70 cm Multimode Beacon for KH6HME Operation

This document is something of a catchall. While I've put a sort of design history and intent into "Overview" and programming/configuration information into "Programming" there remain some details that may prove important in operating and maintaining this beacon. I'll try to discuss some of that here.

As of November 2016, the beacon has been in test for several months. It has been running continuously at several different locations within Northern California and monitored by 70cm WSPRers in the area. The JT modes have also been monitored. Generally, everything seems robust. Power output is somewhat dependent upon ambient temperature, with .5 dB or so drop off once the heat sink gets much above 50C. I've added cooling holes in the sheet metal which has reduced the temperature of the other electronics, the Bodnar, U3s, upconverter and second GPS receiver considerably.

The PA bias adjustment is now externally available on the right side of the unit. Adjusting it changes the quiescent bias point and the gain of the PA slightly, as can be seen from the data sheet. When set for about 10A key down, the result is about 50W out of the copper bandpass filter. This is a fairly efficient operating point for the PA so turning it down, while it does reduce output power, doesn't affect temperature as much.

Temperature is affected by programming since average duty cycle depends upon modes and mode lists. The digital modes presently amount for four minutes, forty percent, of each frame. CW is sent in the other minutes for perhaps 30% of the other 60%, or another 1.8 minutes of equivalent key down time, depending upon message content and length. The result should be something near 60% average duty cycle at perhaps 50% overall efficiency. Thus 13.8V @10A = 138 watts input produces 70 watts of RF from the PA and 70 watts of heat – all for 60% of the time. 60% of 138watts * 24 hours/day would predict about 2 kwh/day. Hawaiis 2016 electric rate was about 28 cents/kWh so this is a bit over $15/month to run the beacon as configured.

It would be possible to put the beacon on a timer if this much power budget is too high. Although the first frame's worth of transmissions may be a little confused due to U3s initialization issues, it appears that the beacon recovers pretty quickly so power cycling once or twice/day shouldn't have much adverse effect. With the copper filter in place, even if there were to be a terrible failure, oscillation or something else unexpected, the output spectrum should always be contained to the amateur band and probably is always legal and shouldn't be a problem. I've seen no evidence of any malfunction of this sort, I'm just pointing out the ultimate firewall protection that the architecture has.

I expect the heat sink to run pretty warm but not truly hot. That is, you should be able to put your hand on it for quite a few seconds with any ambient air temperature that Mauna Loa provides at 8200' ASL. Even a small amount of air flow across the heat sink greatly reduces this. A small muffin fan directly on the fins drops the temperature to little more than skin temperature, if that.

I think the PA can tolerate an open or shorted load and every SWR and phase angle in between. The filter and cables have some loss so the amplifier never sees a reflection right at the edge of the Smith chart.

The CW has hard keying due to the nature of the U3s' synthesizer. This shows up as sidebands associated with the 20 WPM dot rate. When signals are strong, these are audible a few hundred Hertz away. There are also synthesizer sideband spurious a little more than 5 kHz away and about 45 dB down from the carrier. It would be nice if these were smaller but again, they are U3s generated so there's no easy way to improve it. Even so, it will take a pretty good duct to make signals strong enough for anyone on the mainland to notice and if they do, it is sort of a badge of honor at how well they are hearing the 1 milliwatt of output power across that long a path. Hopefully others take this same view about it.

For ideas and advice on other quirks, I recommend the QRPLabs Yahoo user's group since many U3s characteristics and issues are discussed there and many will apply to this beacon as well.

There is a 16V 1W avalanche diode inside the beacon, on the beacon side of the power switch, so an erroneous reverse polarity or over voltage from the supply should cause the part to fail in the shorted mode and blow the line fuse (you should have one in the 12V line) and/or current limit the power supply. If it shorts, it will be necessary to disassemble the rear panel and replace the diode with a new one.

Update December 29 2017

After four months of everything looking fine, suddenly the power dropped 10 dB! Upon examination it appears that the U3s ←→ PA cable was a problem. The beacon end had been an SMB connector and the other end pigtails soldered to the PA board. The cable could flop around inside the box and it looks like things were marginally stable because of it. Looking back into the beacon the return loss looked fine from 0-3 GHz and the PA looked OK. The problem only showed up occasionally.

Because of my concern about temperature, discussed above, I decided to change the 60W PA to a 30W one I had on hand. This is still an LDMOS amplifier but has only one device rather than two parallel devices in the output. It takes the same drive power and operates over the same frequency range. At the same time I put another SMB connector on the PA board and improved cable routing. The result seems to have made everything more stable, consistent and (especially) cooler. Power out of the Cu filter is about 30W instead of the previous 50W but I think a fan will no longer be necessary. This all seems an acceptable trade off.