

# EARTH – MOON - EARTH

1st Part

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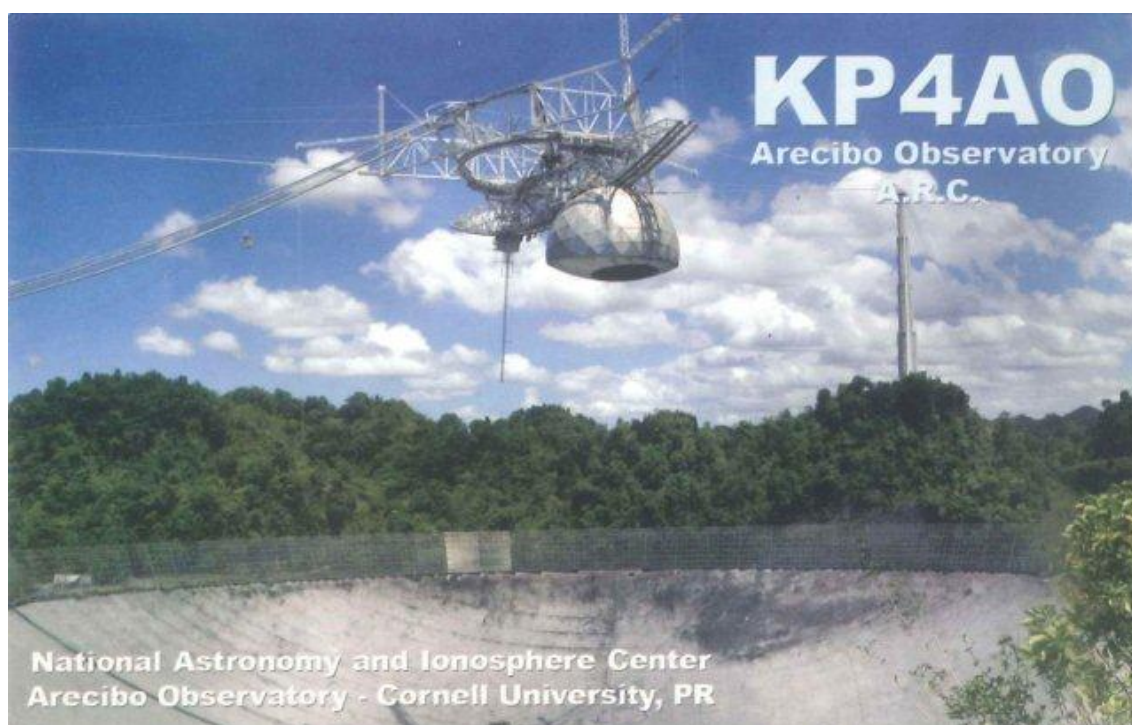
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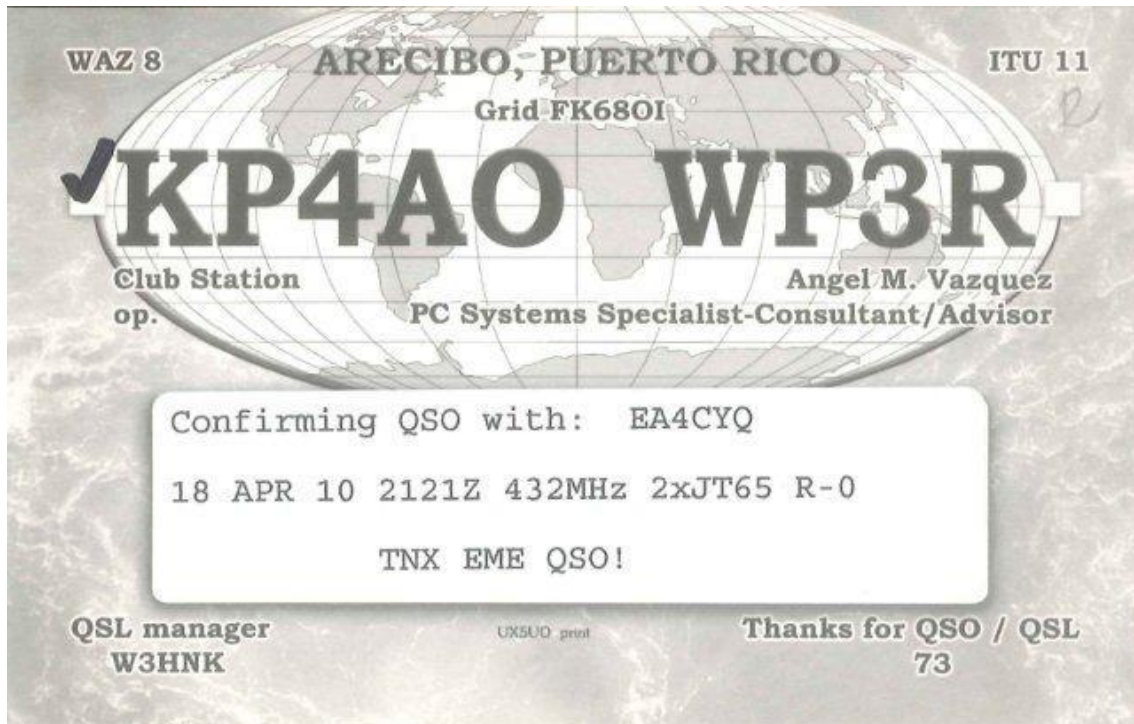
I began with Amateur Satellites some years ago, over 2000. I have been very active, and I told you my experience in many articles published in several magazines (QST, AMSAT, URE, etc.) These publications are in force today and you can find them compiled in the WEB of our partner Rodolfo EA4CAX, <http://www.ea4cax.com>

Out of curiosity, the first Moon bouncing contacts were carried out by military organizations in World War II, although the first contact between amateurs was not successful until 1960.

In April 2010, Nobel Laureate Physicist Joe Taylor K1JT, who developed the weak signal communication protocol called WSJT, agreed with WP3R and WA3FET to carry out a Moon bouncing experiment using the Arecibo (Puerto Rico) telescope in 432 MHz. There is an extensive article about this event In the QST of August 2010.

Surprisingly, with my humble satellite antennas and 80W, I had the opportunity to be the only EA station that made the contact, you can imagine me jumping around the room. This means not looking at the Moon in the same way from now on, I think I started to get hair all over the body the days of full moon.





The avatars of life made me move from a flat to a single-family building, it made me think of being able to have an EME station, so I read as a possessed to learn and learn. Especially to convince my wife that this will not become a house under an antenna. Now that I am writing this article I completed a year with my new 144 MHz antennas and I have got 360 new stations spread all over the world.

My intention is to open a new window, telling you this experience and trying to summarize everything I have learned. This article is not written thinking of the handful of no more than 20 active EME stations in Spain, if not of the rest of you.

When you have read these articles that I have prepared, you will realize why EME is said to be the biggest challenge of an amateur radio, and it is because it is at the limit of what is possible. If it were a little more difficult would not be within reach, if it were a little easier everyone would, it is the edge of the radio.

## **WHAT WE SHOULD KNOW ABOUT THE MOON**

For an amateur radio, the Moon is a passive repeater, a wall, a reflector where we bounce our RF. Allow me to make the following statements:

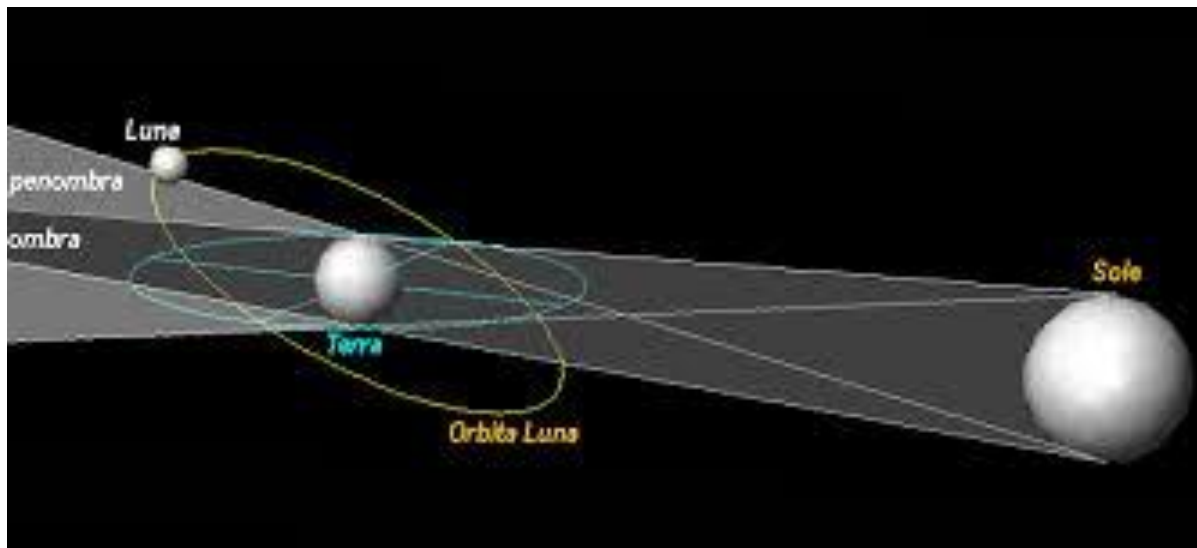
- To get a contact via EME, both stations must be seeing the Moon. It is said that the two stations have a common window or that they are in the footprint of the Moon, or what is the same, the Moon is able to see the two stations simultaneously. Even though there are clouds or daytime, the Moon is there. There are still people who think that the Moon only is at night.

The distance record was reached by CT1HZE with its antipodes ZL1IU, both saw the Moon with less than 1° of elevation.

- In order to make a contact via EME, it is necessary to do it in frequencies of 50 MHz or higher, below 50 MHz it is possible only in some Ionosphere conditions. RF below 50 MHz, generally with greater or less attenuation, is bounced by the Ionosphere towards the Earth.

- The Moon describes an elliptical orbit around the Earth, so the distance between the Moon and Earth is not constant, varies between 360.000 km and 405.000 km.

- The Sun, Earth and Moon, which have elliptical orbits, are not all on the same plane. I'm not going to mess with numbers, we just have to know that the Moon's orbit with respect to the terrestrial equator has an inclination of 28.5°. Given this information, in each location the following figures will vary, but little within Spain. Within the 28-day cycle, in my Locator IM78cx, the Moon appears in the East (between 70° and 120°), disappears in the West (between 240° and 293°), and the maximum height reaches between 30° and 70°.



- The Moon appears every day about 50 minutes later than the previous day, as a consequence of what it moves daily into its orbit about 13 degrees.

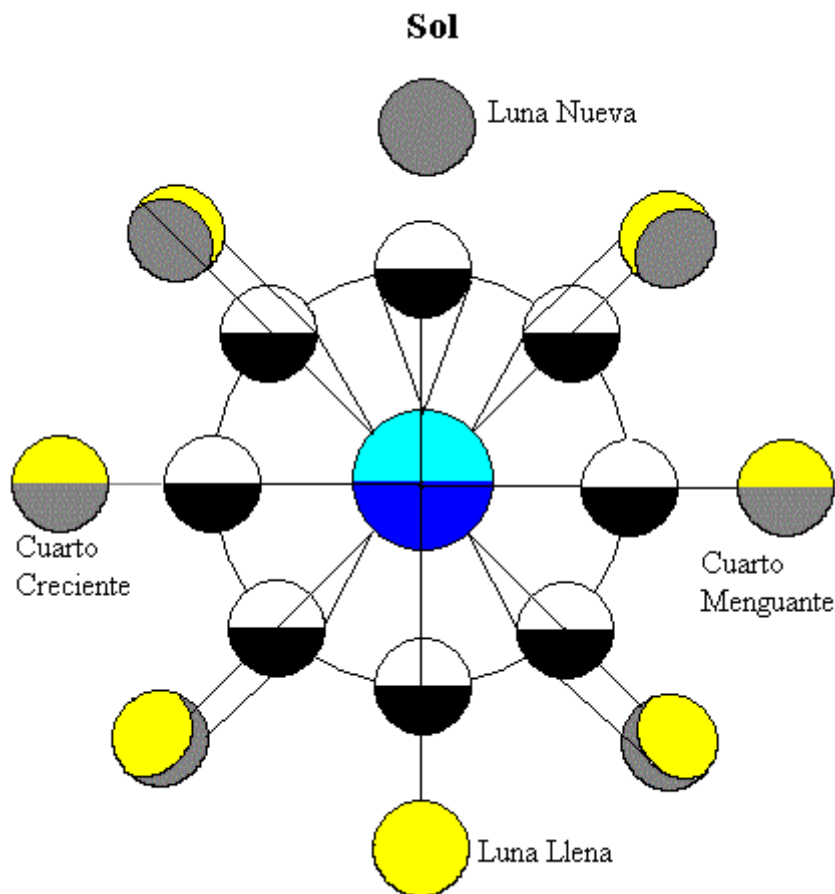
- The Moon seen from the Earth supposes an opening of only 0.5 degrees. So you can get an idea that if our Yagi has a typical aperture of 30° where it concentrates +/- 3dB of its maximum gain, only a minimum amount of RF bounces on the Moon, the rest that is the majority, is lost in the space.

- As a consequence of the fact that the Moon is spherical, it is not metallic, it has mountains and valleys, etc., it only reflects to Earth 7% of the RF that impacts in it.

- The RF as the light, travel to 300.000 km/sg, therefore our signal takes to go and return between 2.4 sg and 2.7 sg, according to the Moon is in the perigee or apogee of its elliptical

orbit, with an average of 2.56 sg. That is, we can transmit a signal and when we release the PTT we can hear our own signal at 2.5 sg before (our own ECHO).

- The optical phases of the Moon (Full, New, waning quarter and crescent quarter), do not affect RF. But in the New Moon, the noise coming from the Sun can spoil us the day. See in the FIGURE of the lunar phases that in the New Moon, the Moon is between the Sun and the Earth, therefore we are in line with the Sun.



## **1.- RF LOSSES IN THE BOUNCING WAY**

Here the proverb did not think about us, "The important thing is not to arrive, but the way". So the 2.5 sg of way is tortuous and complicated. To relativize a bit, let's get an idea that in HF, bouncing in the ionosphere we get happy when we exceed 7000 Km and make a contact with America or Asia, and we can already see the smile when we arrive in Australia, Japan, Pacific or our antipodes, which are just over 19.000 km.

What is 19.000 km compared with the 810.000 km in EME?. We have to travel more than 42 times what we travel in HF.

If we take into account the total sum of way losses, those of space plus those of the

atmosphere that vary according to the state of the Ionosphere, without entering into formulas, the average attenuation in dB versus the frequency is summarized in the following table:

Frequency (MHz)	Attenuation in the path (dB)
50	-242.9
144	-252.1
222	-255.8
432	-261.8
902	-268.0
1296	-271.2
2304	-276.2
3456	-279.7
5760	-284.1
10368	-289.2
24048	-293.5

Do not be alarmed, in the end we will see that these impressive numbers can be saved.

## **2.- DOPPLER**

Those who work satellites already have it dominated, for the rest I will try to explain. There is a physical phenomenon called Doppler, whereby if something moving with respect to us transmitting a carrier on a frequency, we will not receive that carrier in that frequency, if not in a nearby one. The effect is as follows:

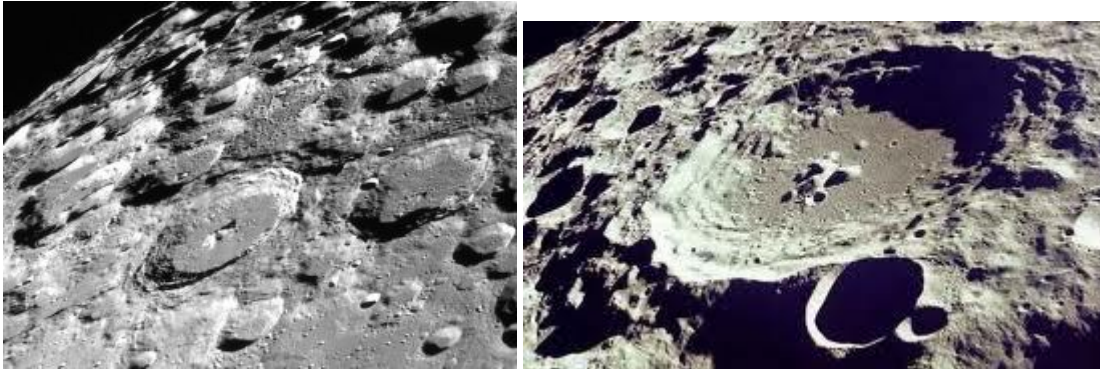
- The higher the speed between the transmitter and receiver is, the greater the Doppler effect is.
- If the transmitter approaches us, we will receive it at a higher frequency.
- If the transmitter moves away from us, we will receive it at a lower frequency.
- The higher the frequency is, the greater the Doppler Effect is.

Taking into account the rotation of the Moon on itself, the rotation of the Earth on itself and the rotation of the Moon with respect to the Earth, figures come out of the following order:

Frequency (MHz)	Doppler (KHz)
- 144	0.44
- 1296	4
- 10000	30

To this end, we must add a distortion in the signal that affect to the carrier "widening" over 0.2 Hz in 144 MHz and 15 Hz in 10 GHz. It happens as a result of the signal is bouncing simultaneously in the equator of the Moon and at its poles, as well as in the different

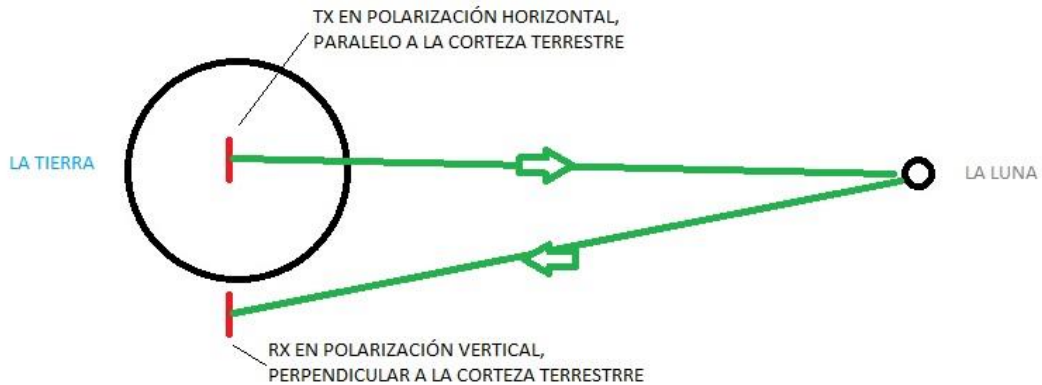
mountains and valleys. This effect is defined as "libration" and is not always as remarkable. You can see in some of the following photos as the surface of the Moon is.



### **3.- SPATIAL ROTATION**

Without considering other rotations that will be discussed later, it has been established that the horizontal polarization is parallel to the Earth's surface. Seen from the Moon, as the Earth is round, two stations at two different points on Earth are very difficult to have the same polarity, one with respect to another.

When two signals have an offset of  $90^\circ$ , they have an attenuation of one with respect to another of more than 20 dB, this is an insurmountable barrier. We will see how we overcome it.



#### **4.- FARADAY EFFECT**

The Ionosphere is very changing as it is illuminated by the Sun and by the effects of the solar storms, this sounds to us a lot of HF, doesn't it?. Here we also get rid of it, on one hand produces a small attenuation, but the really important thing is the randomly changes the polarity of the signal that crosses it.

Over a day this effect can rotate a signal many times in 144 MHz, sometimes every few minutes and other times every hour. But at 432 MHz it can take from 30 minutes to a full day to rotate a signal. In addition this effect is more pronounced during the day and especially when the moon appears and leaves.

Let's be clear, THE POLARITY OF THE SIGNAL WE RECEIVE IS NOT PREDICTABLE, there are so many variables that affect to the polarity, so we will only receive the signal with the same polarity that our antennas when "Mr. Faraday" let us.

Once again getting scared, do not worry we have a solution for everything, the greater the challenge, the greater the joy of overcoming it.

#### **5.- THE NOISE FROM THE SPACE**

If there is nothing in the space!. Until this moment we were happy with this affirmation, again the proverb says to us "Ignorance makes the happiness". It turns out that when the molecules heat up then they rub against each other and produce "noise" in many frequencies, even in ours. Therefore all the celestial bodies and the own atmosphere are producing noise.

The largest source of noise from the space is the Sun (there is high temperature and molecules

there), therefore when the Moon is in line with the Sun, in the New Moon, which happens 3 or 4 days every 28 days, It is better not to turn on the transceivers.

There are many more stars in the space, but they are far away. Although from Earth we see an area where they concentrate and we call it the Milky Way. When Moon aligns with it, again more noise. This noise from the space is measured by an index named "degradation", and it can oscillate over 28 days between -1.8 dB and -14 dB, the most positive number means the best conditions.

## **6.- THE NOISE FROM THE EARTH**

The least important, not negligible, is the one produced by the Earth itself on heating, so it is more pronounced in the summer and during the day.

Without a doubt, our biggest obstacle to get an EME QSO is the noise generated by human activity, not by our bodies but by industry, electronics, etc. This noise is very close, often generated in our own house (a switching PS, a LED bulb), in the neighbor's house, across the street by a security camera, or our brother-in-law's telephone when comes to see us, because it has a local oscillator whose harmonic matches the frequency at which we are working.

On some occasions it is a purposely generated noise to disturb the spectrum, as the inhibitors used by the state security forces.

Now that we know the enemy, which is the first step to win the battle, we will see how the hams have managed to take advantage of the Moon as a passive repeater, but this will be in the next chapter.

I am waiting for you.

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