EME – CHAPTER 4

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This article intends to give continuation to those already published in this magazine in 2014 and 2015.

It seems to be an irony, because we cannot "approach" the Moon, to take advantage of it as a passive repeater, but we can minimize the losses between Moon and us. In the first article I described the orbit of the Moon with respect to the earth and the losses in the way, in the second article I disaggregated what kind of antennas we can use to compensate all the obstacles that allow the communication via EME, and in the third we saw all the pieces that make up the puzzle between the antenna and the transceiver.

In this fourth chapter I intend to demonstrate the importance of everything that we install between the connector of the antenna and the connector of our transceiver, at RF level.

Although it seems to be obvious, you will realize the importance of each detail. As in the previous articles I will focus on the 144 MHz band, but it is perfectly extrapolate to other higher bands and of course, a station not focused on EME. But in EME is where it becomes important, because in terrestrial communications we have the antennas without elevation and the noise created by the man spoils all our effort.

All the calculations that I will show are based on the software of VK3UM, which is highly valued within the EME community for the accuracy of its calculations, taking into account almost all the variables that we can find in a spatial communication. In addition it allows to emulate not only the losses of our station, but to calculate our ECHO or the signal that we will see of another station. Doug has gone to great effort to model the gain of parabolic dishes and the software works on a large frequency range (from 50 MHz to 47 GHz). It's free!, and you can get it at:

http://www.vk3um.com/eme%20calculator.html

Let's not miss our goal, we will not try to explain the benefits of this program, it just to see how everything in our EME station, that we install between the antenna and the transceiver affect us.

Before starting only one point, the average distance of the Moon is 382.500 Km and the losses in the round trip 252.1 dB in 144 MHz, which means that every 1 dB we improve our installation, we are approaching the Moon 1517.25 Km. What do you think?.

1.- PREMISES FOR THE CALCULATION

For the calculation of losses in 144MHz I will keep in mind the premises that I will relate below.

Although some may think I am an exaggerated, all the data is provided by the manufacturers and the VK3UM spreadsheet. Reality always proves to be worse than theory, because of losses in some poorly made connector, a defective cable, a relay that does not tread very well, etc.

- Loss of one "N" connector	0.02 dB
- Losses of one relay	0.1 dB
- Loss of amplifier	0.3 dB (2 relays + interconnection)
- Loss of the splitter	0.5 dB (There are manufacturers that assure 0.1 dB)

And these other considerations:

- The modulation will be WSJT (RX Band-Width 2500 Hz)
- The NF of the receiver 3 dB (the reality is usually between 2 and 3)
- The LNA will have a gain of 20 dB and a NF of 0.4 dB
- Earth temperature 17 ºC
- The moon average distance 381.500 Km
- Power Ampli 450 W
- The frequency 144 MHz
- 4xM2 9SSB antennas have been chosen, being a reference known by all, although today there are more optimized designs, their electrical characteristics are summarized in the TABLE 5. In the schemes only two antennas have been drawn, but it is enough to understand the calculation of losses, since the program takes into account only one of the four phasing lines.

With all these data, Tables 1, 2, 3 and 4 have been made, which collect all the losses of our system, corresponding to Schemes 1, 2, 3 and 4. We only have to take the figures of losses that we have added In the tables, and enter the data in the following boxes of VK3UM software:

- Losses before LNA in "LNA Loss"
- Losses between the LNA and the receiver in "Coax Loss"
- Losses in the TX line in "Transmission Loss"

To compare the results we will focus on the box "Echo S/N". The figure that appears in this box is in theory the signal with which we would receive our own echo "in optimal conditions", that is without Faraday doing his own and without terrestrial noise. If with good conditions we receive our echo with this signal, is that we will have done the calculation of our station correctly.

The figure "Echo S/N" gives us an idea of the "total" improvements of our installation, because this figure includes both reception and transmission losses.

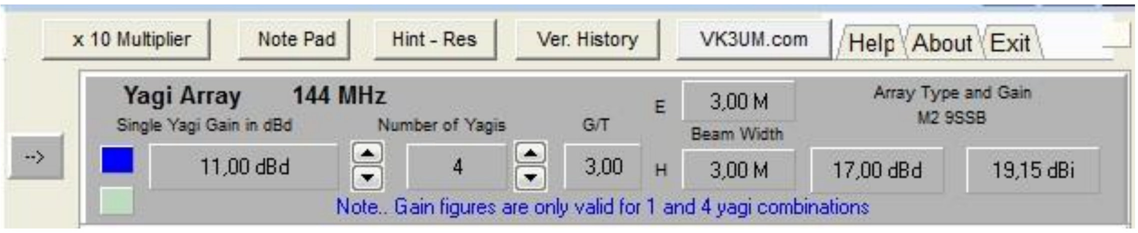


TABLE 5.- ELECTRICAL DATA 4XM2 9SSB ANTENNAS

DATOS ELÉCTRICOS DE LÍNEAS COAXIALES

CABLE	FACTOR DE VELOCIDAD	PÉRDIDAS A 150 MHz	1/2 LONGITUD DE ONDA ELÉCTRICA
LMR 400	0.83	4.95 dB/100m	86,32mm
ECOFLEX 15	0.86	3.7 dB/100m	89,44mm
CELFLEX 1/2"	0.88	2,66dB/100m	91.52mm

2.- SCHEME 1

This is the usual installation of a 144MHz terrestrial station that has been concerned with setting an important radiant system, in features is very similar to a 2x17 element antenna. The following stuff have been estimated:

- The phasing lines are of LMR400, have been used 6 times the electrical length of ½ WL, resulting in 5,182m.
- 15 m coaxial LMR400 between the antenna and the amplifier.
- 2 m coaxial LMR400 between the amplifier and the transmitter.
- LNA has not been set.

The fact of not installing LNA is usual in the 144 MHz terrestrial high power stations, because the terrestrial noise is so important, that the LNA does not usually present improvement, besides that it is a valuable piece. In EME where the antennas do not look towards the earth, if not towards the sky, where there is less noise, the LNA is very important as we will see later.

With these elements we obtain an "Echo S/N" of -23.55 dB, which will serve as a reference for subsequent calculations. You see that this station, only in very good conditions of little noise, could barely receive its own echo.

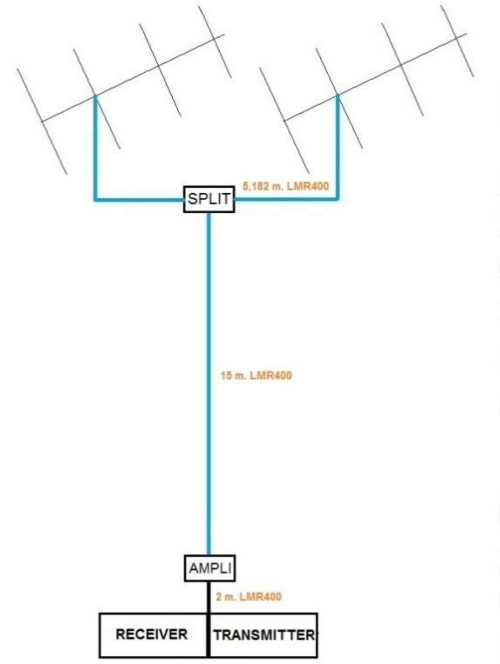


FIGURE - 1

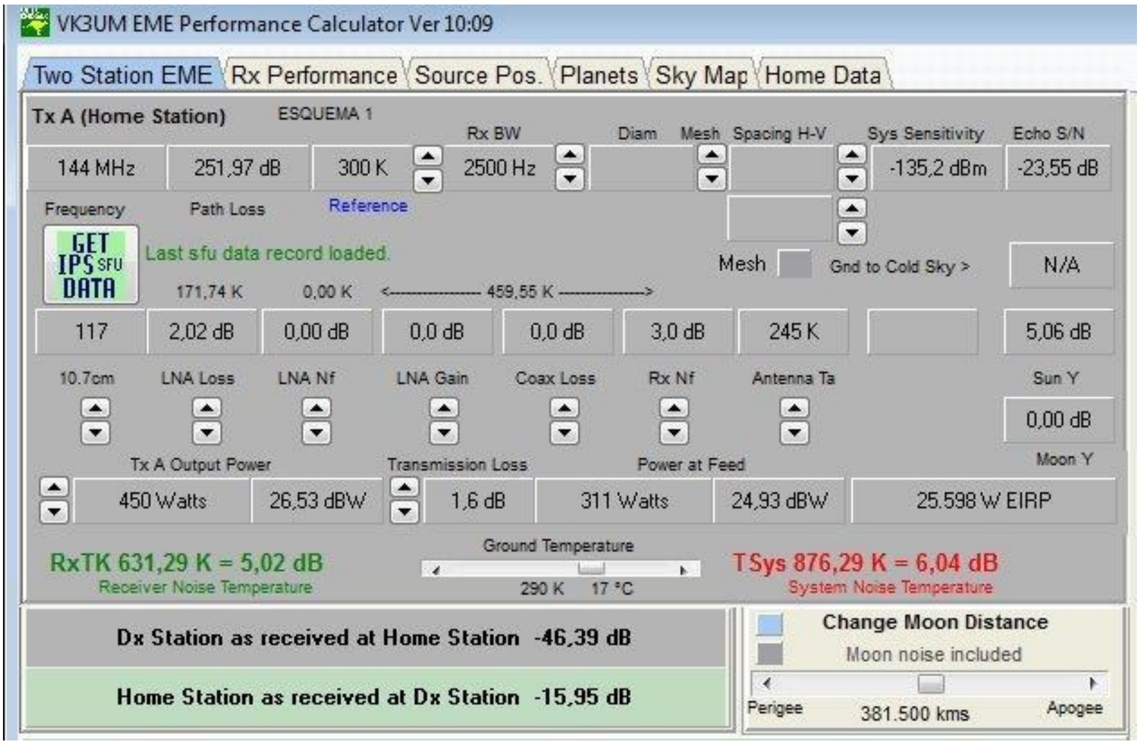
CÁCLULO PÉRDIDAS ESQUEMA 1

1.- PÉRDIDAS ENTRE LA ANTENA Y EL RECEPTOR

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
LMR-400	22,182	0,0495	1,09801
AMPLI	1	0,3	0,3
CONECTOR "N"	6	0,02	0,12
		TOTAL	2,018

3.- PÉRDIDAS EN LA LÍNEA DE TX (AMPLI - ANTENA)

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
LMR-400	20,182	0,0495	0,99901
CONECTOR "N"	4	0,02	0,08
		TOTAL	1,579



CALCULATIONS FROM SCHEME 1

3.- <u>SCHEME 2</u>

We have decided to improve a little and being from the same previous installation, an LNA has been inserted with its two isolation relays, connecting it with a piece of 1 m of LMR400 to the splitter. In terrestrial communications we will not notice much improvement due to the huge noise that surrounds us, but in EME it is different.

Only with this detail we have improved the Echo S/N figure to -20.04dB. No more no less than 3 dB!. It turns out that it is as if we have been working with only two antennas (although there are other considerations). We have improved in reception, but we have gotten worse in TX, since the RF have to go through 2 relays, so now reaches the antenna 20W less than before.

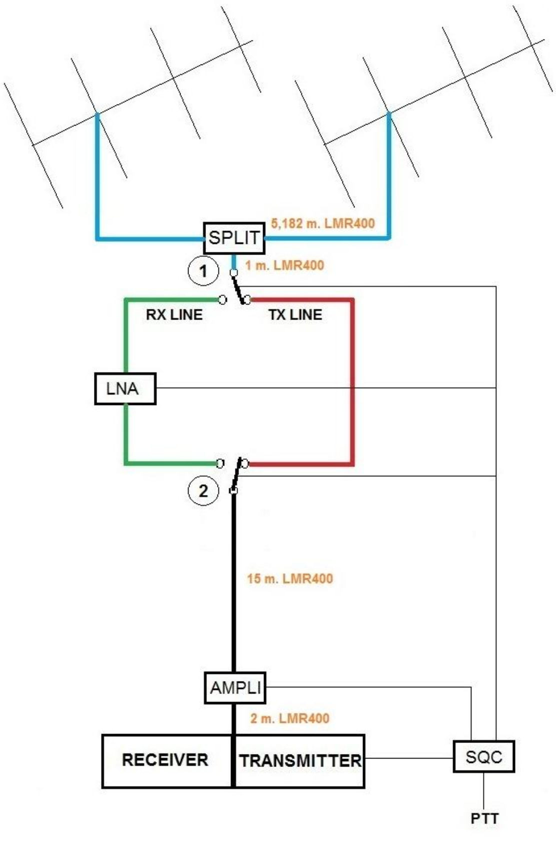


FIGURE - 2

CÁLCULO PÉRDIDAS ESQUEMA 2

1.- PÉRDIDAS ENTRE LA ANTENA Y EL LNA

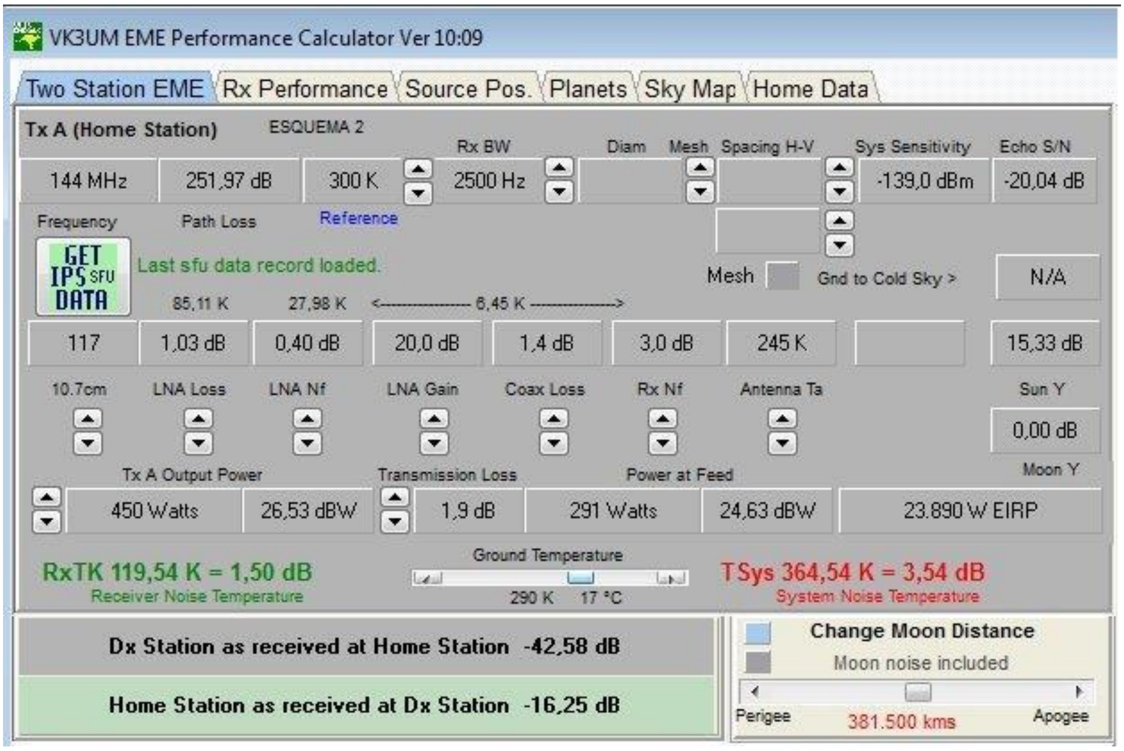
ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
LMR-400	6,1822	0,0495	0,30602
RELÉ	1	0,1	0,1
CONECTOR "N"	6	0,02	0,12
		TOTAL	1,026

2.- PÉRDIDAS ENTRE EL LNA Y EL RECEPTOR

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
LMR-400	17	0,0495	0,8415
AMPLI	1	0,3	0,3
CONECTOR "N"	6	0,02	0,12
RELÉ	1	0,1	0,1
		TOTAL	1,362

3.- PÉRDIDAS EN LA LÍNEA DE TX (AMPLI - ANTENA)

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
LMR-400	21,182	0,0495	1,04851
RELÉ	2	0,1	0,2
CONECTOR "N"	8	0,02	0,16
		TOTAL	1,909



CALCULATIONS FROM SCHEME 2

4.- <u>SCHEME 3</u>

Our concern tells us that something must be done, it is not good that of the 450W of our amplifier only reach the antennas 291W. This means that when we are transmitting we are heating the coaxial with 159W. These data have deeply offended us in our goal of having an efficient installation. We determined to take an important step and install better cables:

- We decided to put the phasing lines between the antenna and the splitter of cable of ½ ", and we short at 5 multiples of half electric wavelength, that is equivalent to 4.57 m
- Connect the splitter with the LNA by 1 m of Ecoflex-15
- In order to pass the rotor, we installed after the LNA 4 m of Ecoflex-15, and the remaining cable to the amplifier of ½ ", about 11 m.
- Between the amplifier and receiver 2 m of LMR400

With this investment the figure of Echo S/N is -19.26 dB. It does not seem a major improvement, but now our antenna sees 334 W, we have won 43 W. At reception we have earned 0.17dB, welcome them!.

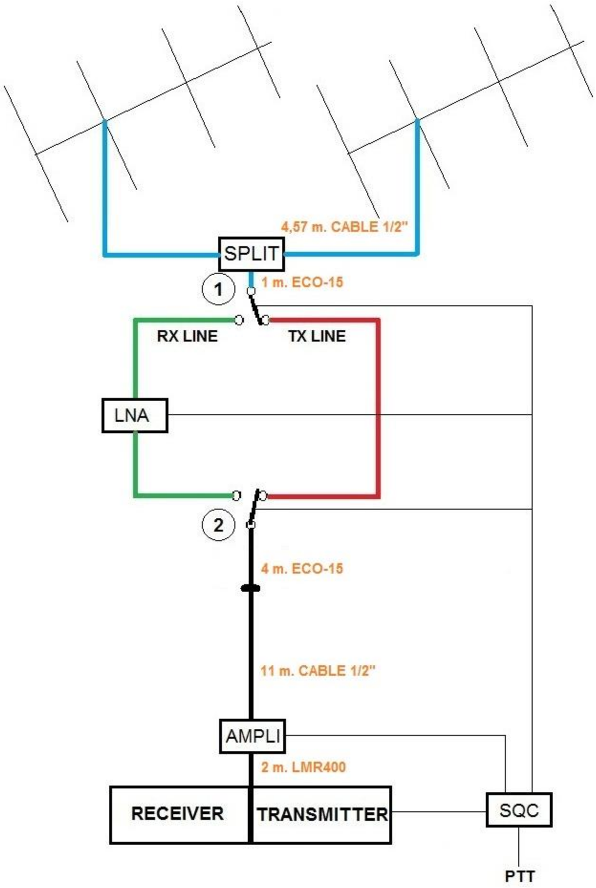


FIGURE - 3

CÁLCULO PÉRDIDAS ESQUEMA 3

1.- PÉRDIDAS ENTRE LA ANTENA Y EL LNA

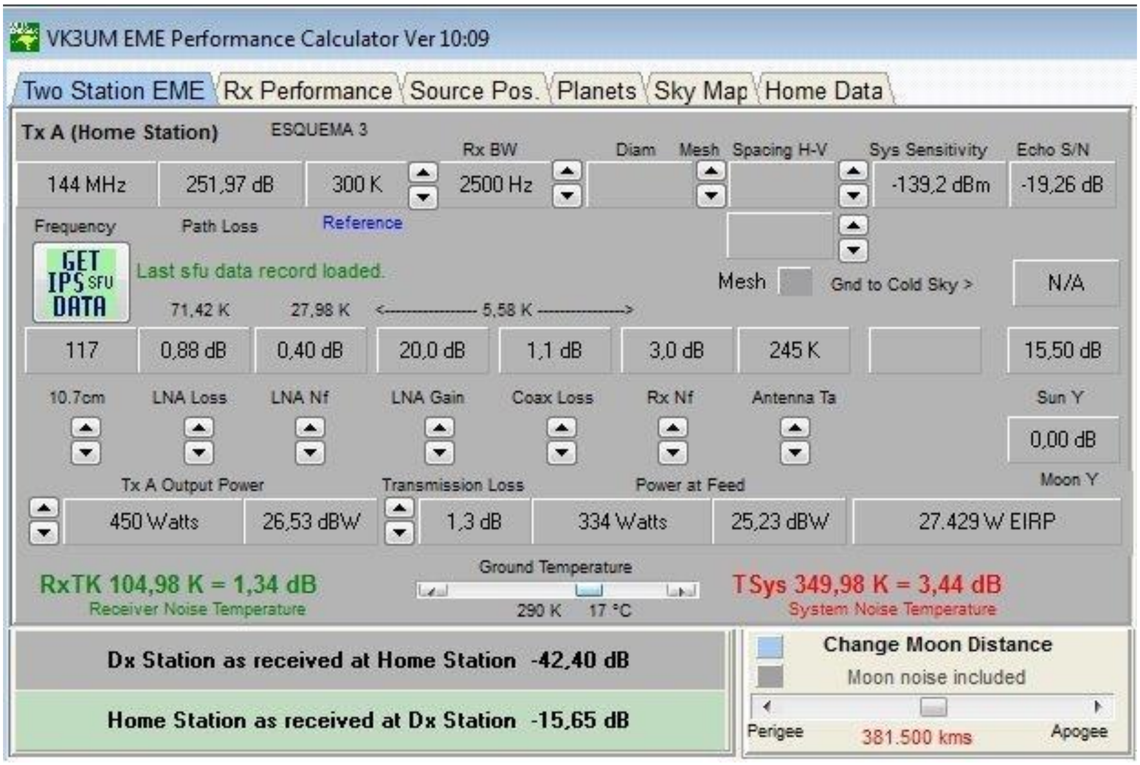
ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
CABLE 1/2"	4,57	0,0266	0,121562
ECOFLEX 15	1	0,037	0,037
RELÉ	1	0,1	0,1
CONECTOR "N"	6	0,02	0,12
		TOTAL	0,878562

2.- PÉRDIDAS ENTRE EL LNA Y EL RECEPTOR

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
ECOFLEX 15	4	0,037	0,148
CABLE 1/2"	11	0,0266	0,2926
LMR-400	2	0,0495	0,099
AMPLI	1	0,3	0,3
CONECTOR "N"	6	0,02	0,12
RELÉ	1	0,1	0,1
		TOTAL	1,0596

3.- PÉRDIDAS EN LA LÍNEA DE TX (AMPLI - ANTENA)

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
CABLE 1/2"	15,57	0,0266	0,414162
ECOFLEX 15	5	0,037	0,185
RELÉ	2	0,1	0,2
CONECTOR "N"	8	0,02	0,16
		TOTAL	1,274162



CALCULATIONS FROM SCHEME 3

5.- SCHEME 4

It turns out that in an oversight the sequencer failed, and we have smoked the LNA. What a pity!, LNA is an expensive stuff. Faced with this stumbling block we made the decision that this does not happen again, and we decided to install separate RX and TX lines. For this, the RX line we have installed is identical to the TX line (although the reality indicates that it is not necessary to be so low losses, since after the LNA the losses are not so critical).

To further reduce losses, we decided to join the splitter to the high-isolation relay using an N-N transition instead of 1 m of Ecoflex-15, and the relay with the LNA through another N-N transition.

The obtained Echo S/N figure is -19.12dB, we have only gained 0.14dB and 7W more in the antennas. But we can sleep peacefully thinking that now it is very difficult that we burn the LNA again.

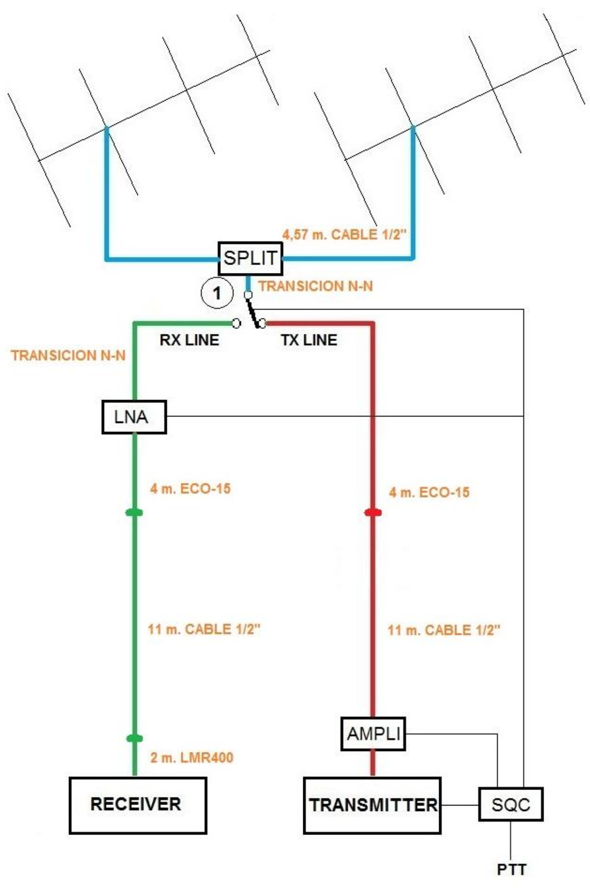


FIGURE - 4

CÁLCULO PÉRDIDAS ESQUEMA 4

1.- PÉRDIDAS ENTRE LA ANTENA Y EL LNA

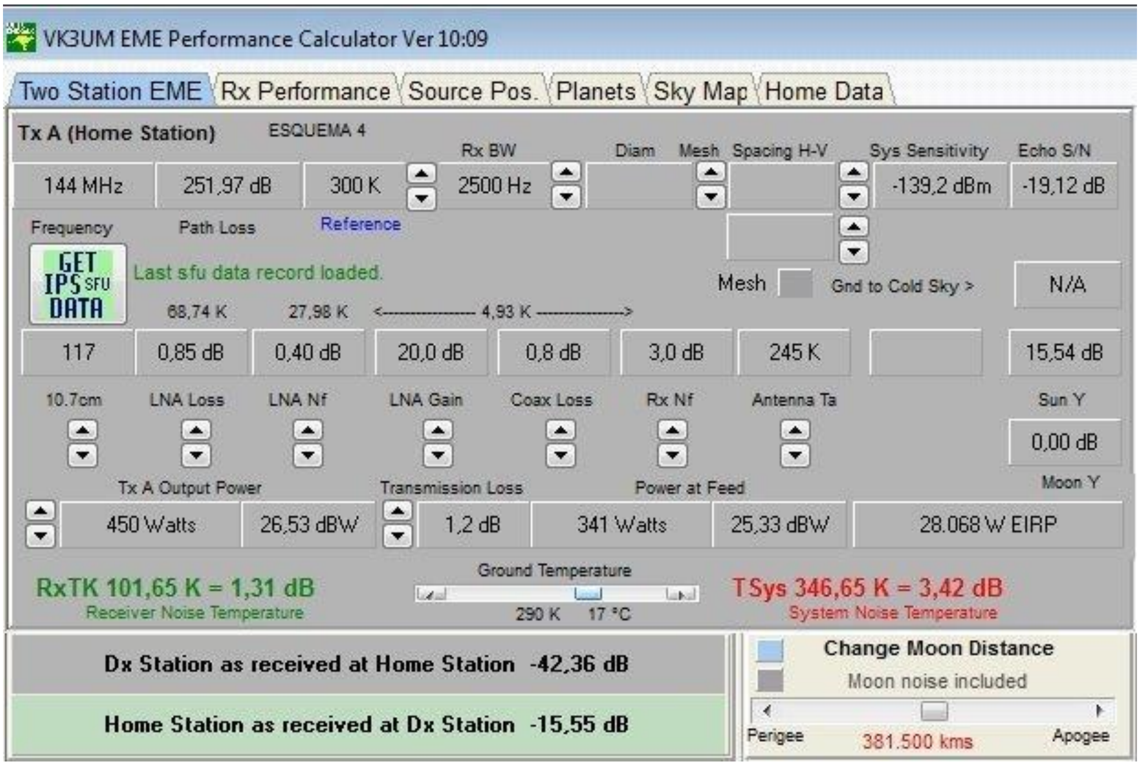
ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
CABLE 1/2"	4,57	0,0266	0,121562
RELÉ	1	0,1	0,1
CONECTOR "N"	6	0,02	0,12
		TOTAL	0,841562

2.- PÉRDIDAS ENTRE EL LNA Y EL RECEPTOR

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
ECOFLEX 15	4	0,037	0,148
CABLE 1/2"	11	0,0266	0,2926
LMR-400	2	0,0495	0,099
CONECTOR "N"	6	0,02	0,12
RELÉ	1	0,1	0,1
		TOTAL	0,7596

3.- PÉRDIDAS EN LA LÍNEA DE TX (AMPLI - ANTENA)

ELEMENTO	CANTIDAD	PERD/UN.	PÉRDIDAS
SPLITTER	1	0,5	0,5
CABLE 1/2"	15,57	0,0266	0,414162
ECOFLEX 15	4	0,037	0,148
RELÉ	1	0,1	0,1
CONECTOR "N"	8	0,02	0,16
		TOTAL	1,174162



CALCULATIONS FROM SCHEME 4

6.- CONCLUSIONS

If we look at the numbers obtained in scheme 1 and those obtained in scheme 4, we have gained in the figure Echo S/N 4.43 dB. This is outrageous, it is as if we had been working with a single antenna of 13 elements. Now in reality, with a fairly optimized system, we are getting a great performance from our radiant system. Even -19.12dB is audible!. The music of the JT65 will emerge from the noise.

Translated into Km, we will have approached the Moon 1517.25 Km x 4.43 = 6898.61 Km. With an installation of this type we can start to enjoy the Moon bouncing, because we start to work the expeditions, which usually have two antennas with 8 elements.

All of these calculations can be extrapolated to other higher frequencies, just by choosing that frequency in the VK3UM calculation software. If you play with it, you will learn a lot about the optimization of your station.

I hope not only to see you on the screen, but also to hear your signals once they have bounced on the Moon.

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