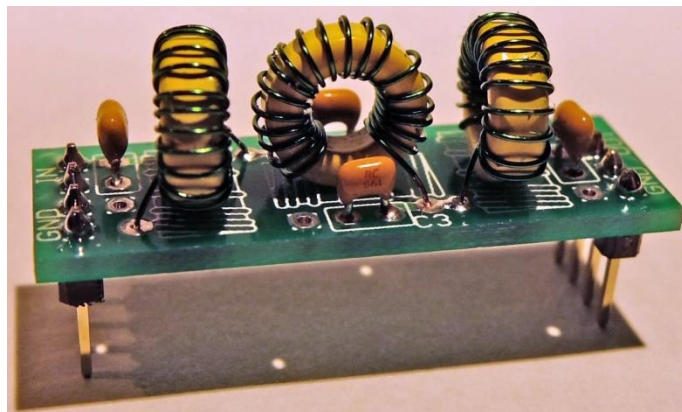


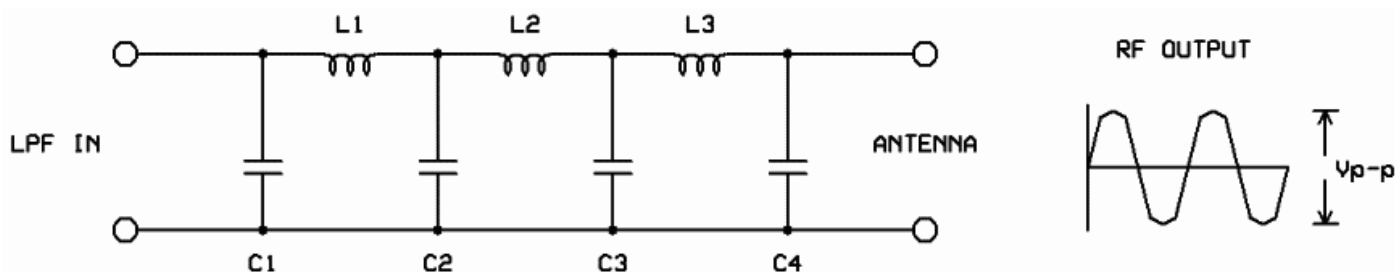
Low Pass Filter kit assembly instructions

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 “Ultimate/2/3/3S” multi-mode QRSS/WSPR transmitter kits, but may of course be used as a LPF for other QRP transmitter designs. It also fits the relay-switched LPF kit.

The kit is supplied with high-quality low-loss class-1 dielectric (CC4) RF ceramic capacitors of the COG type (NPO, 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.

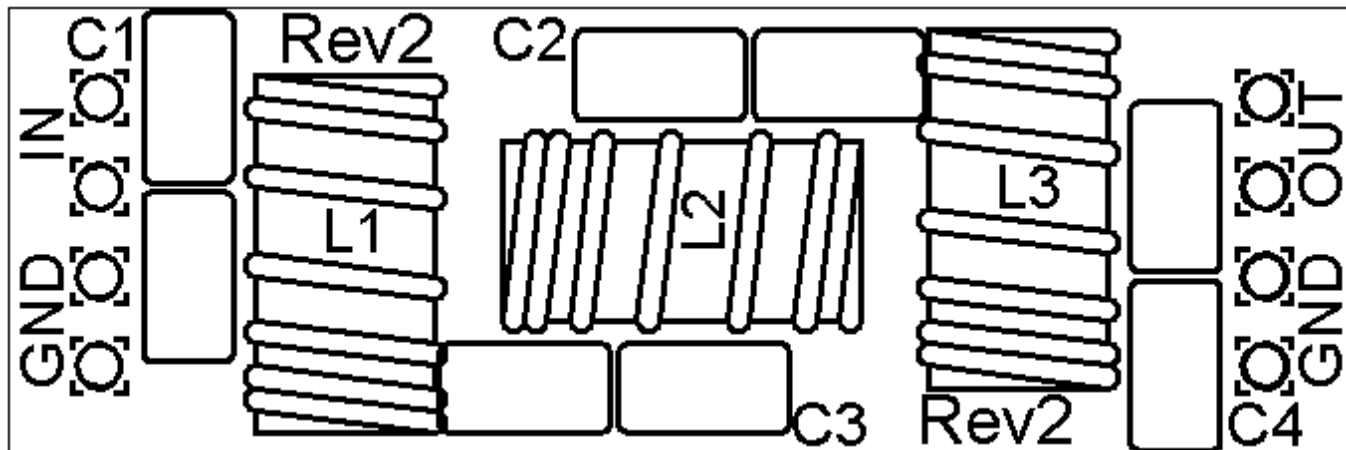
9Band	C1	C2	C3	C4	L1/L3	L2	Toroid
2200m	2.2n//10n	4.7n//22n	4.7n//22n	2.2n//10n	105 (54uH)	105 (54uH)	T50-2 (red)
600m	2.2n//2.2n	10n	10n	2.2n//2.2n	64 (20uH)	70 (24uH)	T50-2 (red)
160m	820	2200	2200	820	30 (4.44uH)	34 (5.61uH)	T50-2 (red)
80m	470	1200	1200	470	25 (2.42uH)	27 (3.01uH)	T37-2 (red)
60m	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)
4m	10	56	56	10	6 (110nH)	7 (150nH)	T37-6 (yellow)
2m	22	33//10	33//10	22	3	3	None (air)
222M	22	33//10	33//10	22	2	2	None (air)

The following table is the same except that it 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)
4m	100	560	560	100	6 (110nH)	7 (150nH)	T37-6 (yellow)
2m	220	330+100	330+100	220	3	3	None (air)
222M	220	330+100	330+100	220	2	2	None (air)

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 some Bands, which require two capacitors paralleled to make the right value. The PCB can also accommodate either 2.54mm spaced capacitor pins or 5.08mm (0.1 inch or 0.2 inch).

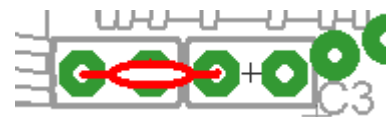


The PCB is quite small and the parts are close together. You are recommended to use a low wattage iron with a fine tip, and fine solder e.g. 1mm diameter or less. Take care not to overheat the PCB and risk damaging it. A well-lit area and magnifying glass may assist. Be careful not to bridge solder across 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.

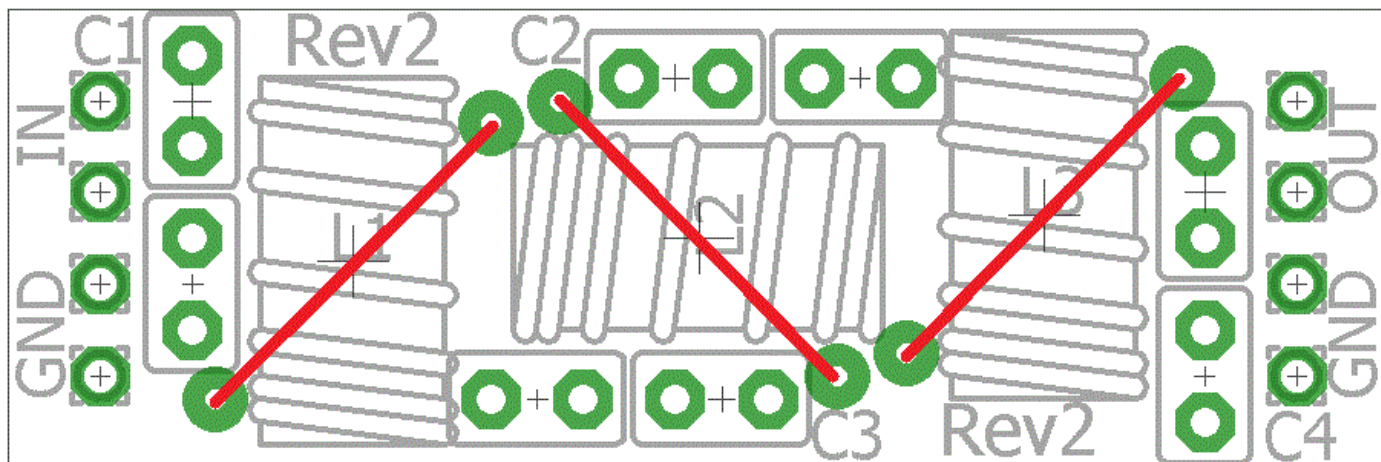
Winding the toroids is quite straightforward, and the supplied wire should be enough for all three toroids, just divide it into three pieces. Remember that each time the wire goes through the centre of the toroid counts as one turn. You should aim to fill about 90% of the core (330-degrees). Leave a 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, this image (below) 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 table 3). 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 21 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.

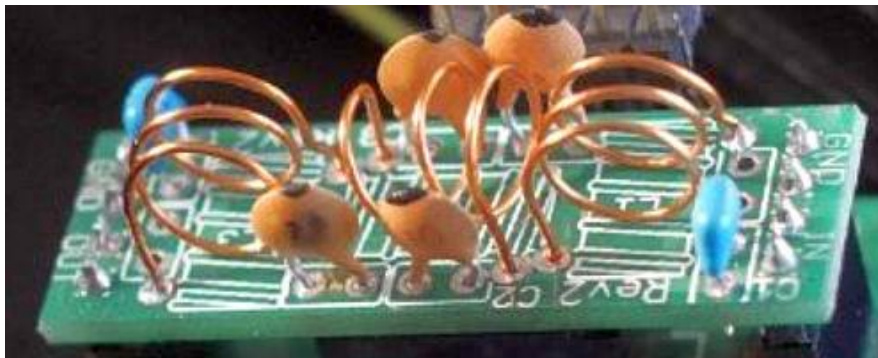
If you have an LC meter then I think it's a good idea to wind 10 turns too many and then remove them until you get close to the target value. However I believe that even with no measurement, just winding by the numbers, you will still get an excellent result.

6. Special notes for 4m kit

The 4m LPF kit design is by Ken G4APB and also verified by QRP Labs. Please refer to <http://qrp-labs.com/lpokit#4m> for measurements.

7. Special notes for 2m kit

The 2m LPF kit design is by Tor SM6FWF and also verified by Rick NM3G. Please refer to <http://qrp-labs.com/lpokit#2m> for measurements. The inductors are 3 turns of wire wound on a 6mm diameter air-core, as pictured (right). The middle coil should be a little longer (for lower inductance).



8. Special notes for 222MHz kit (same kit as 2m)

The 222MHz LPF kit design is by Rick NM3G and uses exactly the same components as the 2m LPF kit. The supplied kit is labelled "2m". Only the inductor lengths are different. The 2m filter and testing results are described on this page <http://qrp-labs.com/ultimate3/u3info/ultimate3222.html>

The inductors should be constructed from three pieces of the supplied enamelled wire 1.43" (36mm) long. Strip and tin the ends 1/4" (6mm), and wind two turns around a 0.15" (5/16", 4mm) drill bit, before installation on the PCB. At 222MHz the length of wire making the inductor is much more important than the shape. So do not worry too much about the diameter or length of the coils.

9. Resources

Please see the kit page <http://grp-labs.com/lpokit> for information on latest updates and issues.

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

Please join the QRP Labs group <https://groups.io/g/QRPLabs> 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.