

6.7 GHz methanol maser line receiver project

The line 6.7 GHz (6668 MHz) of methanol corresponds to the transition $5_1 \rightarrow 6_0$, A^+ type methanol molecule, II class of maser excitations; it is expected stronger than 12 GHz line, therefore, a list objects could be detected at 6.7 GHz by amateur means is expected wider. RFI at nearby frequencies are not too strong in comparison with 12 GHz band. Here are some pictures from the receiver project with my short comments. Hope the project is far from final, but this is a first version of receiver working today.

The receiver consist of indoor and outdoor parts. Outdoor part is just downconverter from 6668 MHz to IF less 1 GHz (968 MHz in my project). USRP B200mini controlled by LabVIEW software was used as the indoor part, see a detailed description in SARA journal 2022, September-October issue, p. 71. Indoor and outdoor parts are connected by 20 m coax with additional amplifier compensating the coax losses.

About downconverter in the outdoor part:

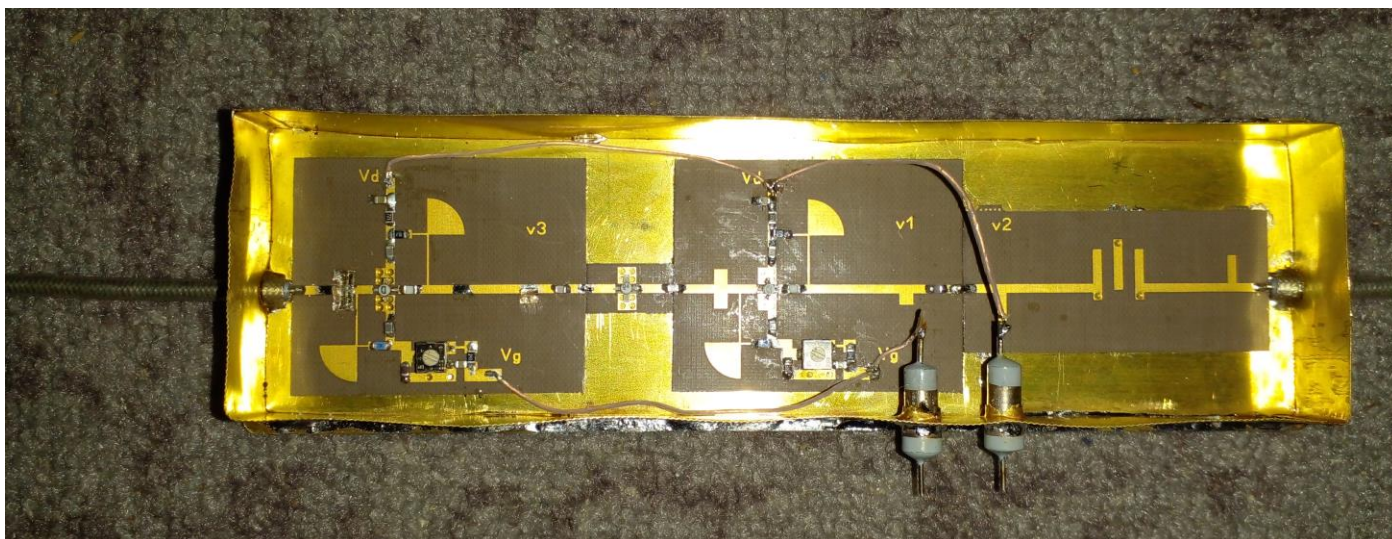


Any attempts to modify an equipment for 5.7 GHz amateur band gave poor results; the gap with needed frequency 6.668 GHz is too large, and no accepted Noise Figure was obtained. I applied RX module from Terrasat outdoor 6 GHz link purchased at eBay several years ago. It can be applied as downconverter with external LO, but the inner filter was removed (bypassed). Unfortunately, the filter rejected at 6668 MHz already. The module was intended initially for lower frequencies; its nominal upper frequency was about 6.5 GHz. I think his brother, the Terrasat RX downconverter <https://www.ebay.com/itm/144887655689> will work at 6668 MHz without modifying (and will not require the filtering in LNA, see below). Terrasat modules require about several dBm at LO input; the Noise Figure at their RF input can be expected about 2-2.5 dB, conversion gain is about 25 dB.

My LO frequency was 5.7 GHz. As LO I used Chinese RF source from AliExpress based, as declared by seller, on PLL HMC833, <https://aliexpress.ru/item/10000201112020.html>. The source's output at this frequency was too low; an amplifier with ADL5611 was applied to enhance the level. The PLL uses 25 MHz TCXO inside RF source as a reference. I didn't find a good available 25 MHz OCXO as an external reference instead; unfortunately, bought at AliExpress Chinese reference <https://aliexpress.ru/item/1005004601387265.html> spoils the spectrum of PLL output significantly.

The TCXO frequency error is checked and taken into account in VLSR calculations.

The downconverter module requires a LNA in any case. My LNA includes two stages of amplifying and an output filter for 6668 MHz. GaAs FETs NE32584c were applied in amplifiers. The LNA was composed from several PCB (amplifiers itself, attenuator between stages, output filter, each projected separately) in enclosure with semirigid coax connections without DC blocking capacitor in the input for the sake of lower NF, see the picture below:



Output 3-order interdigital filter characteristic (measured with VNA R&S FSH):



Transfer characteristic slopes are not too steep, but the stopband attenuation is acceptable for the receiver.

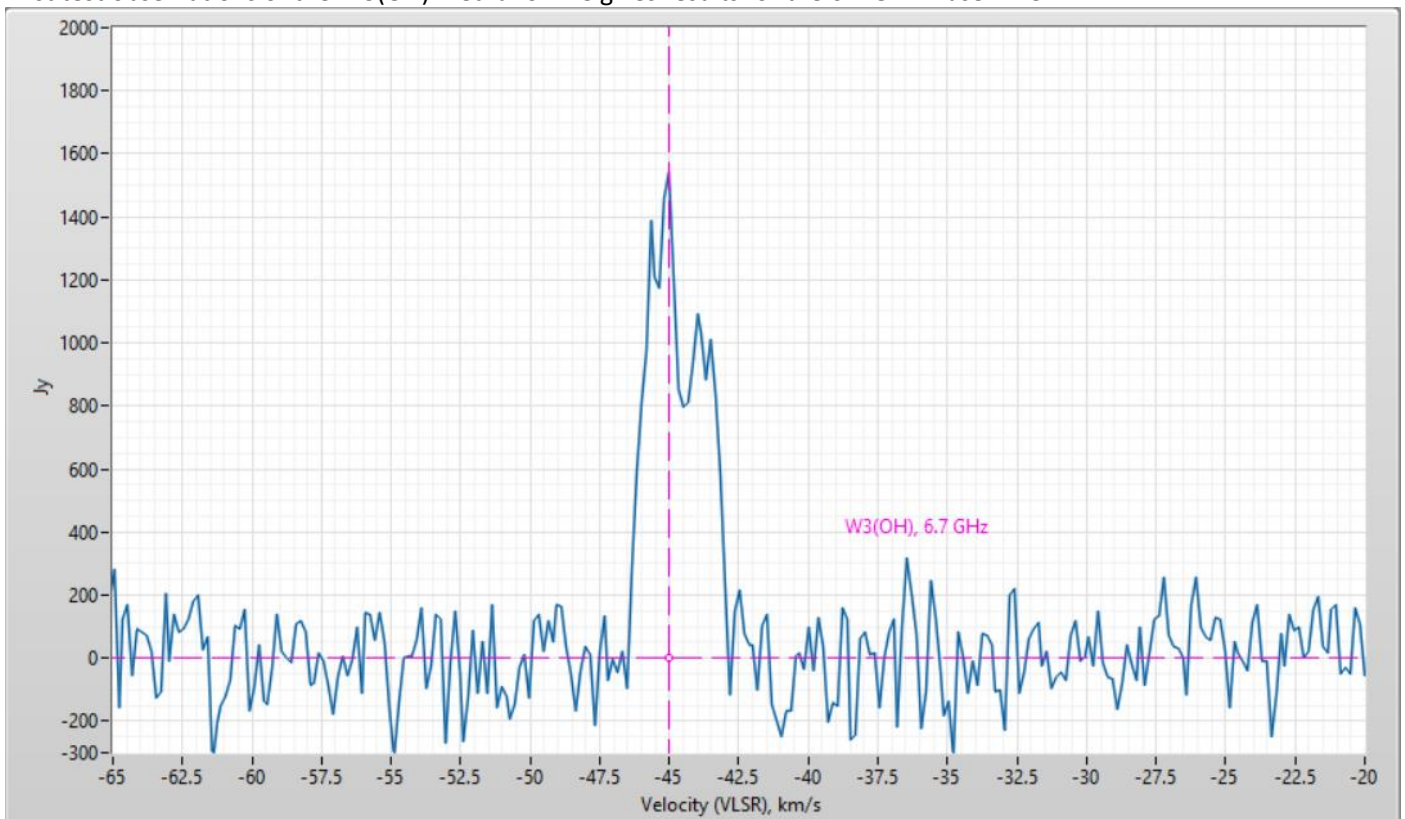
The FETs for amplifiers were extracted from old sat LNB and, as it seems, already degraded. I spent many days in attempts to get expected NF (less 0.7-0.8 dB), but the best I have squeezed from the LNA is about 1.6 dB. Not too good, but acceptable for first tests. One can see on the LNA picture that projected tuning stubs were removed and new ones are soldered.

The foto of the outdoor part under Noise Figure tests (noise head – Noisecom NC346A Precision with DC blocking adapter):



The feed was initially intended for 5.7 GHz amateur band (for terrestrial links, not for EME), and modified for our frequency just shortening the probe inside. This circular horn was modelled in Comsol, 2D axisymmetric RF module; calculated far field pattern shows the feed provides a good illumination of the dish with aperture efficiency about 0.68.

First test observations of the W3(OH) methanol line gives results for the 6.7 GHz maser line:



Integration time was about 40 min, receiver resolution – about 5 kHz (0.2 km/s in the VLSR scale), the dish position was controlled by automatic tracking of the source. Expected line width and peak position are reproduced well, but received peak level is somewhat lower than expected >3000 Jy. There was a real snow during measurements; the atmospheric absorption was taken 1 dB, but higher absorption values were probable.

The last foto is the view if my dish in action:



Dish telescope characteristics: Antenna Sensitivity (Forward Gain) – 0.63 mK/Jy, T_{sys} was this day 200 K or higher (including the atmospheric thermal noise).