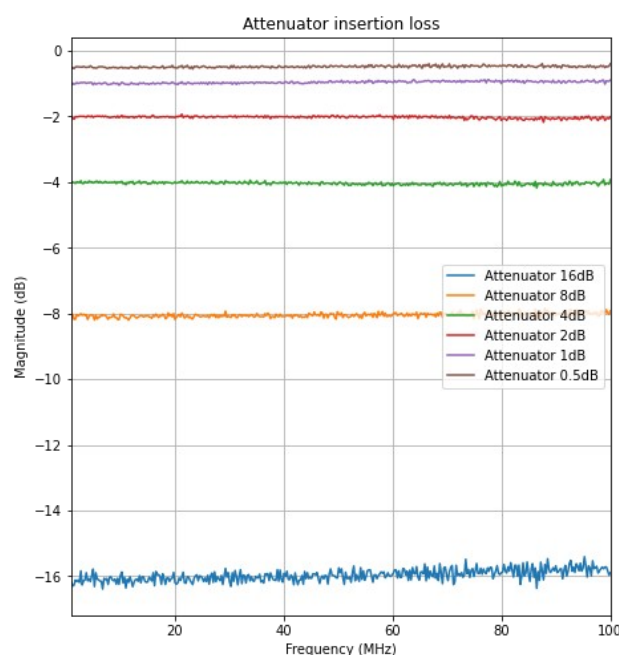
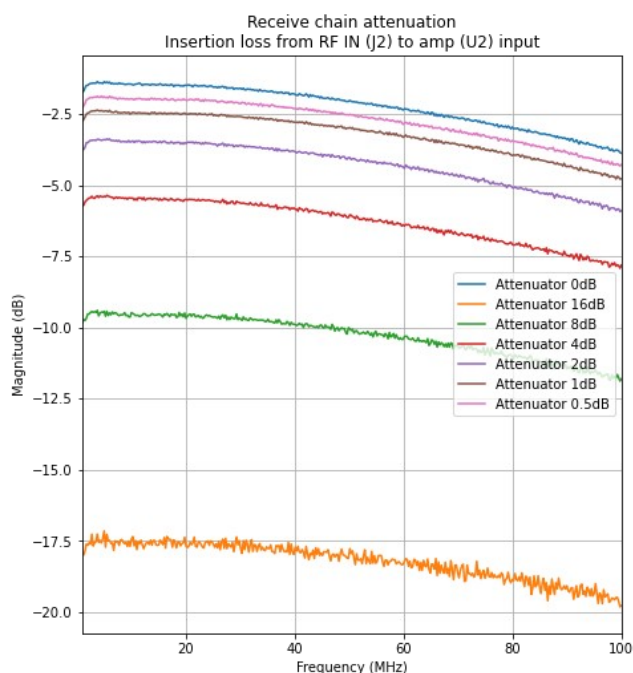
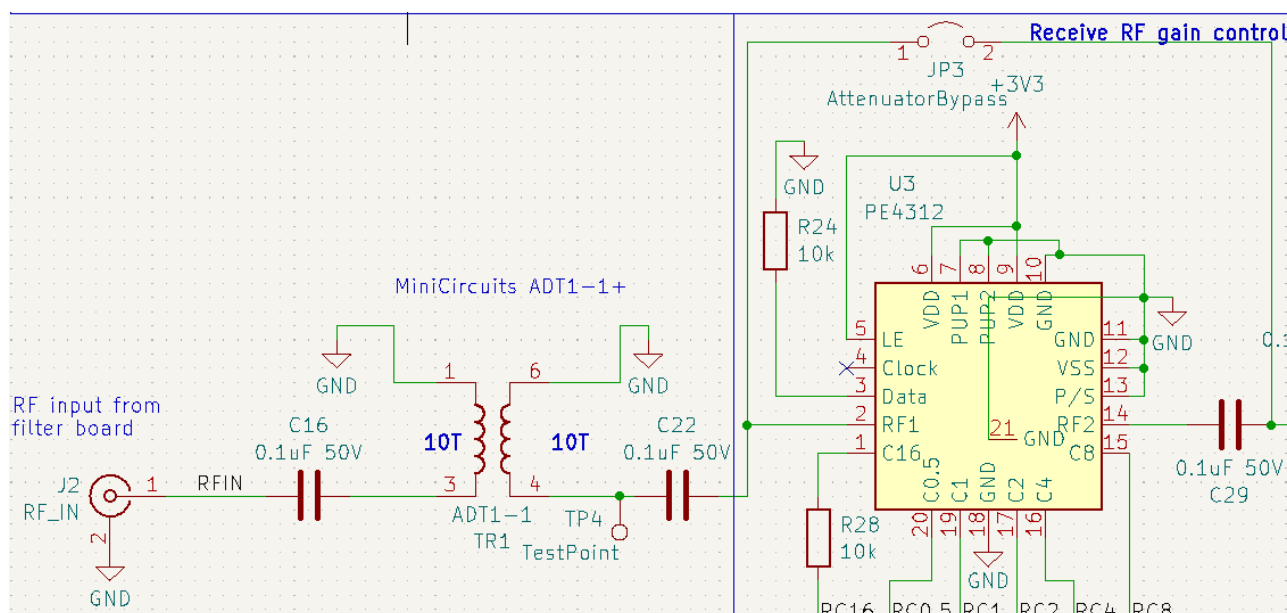


T41 RF Board Prototype Testing Report

Board rev version	Tester	Date
01/25/2024	Oliver KI3P	02/25/2024

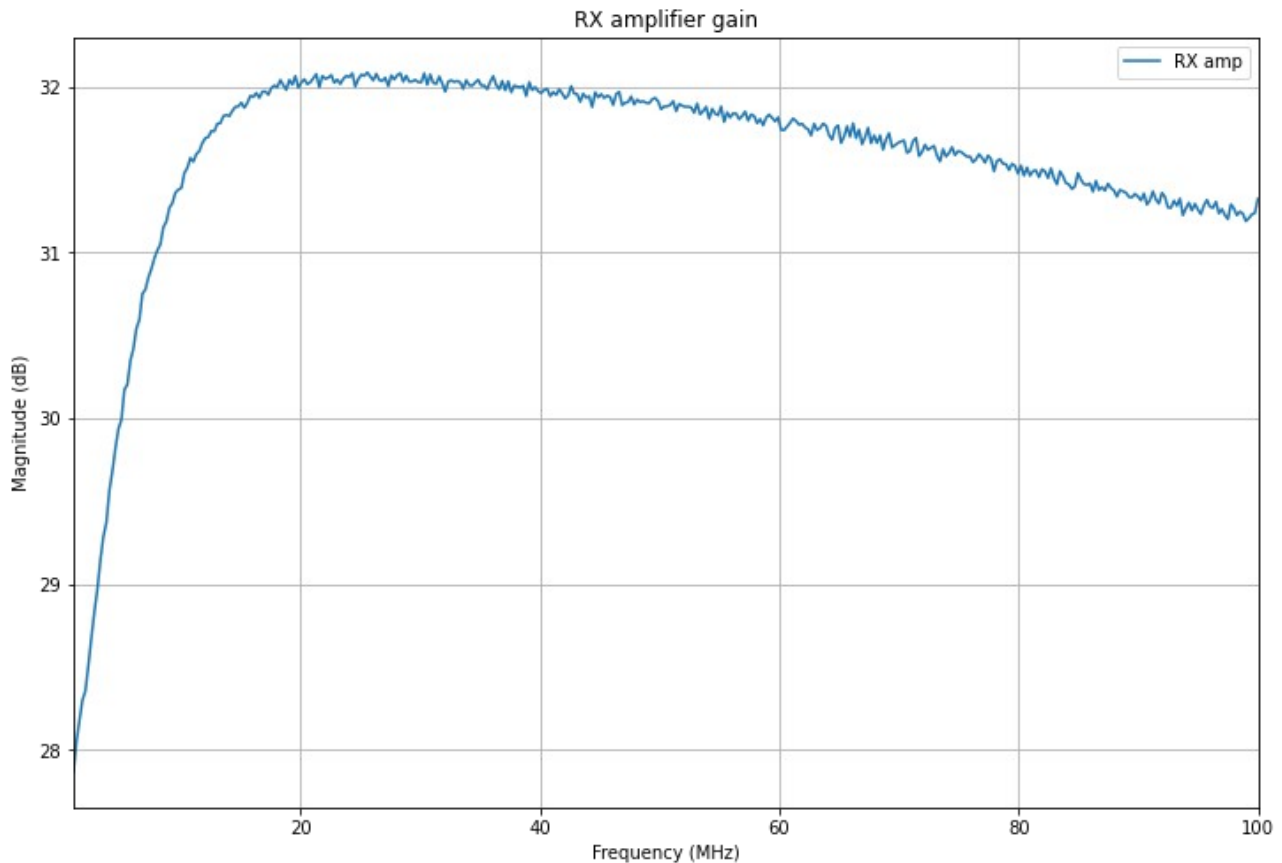
RX attenuation test

Use a calibrated VNA to measure insertion loss between J2 (RF In) and pin 2 of JP3 (attenuator output/amplifier U2 input). This is the receive chain attenuation. Plot this with varying settings on the digital attenuator, and then divide by the 0dB attenuation values to measure the attenuator U3's insertion loss.



RX gain

Measure the gain of the RX amplifier chip by soldering SMA cable pigtails to the board. Remove C29 and solder SMA input cable to its pad. Remove R20 and solder SMA output cable to its pad. Lift the legs on pins 7 and 9 of U1 to disconnect mixer chip. Use a VNA to measure the RX amplifier gain.



RX Mixer Conversion Loss

Method 1

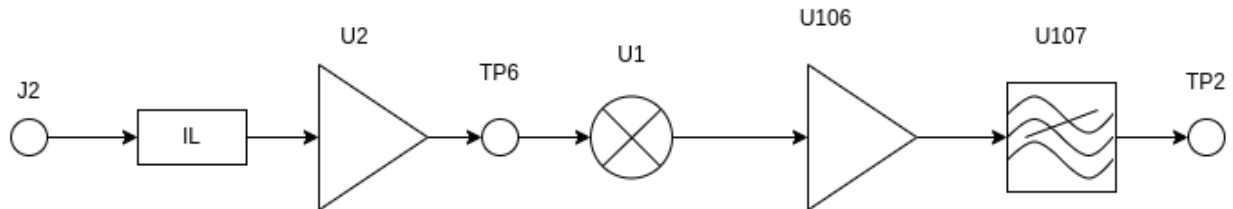
Generate an RF signal with an external Si5351. Generate a slightly lower LO frequency with the onboard Si5351. Measure voltage using oscilloscope at TP6 (input to mixer) and at TP1 / TP5 (output of mixer) and TP2/TP3 (output of anti-alias filter). Set the digital attenuator to 8 dB of attenuation and add 50 dB of external attenuation in the RF chain. Note that this is a very noisy measurement and is only an approximate gauge of circuit performance.

Band	Amp input	Mixer input	Mixer Output	Filter Output	Gain [20 log(Vgain)] should be ~26 dB
40m	9.4	6.5	24.5	757	29.8
20m	17.8	17.52	33	638	25.7
15m	*	*	21.1	523	27.9
10m	*	*	29.5	619	26.4

* too noisy to approximate

Method 2

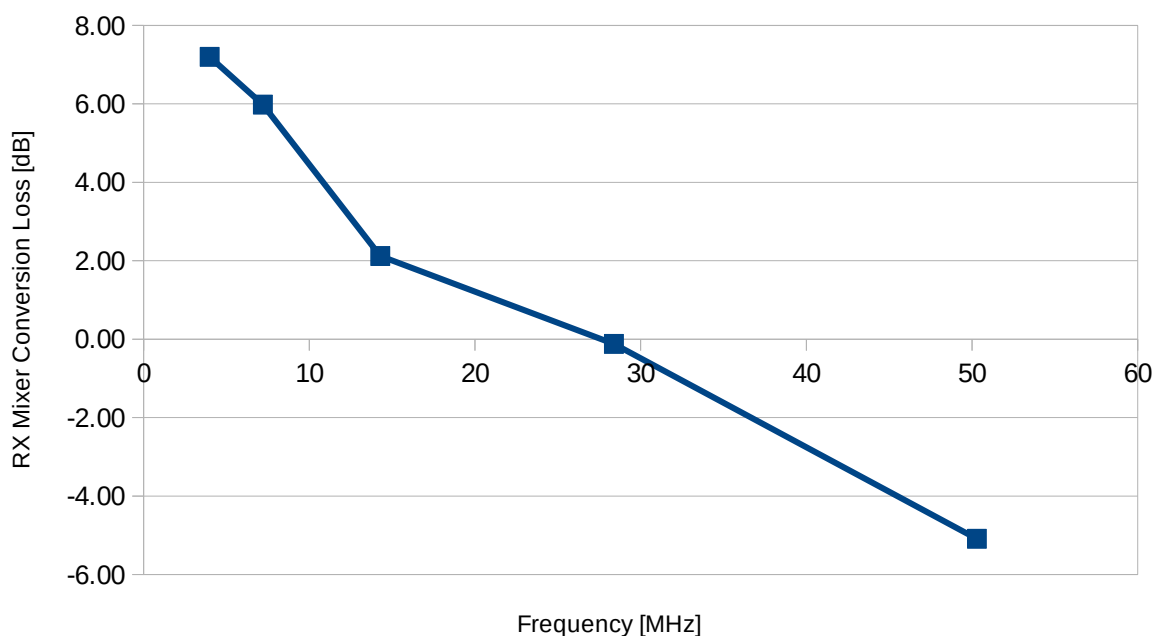
Generate a -47 dBm signal with Tiny SA and inject it into J2. Measure the amplitude of the output voltage at TP2. Calculate the power at U1 mixer input (TP6) given known J2 input power and measured insertion loss and gain up to TP6. Calculate the power at U1 mixer output from measured voltage at TP2 and assumed gain of U106 and insertion loss of U107.



Full values and calculations for 7.2 MHz:

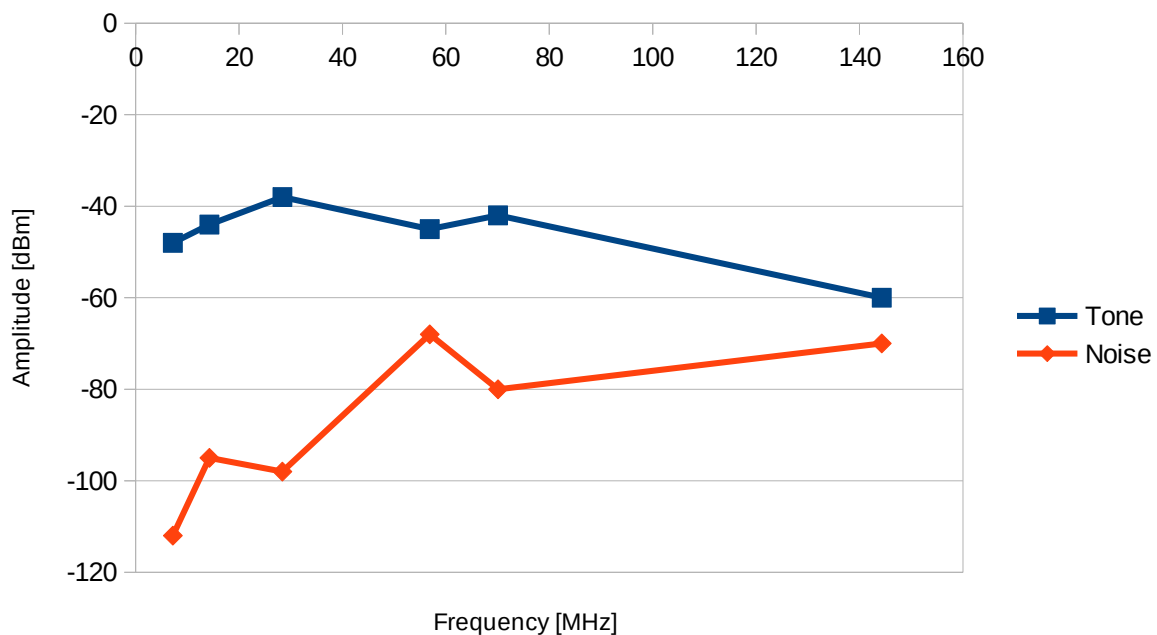
	J2 (RF input)	IL J2 to U2	U2 gain	TP6 (mixer in)	Conversion loss	Mixer out	U106 Gain	U107 IL	TP2
Power [dBm]	-47.0	-1.40	30.8	-17.6	5.98	-11.6	26.0	-0.10	
Vrms [mV]	1.00			29.5	1.99	58.7	20.0	0.99	1160

Green cells are measured values. The rest are calculated. Yellow cells are “Mixer out” / “Mixer in”. Repeat above process for other bands. Result:

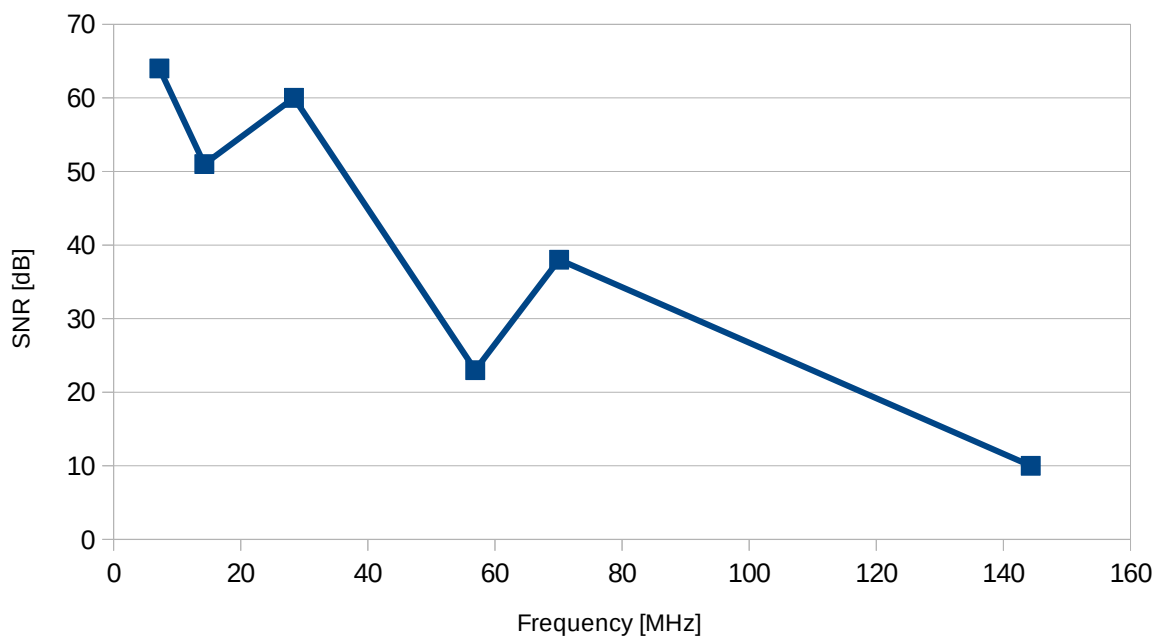


Max frequency

Generate a CW signal with amplitude -66 dBm. Measure the S meter power on the T41 screen with signal on and off at a variety of bands. SNR is “Tone on” [in dBm] – “Noise” [in dBm].



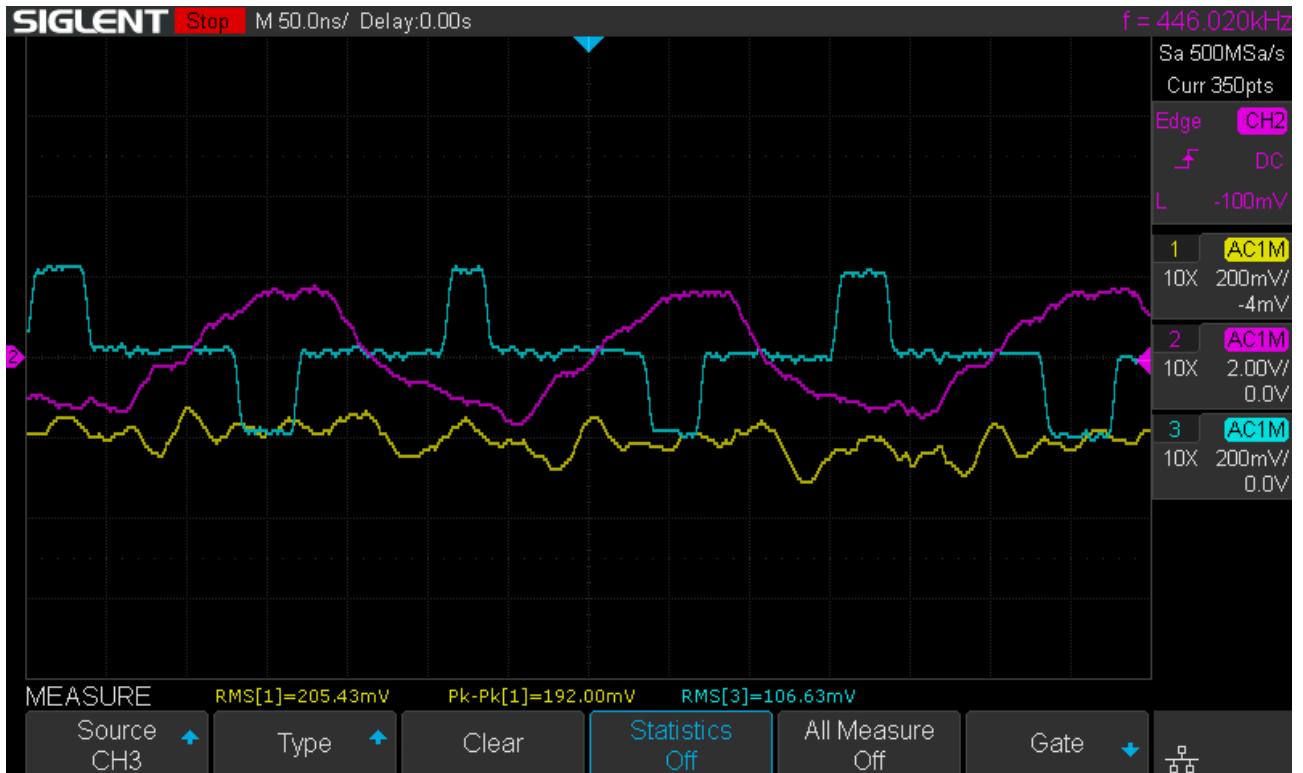
Note that my receiver has an unusually high noise floor at 6m.



Transmit testing

Generate 1 kHz sinusoidal tone with signal generator. 120 mV RMS. Inject into Q audio channel (TP9). Connect I audio channel (TP14) to ground. Measure output power and frequency with Tiny SA spectrum analyzer, 621 kHz RBW, span 199 MHz (1 to 200 MHz), 10dB input attenuation.

Mixer inputs and outputs:

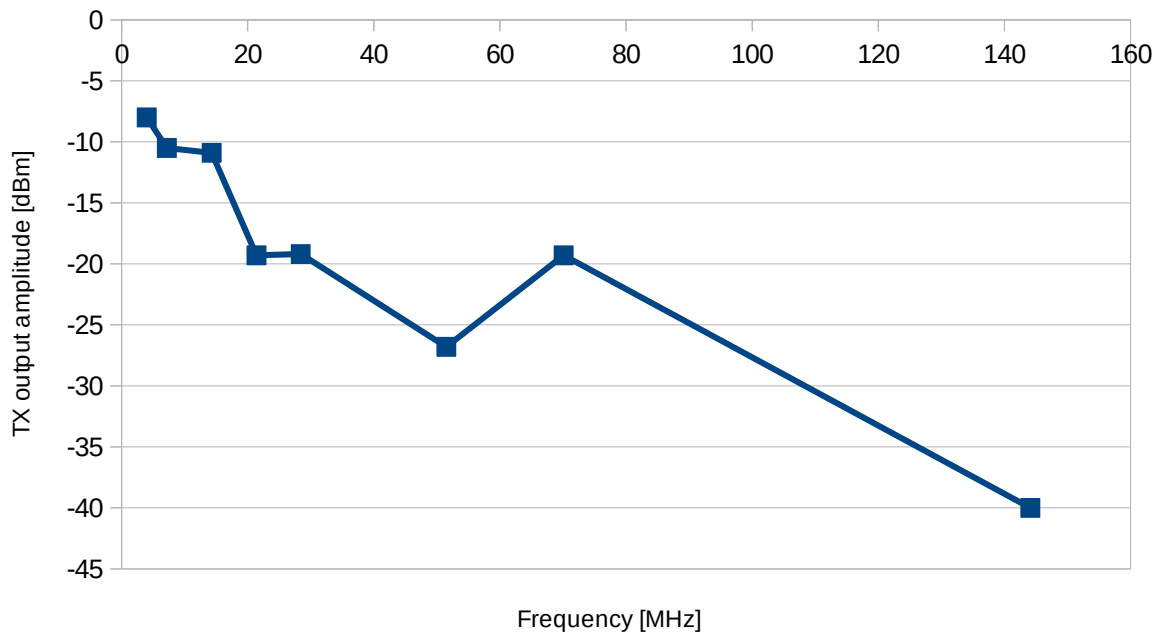


Channel 1 (yellow): Q audio in at TP7.

Channel 3 (cyan): Mixer output at JP13 (input to attenuator).

Channel 2 (pink): LO signal at TP16.

Freq [MHz]	Power [dBm]
3.985	-8.0
7.1808	-10.5
14.285	-10.9
21.386	-19.3
28.404	-19.2
51.5	-26.8
70.1	-19.3
144.1	-40.0



I am unsure why my 6m (50MHz) performance is worse than 30 MHz and 70 MHz.

CW Transmit

Generate CW signal on CLK2 of Si5351. Turn CW on and off.

Errata1: pinout of LM317 (U17) was wrong. Pinout was for TO-92 footprint, but BOM specified SOIC-8 footprint. Changed pinout of SOIC-8 footprint.

Errata2: MC33078 (U16) does not work in this application – exhibits large output voltage swings when desired output falls below 1V. Change to LM358B, which works in my tests.

After making above changes, CW power output changes as CW on/off is toggled.

CW on/off	Power at J6 (RF out)
LOW	-53 dBm
HIGH	-33 dBm

Cal connection

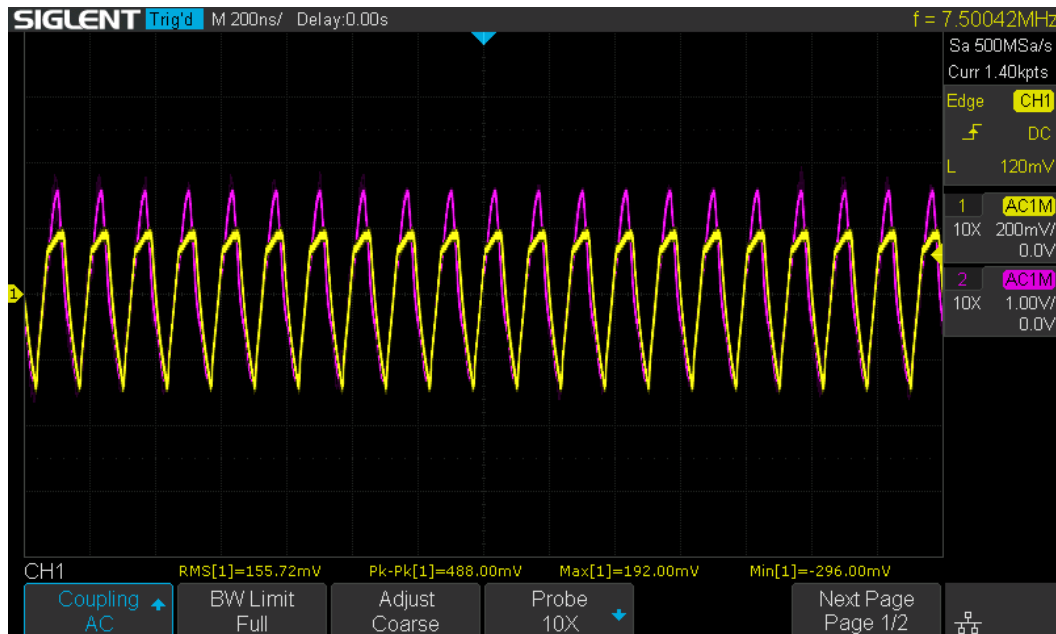
Generate output RF signal. Confirm that it is present on TX when in CALOFF mode and missing from RX. Turn CAL on and confirm that it moves from TX to RX. PASS.

TX attenuator

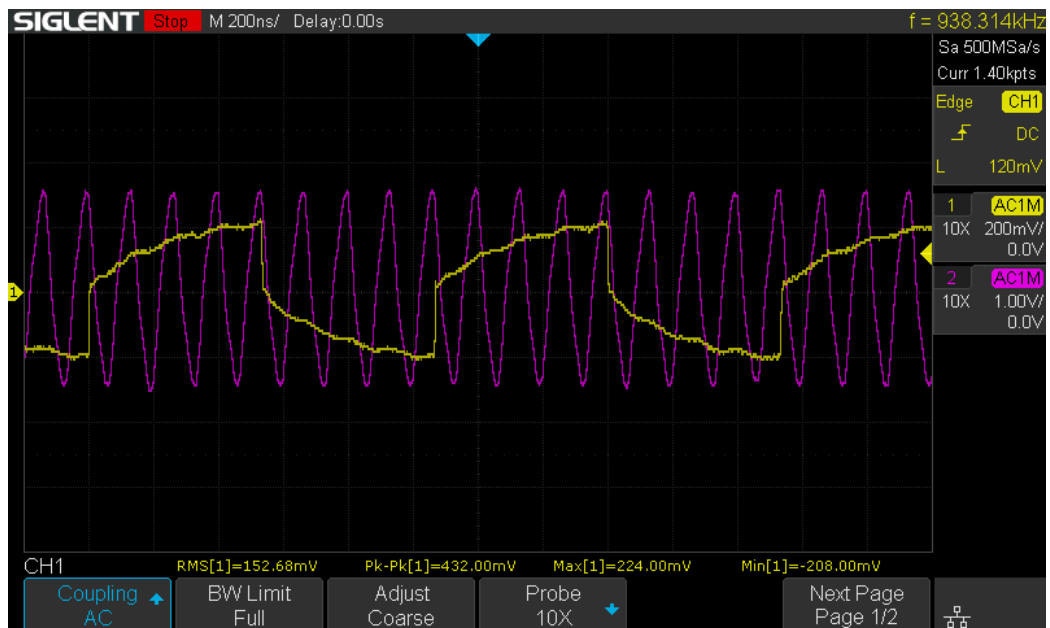
Generate output RF signal. Vary attenuation and confirm that it changes as expected. PASS.

MF operation

Connect oscilloscope probes to output of Si5351 (pin 2 of JP19) and TP15. Select HF mode by driving “MF/HF” low. Then select MF mode by driving “MF/HF” high. Confirm divide-by-8.



HF mode shows 7.5 MHz on both probes.



MF mode shows 7.5 MHz on input, 936 kHz on output.

Errata and changes

- Y1 footprint is mirrored. Flip it.
 - Done? Yes
- Pinout of LM317 (U17) is wrong. Pinout is for TO-92 footprint, but BOM specified SOIC-8 footprint. Change pinout to SOIC-8 version.
 - Done? Yes
- MC33078 (U16) does not work in this application. Change to LM358B.
 - Done? Yes

Other changes:

- Add ground test points.
 - Done? Yes
- Add an M3 hole with grounded pad close to the MCP23017 chip.
 - Done? Yes
- Make pin 1 indicating dots on silkscreen larger.
 - Done? Yes
- Add heatsink mounting holes for U15 (3V3 regulator).
 - Done? Yes

Board layout and schematic that incorporate all these changes are dated 2024/02/25.