# EME ON 77.5 Ghz

## Sergei RW3BP, EME Meeting in Orebro, Sweden, May 2013.

First of all few words about difficulties we have for EME on this band.

### *77.5 GHz EME Budget*

$$\frac{S}{N} = M \frac{P_{tx} G^2}{T_A + T_{rx}} \sigma$$

$\sigma = \pi R_M^2 \eta$ - *radar cross section*

$R_M$ - *radius of the Moon*

$\eta$ - *lunar reflection coefficient*

$P_{tx}$ = 60W, $T_a + T_{rx}$ = 700K, $G_a$ = 62 dB, Beamwidth = 0.12 deg, **S/N = 0 dB**

Cross section loss: $\left(\frac{0.12}{0.5 * 0.75}\right)^2 = 0.1$ - 10 dB

Atmosphere loss: (30 deg elevation) summer / winter -6.5 dB / -2.5 dB

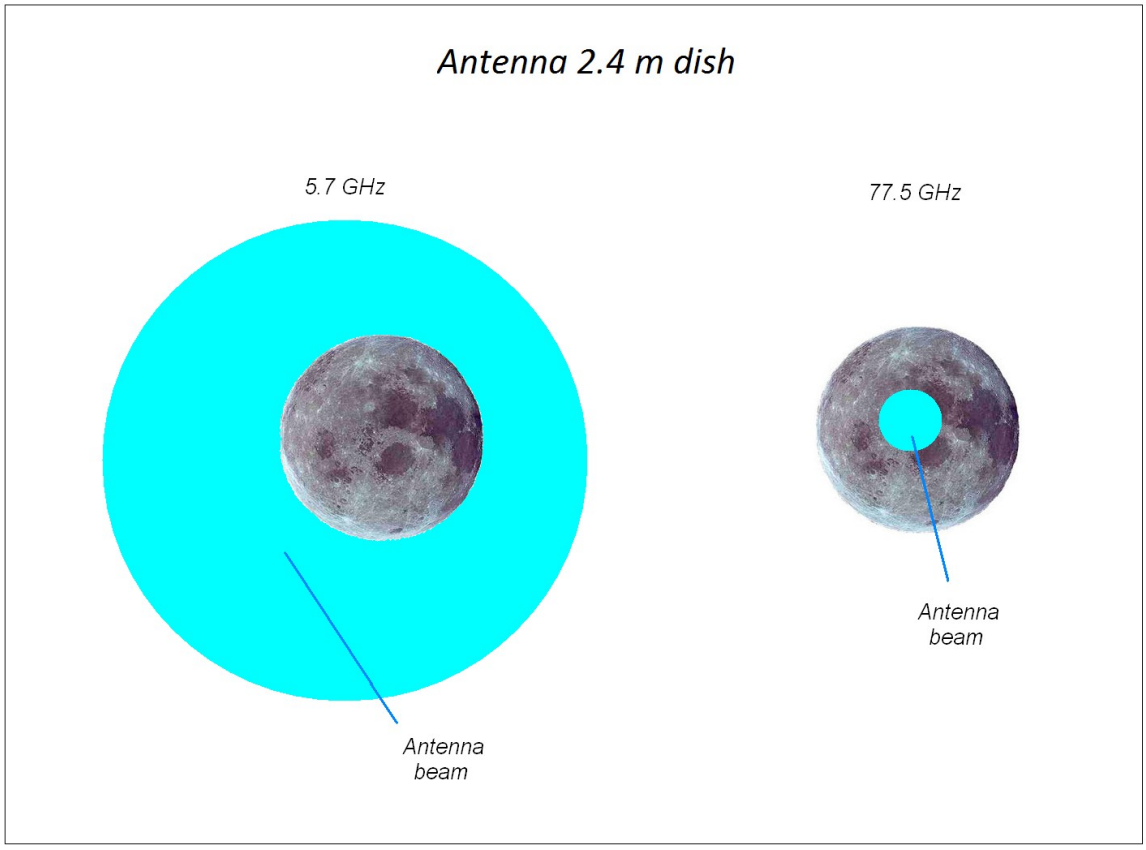
Libration signal width loss (in comparision with 50 Hz width) up to -7 dB

**Total S/N summer/winter - 23.5 dB / - 19.2 dB**

You can see formula for signal to noise ratio. It is based on well known Radar equation for the Moon as a target. In this case it is simplified formula for fixed band, for fixed bandwidth of receiver, for fixed distance to the moon. All constant values are in general coefficient "M" and I left here only variable things. Really Radar cross section is also constant on all low bands but on this band it is not true. Let me remind you that radar cross section for EME is square of the moon disk multiplied by lunar reflection coefficient. For all bands lunar reflection coefficient is about 7 %. Let us consider now my case. Transmitter power 60 W, system noise temperature about 700K and antenna gain 62 dB (one and half million). If to calculate signal to noise for echo the same way as on lower bands we'll get "0 dB" for 2.5 kHz bandwidth of receiver. It is good ratio. On 23cm it is easy copy SSB signal.

**But real life is much worse.**

First problem is reducing of radar cross section. Second picture shows two examples of moon illumination.




It is for two bands 5.7 GHz and 77.5 GHz and for my 2.4 m dish. It is easy to see what is difference for these bands. For 5.7 GHz the moon is small target and radar cross section of the moon is constant and not depends on antenna gain. On 77.5 GHz it is illuminated only part of the moon surface and radar cross section is function of antenna gain. More gain - less cross section. In first approximation this effect is begin when beam width of antenna is equal to angular size of the moon or when it is equal to 0.5 degree. Really only central part of the moon disk is reflect radio waves and it can be some equal diameter of the moon. For optical band it is nearly full diameter. On 77.5 GHz it is about 75% of the full diameter. On low bands the moon is reflect as a smooth shiny ball and equal diameter is small.

Well, 75% of angular size of the Moon is 0.375 degree. So on 77.5 GHz band starting from this beam width we'll get decreasing of cross section proportional to increasing of antenna gain. For my dish with 0.12 deg beam width we get echo signal loss about -10 dB.

Next problem is atmosphere loss. It is negligible on low bands but here it is very important. For 30 degrees elevation of antenna and for standard atmosphere it is -6.5 dB loss in summer time and -2.5 dB in winter time. It is for no rain and no clouds of course.

Third problem is moon libration signal width. On 77.5 GHz it can be up to 1.5 kHz on my latitude. Fortunately it can be decreased by narrow beam antenna. In my case it is

decreased from 4 to 5 times. BTW it is funny to tune received frequency by moving antenna from one edge (one Doppler shift) of the moon disk to another (another Doppler shift). And this is why the moon tracking must be accurate and smooth to get straight trace on Spectran. In my tests maximum libration signal width was about 250 Hz. Not sure how to calculate this loss. If standard brain filter for CW is about 50 Hz the loss will be about 5 times or -7dB.

If to summarize all these losses we get -23.5 dB S/N in summer time and -19.2 dB S/N in winter time.
It is really not easy band and not many ways to improve results.

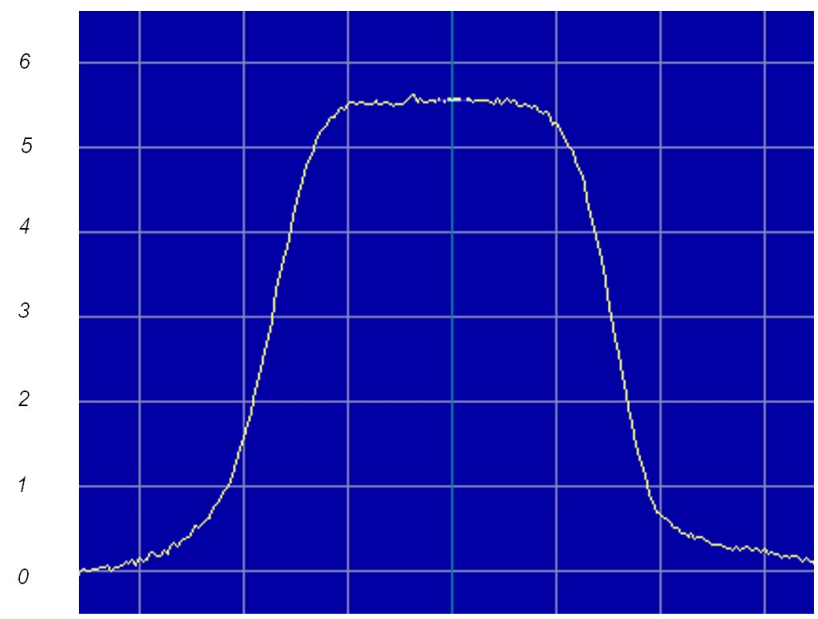
Transmitter: 60 W is very high power for this band and I not see how to increase it. For me it is more important to save it because I have no spare one. It is a long story how I get power from this TWT. It is some pilot unit and there were some design errors in it.

Antenna: It is a luck that my 2.4 m dish is now workable on this band. First result was very poor and I spent a lot of time trying to improve antenna. Even tried to use dielectric lens for correction. And all this is impossible without proper beacon. Sun and moon are too big for this band. So 2.4 m dish is limit for me now.

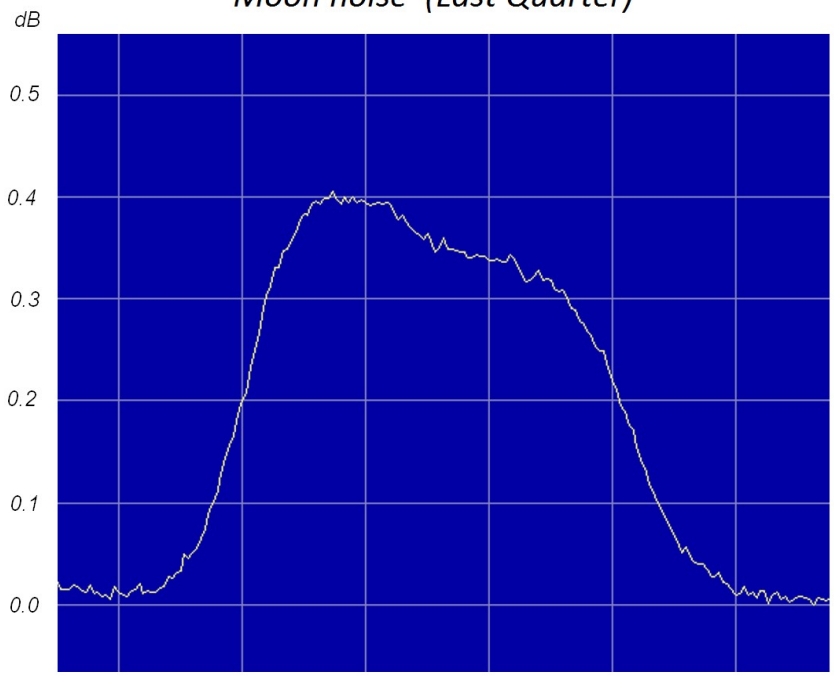
*Styrofoam table for the dielectric lense*

*PTFE lense*

*Sun noise*

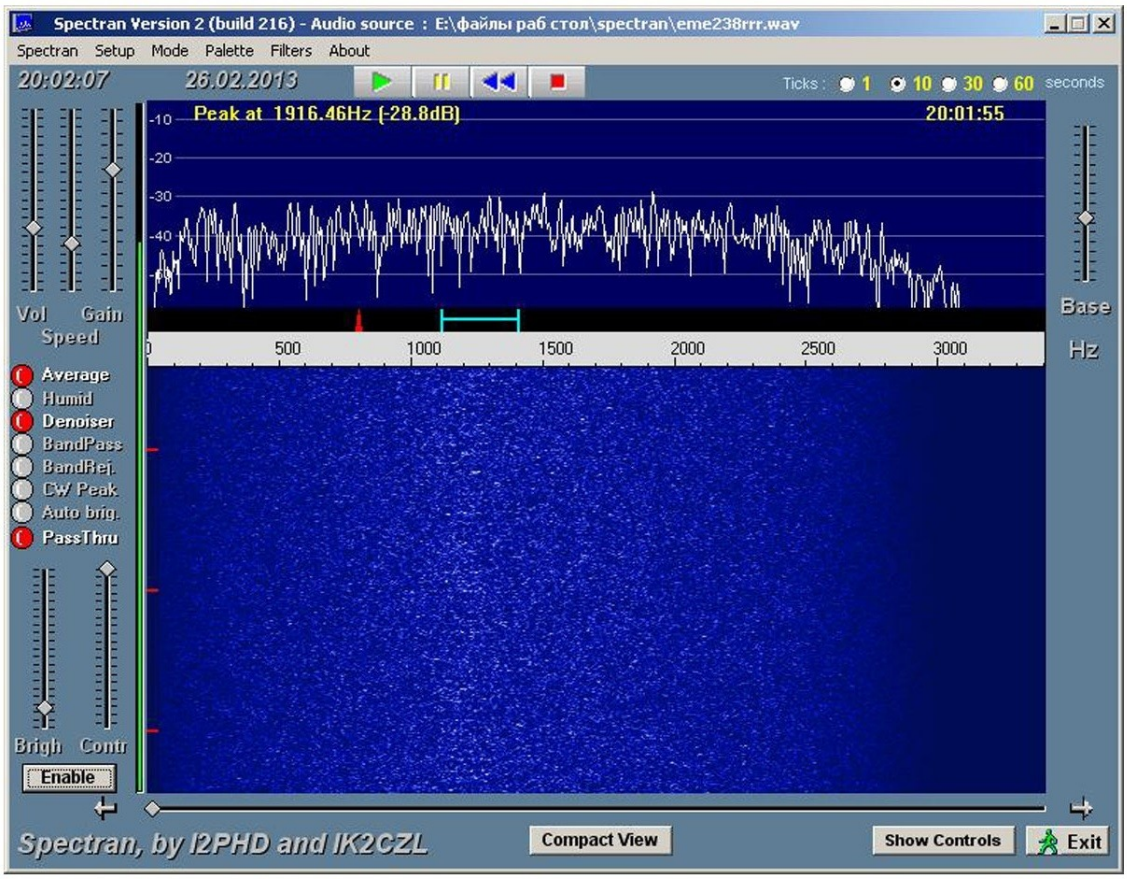



*Moon noise (Last Quarter)*



Receiver: There are some reserve there. I use not very new chips by UMS in LNA and now it is possible to improve it. I hope it can be improved from 5dB to 3dB noise figer. Also it is possible to try cooling. But there is also a limit. Antenna noise temperature is fully determined by moon noise. If to add atmosphere loss noise we get more then 200K for antenna and this is a limit.

## *30 deg elevation*




**Finally I can say that two way QSO is possible on this band but it is hard work.**

The next is video. It is recorded in February 2013

http://www.youtube.com/watch?v=2En_W2EaJFw