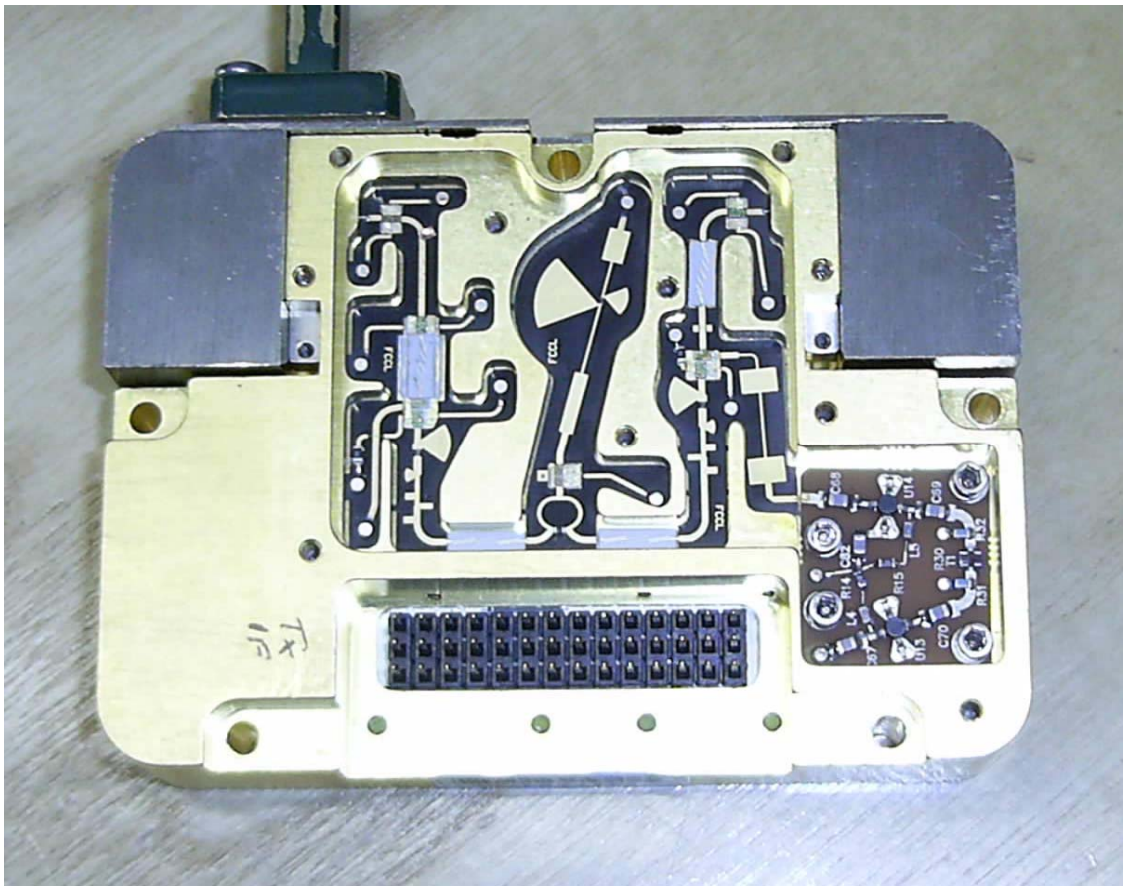
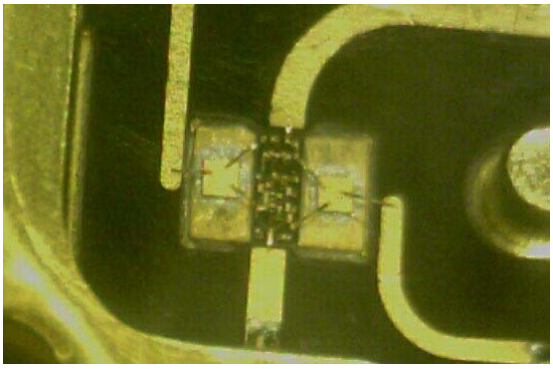
28 – 47GHz Amplifier

By Roger Ray G8CUB

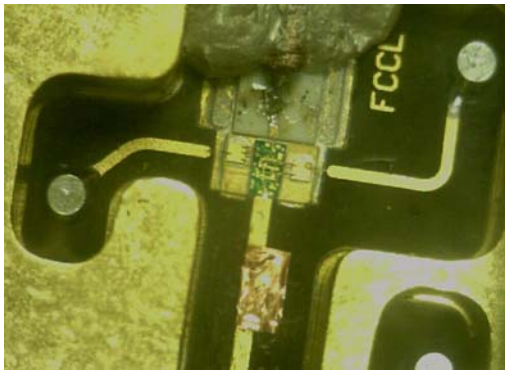


I was intrigued by a 'milli-meter transceiver' on ebay from 'rf-buy2008'. Described as a 'Signal Technology' unit, but with no frequency information. From the dimension of the waveguide hole I guessed at 40GHz. What I was hoping for was >40GHz, what I got was 37.4GHz – bother! The picture shows the business part of the unit, with the duplexor and waveguide power coupler removed.
What looked potentially hopeful, was that it had a LNA amplifier on the receive side, and a driver and PA on the transmit side. Looking under the microscope, I identified the PA as an Agilent HMMC-5040. Looking further the LNA (marked 6561H) driver (marked 6742) & LO amplifiers (6561H) were UMS dies CHA? However asking UMS to identify them appeared akin to asking for the launch codes to France's nuclear arsenal! Both mixers were Hititte devices, but again un-identified.
Firstly I decided to try the unit. Supplies were marked with voltages, except for the Tx amplifier supply, which turned out to be +5V to give around 4.5V on the PA supply. On the opposite side to the one shown was a VCO (V950ME01) which covers 4.3 – 4.65GHz. There are two X3 multipliers in the LO chain (back to back diodes), thus the LO was 38.7 – 41.85GHz. I connected the supplies, and applied 5mW of

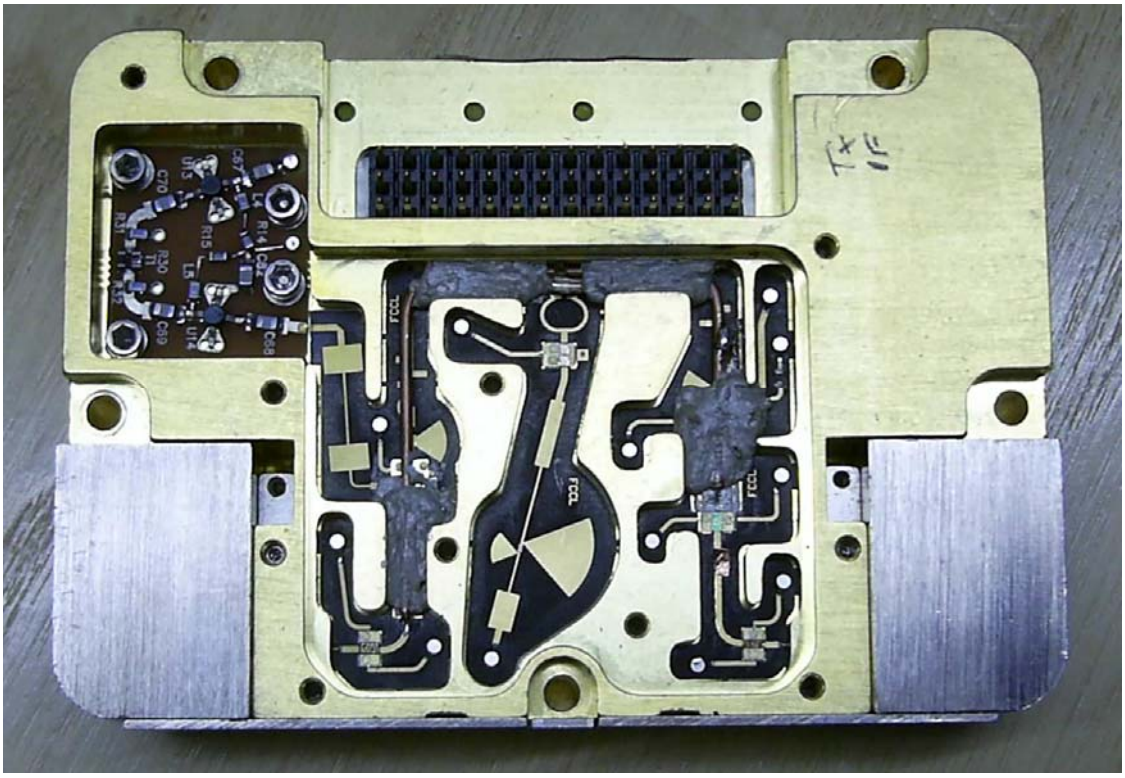
2GHz to the IF in port. The output was +17dBm peaking (by adjusting VCO voltage) at 38GHz. Could I get anything out at 47GHz? I put a piece of foil on top of the filter, and applied 5Ghz to the IF. I got at best -17dBm out at 47GHz. Not too good. Very little if I made the IF 5.76GHz, so I decided this was not going to work as a 47GHz transverter. In playing with the Tx filter, I broke the bond wire from the filter to the driver – double bother!
Could I make something of what was left. I first thought of trying to use the Tx and driver stages as an amplifier. However trying to find a way of coupling into the board was defeating me. Then I hit on the idea of using the wr-28 input and output ports. Would it be possible to connect the LNA through to the driver? The most likely outcome I guessed if it worked at all, was that it would oscillate. Nothing ventured nothing gained etc, I gave it a try.



Agilent PA

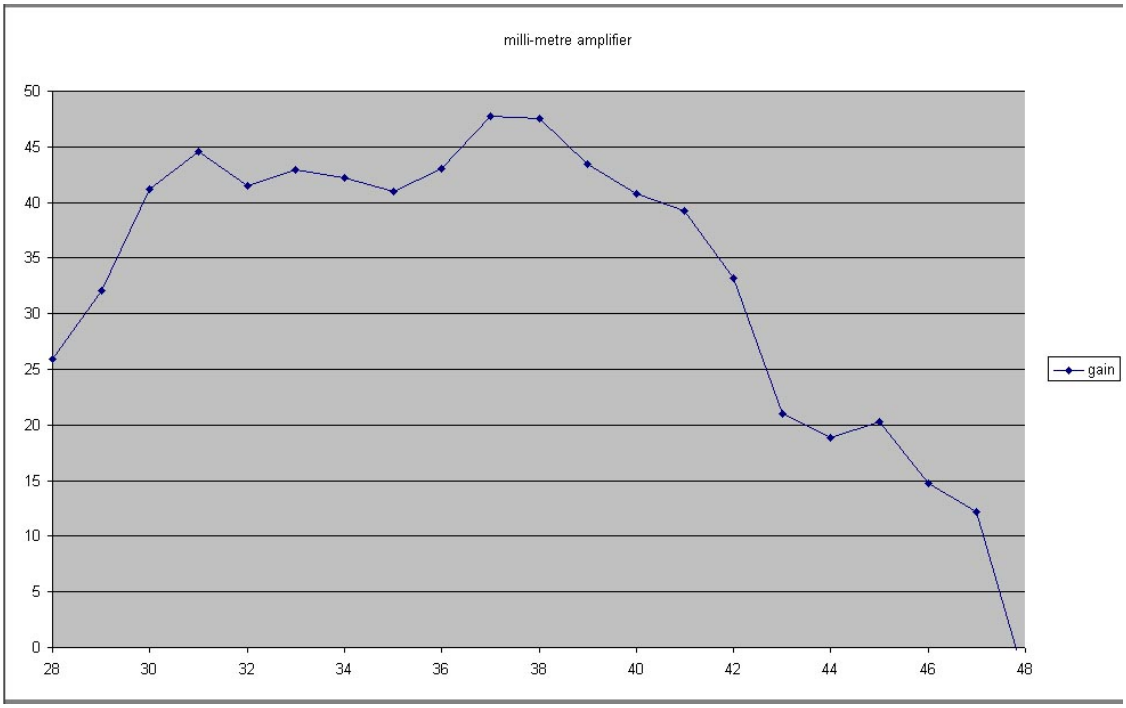


Driver



I used miniature coax that was to hand, as it was likely to propagate the high frequency and give some attenuation between LNA and driver. I soldered the inner on to the track at the LNA end, and used liberal amounts of silver epoxy to connect the outer. This I found I needed to cure, so I put it in the oven at 100 deg.C for an hour, which seamed to do the trick. At the Tx filter end, I bent the inner down and used silver paint to make the connection.
I disconnected the positive and negative supplies to the parts that I had now shorted, and applied power. Firstly I very pleased to find that I had gain, and secondly that it was stable! I did a sweep from 40 – 48GHz and found very healthy gain at 40GHz - 41dB! but very little at 47GHz. The amplifier was at its best with the lid in place.

Test set-up shown measurement 40 - 48GHz, 47.088GHz on screen. This used a Wiltron 40 -60GHz generator and a Flann attenuator and transition WR-19 to WR-28. On the output side a transition to WR-22 and WR-22 attenuator fixed at 40dB and a 33-50GHz HP harmonic mixer with HP 8563E analyser. I later checked the 28 – 40GHz response using a Spacek doubler on my sig gen, and an MI power meter.



The response shows gain in dB on the vertical scale, against frequency along the bottom in GHz.
Gain was a massive 47dB at 38GHz, 40dB at 40GHz, but only around 10dB at 47GHz. 1dB compression was 21dBm at 40GHz, around 18dBm at 37GHz, but only 8dBm at 47GHz.
To get the best performance at 47GHz, I added a small tab on the line between driver & PA, and turned the current up on the amplifiers a bit. At best I got 11.2dB at 47.088GHz, but could not quite repeat that later.
There may be more to be had by adding tuning screws to the waveguide ports, and more careful tabbing. Also I think that if I had ground off the unwanted filter elements it might of helped – though I could easily have broken another bond wire, in doing so.
So was it worth it – as a 47GHz amplifier probably not. As a wideband amplifier to drive a mixer X4 for 134GHz hopefully! For this application it could well be easier to use the internal last X3 multiplier in the LO chain. In this way a coax input could be used after the LO splitter and the following filter. The Tx mixer would need to be shorted out, and possibly the final Tx filter shifted in frequency.
At the time of writing units are still available on ebay.