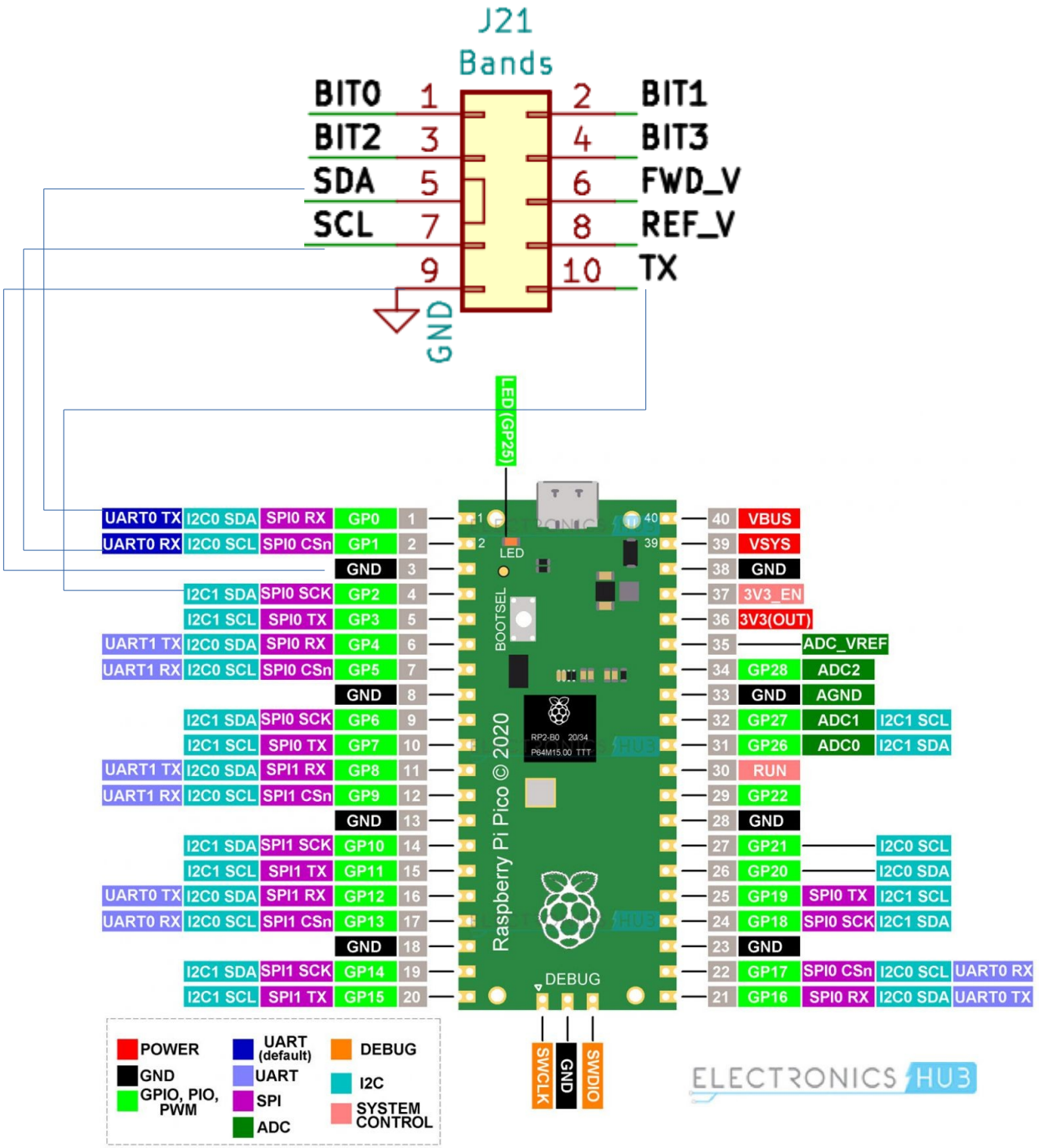
K9HZ LPF Module Prototype Testing Report

Board rev version	Schematic version	Tester	Date
2024-01-14	V1.00	Oliver KI3P	2024-02-15

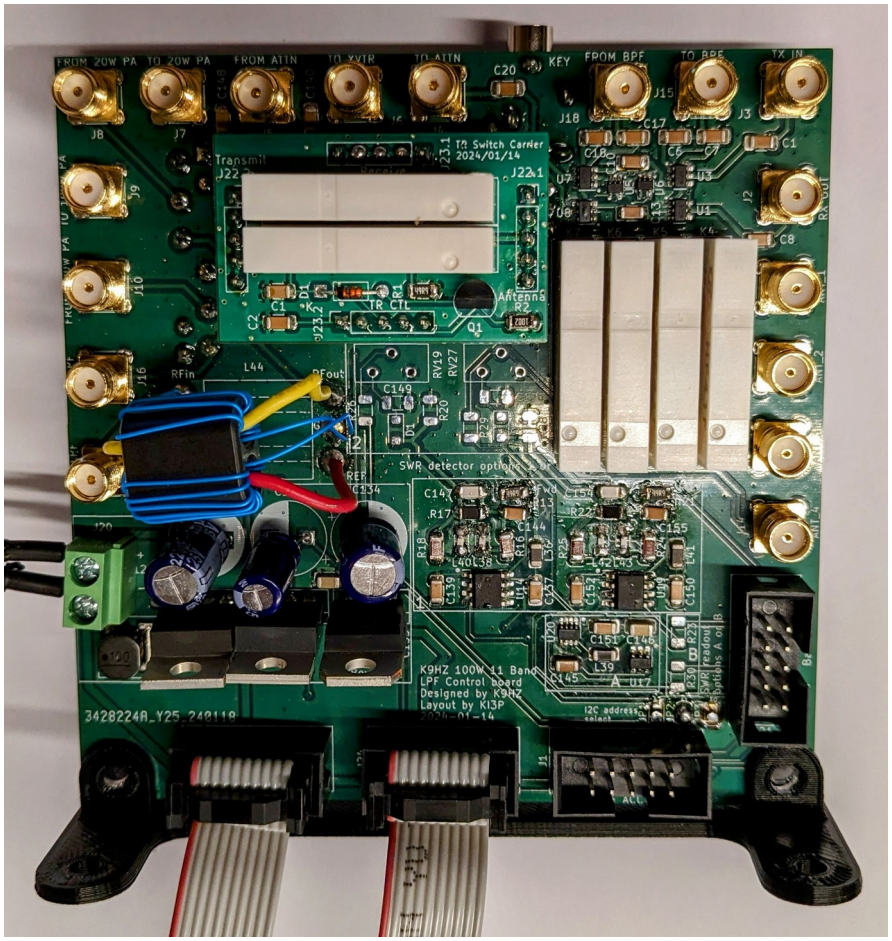
Testing setup

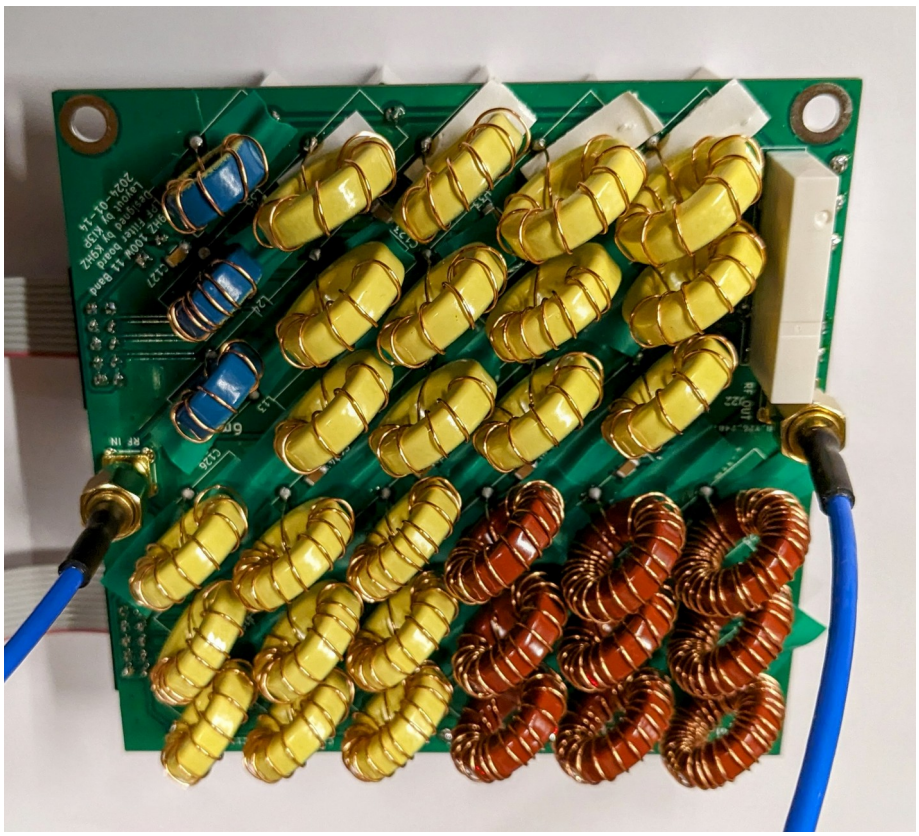


Drawing 1: Wiring from Pico to Bands connector

Test sketch used: `pico_T41_LPF_tester.ino`

Assembled prototype boards





Test table

#	Name	Description	Pass/ Fail
1	Band selection	Can we select the appropriate relays in the LPF bands?	PASS
2	Antenna selection	Can we select the appropriate relays in the antenna output?	PASS
3	Transverter selection	Can we place the transverter into the signal path?	PASS after fixes
4	100W PA selection	Can we place the 100W PA into the signal path?	PASS
5	BPF selection	Can we place the BPF into the TX signal path? Can we place the BPF into the RX signal path?	PASS
6	High pass filter performance	Measure the passband of the RX HPF	PASS
7	Low pass filter performance	Measure the passband of the LPF bands	PASS after fixes
8	SWR measurement	Confirm the correct operation of the SWR measurement section	PASS after fixes
9	Key out	Confirm that Key Out operates as intended	PASS after fixes
10	Transmit/receive	Confirm that the TX/RX switching operates correctly	PASS

1. Band selection

Can we select the appropriate relays in the LPF bands?

Test approach:

1. Use test sketch to select relevant filter.
2. Use multimeter to confirm 0 Ohm connection from RF center pins on input and output to relevant inductors.

Band	Result
160m	PASS
80m	PASS
60m	PASS
40m	PASS
30m	PASS
20m	PASS
17m	PASS

15m	PASS
12m	PASS
10m	PASS
6m	PASS
NF	PASS

2. Antenna selection

Can we select the appropriate relays in the antenna output?

Test approach:
1. Use test sketch to select relevant antenna.
2. Use multimeter to confirm 0 Ohm connection from Antenna output (J16.1) to center pin of RF connector

Antenna	**Result**
1	PASS
2	PASS
3	PASS
4	PASS

3. Transverter selection

Can we place the transverter into the signal path?

Board fix was required to get transverter selection working. Transverter getting “stuck”: when changing from transverter selected state to HF state, it took a long time for the SPDT switch to change after the logic line out of the MCP23017 changes. Switching from HF to Transverter is almost instantaneous. Changing from Transverter back to HF exhibits the long delay. Typical times: 15s, 16.5s, 16.5s. Reason: transverter control is not supposed to go through the ULN2803 part. After board mod, testing continued.

Test approach:
1. Use test sketch to toggle transverter.
2. Use VNA to measure low insertion loss between J5 and J6 when transverter selected, and low IL between J5 and J7 when transverter is not selected.

State	**Result [IL]**
Selected	PASS [-0.4 dB]
Not selected	PASS [-42 dB]

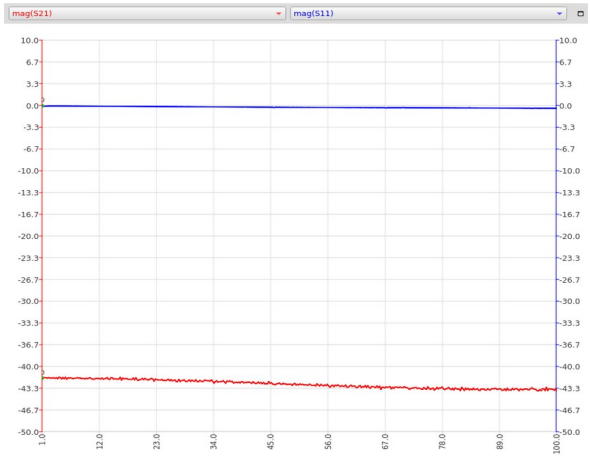


Figure 2: J5 to J6 when transverter NOT selected (should be high insertion loss)

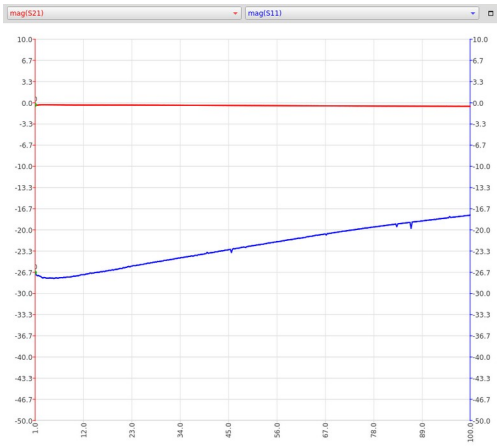


Figure 1: J5 to J6 when transverter is selected (should be low insertion loss)

4. 100W PA selection

Can we place the 100W PA into the signal path?

Test approach:
1. Use test sketch to toggle 100W PA.
2. Use multimeter to measure 0 Ohm resistance between J8 and J9 when 100W PA is selected, and high resistance when not selected.
3. Measure low resistance between J10 and J16 when selected, and high resistance when not.

State	**Result**
Selected	PASS
Not selected	PASS

5. BPF selection

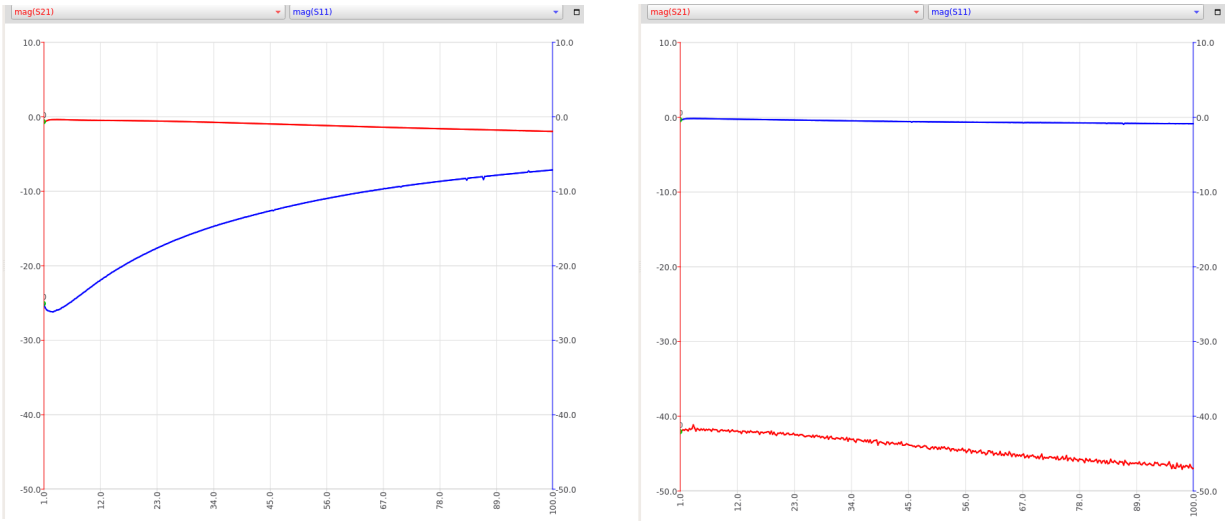
Can we place the BPF into the TX signal path?
Can we place the BPF into the RX signal path?

Test approach:
0. No BPF connected, TX path testing.
1. Use test sketch to toggle BPF.
1. Use test sketch to select TX BPF, not select RX BPF, and put in TX mode.
2. Use VNA to measure low insertion loss between J3 (From TX) and J15 (To BPF) when TX BPF selected, and high IL between J3 and J15 when TX BPF is not selected.
3. Use VNA to measure low insertion loss between J3 (From TX) and J4 (To ATTN) when TX BPF not selected, and high IL when TX BPF is selected.

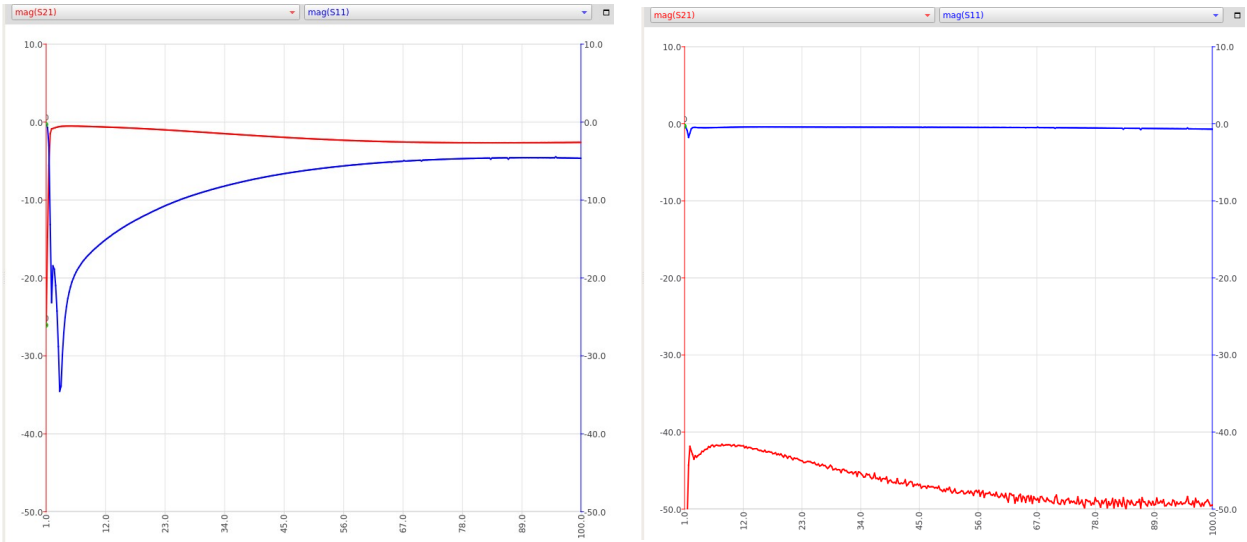
0. No BPF connected, RX path testing.
1. Use test sketch to select RX BPF, not select TX BPF, and put in RX mode.
2. Use VNA to measure low insertion loss between appropriate antenna input and J18 when RX BPF selected, and high IL between antenna input and J18 when RX BPF is not selected.
3. Use VNA to measure low insertion loss between antenna input and J2 when RX BPF not selected, and high IL when RX BPF is selected.

State	J3 to J15	J3 to J4	Result
TXB selected	Low (PASS)	High (PASS)	PASS
TXB not selected	High (PASS)	Low (PASS)	PASS

State	Ant to J18	Ant to J2	Result
RXB selected	Low (PASS)	High (PASS)	PASS
RXB not selected	High (PASS)	Low (PASS)	PASS



“TX In” (J3) to “To BPF” (J15) when TX BPF is selected (left) and not selected (right). RX BPF is opposite selection.



Antenna to “From BPF” (J18) when RX BPF is selected (left) and not selected (right). TX BPF is opposite selection.

6. High pass filter performance

Measure the passband of the RX HPF.

1. Use test sketch to not select RX BPF.
2. Select antenna 1.
3. Use VNA to measure insertion loss between J11 (antenna 1) and J2.

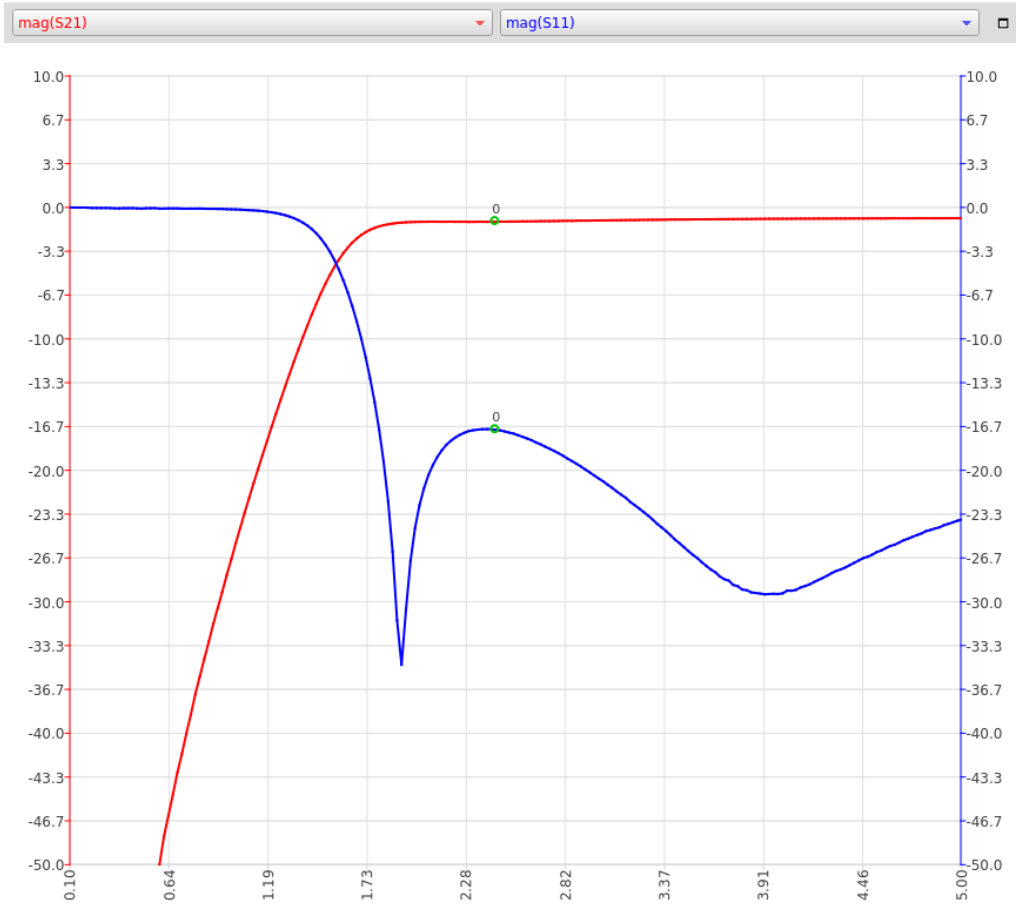


Figure 3: Receive High Pass Filter response (J11 to J2)

PASS

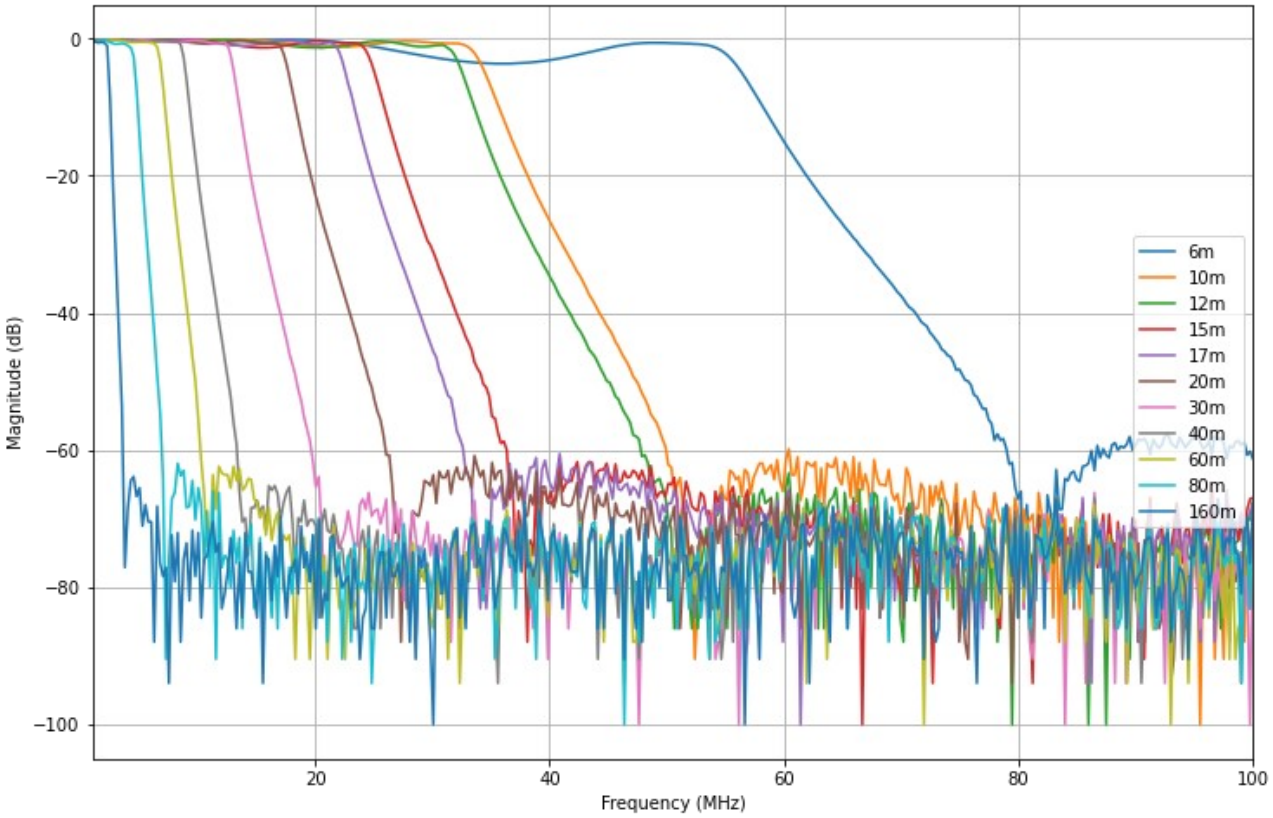
7. Low pass filter performance

Measure the passband of the LPF bands.

Filter selection was not working at first. Reason was footprint error with ULN2803 parts (U4,U9,U10). After board modification below testing was conducted.

Band	**In-band freq**	**3x freq**	**In-band IL [dB]**	**3x IL [dB]**
160m	1.9 MHz	5.7 MHz	-0.5	-70.4
80m	3.75 MHz	11.25 MHz	-0.8	-66.8
60m	5.37 MHz	16.11 MHz	-0.5	-71.4
40m	7.15 MHz	21.45 MHz	-0.2	-67.8

30m	10.1 MHz	30.3 MHz	-0.3	-83.0
20m	14.175 MHz	42.525 MHz	-0.4	-79.4
17m	18.1 MHz	54.3 MHz	-0.4	-70.0
15m	21.2 MHz	63.6 MHz	-0.5	-70.9
12m	24.93 MHz	74.79 MHz	-0.4	-82.6
10m	28.8 MHz	86.4 MHz	-0.4	-75.0
6m	52 MHz	156 MHz	-0.8	?



Value	#	Core	BOM Turns	Final Turns
0.17	L24	T50-17	9	8
0.188	L13, L35	T50-17	10	8
0.305	L23	T68-6	8	7
0.335	L12, L34	T68-6	8	7
0.337	L11, L33	T68-6	8	7
0.342	L22	T68-6	8	7
0.406	L21	T68-6	9	8
0.447	L10, L32	T68-6	10	9
0.471	L20	T68-6	10	9
0.519	L9, L31	T68-6	11	10
0.608	L19	T68-6	11	10
0.67	L8, L30	T68-6	12	11
0.843	L18	T68-6	13	12
0.928	L7, L29	T68-6	14	13
1.22	L17	T68-6	16	15
1.34	L6, L28	T68-6	17	16
1.6	L16	T68-2	17	16
1.76	L5, L27	T68-2	18	17
2.43	L15	T68-2	21	20
2.68	L4, L26	T68-2	22	21
4.73	L14	T68-2	29	28
5.21	L3, L25	T68-2	30	30

8. SWR measurement

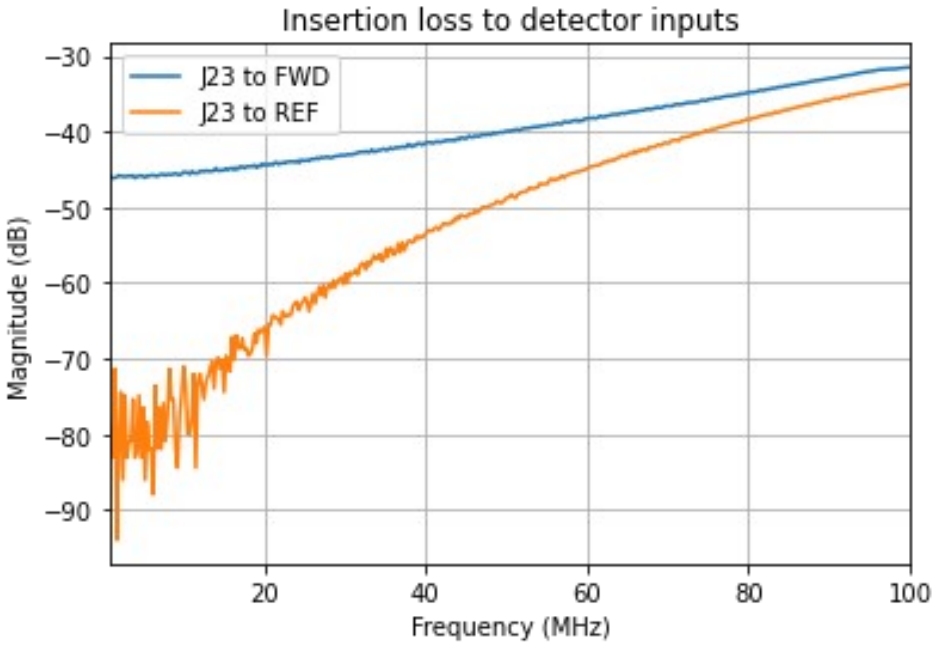
Confirm the correct operation of the SWR measurement section.

SWR measurement was not working at first. Reason was incorrect inductance (22uH) for L38, L40, L42 and L43 specified on the schematic. It should be 22 nH. Testing below conducted after this was corrected.

1. Use test sketch to select TX, put dummy load on antenna, place ATU-100 and KO4THB SWR meter inline between radio and LPF board, connect RF path to J23.
2. Transmit a variety of sounds and compare SWR measurements.

Waveform, freq	ATU-100	KO4THB	LPF DUT
100 WPM CW,10 MHz	1.1	1.26	1.31
Whistling, 5 MHz	1.13	1.24	1.17
Whistling, 10 MHz	1.1	1.22	1.24
Whistling, 20 MHz	1.1	1.40	1.47
Whistling, 30 MHz	1.1	1.20	1.80

Seems close enough without calibration, PASS!



9. Key out

Confirm that Key Out operates as intended.

Key out did not work at first. Reason was footprint of Q2 (2N7000) was wrong. After board mod, below testing was conducted.

Test method.

1. Measure conductance between tip and shield of audio cable plugged in to J19. When in RX mode they should be disconnected. When in TX mode they should be connected.

PASS

10. Transmit/receive

Confirm that the TX/RX switching operates correctly.

Test approach:
0. Put TR carrier in place.
1. Put into RX mode. Confirm that IL from Antenna to J2 is low.
2. Put into TX mode. Confirm that IL from Antenna to J23 is low.

PASS

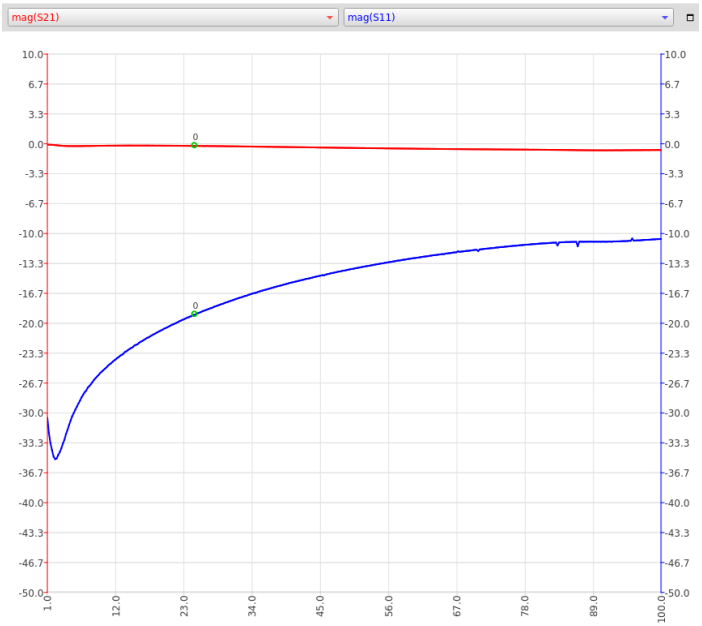


Figure 4: Antenna to J23 (LPF) when in TX state. Should be low insertion loss.

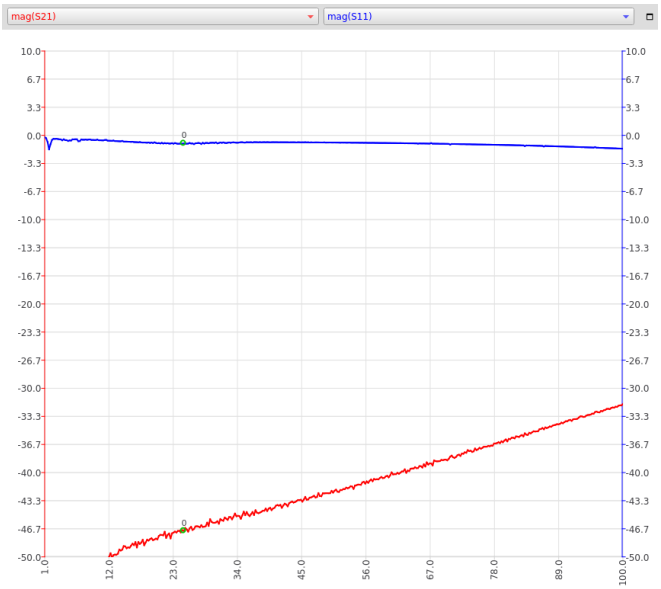


Figure 5: Antenna to J23 (LPF) when in RX state. Should be high insertion loss.

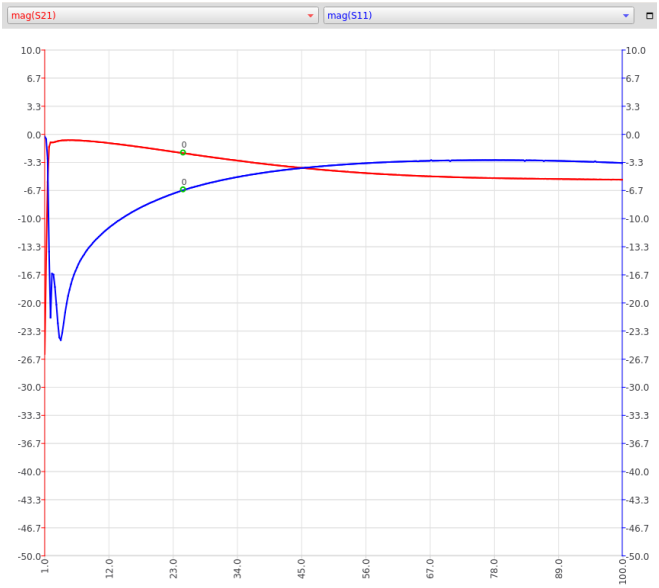


Figure 6: Antenna to J2 (receive in) when in RX state. Should be HPF response curve.

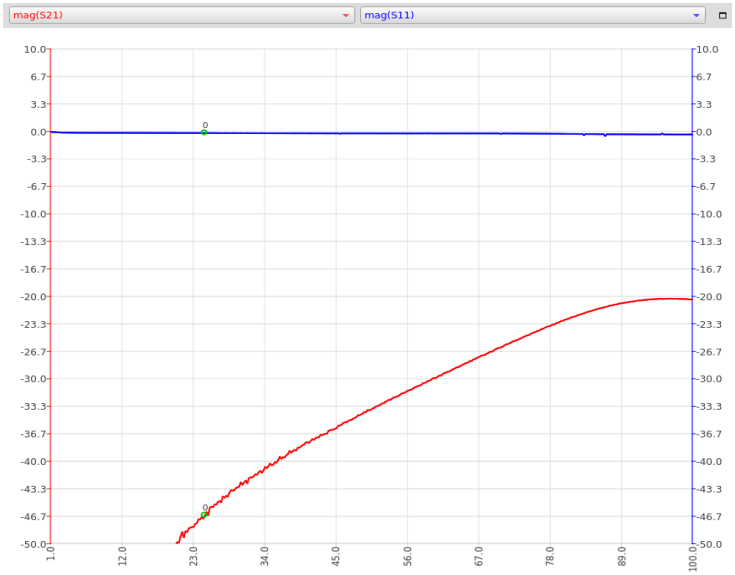


Figure 7: Antenna to J2 (receive in) when in TX state. Should be high insertion loss.

ERRATA

Fix pinout of ULN2803 components to the ULN2803C variant (U4,U9,U10), put 20-pad footprint down, redraw traces. Implemented?: yes.

GPB6 of U15 (transverter select) must not go through ULN2803C (U4). It should drive the MASWSS0179 directly. Implemented: yes.

Incorrect inductance (22uH) for L38, L40, L42 and L43 specified on the schematic. It should be 22 nH. Implemented: yes.

Footprint of Q2 is wrong. It should have 1 = source, 2 = gate, 3 = drain. Implemented: yes.

Layout and schematic versions that implement all of the above are dated 2024-02-14, version 1.1