# Qbeacon Board

## Beacon for 10, 24, 47 GHz plus 5760

**Paul Wade W1GHZ & Tom Williams WA1MBA ©2026**
w1ghz@arrl.net

The Qbeacon board is intended to enable cheap and simple microwave beacon transmitters capable of transmitting both CW and Q65 modes. In conjection with an RFZero module and a synthesizer, it can operate on 10 GHz or 5760 MHz and on 24 and 47 GHz with additional frequency multipliers.

This is a joint project, which we both ended up writing about. Tom's paper[1] describes the whole beacon system. This paper concentrates on the PC board part. I is W1GHZ.

### Background

Several years ago, the 47 GHz amateur band was under attack from commercial interests. One of the arguments was that hams are not using the band. At an Eastern VHF/UHF/Microwave Conference, we discussed the problem over some beer and concluded that having beacons on the band would demonstrate usage. Tom, WA1MBA, decided to design a frequency quadrupler[1] from 11.75 GHz to 47 GHz amd produce enough to put some beacons on the air.

The quadrupler development took a few years but was successful. An antenna is also needed to make a beacon station. I found that a slot antenna for 47 GHz is impractical with available technology, requiring very small dimensions with high tolerances. Instead, I developed a sectoral horn antenna[2] with wide beamwidth useful at both 24 and 47 GHz and had enough made for the available quadruplers.

The power level at 47 GHz, is quite low, perhaps +10 dBm, so a weak-signal digital mode is needed for detection at any significant distance. The Q65 modes seem to be the best choice. Jim, KM5PO, showed a prototype Q65 beacon for 47 GHz, shown in Figure 1, at Microwave Update 2024. The system was built with various amplifier modules, using an RFZero[3] board to generate the Q65 signal at an IF frequency, a mixer upconverter to 11.75 GHz, and a WA1MBA Quadrupler to reach 47 GHz.

The RFZero board can generate the Q65 signals at frequencies under 200 MHz, but multiplying to 47 GHz would require extremely small frequency steps from the RFZero board. Instead, the signal from the RFZero board is mixed with a local oscillator up to a microwave frequency. This also improves phase noise at the final frequency – the LO synthesizer can be a frequency generated by an integer-N PLL for better phase noise, and the final beacon frequency can be fine-tuned by the RFZero.

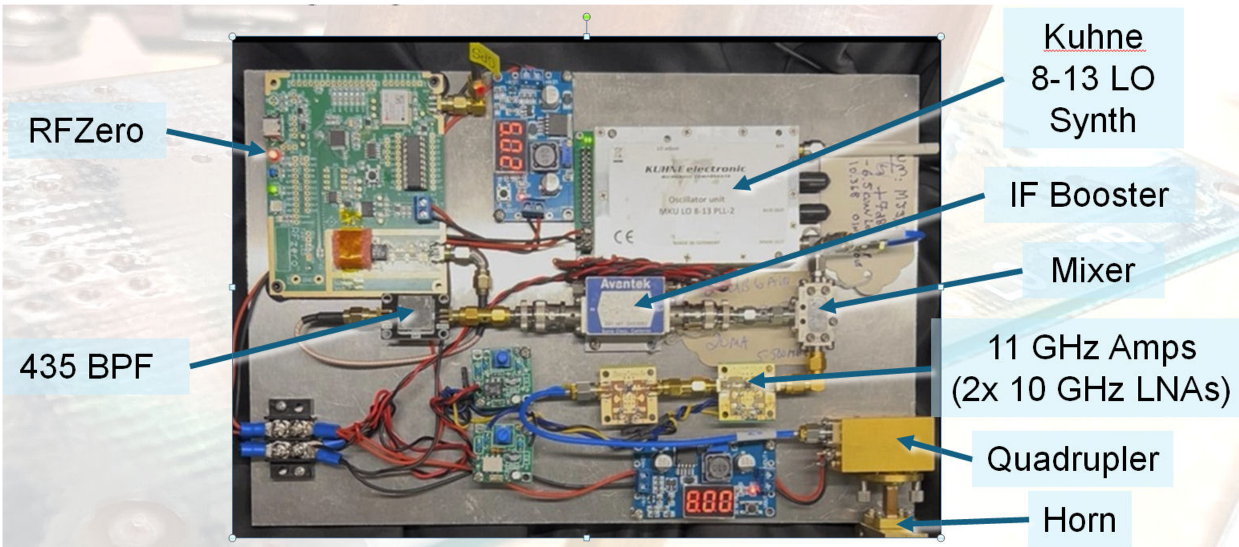


**Figure 1 – Prototype 47 GHz beacon by Jim McMasters, KM5PO**

## Qbeacon Developemt

Tom decided that the lower frequency portion, up to 11.75 GHz, could be done on a single PC board to make it reproducible. He took one of my 10 GHz transverter boards as the starting point. He found that the two stages of pipe cap filtering did not provide adequate reduction of LO and image frequencies. Reducing these unwanted products at 11.75 GHz is important because they will be out of the amateur band at 47 GHz and may be enhanced during by the frequency multiplier. Radiation out of band can probably be ignored for low-power rover stations but is bad practice for a continuous beacon.

Filters at 47 GHz are very difficult, so doing the filtering at 11.75 GHz is preferable. To reduce the LO and image outputs, Tom hacked the transverter board to add an additional pipe cap and more amplifier stages. To further reduce the LO leakage, he increased the IF frequency to 432 MHz. The RFZero only operates to 260 MHz, but the 144 MHz output has a very strong third harmonic at 432 MHz , so Tom used a filter to select the harmonic. Then he added an IF amplifier to bring the 432 MHz power up to a usable level for the mixer. The hacked up transverter board is shown in Figure 2.

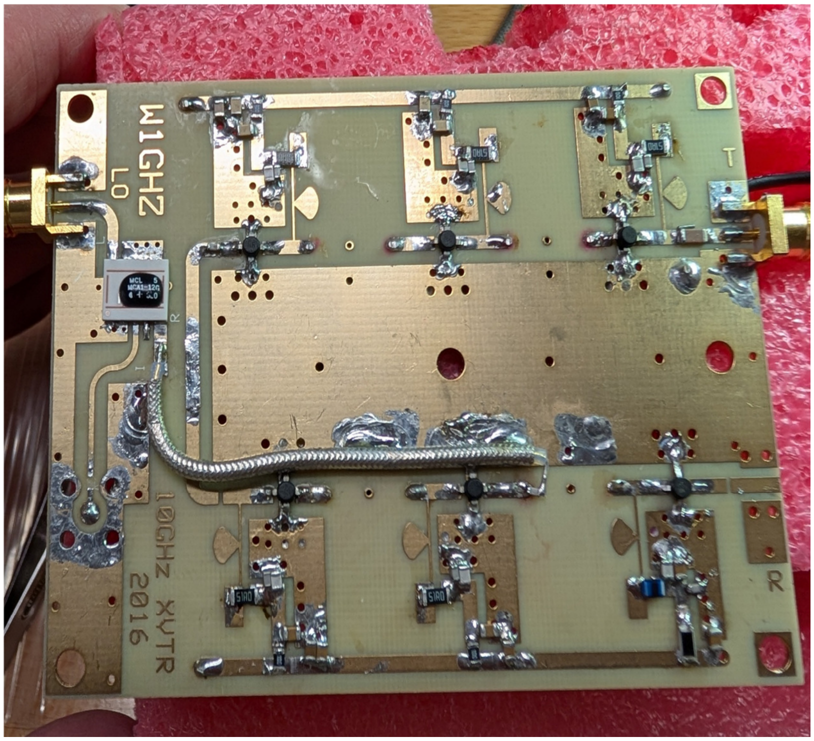


**Figure 2 – Prototype beacon PCB from hacked 10 GHz Transverter board**

Tom also found some nail-head pins (MILL-MAX 5068-0-00-15-00-00-03-0, Mouser 575-5068000150000000) that are a perfect size for  probes in the pipe-cap filters, giving more repeatable results.  I tested a standalone pipe-cap filter with the pins[5] with very good results – see Figure 3.

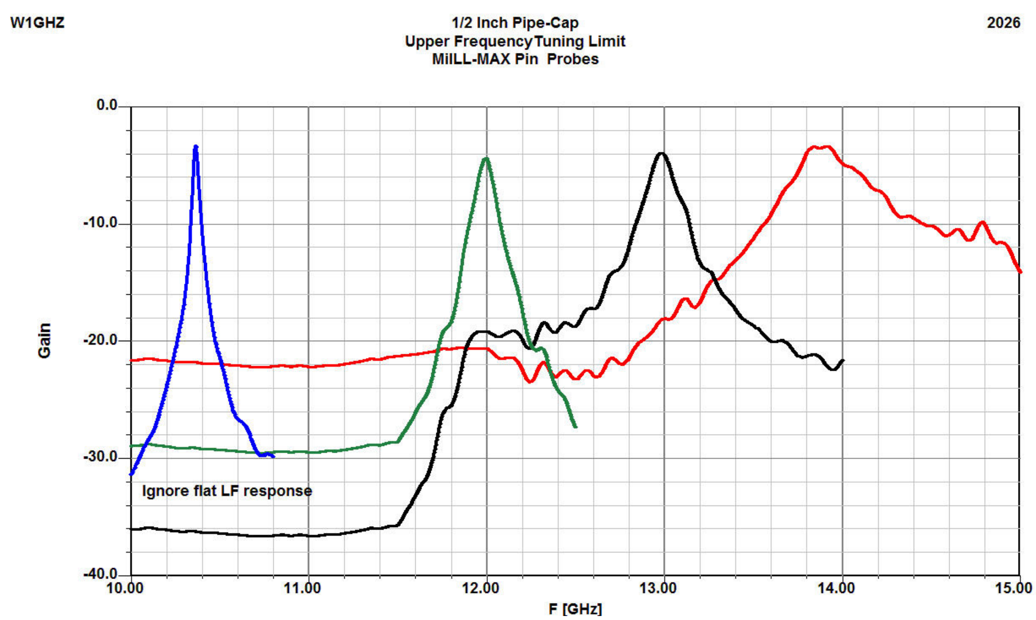


**Figure 3 – ½ inch Pipe-Cap Filter with MILL-MAX pin probes**

Tom and I discussed designing a new board with the modifications. Since they seemed pretty straightforward, I took the transverter artwork and used cut-and-paste to remover the RX section, add an additional pipe cap and two more RF stages, plus a MMIC IF amplifier for 432 MHz. This version, shown in Figure yy, worked better than the hacked up board, providing too much gain which amplified the unwanted signals as well as the desired output.

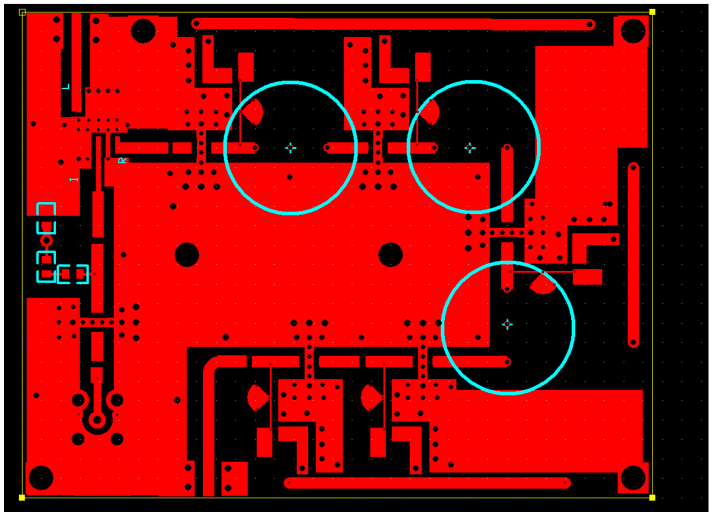

**Figure 4 – PCB artwork for version 1 of Qbeacon board**

Tom concluded that one additional RF stage would be adequate. I modified the artwork again to remove the last amplifier stage and made a few cleanup tweaks and ordered more boards. These proved satisfactory. A completed board is shown in Figure 5.

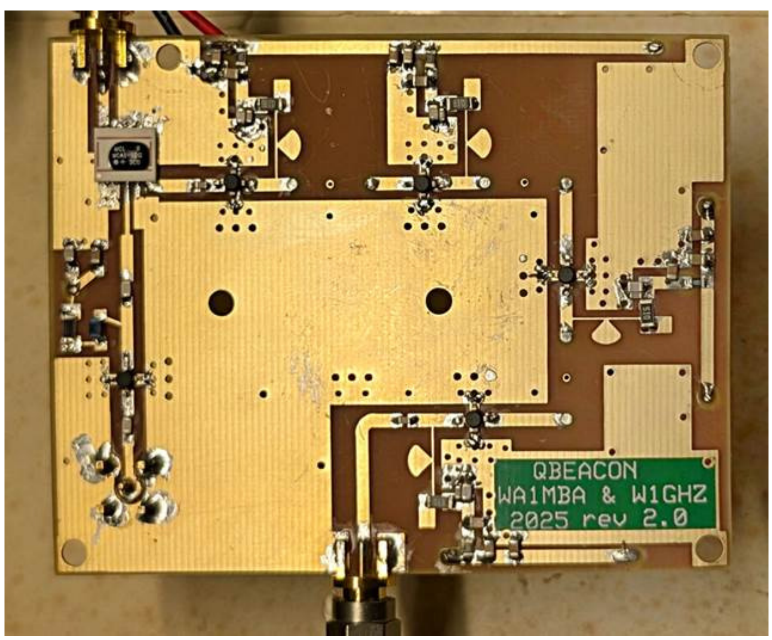


**Figure 5 – Qbeacon board, version 2**

## Performance

To test the board performance, I assembled a board without the IF amplifier, replacing the MMIC with a 1206-size zero-ohm resistor as a jumper so that both inputs can be tested at controlled levels. The tuning screws are set to approximately the desired length inside the pipe cap, 0.175" for 10.368 GHz or 0.150" for 12 GHz. The board then tunes easily to either frequency by injecting an LO signal at the desired output frequency and tuning the pipe caps for maximum output, more than +10 dBm.

At 12 GHz, full output of about +10 dBm was reached with about -9 dBm IF drive and +7 dBm LO drive. The 432 MHz IF provides a cleaner output spectrum, with the LO down 43 dB and the image down more than 50 dB. With 144 MHz IF, the LO was only 31 dB down and the image about 50 dB down. Results at 11.75 GHz (47 GHz) and 12.1 GHz (24 GHz) should be very similar.

At 10.368 GHz, full output of about +12 dBm was reached with about -7 dBm IF drive and +7 dBm LO drive. A 144 MHz IF should be usable, with LO down 48 dB and image more than 57 dB down. With 432 MHz IF, the LO was 57 dB down and the image down even more.

The LO power for these tests was +7 dBm, as specified for a standard level mixer. The LO level can be reduced by 6 dB before the output from the board drops one dB, so there is some margin.

## 5760 MHz

The pipe cap filters will tune down below 5760 MHz with long brass screws. For 10 GHz and above, I used ½ inch long screws, which would only tune down to around 6.6 GHz. With ¾ inch long screws, 5760 should not be a problem, but I was unable to get any signal out with 5760 as LO. I went back and retuned to 10 GHz, then started walking the frequency down in small steps and retuning at each frequency. By the time I got to 9 GHz, the output power was down by 7 dB and tuning was extremely critical. It seems like the pipe cap tuning was getting so sharp that I couldn't get all three on the same frequency at once.

I measured the bandwidth with all three pipe caps peaked at the same frequency: 23 MHz BW at 10.368 GHz, 16 MHz at 9.7 GHz, and 9 MHz at 9.0 GHz. Referring back to Figure 3, the pipe cap bandwidth with the MILL-MAX pin probes becomes very narrow as frequency decreases. Longer probes are needed for 5760 MHz. Figure 6 suggests that around 0.175 inches should be good.

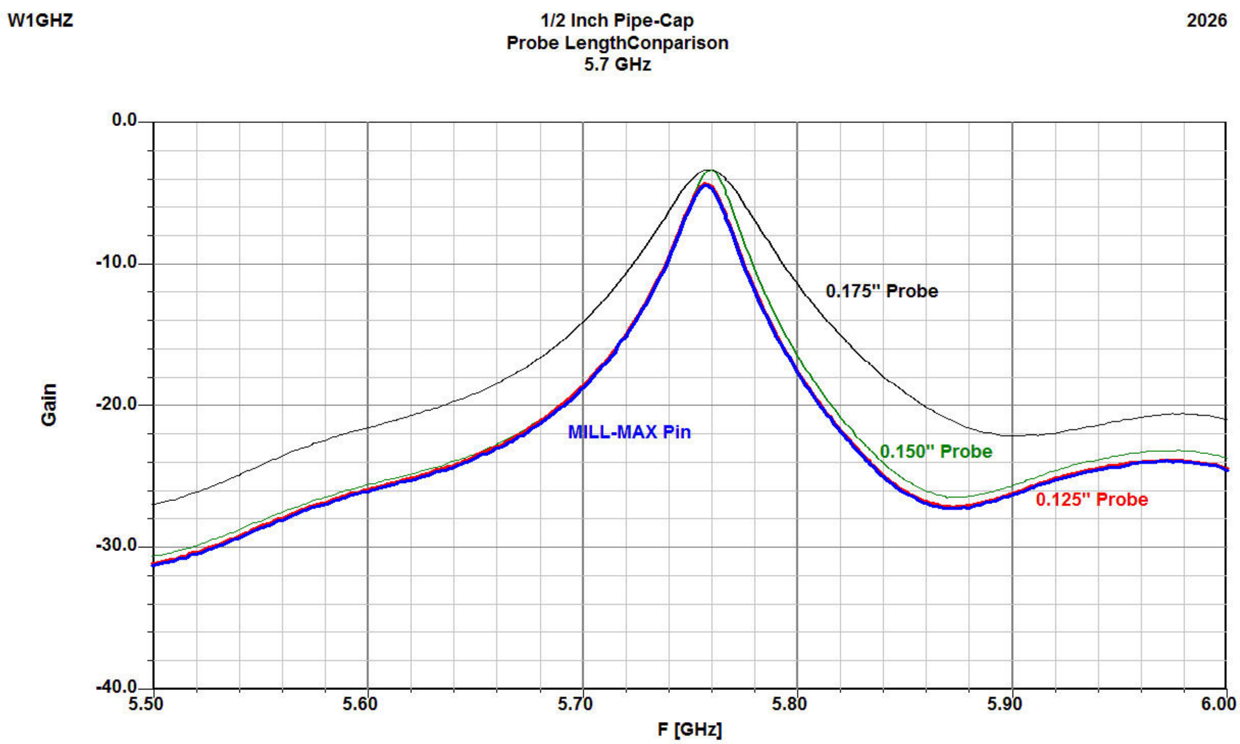


**Figure 6 – ½ inch Pipe-Cap filter at 5760 MHz with various probe lengths**

Since the first board works well at 10 GHz and I didn't want to change it, I built another with longer probes, about 0.170 to 0.175 inches long inside the pipe cap. I used capacitor leads as probes. To set the length, I measured the distance needed from the capacitor body to the PC board that would produce the desired probe length, and used a drill bit of that diameter to set that distance, as shown in Figure 7.

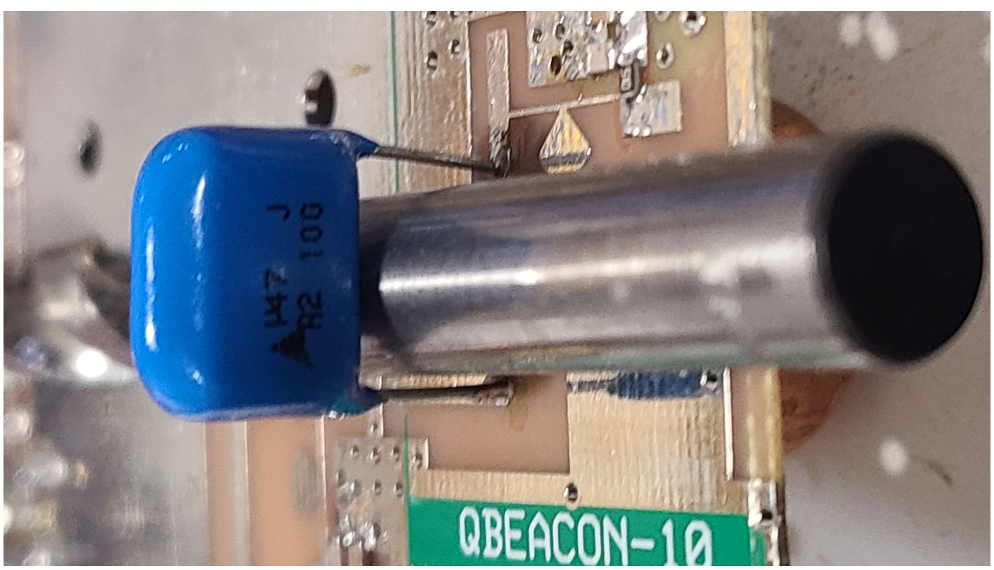


**Figure 7 – Setting probe depth by using a drill bit as precision spacer**

The second board is a prototype PCB without gold plating, shown in Figure 8, and uses cheap SMA connectors and components – all adequate for 5760 MHz. The MMICs are readily available ERA-1SM, which should provide adequate performance at 5760 MHz, and probably usable performance at 10.368 GHz.

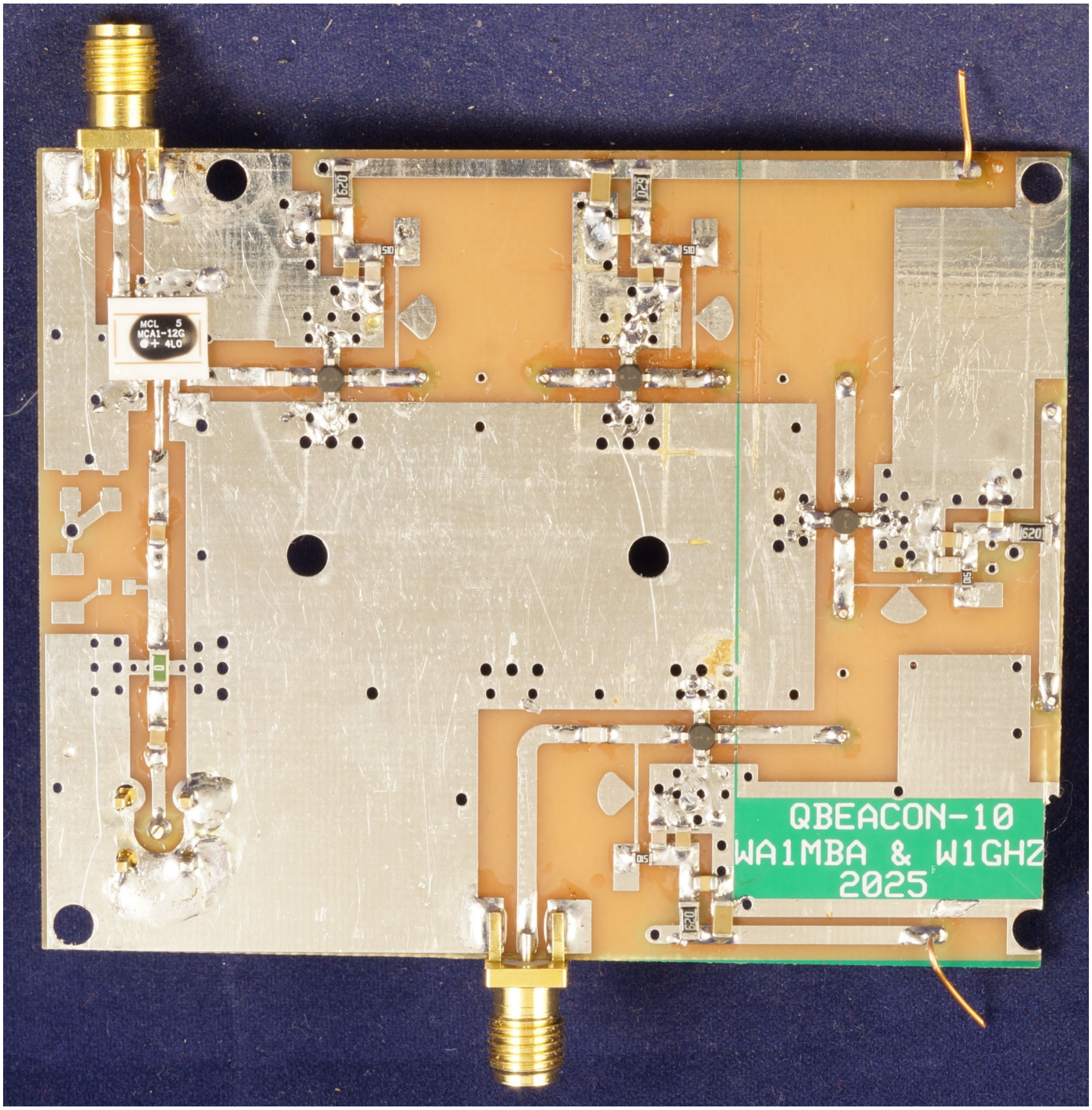


**Figure 8 – Qbeacon board for 5760 MHz**

Testing was done first at 10.368 GHz, since it is easier to tune at the higher frequency with the longer probes. At 10.368 GHz, full output of about -0.4 dBm was reached with about -5 dBm IF drive and +7 dBm LO drive. The output with ERA-1 MMICs (and cheap components) is about 10 dB less than the first board at 10.368 GHz.

With the longer probes, filtering at 10.368 GHz is not good enough for a 144 MHz IF:  the LO rejection is only -20 dBc, and the image is -31 dBc.  It is adequate with for a 432 MHz IF, with LO rejection of -40 dBc and image more than 50 dB down.

From 10 GHz, the pipe-cap tuning was walked down, injecting an LO signal at each frequency step down to an output frequency of 5760 MHz.   Tuning becomes sharper with decreasing frequency – the 3 dB bandwidth is about 20 MHz at 5760 MHz.  Output power at 5760 MHz is about +2.6 dBm with  -5 dBm IF drive and +7 dBm LO drive.  The output with ERA-1 MMICs (and cheap components) is less than the first board at 10.368 GHz.  Changing to a little hotter part in the final stage or two should improve the power if needed.

The LO power at both frequencies for these tests was +7 dBm, as specified for a standard level mixer.  The LO level can be reduced by 5 dB before the output from the board drops one dB, so there is some margin.

## Construction

The circuit is basically a copy of the 10 GHz Simple and Cheap Transverter.  The four amplifier stages are the same.  See that paper[4] for details and a closeup of an amplifier.

Alternating amplifier and pipe-cap filters helps both work well.  The amplifiers isolate the filters from each other, so that there is little tuning interaction, and all can be tuned to the same frequency or stagger-tuned for more bandwidth – this was called a synchronous amplifier in the TRF receiver days.  The pipe-caps provide a bit of loss between the amplifiers, reducing interaction and impedance mismatch, and making them more stable – Rick, KK7B, pointed this out.  Remember: *Gain is Cheap*.

## Summary

The Qbeacon board is a building block for beacons for 5.7 thru 47 GHz.  It is simple and cheap, and can be used for any mode you choose.

## Notes


1. Tom Williams, WA1MBA and Paul Wade, W1GHZ, "An Approach to 5.7, 10, 24 and 47 GHz Q65 Mode Beacons," ," 49th Eastern VHF/UHF/Microwave Conference, 2026. https://www.newsvhf.com/conference/conf2026/PresPapers/WA1MBA-5_10_24_47GHz_Q65_Beacon_Board.pdf
2. Tom Williams, WA1MBA, "A 10-12.5 GHz in, 40-50 GHz out Quadrupler – Final Report," Proceedings of Microwave Update 2023 & 46th Eastern VHF/UHF Conference, ARRL, 2023. https://www.newsvhf.com/conference/conf2023/2023papers/PresPapers/WA1MBA_10-12.5GHz_in,40-50GHz_out_Quadrupler-Final_Report.pdf
3. Paul Wade, W1GHZ, "Sectoral Horn Antennas for Microwave Beacons," *DUBUS 1/24,* 2024, p54. http://www.w1ghz.org/new/Sectoral_Horn_Antennas_for_Microwave_Beacons.
4. https://rfzero.net/
5. Paul Wade, W1GHZ, "10 GHz Transverter and Pipe-Cap Filter Improvements," 49th Eastern VHF/UHF/Microwave Conference, 2026. https://www.newsvhf.com/conference/conf2026/Papers/W1GHZ-10GHz_Transverter_and_Pipe-cap_Filter_Improvements.pdf
6. Paul Wade, W1GHZ, "Simple and Cheap Transverter for 10 GHz," https://www.w1ghz.org/xvtr/Simple_and_Cheap_Transverter_for_10GHz-2024_update.pdf