SMARC 10GHz experiments from a beginner's perspective – as of 10th of December 2022

This article is intended mostly to serve as a progress record, rather than entertainment value, however it might be of interest to those who dabble in microwaves!

Background

From my perspective, the SMARC 10GHz project came about when our club president Brett VK2CBD spoke on the Saturday net about the ease (and low cost) of getting something up and running using the HB100 Doppler radar module.
On the other hand, long time club member Bill VK2ZZF has been experimenting for years with this band, and has some impressive transmitters, receivers and even wavemeters, using more traditional methods, e.g. Gunn diodes. I never fail to be impressed by the amount of work that Bill has put into his gear.
In contrast I'm taking the easy route!

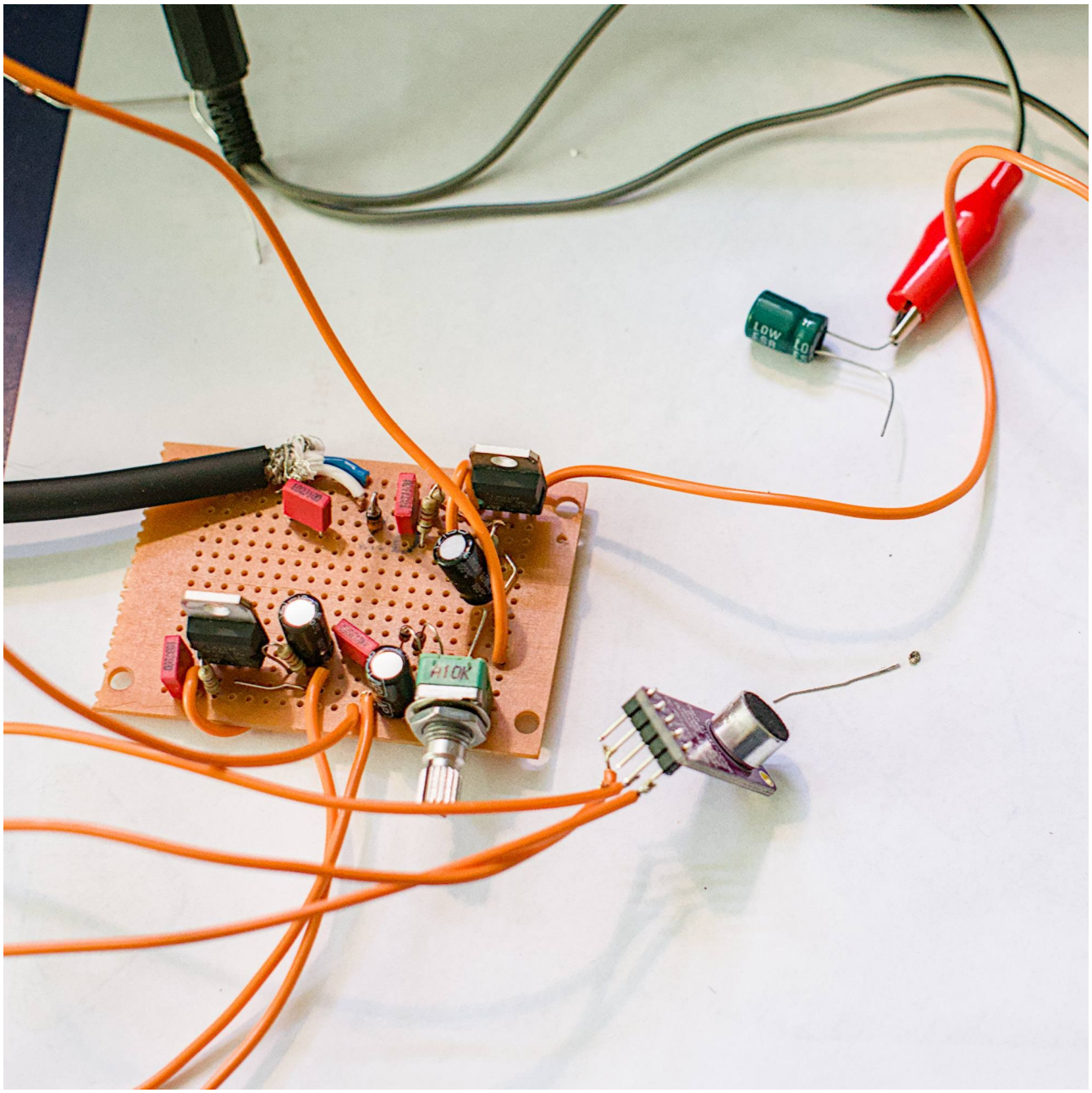
RX

My receiver is a "Bullseye" LNB with a 9750MHz LO, feeding a RTL-SDR dongle via a cheap Bias-T from Ebay. Very easy to set up. On the software front I've been using spektrum[1] to sweep the band to find the slightly unpredictable working frequency, then SDR# as the receiver.[2]

Testing my RX

TX

My transmitter is a HB100 module, modulated via the supply voltage using a simple LM317 based circuit that I found on IK1WVQ's website[3], with a slight mod.
There's a reasonable amount of info online about using the HB-100 module, both for its intended purpose and for amateur radio. It has both TX and RX antennas onboard, literally as they are PCB tracks. I won't go into the details of how it's meant to be used, but I am simply using it as an easily modulated signal source. It has 5V, GND and IF connections.



Testing the modulator

Modulation

Apparently depending on the version, it can be modulated by simply injecting an audio signal into the IF port.
Mine is the early version, identified by having a tuning screw under the QC sticker. Which is a useful feature in itself. This early version apparently works well using the IF port to inject the audio, however I'm using the method suggested for the later modules, that is modulating the power

supply. The circuit I built gives an output around 4.8V, comfortably below the 5.2V (I think) limit of the module. I found a need to change this however. I'll come to that later.

Audio

I used a MAX9814 microphone module – very convenient, and easy to use. Just needs a few volts DC, ground and audio connecting, and it does the rest! It has a built in compressor, (very good) and a few other features that I'm not using. I added a second LM317 circuit to the small modulator board to supply the MAX module.

Testing

The biggest (and recurring) issue I've had is finding the frequency that I'm transmitting on! To be honest, this shouldn't really be an issue, especially once I mount the HB-100 in a fixed position in a dish. It's quite stable then, given some temperature stability.
But in my testing so far, it's been 'plonked' down in different places, and the result has been variations over at least a 3 MHz range. Again, this isn't bad really, but my lack of experience with this band, combined with the ~1MHz waterfall bandwidth of my SDR has caused me some head scratching. The spektrum software sweeps the SDR tuning through any given range, and graphs the result, essentially giving a spectrum analyser display. Useful, but I found that if the signal is weak it's hard to spot – I'm still learning this software though, so I may not be using it to it's full potential.

The bandwidth transmitted is easily changed by varying the modulation level. I've seen 150kHz recommended, but haven't checked whether there's a real standard as yet. In the early tests, I got it working well in terms of audio with just a 25kHz bandwidth, but stability was a real issue. For some reason, I found the audio started distorting if I tried to go wider than around 50kHz. Looking at the waterfall, it was clear that something was limiting the frequency 'swing' in one direction.
Working on the assumption that it was the HB-100 unit, I lowered the output voltage from my modulator circuit slightly... and that fixed it. It is possible, and I haven't checked yet, that I was supplied with the wrong voltage of Zener diode, (see the circuit) and that was clipping the audio. Either way, the lower voltage of around 4V solved the issue in my case. I can now set the bandwidth pretty much where I want it. 150Khz works well. This is an audio level of about 40mV peak-to-peak overlaid on the 4V supply, as checked (roughly) with a CRO.

In the field with VK2ZZF

Last Saturday, I headed over to Bill's QTH, for some more testing and discussion. Bill actually has a HB-100 set up as a receiver as well – we hoped to try using it to receive my TX, but the frequencies were different, and we (I) didn't want to start attempting adjustments at this point.

I set up my LNB in a small garden variety satellite TV dish, on a tripod, and we did some RX testing with different TX units sitting on a step ladder 5m away. Part of the purpose of this was to get some idea of the different frequencies we were working on – problem was I did have some confusion at the time due to forgetting my LO frequency!

My dish and LNB+Bias-T+SDR

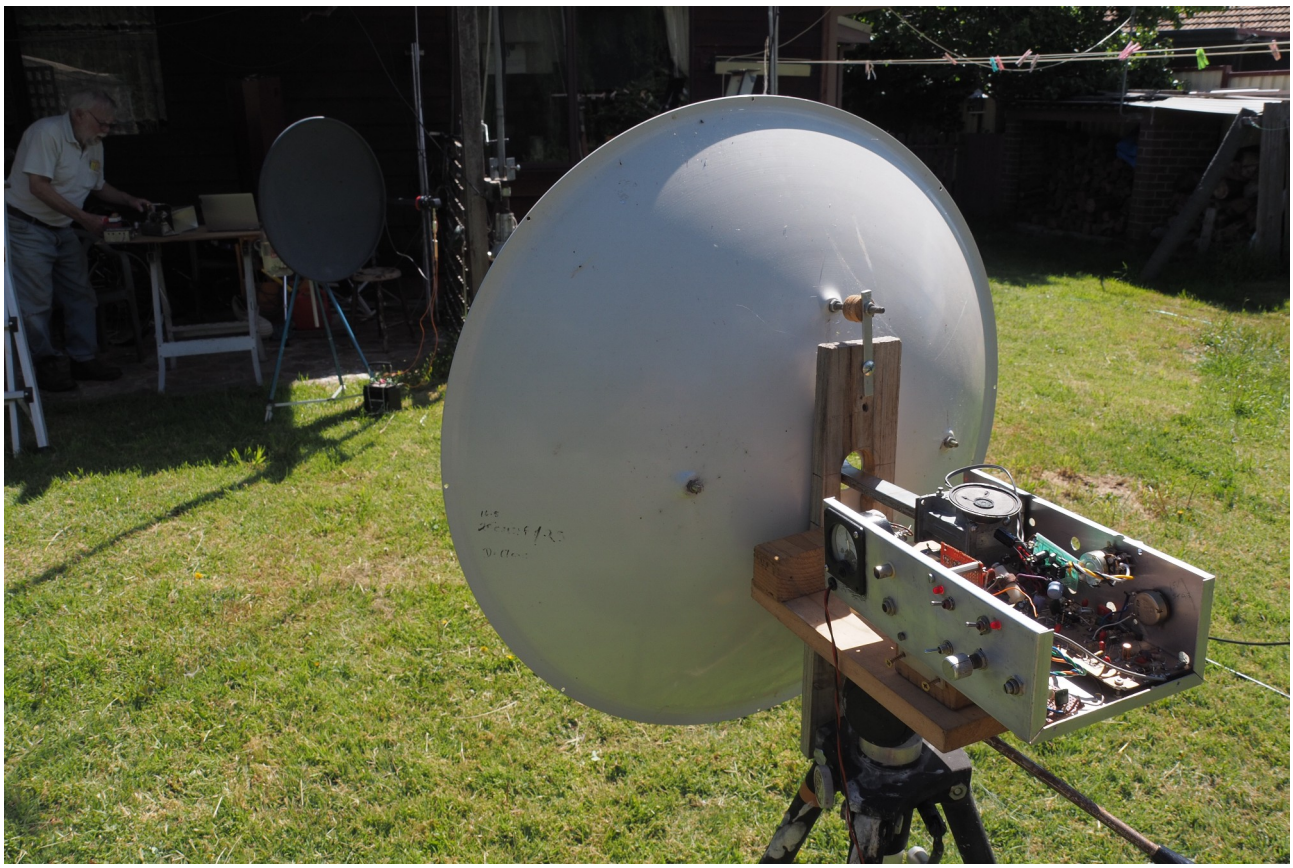
I received a lovely signal from a 10GHz transceiver Bill has built that uses a Gunn diode.

Bill, if you're reading this, I was tuned about 10489.3MHz for this one.

Bill's other TX, using a HB-100 was on 10501.05MHz

My HB-100 TX was on 10488.58 MHz - at one point! Later, in a different mounting, it was on 10491.3MHz…

According to the WIA band, the amateur allocation is from 10. 10.5GHz, with 10.450 upwards for amateur satellite use. So we are mostly in band, (good!) but in the satellite section. Given the low power (reputedly 10mW) and highly directional nature of what we're doing I don't think this is a problem, but it is something to bear in mind. I intend to try tuning my HB-100, but that is not so easy with the later version. It can be done though.[4]



Bill's Gunn diode transceiver

I was using a small FM radio (broadcast) to provide some 'test modulation' which was coming through in almost broadcast quality, with SDR# set to WBFM. Bill was able to receive the audio on his wavemeter receiver as well! It's funny hearing pop music coming out out of an instrument like this…

DX attempt...

Going back to mounting, initially I had my HB-100 wrapped in a pair of old socks (!) inside a plastic food container. No dish. This gave excellent short-term temperature stability, but I have a suspicion that the plastic is lossy at 10GHz. Not confirmed yet.

I took the TX, in its container, down the slope from where we were working and wedged it into a tree, about 80m away. I switched it on, and came back to the receiver. I need some practice with aiming an offset feed dish, but after a lot of panning, tilting and tuning, we couldn't pick up a squeak. This was a bit disappointing… so I brought it back.

Some troubleshooting followed, suspecting a low battery, but swapping it for a different one didn't help, and subsequently a DVM confirmed that there was the correct supply voltage going to the HB-100. But it still seemed dead.

But… after some more poking around, and trying again, I found the signal, as if it had never stopped working! My best theory is that during its time in the plastic tub in the sun while we relocated it, it had warmed up to the point where the TX frequency was well out of the range where I was looking for it. And removing it from the enclosure had allowed it time to cool, so I found it again. Not sure.

DX!

After this failed attempt, Bill removed the transceiver and feed from his tripod mounted Cassegrain dish, and I used tape and cable ties to mount my bare HB-100 module more or less at the focal point of his dish. We first tried it at a 15m range, and it worked well. Then I hauled this setup down the hill to about 60m away (as far as I could get it with a clear path). I got it pointed as best as could, then headed back to the other end. Lots of exercise!

Bill's dish, my HB-100

This time things went quite smoothly – got it tuned in quite easily, and after a bit of fine tuning of the dish alignment, we had a 30dB SNR reported by SDR# at a bandwidth of 70kHz. The frequency was quite stable too, even though the TX module was exposed. It was in the shade though, and it was fairly calm. Success.

I expect that with proper mounting of the HB-100 at the actual focal point one could get a bit better signal level. We left it running for a while as we discussed the progress up to this point and noticed some variation in signal strength of up to 6db or so. Air currents? I think possibly a more likely cause was movements at the TX end, with the improvised mounting.

I wonder, given the 30dB SNR at a 60 meter distance, can I calculate the SNR at longer distances? I'm sure one can – need to look into how it's done. Or ask Brett!

I'm looking forward to seeing Brett's version of a HB-100 TX as well.

What's next

I think the main work now is mechanical – making enclosures, mountings for all the different bits, patch leads... so that we can do more experiments in the field without having to worry about things falling apart. I also want to mount the HB-100 TX in a second dish I have.

After these boring bits (sort of) are out of the way, I think we should try some more tests over increasing distances. We have our eye on two hills near Cooma and Berridale respectively, with a clear 30km path. Hopefully we can conquer it!

73,

Steven Gawen VK2STG

Where I sourced my bits

Bullseye LNB	https://www.ebay.com.au/itm/194069803346
RTL-SDR	https://www.ebay.com.au/itm/272411458376
HB-100 Doppler module	https://www.ebay.com.au/itm/174780920133
Bias-T	https://www.ebay.com.au/itm/314167663186
MAX9814 unit	https://www.ebay.com.au/itm/274906677322

Most other bits from Jaycar, including adaptors etc.

Safety

One should bear EMR safety in mind when working with microwaves. (think oven...) These power levels are fairly safe, however if you're using high gain dishes you do need to consider it. In theory, at 10GHz, a 1m diameter dish might have a gain of 38dB (or more...). That would turn our 10mW into 65 watts! The VK3UM EMR Calculator is available on the WIA website, and will calculate safe distances at different power levels. It doesn't go as low as we're working, but you can set a loss to compensate. I don't have the knowledge be sure I'm calculating this properly, so my approach after some trial and error with EMRCalc is to stay at least couple of meters from the front of the dish. This is almost definitely massive over-caution but I prefer to be on the safe side!

EMRCalc - https://www.wia.org.au/newsevents/news/2012/20120921-1/index.php

References:

1. Spektrum software download - https://github.com/pavels/spektrum/releases
2. SDR# download - https://airspy.com/download/
3. My modulator circuit is the last on this page. https://ik1wvq.blogspot.com/2020/01/10ghz-facili-prima-parte-tx-10ghz-con.html This is a very useful site, and hard to find for some reason.
4. Frequency modification - https://ik1wvq.blogspot.com/2020/06/nuovi-hb100-modifiche.html