Source: http://dl7apv.darc.de/start/start.htm

What did it need to run first 432 EME QSO ?

There are several stations QRV with 8-15m dishes and 16yagies and they are abel to work very small stations in JT65 :

Only with a single yagi and 20W !

BUT
There are several things that have to be fulfilled like:
1. Antenna and environment:
- minimum of 15elements
- elevation rotor would be fine, but no must. A fixed el. at 10° or 25° can help
- if no separate preamp and PA is used, a low loss **short cable** to the antenna is a **must (<2dB!!!)**
- free view to moon, special if no elevation is possible
- no qrm from neighbors due to plasma TV and others sources

2. Transceiver + PC
- Low frequency drift of the transceiver (<10Hz per minute)
- Sensitive RX (or better preamp at antenna)
- >= 20W output
- WSJT installed on your PC and connected with the radio
- a preamp and PA close to the antenna would be fine

- How to check if the system will work ?

First possibility is just to go to N0UK Logger or HB9Q logger or Live-CQ and see if anyone is qrv on 432 EME. Someone is always qrv on weekends with positive declination (see moon-calendar).
- Nothing on screen, WHY?

1. Doppler shift

- Don't forget to set 432 in the **Band** drop down menue
- If moon is up you see now the doppler shift (dop) of your own echoes if the box grid is empty.
- When the grid box is filled with the locator of the other station the doppler shift between DX and Home station is displayed.
- If a station spots CQ 432050 expect his signal + the shown dop.

On 432MHz doppler shift can be up to +/-**1000Hz !!!**

2. Faraday and Spatial offset

- Most stations have a linear polarized system on 432 so if no signals detectable maybe faraday rotates the signal while passing through geomagnetic field of the earth. Try again later or ask a station with a dish to change polarization.
- Spatial offset is the geometrical polarization offset between two stations on earth when signals reflected from moon.

This will change during mon pass and declination.
- E.g. from EU to JA we have mostly around 90 deg (abt. –20dB) but the Jas using V-pol. antennas and EU hor.pol. antennas so no extra loss due spatial offset.

EU- north America west coast, both using mostly hor.pol. antennas and we have also mostly 90deg offset so that's hard to work them with linear pol.
EU to Australia is easy as spatial offset is mostly <30 (45deg are 3dB loss)
- Use VK3UMs EME planner to check spatial offset

If this will not show any results we have to look why.

2nd check will be the sun-noise:

Example :
With Solar flux = 130 (what we have now aprox) see http://www.solen.info/solar/

Antenna	RX	Sun noise vs cold spot	Sun noise is :	Big guns can be heard :
11el. 12 dBD No elevation	2.0dB cable loss ant-TRX & 2.0dB NF, no preamp	0.7 dB	Hard to detect !	Up to -20
19el. 15dBD No elevation	2.0dB cable loss ant-TRX & 2.0dB NF, no preamp	**1.3dB**	Hard to detect !	Up to -17
11el. 12 dBD +elevation (measure cold sky)	2.0dB cable loss ant-TRX & 2.0dB NF, no preamp	1,0 dB	Hard to detect !	Up to -18
19el. 15dBD + elevation (measure cold sky)	2.0dB cable loss ant-TRX & 2.0dB NF, no preamp	1.8 dB	Should be detectable	Up to -16
11el. 12 dBD +elevation (measure cold sky)	Preamp at antenna Cable loss and NF 0.5dB	2.8dB	Light move on S-Meter	Up to -13
19el. 15dBD + elevation (measure cold sky)	Preamp at antenna Cable loss and NF 0.5dB	4.5 dB	Easy on S-Meter	up to -10 !!!
AGAIN, that's **maximum possible** values under optimal condx !!! Add some extra loss due to drift of radio, faraday, spatial offset, maybe apogee, libration, and MAN MADE noise !				

· The S-Meter on the common Transceivers are nor accurate enough to check sun noise. To measure sun noise turn off the agc of the TRX (if possible) and use the measure mode in WSJT.
· Or use a switchable attenuator between preamp and TRX. Turn attenuator to 0dB, turn the antenna to the cold point in the sky, storage the S-Meter reading in your brain and turn the antenna to the sun. Now switch the attenuator until to get the stored s-Meter reading and you see the sun noise on the attenuator. This will work when the gain of the preamp is good enough, you hear increasing noise when connect to the radio.-
· Most SDRs have an accurate S-Meter and can be used direct.

If the sun noise is below the expected value it can have different reasons.

1. Check the cable, water inside connector not properly mounted
2. Receiver / preamp ok
3. Antenna bad

..4. Man made noise

While 1 and 2 can be checked on the workbench (maybe at the club or a friend), 3 and 4 are hard to check. 3 test the antenna with a local beacon, or carrier. There should be 2 sidelobes at 10-20dB down at each side and all other lobes should be down by 20dB or more. The main lobe should have abt 23 degree. This will give a feeling for the antenna. When there are some elements bent is not critical, bad contacts by corrosion is a bigger problem. Man made noise is hard to find.

<u>Doppler on 432</u>

First what we have to remind on 432 (and up much more) is the **doppler shift**.
The Doppler shift can get as high as 1KHz on 432 MHz. So I knew of several qso which failed by not paying attention to this. We have to see different cases:

1. Station A is calling CQ on 432,010. His program tells him a Doppler shift of +600Hz (he has moonrise and moon in the east). So he is turns his RIT to +600Hz and hears his echoes clear.

Station B has the moon in the west and a Doppler of -300Hz. Hi turns his RIT to -300Hz and hears his echoes. B now turns his VFO knob and hears A (with rit at -300Hz) he can reply and A hears B on the qrg where A hears his echoes. ----That's fine for random qso.

2. in skeds :
In every sked you should announce your TX qrg. Like 1. A TX on 010 with RIT. B answers as described.
What if you don't hear A in sked. Set your TX on sked QRG 010 and use your RIT to find A.

VK3UM planner shows you all 3 doppler shifts between you and the DX station (if selected).

For example:
A_Home-A_Home +567
A_Home-B_DX -165
B_DX-B_DX -1096
If both have no Rit activated
A hears his echoes 567 Hz above his TX QRG
B hears his echoes 1096Hz below his TX QRG
A hears B & B hears A 165 below their TX qrgs
So for a sked both A and B set their TX on 010 and with the RIT at -165Hz they will hear each other.

The WSJT program shows different Doppler shifts depending if there is a locator put in the field Grid. If grid is blank you see Doppler home-home. If Grid is filled by the grid locator of the DX Station, the Doppler shift home-DX is shown. That's a bit confusing, but ok.

3.
This time we count the frequency like a viewer/listener on the moon (Moon RX) will see it. The qrg on the moon is for everyone added half on the own doppler effect.
Now we have the following situation:

Two stations will run a <u>sked on 432,1000 MHz</u>
Station A has a dopplershift of +600Hz
Station B has a dopplershift of -800Hz

<u>Station A</u> tunes his TX to 432,0997 MHz
=432,1000 MHz – ½*600Hz
So his TX signal will appear at the moon on 432,1000 MHz.
To hear his echoes Station A tunes the RX to 432,0997 + 600Hz = 432,1003 MHz

<u>Station B</u> tunes his TX to 432100,4 MHz
=432,1000 MHz + ½*800Hz
So his TX signal will appear at the moon on 432,1000 MHz.
To hear his echoes Station A tunes the RX to 432100,4 - 800Hz = 432,0996 MHz

So both Stations can hear their echoes and on the same qrg they can hear the other station. This situation has all advantages:

The QRG is exact defined and independent from location on earth.

Both stations can hear their own echoes and the other station at the same QRG.

On random we can use the same RIT adjusting to make qso like on tropo.

Using this method the operator has to tune on both RX QRG and TX QRG, while the doppler changes over the moonpass. Best is to use 100Hz steps while this will be easily heard by ears and on JT is no big deal while it can be seen in waterfall display. Special in JT don't tune while Txing, use the 5 seconds when the computer is decoding.

On 2m this is no big deal, while doppler is not so high, but on 432 we have up to 1KHz doppler and I remember several cases where QSOs where nil by wrong doppler compensation from one or both stations.

Spatial offset and Faraday

In my years of EME I realized that I could work very small Stations in Europe and JA, but to the US I always had problems to work horizontal polarized small stations. I believe many of you horizontal polarized stations made the same experience. There are two effects which causing this. First is the spatial offset between two stations, which depends only on the locations of the stations and the position of the moon. The VK3UM planner with the online spatial offset calculator makes it clear. Eu to Eu is always below 20 degree, means losses of about 1 dB. Remember 45° is a loss of 3dB.
JA has mostly 90 degrees offset to EU, but the JA stations are vertical polarized so it fits perfect. The same we have with the US, but they using horizontal as we do in Europe. So we have a polarization offset close to 90 degrees. That means an extra loss of 10 or 20 dB. Unacceptable on EME.

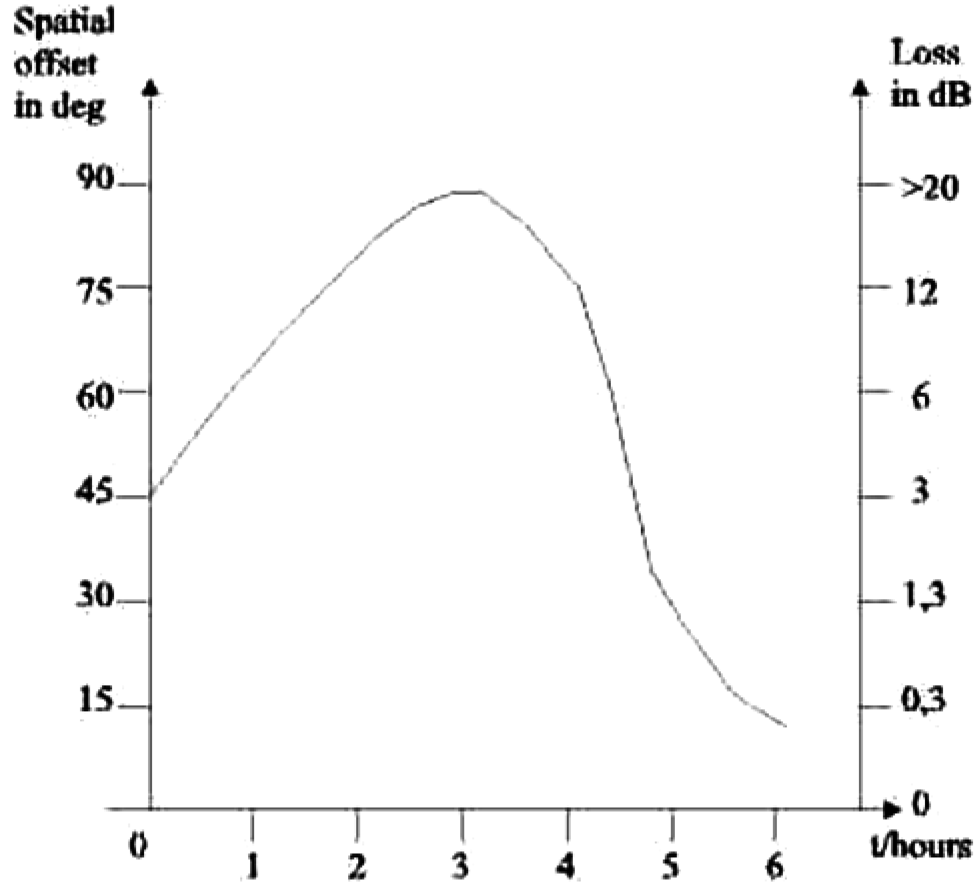
But we can make QSOs to the US from time to time. Also reported that the US guiys hear us but we don't, and vise versa.
The reasons are : one of the stations has polarization rotation or cross yagis, or 2nd Mr. Faraday turns the polarization. The earth's magnetic field causes the wave front from the radio signal to rotate in polarization several times as it passes through the ionosphere on the way to the moon and back.
That causes not only the wishful turning of 90 degree, but all degrees between 0-90° and to make it real complicated this effect is not reciprocal. And the polarized waves can be split of into many different polarizations. So even with pol. Rotation or H+V antennas we have a big loss, what looks like an absorption. As we know so far Murphy turns into a bad angle ever when we have only one sked with THE MEGA-dxpedition. HI !!
The observed fading on EME is caused by faraday and by libration.

As viewed from earth, the moon appears to rock back and forth on its axis. This motion is called "libration". Both effects cause deep and fast qsb. This qsb can cut in a CW-letter a dash or dit so you hear a station loud but cannot decode the callsign.

As observed it needs an optimal speed for CW to make a qso under such condx. The perfect solution is cross polarization like on 23cm, but this causes other problems on 432 for yagi stations. With dishes its so easy. We observed times when libration is less than at other times, but a calculatable solution is not available. Faraday is also not predictable. We know it is a bit less in times when we have sunspot minimum and aurora causes absorption and extra loss, but we cannot calculate this. In my mind, this makes skeds and random more real a challenge, because you cannot predict all. You have to try and retry until a qso is successful.

Spatial offset

Here we add a practical example to the spatial offset problem. In the chart below is shown the spatial offset during a window EU-US.



Moonrise US **to moonset EU**

At US moonrise we have 45° offset / 3 dB of extra loss. At half of the window spatial turns to nearly 90° / >20dB of extra loss. At Eu moonset the angle turns to below 30° / 1 dB loss. Here is the best chance to place a sked if other parameters are fit as well. Europe to the northwest US is much worse, for example my qth to KA7V in Oregon is always >70° / >10dB loss. This makes it very hard for linear polarized stations to complete a qso. Better is the path EU to VK5 where spatial is always below 30° / 1dB loss.

N8CQ 16 yagi portable on trailer with pol. rot.

This antenna above shows how to solve the polarization problem.

Libration

Libration in latitude variations have showed the greatest effect during the tests from SV3AAF. Libration in longitude variations (thin sine) have not showed significant effect. Anyway for the most of 2009 they almost coincide so it will be more difficult to distinguish for someone that does not have the experience of 2008.
For the moment the most important:
If you make some echo tests of your own for the purpose of libration study please correlate your observations also with lunar declination. At higher positive declinations I expect more clear results of the libration effect highs and lows. Perigee is of lesser relevance and it better be avoided for the purpose of libration tests at second half of 2009 because it doesn't coincide with high moon at northern hemisphere. Audio spectrum waterfall monitor like Spectran can help the observation always along with our good ears.
Tnx to SV3AAF for this info !!

Maybe all of us can check if this fits with own observations. More theory at :
http://en.wikipedia.org/wiki/Libration

After we learned about the conditions we will have a look to the <u>station</u> we will use for 432 EME.

We have 3 major things to observe:
Preamp & RX
2.1 sensivity & gain of preamp
2.2 good IP3 & filter
2.3 high qrg stability for dig. modes
PA & Transmitter
3.1 Power
3.2 losses tx-ant
3.3 qrg & power stability for dig. modes
Antenna
1.1 Gain & SWR
1.2 Side lobes
Losses dipol-relay
Location
4. Simulation of your system

<u>Minum requirement</u> for a qso in cw. So far I know the smallest stations used so far were :
I5TDJ single long yagi 1K – EA3DXU 2x13wl &KW, both were using a good preamp and more then one attempt. 4 yagi to 4 yagi is always easy if pol. is cooperative. In JT its possible to work with 30w and a single medium yagi the bigger stations like 10 or 15m dish.
I would like to hear what was the smallest station so far from little or medium sized stations.
Most important is the antenna, but I will start with the preamps.

2.1 sensitivity & gain of preamp
Like we will see later on 432 we need sensitive preamps as close as possible to the antenna. I will not go to deep into the well known theory but the preamps have to fulfil following requests:
Low noise figure **NF** <0,5dB
Good Gain, **G** > 20dB depends on cable loss to RX
High **IP3** >10dBm
Absolute stable K>1
Maybe a resonator in the input circuit to have a filter function

This issue we will have a closer look to the <u>preamp</u> needed for EME.
In all cases sensitivity is needed to hear better. This is more valid on 432 & up due to colder background in the sky. The best preamps I know are around 0,25dB. BUT when talking about absolute values of noise figures we have to remember that the measurement error is nearly in the same range!!! You need a good Noise figure meter and you have to know what you are doing. If no expensive noise figure meter is available there is only the chance to measure the performance in the antenna with sun noise or other galactic sources.

I will give some <u>examples</u> from the VK3UM simulation software with a single 21el. F9FT yagi. Sun flux =70, Tsky = 30K, gain preamp 20dB.

RX	**Noise figure**	**Sun noise**	**Difference**
Trx+ 10m RG213	3,5dB	1,9dB	0
Trx+5m Aircom	2,3dB	2,7dB	+0,8dB
Trx+preamp 1dB	1dB	4,1dB	+2,2dB
Trx+preamp 0,5dB	0,5dB	4,8dB	+2,9dB
Trx+preamp 0,25dB	0,25dB	5,3dB	+3,4dB
Trx+preamp 0,35dB	0,35dB	5,1dB	+3,2dB
Trx+preamp 0,45dB	0,45dB	4,9dB	+3,0dB

We can see that a low loss cable + preamp in front of an antenna can improve signal like doubling the antennas. If all other parts are optimal a tenth of a dB at the preamp makes not the big difference. But 10m **RG213 will kill** all possibilities of a EME qso where small signals expected.

<u>Which preamp</u> is best ?? This question has no answer which will fit every case. It depends on location and your wallet. In an urban area you need all selection what is possible and IP3 must be good, NF is secondary. On a lonely island only NF is interesting. And if you are able to use a soldering iron it can cost 20.-Eur, but you can pay up to several hundred euros for a commercial one. The one I use today is from Hubert, DJ3FI a very fine cavity with <0,3dB NF. Bandwidth is small and IP3 fair. Better IP3 have for example the DB6NT preamps with ATF54.. series Transistors, but they have wideband input. OZ2OE published in Weinheim some years ago a preamp with ATF54143 which will cost only <20Eu. He used only a serial C input to Gate and no tune. Simple and good, a bit difficult to handle self oscillation. The production charges of the ATF are not always the same, so depended on the individual transistor you have NF will be 0,3 to 0,5 dB.

There are of course many other preamps available. Google for preamp 432 and there will be much info. Or look here :
http://www.g0mrf.com/432LNA.htm
http://www.ssbusa.com/db6ntvhfuhf.html
http://www.qsl.net/dl5lf/432_preamp.html
http://www.downeastmicrowave.com/PDF/70ulna.PDF
http://www.rfham.com/ preamps
http://www.kuhne-electronic.de/de/shop/143_Vorverstaerker

Next important point is the **<u>matching</u>** from the antenna to the preamp. If you buy a preamp or the homebrew preamp is optimized at a noise figure meter the best NF at the antenna can achieved only if the antenna has the same impedance as the noise source, typical 50R. So not loose sensitivity the return loss of the antenna has to be 16dB or better (SWR <1,4).

Enough **<u>gain</u>** of the preamp is recommended. Based on the example before, we change gain and cable length. The NF of the TRX 2dB, the gain of preamp is 20dB, cable preamp-TRX has a loss of 1dB. Now we change the values and see that with a 1 dB cable loss the gain can be as low as 16dB to effect the noise figure.

RX Trx+preamp 0,25dB	**Cable loss**	**Preamp Gain**	**Sun noise**	**Difference**
	1dB	20dB	5,3dB	0 dB
	1dB	15dB	5,2dB	-0,1dB
	1dB	13dB	4,6 dB	-0,7
	1dB	10dB	4,4 dB	-0,9
	2,5dB	20dB	5,2dB	-0,1dB
	3 dB	20dB	4,8 dB	-0,5dB
	5 dB	20dB	4,7 dB	-0,6dB
	10 dB	20dB	4,1 dB	-1,2dB
	10 dB	10dB	1,7 dB	-3,6dB

Tuning. All OMs who have a noise figure meter I hope know how to use, but for all other I have a very simple trick from OE3JPC. All you need is your station with a FM RX an analog ac-voltmeter and a very small signal in band. The Voltmeter is connected to the audio out of the transceiver. Use long wires that you can read the voltmeter while tuning the preamp at the antenna. Tune the RX on a very small signal. Turn the antenna into the "cold" sky and tune the preamp until the reading of the voltmeter is minimum. (In german a better description is here: http://www.qsl.net/oe3jpc/eme/UHFTECH3.pdf

Its very simple to optimize the preamp in the used antenna, all problems due to mismatch (bad SWR) are solved this way. The only disadvantage is, you optimize relatively, so no idea about the absolute noise figure. This can be solved by measuring the sun noise or other noise sources compared to the cold sky.

Checking **absolute noise figure** of the preamp with the sun. If there is no noise figure meter, we can use easily the antenna and TRX as measuring system. We need two things to measure, a good S-meter (or a chance to get the voltage from the S-Meter) and a step attenuator. The measure function of the JT65 WSJT 4 fits not, because the demodulators of the receivers are often not linear. The preamp must have enough gain so that the step attenuator does not decrease the system noise figure. As we can see in the table above we need more than 20dB gain when a 10dB attenuator is needed. (depends on estimated sun noise)

With the **VK3UM EME planer** (or other software) we can calculate where are the cold sources and the sun are at a given time.
Procedure is to point the antenna first to cold sky (Aquarius, Leo or Pictor) and read the S-meter (or better a voltmeter parallel to the s-meter). Then we point to the sun and now we switch the step attenuator to the postion that we get the same s-meter reading as before. Now we see our sun noise on the step attenuator. Because of local noise and (at high sun activity) various flux values this should be repeated 3-5 times a day. With the mean value of this values we should get close to reality.

The same procedure can be made with the **ground noise**, but there are several problems to solve. First is to have a dry non conductive ground in your garden. It took me 3 years to find out that my garden is wet and has a good conductivity. Good for 80m verticals, but gives not the estimated ground noise values. Second is man made noise, modern plasma TVs switching power supplies make some more or less noise. So I found out, that my housewall is the best "ground noise" when all PC & TVs are off. So instead pointing to the sun the antenna is pointing into the ground or housewall with the full beam and we get the ground noise.
With this to values measured carefully and some more times to get a feeling for this we can calculate the RX parameters.

Getting own NF by two measures.
The VK3UM EMEcalc helps us to find out if the station is ready for EME. For our example we take a single 21el. yagi which is very popular in Europe.

Gain	18,2 dBi = 16dBD
Flux today	75
Cold sky	20K (Aquarius) or 25K (Leo)
Loss ant-preamp	0,2dB (2m aircom+2N-connectors)
Preamp NF	0,5dB (start value)
Preamp Gain	19dB
Loss preamp to RX	0,4dB (5m aircom+connectors)
NF of RX	3dB (I hope worst case)
sidelobes	15K
backlobes	5K

These values we put in the VK3UM calculator. The last two needed values are a bit difficult, spillover and feed thru. These names come from dishes and mean at yagis sidelobes and backlobes. The lobes give some extra noise to the dipol and the system. We go into the datasheet of the antenna and see first sidelobe is 13dB down and the front/back ratio is >20dB. So we have up to 15K from the sidelobe and about 5K from the back. These values can be much higher in a noisy urban area !!!

Now we can calculate the noise figure and gain of the system. For a 0,5dB preamp we have to measure 5,6dB sun and 4,7dB ground. If not :

Sun	Gnd	what is wrong
4,6	3,2dB	preamp has 1dB NF
4,6	4,7	antenna gain is 1,5dB low
4,0	3,2	NF is 1dB & 1db low Gain

For the two measured values we can calculate exactly gain & NF of the system when all other parameters are fixed and known. So this way shows how to find out the own parameters. With one yagis the gain should be as it was taken from the datasheet, otherwise the antenna has a problem. At bigger groups as 4 or more yagi also the gain can be wrong by error in phasing lines. This should be found out also by the method above.

Simulation

This time I would show the possibilities of the simulation, so everyone can assume what is possible to work with his station or check if all works fine. A good tool is the VK3UM EMECalc. There are others of course, but I believe Dougs software is the most popular.

Important:
What we get from the simulation is the absolute **BEST** value we can achieve. In practical the achievements may reach the simulation only for a short time under best condx. Not calculated is libration, absorption from the atmosphere and polarization due to faraday. When used circ.pol. the polarization is not a big problem, but on 432 and 144 MHz where most of the Hams using linear pol. it's a big problem. During low sun activities absorption is not seen for longer and also faraday is not rotating so much.
But in real world you have to subtract from the calculated values a few dB.

Like all other simulations we need exact values to get good results.
Following values are needed, beginning at the left upper side.

Tsky
That's the background temperature of your cold sky. For 432 it is 20 or 25K depends on which cold spot is visible for measuring, Aquarius 20K or Leo with 25K. For EME contacts you have to put in the background temperature of the moon out of the lunar calendar or VK3UM EME planner software. If you have no elevation you have to put in your local outdoor temperature in Kelvin (K); 290K is the value for 17°C = 62F.
In this case the cold sky (C/S) to ground value is not valid and has to be zero.

RxBW
The RX bandwidth has to be set to 2500 Hz at JT65 and to 120-50Hz in CW. In CW it depends very on your ear-brain filter training, how small a CW signal can be to decode the signals. DL9KR can decode small CW signals down to 50Hz or better, while an untrained operator has 120Hz or more.
Physical theories is, that the signal/noise ratio becomes better when the bandwidth becomes smaller. Easy to understand your signal goes through the filter, while the noise left and right of the filter is blocked. So sum of noise is less with smaller filters and the signal is constant and so the signal / noise ratio increases. When we hear small signals the ear-brain uses biologics filters to decode the CW. This can be trained and represented as bandwidth of your ear-brain.

Mesh Diam & Spacing Only for dishes is Self-explanatory

LNA loss is the sum of the losses between dipol and preamp, Baluns, connectors, dividers, cables and relays. (more than you expect !!)

LNA NF noise figure of the preamp, can be worse by bad SWR. Normally all preamps are tuned at a 50 Ohms system. So if SWR is not too good NF can be less then measured.

LNA gain Self-explanatory gain of the preamp in dB.

All the above values are zero if no preamp is used.

Coax loss with preamp it's Self-explanatory the loss between LNA and TRX
b) without preamp it's the loss between Dipol and TRX

RxNf is the NF of the TRX (Tranceiver)

Spillover& Feedthrough I explained last issue. Then TX power and loss of TX line has to be set and also the outdoor temperature and distance to the moon (apogge or perigee).

Yagi Array

The last value will be the antenna gain. There it is easy to choose from a menue well known types, but you can put in just a value from your own antenna. Important to known that this software calculates always 2,85dB for doubling antennas. This can be wrong when stacking distance is not the best.

More to come

Home