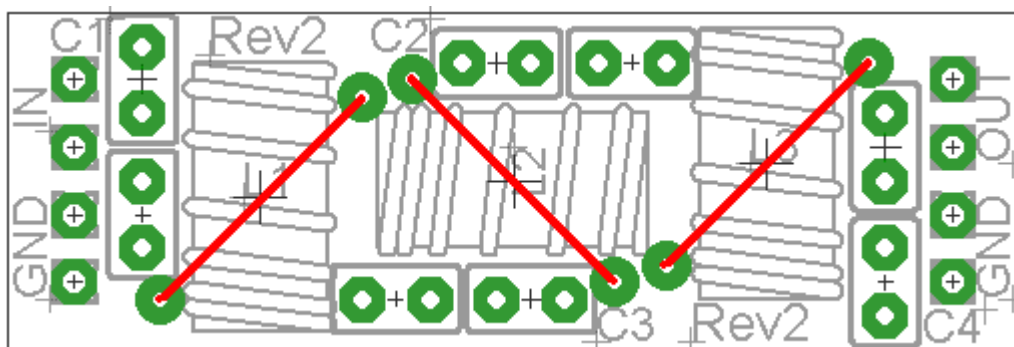
counts as one turn. You should aim to fill about 90% of the core (330-degrees). Leave a small gap between the winding ends, approx 10% of the core (30-degrees) to prevent capacitance effects between the ends. Labelling the toroids aids identification later! Trim the ends of the wire, scrape the enamel off and tin them with solder.

As an alternative to scraping the enamel off, my preferred method is to trim the wire ends back to 2mm below the board, then solder them with a small blob of solder. I hold the iron on the joint for 10 seconds. After about 7-8 seconds you can see the enamel bubble away and the solder sticks to the copper, making a good joint with the board. Check continuity on the board with a DVM.

At each capacitor position the PCB provides space for two capacitors in parallel, required for the the LF band kits. For capacitors having 5mm spaced wires, you can insert the capacitor wires into two holes as in the example (right).



Since it can be confusing to see which holes are used for the toroid wires, the image to the right paints red lines between the holes designed for the inductor wires.



Note for 17m kit: the C1 and C4

capacitors should be 110pF according to the G-QRP web page, however I could not source a 110pF capacitor, so 100pF is used and should be a reasonable substitute.

5. Special notes for LF kits (600m and 2200m)

The capacitors in the LF kits are made up of two capacitors in parallel (see above table). Make sure you put the correct capacitors in the correct positions. Where these capacitors come in 5mm wire spacing, you will need to straighten out the wires and fit them in the 2.5mm-spaced capacitor holes.

In all cases you are not going to be able to fit all of the turns on the inductor in a tidy single-layer winding. I have done tests where I wound the turns messy-style over each other and measured the inductance at every step. There is a chart of the results on the kit page (see resources section below). The practical measurements match closely with the theoretical values.

I think the best way to wind these coils is to try to wind the adjacent turns on top of each other in order to evenly distribute the total number of turns around the core, and leave a small gap between the start and finish of the winding. This appears to be to be the best way to construct the coil on a theoretical basis. So for example, if you want to wind the 105 turns of the 54uH core, then conceptually divide the core into 4 quarters, and aim to wind turns on top of each other to such an extent that you fit 26 turns onto each quarter. This should keep you roughly even as you wind.

Note that for the 105 turns you need nearly 2m of wire, and so you end up drawing through a long length of wire with each turn, that's a reasonable amount of physical work! My trick is to first drop the toroid onto the wire so that the toroid's first turn is at the centre of the wire. Then wind outwards towards one end of the wire, half the turns, onto half the core. Count as you go. Then go back to the other half of the wire, and

wind that on. The end result is the same but rather than pulling 2m of wire through the core each turn, you only have to pull a maximum of 1m of wire.

In all cases for the LF kits, there are three lengths of wire, you do not need to cut them into three pieces! They are already measured (roughly with some spare) to fit the required number of turns. E.g. for the 2200m kit you have three lengths of wire, of approx 2m each.

If you have an LC meter then I think it's a good idea to wind 10 turns too many and then remove them until you get close to the target value. However I believe that even with no measurement, just winding by the numbers, you will still get an excellent result.

6. Resources

Please see the kit page <http://www.hanssummers.com/lpokit> for any information on latest updates and issues.

The G-QRP club LPF design: please see document on page: <http://www.hanssummers.com/lpokit>

Please join the Yahoo group <http://groups.yahoo.com/group/qrplabs/> to for new kit announcements and to discuss any problems with the kit, enhancements you've made, or just to tell everyone how much fun you're having.