T41 BPF Assembly Manual

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WJ Schmidt - K9HZ

INTRODUCTION

The new T41 V12 BPF is really a general-purpose band-pass filter that can be used by all SDRs and SDTs as a preselector on receive, and as a true band pass filter on transmit. There are filter sections on the board for 160M, 80M, 60M, 40M, 30M, 20M, 17M-15M, 12M-10M, 6M, and BYPASS. There is no requirement to build out all filter sections if you intend on using a smaller set. The filters are selected using I2C communication and provide over 50dB of isolation on harmonic multiples, and better than 40dB on adjacent bands. Integrated logic is used to switch the BPF from the receive "antenna to receiver" path to the transmit "low power exciter to PA" by pin 1 of J4, the "BANDS" connector. BPF boards are sold individually, as part of the T41 V011 upgrade to V12 kit, and as part of a new T41 V12 radio board set. Note that if you will build the second receiver for the T41 V12, the second receiver BPF in identical to the first receiver BPF except for the I2C address (

THEORY OF OPERATION

1. **Power.**
   Board power is 12VDC provided by a connector placed on the back side of the board. A 3.3V regulator provides voltage for the remainder of the parts on the board. Total power draw is on the order of 12ma.

2. **I2C addressing and switching.**
   The BPF board is completely controlled via I2C communications. A MCP23017 16 bit I/O expander is used to communicate with a central processor (not provided) via SCL and SDA serial lines brought in through pins 7 and 5 of the J4 the "BANDS" connector. The I/O expander has hex address 0x24, and the user can select any of eight chip addresses from "000" to "111" shorting the solder switches provided (nb. the address of the expander for the T41 V12 primary receiver BPF address is "100"… so the solder switch on the board for A2 at JP4 should be filled and the rest left blank. The BPF address for the second receiver is "101"… so the solder switches for A2 and A1 at JP4 should be filled; and A0 should be left blank). See the following for more information: https://github.com/DRWJSCHMIDT/T41/blob/main/T41_V012_Files_01-15-24/T41_V012_Design_Documents/T41_V12.6_I2C_Assignments.xlsx

   Two eight-bit words written by the external processor to the I/O expander to activate the expanders output lines to select the filters. Only one filter (or BYPASS) should be

selected at a time even though multiple filters could be theoretically selected. The I/O expander has two output ports, designated GPA0-GPA7 and GPB0-GPB7. Writing a "1" to these locations selects the filters and the TX or RX switched paths. The truth table for this is:

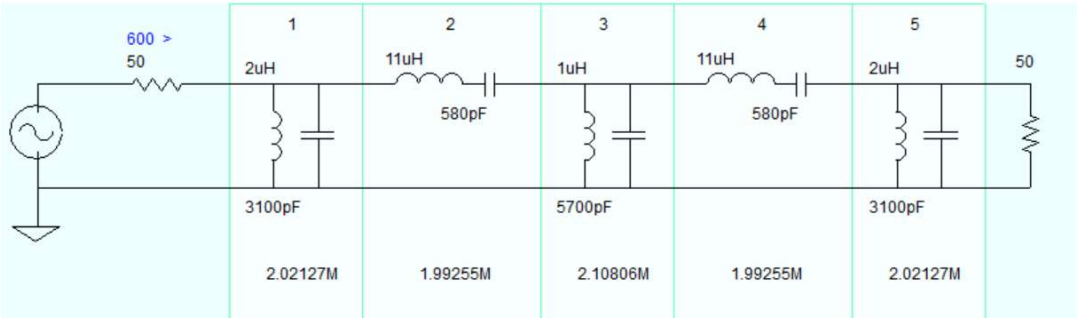
BAND	GPA0	GPA1	GPA2	GPA3	GPA4	GPA5	GPA6	GPA7	GPB0	GPB1	GPB2	GPB3	GPB4	GPB5	GPB6	GPB7
160M	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
80M	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
60M	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
40M	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
30M	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20M	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
15M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12M	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10M	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6M	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bypass	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

The BPF is switched into the TX path when pin 1 of J4 the "BANDS" connector is HIGH (=3.3V), and in the RX path when pin 1 is LOW (=0.0V).

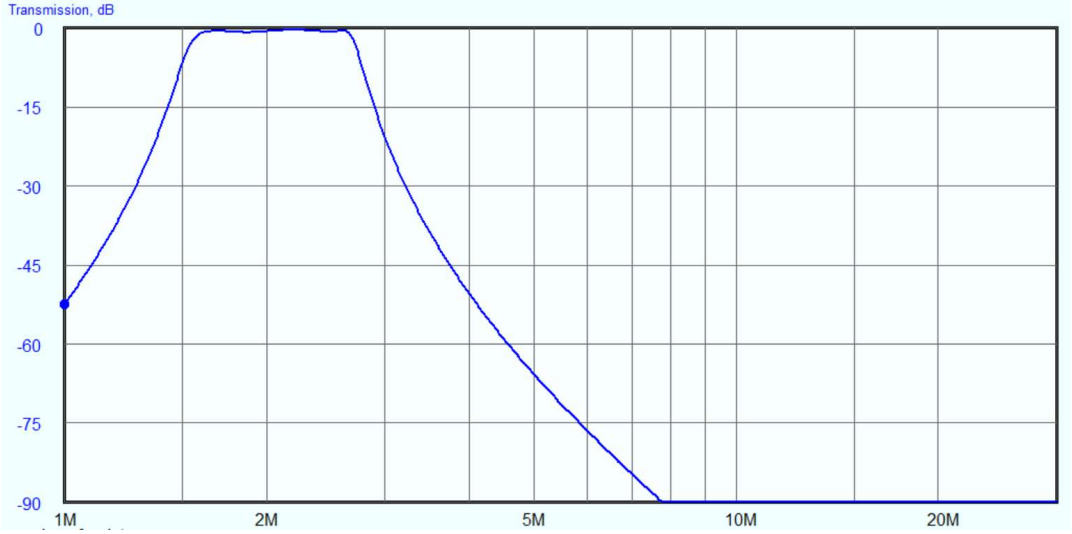
All RF switching is accomplished using MASWSS0179 SPDT switches. Opposite switch polarity is accomplished using SN74LVC1G04DCK signal inverters.

3. Filter Design.

Each of the individual filter sections were designed using ELSIE as five section, ten pseudo pole, shunt-input Chebyshev filters as seen below (example for 160M):



The filters are designed for 50 ohms input and output, and have very tight bandwidths as can be seen in the transmission plot (160M) below:



The design files and plots for all filters can be found here: [T41/T41_V012_Files_01-15-24/T41_V012_BPF_Design_Files at main · DRWJSCHMIDT/T41 (github.com)]

CONSTRUCTION

Begin by deciding how many of the filter sections you will build. For those sections, the inductors can be EITHER hand-wound T-37 sized toroids, or 1206 SMD sized fixed inductors. Either approach gives good results. Two capacitors are stacked together in some cases to get the required value for the filter section. Soldering stacked capacitors is not difficult… place one on the board first, solder it on both ends, and then solder the stacked capacitor on top of the soldered capacitor… soldering it in place as if it were being placed directly onto the board.

Inventory all parts for your BPF. Print out the BOM and check them off so you know is something is missing. The BPF can be found here: https://github.com/DRWJSCHMIDT/T41/blob/main/T41_V012_Files_01-15-24/T41_V012_BOMs/T41_BPF_Board_BOM_V12.6_03-09-24.xlsx

1. **Switches and Inverters first (top).**

   Place all of the MASWSS0179 switches (U1, U3, U4, U6, U7, U9, U10, U12, U13, U15, U16, U18, U19, U21, U24, U25, U27, U28, U30, U31, U36) on the top of the board first. Place the SN74LVC1G04DCK parts (U2, U5, U8, U11, U14, U17, U20, U23, U26, U29, U37) at the same time.

2. **Diodes and Resistors (top).**

   Place diodes D1-D4 and the three resistors R1, R2, and R3 on the board top. Watch the polarity of the diodes… the bar can be hard to see. The white bar should be on the left

side of the diode as the board sits with the two mounting holes at the bottom. Now is a good time to select the address for the I/O expander too. Place a solder blob to make the associated address line a "1" (for the T41 project, that would be JP4 or address line A2 only for the primary receiver).

3. **Capacitors (top).**

   Place top-side capacitors. There are 119 SMD capacitors to place if you elected to build the entire BPF.

4. **The Bottom.**

   Place parts on the bottom of the board. Turn J3 so that the wires enter the connector from the top. TP15 can be placed on either side of the board… your choice.

5. **The Inductors (top).**

   If you are using SMD 1206 form inductors, simply put the indictors in the spaces provided. For using toroids, the winding information is on the BOM. There is no right or wrong way to wind the toroids. Just wind them so that the wire is spread out over the entire space of the core. A trick here is to use special low melting enamel wire… so that you can simply tin the end of the wires on the toroid with a hot blob of solder… the enamel burns off and leaves bare copper that tins with the solder (wire that comes in the kit from KitsAndParts is this kind of wire). I usually wind all of the toroids before placing them. You can print out the PCB from the PDF file in the Github and place them on the paper in their spots for safe keeping.

   Placing toroids can be difficult without a little help. I use small strips of carpet tape (double sided tape) cut to fit inside the toroid outlines on the PCB. Put the tape strip down first, then place the toroid. Then flip the board over… push down a little… and solder both leads.

6. **Finishing up (top).**

   Mount the four SMA RF connectors on the top (or bottom if you prefer) of the PCB and solder them into place.

7. **Inspect and Clean.**

   Inspect your BPF board to make sure there are no empty spots for parts unless you intended on leaving some parts off.

You can clean your BPF board using IPA followed by dishwashing detergent. A toothbrush helps get all the flux off. Dry the board with a hair dryer on LOW HEAT until completely dry. Your BPF is ready to use.

8. **Testing.**

   Routines for testing the BPF are located here:

   www.GitHub.com\T41\T41_V012_Files_01-15-24\T41_V012_Software\T41_V12_Software_For_Board_Testing\V12_BPF_Board_Test\BPFTest.