OPTIMIZED 2 YAGIS 144 MHz EME SYSTEM

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EA4AK phoned to EA8TJ as administrator of the EME group that has been created in Spain, to see the possibility of writing for our magazine an article that will encourage hams to approach this branch of the Radio, Earth Moon Earth (EME), which always seems a bit impossible. The ideas I present here are the result of many hours of reading and WhatsApp. For those who already work EME will be irrelevant, but the goal here is intended for those stations that already work satellites, or SSB a with terrestrial setup, or for those who after many years of HF want to experiment in a new field, for me one of the most beautiful and impressive of the radio. The first time you receive and decode a signal from a station that has bounced off the Moon, it is an emotion that you will not forget.

EME in 144 MHz has been treated in this magazine in Oct-Nov 2014 and in Nov-Dec 2015 with 4 articles entitled "The Moon a little nearer", and it is convenient to read them to establish the bases of what we will comment here. At this time we will try to go to a practical case of a 6 λ or 7 λ length radiant system, but as a single antenna of ≈12 m boom is not practical mechanically to install in a tower with a elevation system, I will propose a system of 2 antennas of ≈6 m (3 λ) or ≈7 m (3.5 λ) of boom. This system is similar to a 2 element HF yagi, and it will give us many satisfactions and the opportunity to experiment another radio mode. In addition a system of this size could be made portable, with the advantages that it reports to make activations, expeditions, etc.

As we try to encourage you, we are not going to design a system of two polarities, but a system of a single polarity. To work EME it is irrelevant to install the two antennas in V or H, even some expeditions choose V, since it is mechanically easier. But thinking about taking advantage of our system in the terrestrial contests, we will propose the horizontal polarity.

1. WHAT ANTENNA TO CHOOSE

This question is asked by all amateurs and as you all know the answer is not easy, since the optimization of an antenna depends on the designer, and each one can weigh one of the main factors, Gain (front gain), F/B (Front/Back gain ratio), G/T (Front Gain/Temperature), etc.

The decision may depend on whether we live in a low noise area, then we can select an antenna in which predominates front gain, or if we live in a low-medium noise area, then we should choose an antenna with a lower G/T, this factor will indicate If the design has taken into account, among other things, the suppression as far as possible of the side and rear lobes, yes, sacrificing in part the frontal gain.

We only must not take into account the electrical magnitudes, the mechanical ones are important if we live in a windy area. The antenna can always be built by us; there is no reason to choose a commercial antenna.

To make a choice, it is almost obligatory to study the Excel sheet of our partner Lionel VE7BQH. Lionel has done a recognized work in the EME world, making a homogenous and objective comparison of all the antennas that he has found, and even if you design one, Lionel will be glad to including it in his table. Their conclusions can be found in:

http://www.dxmaps.com/VE7BQH.html

TABLES 1 show us the antennas whose lengths are between 3 λ and 3.5 λ.

TYPE OF ANTENNA	L λ	GAIN (dBd)	E (M)	H (M)	Ga (dBd)	Tlos (K)	Ta (K)	F/R (dB)	1st SL (dB)	2nd SL (dB)	Z (ohms)	VSWR andwidt	G/T (dB)	Feed System	Convergence Correction req.	Polarity
*BVO-3WL	3,01	13,43	3,9	3,7	19,38	8,6	253,1	20,5	12,9	17,7	52,7	3.08:1	-2,5	Dipole	No	
BVO-3WL	3,01	13,43	4,03	3,78	19,42	8,6	256,1	20,5	12,9	17,7	52,7	3.08:1	-2,51	Dipole	No	
#BVO-3WL	3,01	13,41	3,9	3,9	19,41	8,6	256,6	20,5	12,9	17,7	52,7	3.08:1	-2,53	Dipole	No	
+G0KSC 11LFA3R	3,01	13	3,6	3,33	18,92	4	223	25,7	18,2	24	50,1	1.08:1	-2,41	LFA Loop		
+YU7EF 11	3,04	13,07	3,56	3,3	18,87	4,7	222,6	22,2	17,8	22,5	49	1.62:1	-2,46	Dipole	No	
F9FT 16	3,06	12,64	3,54	3,26	18,63	6	241,3	21,1	13,8	16,4	20,8	1.37:1	-3,05	HairPin		
#SM2CEW 14 XPOL H	3,08	13	3,5	3,5	18,92	9,6	228,9	24,7	15,8	22,6	18,1	1.48.1	-2,53	Dipole	No	XPOL
#SM2CEW 14 XPOL V	3,08	13	3,5	3,5	18,92	9,6	223,6	24,7	15,8	22,7	18,2	1.48:1	-2,43	Dipole	No	XPOL
CD15LQDver2	3,09	12,9	3,58	3,33	18,85	4,4	231,6	26,1	14	17	50	1.25:1	-2,65	Gamma Match		
*CD15LQDver2	3,09	12,9	4	3,8	19,02	4,4	238,8	26,1	14	17	50	1.25:1	-2,61	Gamma Match		
CD15LQDver1	3,1	12,83	3,6	3,35	18,76	4,1	247,8	20,7	14,5	17,5	50	1.23:1	-3,03	Gamma Match		
*CD15LQDver1	3,1	12,83	4	3,8	18,97	4,2	249,9	20,7	14,5	17,5	50	1.23:1	-2,86	Gamma Match		
I5MZY 13	3,1	12,97	3,56	3,3	18,83	6	225,9	20,3	15,1	17,8	49,3	1.50:1	-2,56	Dipole	No	
MBI ModFT17	3,12	13,29	3,85	3,6	19,27	8,2	239,5	24,3	12,9	19,7	50,1	1.41:1	-2,37	Dipole	No	
*F9FT 17	3,14	12,87	3,68	3,5	18,9	5,8	235,7	22,6	14,7	18,6	50,6	1.32:1	-2,67	HairPin	Yes	
F9FT 17	3,14	12,87	3,59	3,31	18,81	5,8	233,6	22,6	14,7	18,6	50,6	1.32:1	-2,73	HairPin	Yes	
*CC3219	3,17	12,77	4,27	3,66	18,8	5,7	307,8	14,9	15,1	18	18,3	1.49:1	-3,93	T Match		
CC3219	3,17	12,77	4,07	3,82	18,79	5,7	308,6	14,9	15,1	18	18,3	1.49:1	-3,95	T Match		
CC3219 MOD	3,17	13,26	3,87	3,62	19,27	5,1	245,6	24,1	13	16	28,6	1.05:1	-2,48	Dipole	Yes	
BQH 13	3,19	13,3	3,85	3,6	19,28	4,3	244,9	20,8	13,7	17,5	50	1.11:1	-2,46	Dipole	No	
InnoV 11 OWL G/T	3,2	13,62	4,02	3,77	19,61	4,7	241,7	22,2	13,6	18,5	49,5	1.16:1	-2,07	LFA-FD	Yes	
DJ9BV 3.2	3,22	13,3	3,85	3,58	19,29	6,5	239,5	21,1	13,7	18,1	71,8	1.36:1	-2,35	Dipole	No	
+DG7YBN 12 Ver1	3,23	13,45	3,87	3,62	19,41	5,5	229,1	26,2	15	20,1	46,2	1.40:1	-2,04	Bent Dipole	No	
*+DG7YBN 12 Ver1	3,23	13,45	3,99	3,83	19,47	5,6	231	26,2	15	20,1	46,2	1.40:1	-2,02	Bent Dipole	No	
K1FO 14	3,26	13,34	3,8	3,56	19,29	4,7	237,8	18,1	14,4	19,3	29,6	1.42:1	-2,32	T Match	Yes	
+DG7YBN 12 Ver2	3,26	13,38	3,77	3,54	19,31	5,8	222,9	28	17,2	21,6	46,2	1.28:1	-2,02	Bent Dipole	No	
*+DG7YBN 12 Ver2	3,26	13,38	3,99	3,82	19,41	5,8	225,5	28	17,2	21,6	46,2	1.28:1	-1,97	Bent Dipole	No	
+KF2YN Boxkite 13	3,26	15,11	4,83	4,32	21	5,9	226,2	28,8	20,4	28,9	52,5	1.07:1	-0,38	Dipole	Yes	
UR5EAZ 12	3,27	13,31	3,71	3,44	19,21	3,8	223,4	24	15,3	18,3	50,2	1.04:1	-2,13	Dipole	No	
+*DG7YBN 12 Ver3	3,3	13,53	4,2	3,74	19,56	5	223,5	25,7	16,5	21,1	48,1	1.49:1	-1,78	Bent Dipole	No	
+DG7YBN 12 Ver3	3,30	13,53	3,82	3,56	19,45	5	220,4	25,7	16,5	21,1	48,1	1.49:1	-1,83	Bent Dipole	No	
+*Dual PA144-12-7	3,3	13,55	4	3,75	19,56	6,1	221,4	25,9	16,6	22,5	49,3	1.18:1	-1,74	Hair Pin	Yes	
+Dual PA144-12-7	3,3	13,55	3,82	3,59	19,47	6,4	219,6	25,9	16,6	22,5	49,3	1.18:1	-1,79	Hair Pin	Yes	
+DK7ZB 12	3,31	13,45	3,75	3,5	19,35	4,8	219	23	18,4	21,2	47,8	1.21:1	-1,9	Bent Dipole	No	
+InnoV 11 G/T-2	3,31	13,75	3,94	3,7	19,68	5,8	223,9	24,8	17,1	22,6	51,5	3.97:1	-1,67	Folded Dipole	Yes	
+G0KSC 12 LFA	3,32	13,39	3,78	3,52	19,34	5,2	220,7	24,4	18,1	23,1	49,9	1.07:1	-1,95	LFA Loop	Yes	
+G0KSC 12 OWA	3,33	13,34	3,85	3,5	19,3	5,5	225,3	25,3	16,3	23,4	49,3	1.05:1	-2,08	Dipole	Yes	
G4CQM 11	3,36	13,55	3,92	3,66	19,5	8,3	232	30,1	13,3	17,9	46,2	1.94:1	-2,01	Dipole	No	
+InnoV 12 OWL G/T	3,37	13,71	3,92	3,68	19,63	5,9	226,1	23,3	15,3	22,8	50,1	1.34:1	-1,76	Folded Dipole	Yes	
+*InnoV 12 OWL G/T	3,37	13,71	3,92	3,69	19,63	5,9	226,1	23,3	15,3	22,8	50,1	1.34:1	-1,76	Folded Dipole	Yes	
DK7ZB 11	3,4	13,68	3,94	3,71	19,61	5	234,3	22,3	14,2	17,4	27,9	1.27:1	-1,94	Dipole	No	
+UA9TC 12RS	3,40	13,55	3,8	3,56	19,46	5,1	218,2	32,1	18,6	21,2	51,7	1.09:1	-1,78	Dipole	No	
+G0KSC 12 LFA	3,41	13,61	4,59	3,6	19,6	4,9	223,9	26,1	17,3	22,6	50,3	1.22:1	-1,75	LFA Loop	Yes	
*+G0KSC 12 LFA	3,41	13,61	3,9	3,7	19,56	4,9	221,1	26,1	17,3	22,6	50,3	1.22:1	-1,73	LFA Loop	Yes	
MBI 3.4	3,42	13,62	3,89	3,64	19,43	9,2	226,3	23,2	16	19,9	39,3	1.38:1	-1,97	Dipole	No	
+G0KSC 12LFA 2R	3,43	13,46	3,79	3,52	19,37	5,5	217,9	25	19,3	23,6	50,7	1.09:1	-1,86	LFA Loop	Yes	
+*G0KSC 12LFA 2R	3,43	13,46	3,95	3,75	19,47	5,5	220,5	25	19,3	21,6	50,7	1.09:1	-1,82	LFA Loop	Yes	
InnoV 12 LFA	3,43	13,54	3,8	3,6	19,46	6,4	218,8	23,5	17,4	23,7	49,3	1.07:1	-1,79	LFA Loop	Yes	
Gulf Alpha 14	3,44	13,25	3,71	3,44	19,14	5,5	229,6	19,9	15,3	21,9	198	1.21:1	-2,32	T Match	Yes	
Gulf Alpha 14 XPOL H	3,44	13,25	3,57	3,57	19,13	5,5	231,4	19,9	15,3	22	198,2	1.21:1	-2,36	T Match	Yes	XPOL
Gulf Alpha 14 XPOL V	3,44	13,25	3,57	3,57	19,13	5,5	227	19,9	15,3	22	197,9	1.21:1	-2,28	T Match	Yes	XPOL
YU7EF 12	3,49	13,67	3,85	3,6	19,55	6,1	221,1	23,6	16,8	21,9	45,4	1.77:1	-1,75	Dipole	No	
M2 2MXP22A XPOL H	3,5	13,85	3,99	3,99	19,78	10,7	243,9	21,6	14	18,5	203	1.23:1	-1,94	T Match	Yes	
M2 2MXP22A XPOL V	3,5	13,85	3,99	3,99	19,78	10,7	239,6	21,6	14	18,5	203	1.23:1	-1,86	T Match	Yes	

TABLE 1.- VE7BQH COMPARATIVE TABLE OF 144 MHz ANTENAS

It is important that you visit the above link since at the end of the table is the legend that explains the meaning of each column. The information is complete, gain, stacking distances in the horizontal and vertical planes, F/B, Z, Bandwidth, G/T, etc. Note that the bandwidth should be broad, otherwise the antenna is easy to detune with rain, a problem that some expeditions have experienced in wet areas.

From this table I would discard those antennas whose feed system is Gamma Match, since this system slightly deforms the lobes, which is demonstrated by its G/T which is the largest of the whole table. Any other feeding system is valid, as it is a symmetrical feed (dipole, folded dipole, loop, LFA loop, T-match, Hair-Pin, etc.). Either of these systems must keep in mind the transition of the coaxial, which is asymmetrical or unbalanced, to a symmetric or balanced system, like our driven element. So all these systems have some kind of balum, in some cases it is used not only to pass from an asymmetric to a symmetric system, but also to adapt impedances, as is the case where the Z (Ohm) column is different from 50 Ohm.

Deliberately I have not spoken of number of elements, only of boom length in terms of nλ, and it is because the number of elements does not provide us with any useful electrical information, and as you can see in the table in lengths between 6 and 7 meters, we can find antennas between 11 and 17 elements, and for more elements is not better antenna.

If you want to get some conclusion from this TABLE 1, within the same length range (nλ), the differences between G, F/B or G/T is not significant, so I do not recommend any particular antenna, only which I would discard, it is preferable that you make a mistake yourself . . .

2.- CONSTRUCTIVE DETAILS OF AN OPTIMIZED YAGI

I have just commented some of them, such as the way to feed the driven element. It is necessary to take into account that the design of a yagi has as a goal that in all the elements the RF must be induced in the form of voltage and intensity, such that they contribute to an increase of the RF induced in the driven element, In the case of reception, and the same route but the reverse for the transmission. We also have to know that the center of an element is zero potential, be or not connected to ground.

When we try to build a theoretical design, experience has taught us that:

- It is necessary to avoid elements that are in electrical contact with the boom (either passing through or on top of it, because if this electrical contact deteriorates (rust or bad contact), noise and malfunction will be introduced.

- The narrower the boom and the more separate the elements from it, then it will have less influence. Insulated boom tests have been done and much cleaner radiation patterns have been obtained. I refer to the experience shown at the EME congress in 2015 by K1JT with a system of 4 yagis for 432 MHz

- The elements although isolated, can be joined to the boom by a central screw, it will have fewer adverse effects as less diameter that screw be, because if it is wider we will be connected to ground part of the element that is not at zero potential.

- In a horizontal yagi, the metal parts located in the vertical plane rarely affect. The mast, lower straps, or upper steel wires not far from the boom, just in the vertical plane of the boom, will not affect to the radiation lobe. Someone will not believe it, they then can model it and check it out.

3.- HOW TO STACK ANTENNAS

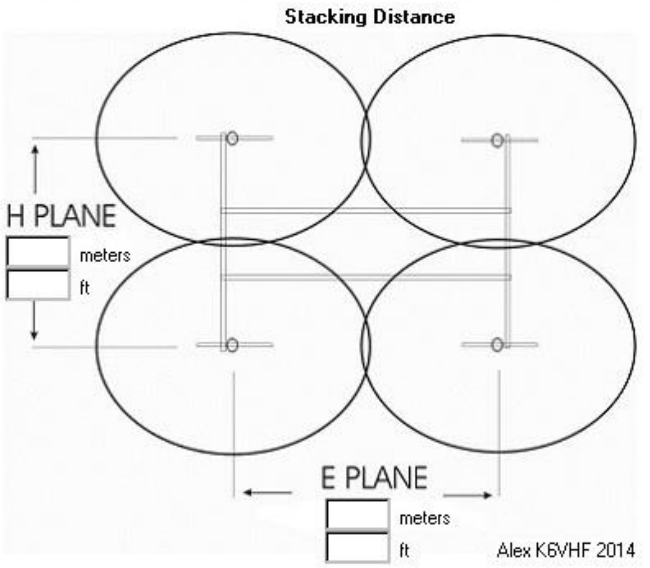
3.1.- STACKING DISTANCE

The distance between two yagis depends only on two data, the boom length and the opening angle of the main lobe, defined by the points where the gain decreases 3dB from the point of greatest gain, we can see it in the DIAGRAM 1. With these data, provided by the manufacturer, or if we model the antenna with some program, such as EZNEC, the DL6WU formula is used:

D = λ / (2 * (sin B / 2))

D: Stacking distance in meters
λ: Wavelength in meters [300 / f (MHz)]
B: Angle of the main lobe defined by the points of -3 dB

At this point we have to know that a yagi in horizontal polarization, the main lobe does not have the same opening in the horizontal plane than in the vertical plane. Therefore, the VE7BQH table shows the "H" as stacking distance in the vertical plane, and "E" as the stacking distance in the horizontal plane. Schematically we see it in PHOTO 1, which is a screenshot of the K6VHF stacking sheet.



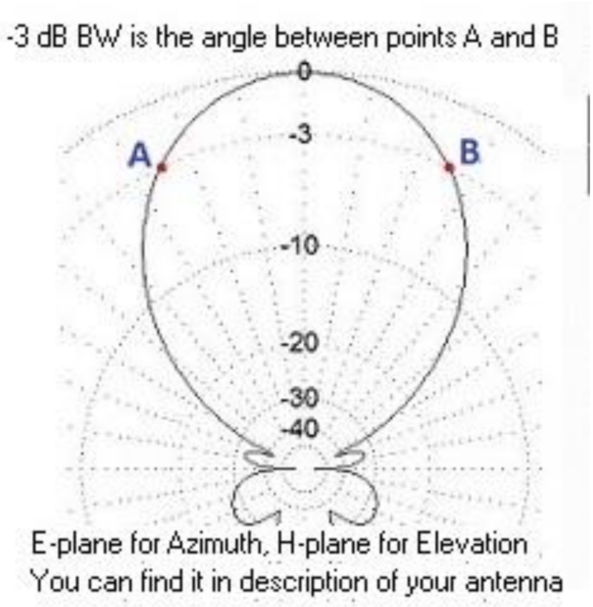


PHOTO 1.- K6KVH STACKING DISTANCE CALCULATOR

DIAGRAM 1.- OPENING ANGLE OF THE MAIN LOBE

When two horizontal antennas are embedded in the horizontal plane (side by side), the vertical lobe opening is preserved, but the horizontal opening lobe is reduced. When two horizontal antennas are embedded in the vertical plane (one on top of another), the horizontal opening lobe is preserved, but the vertical opening lobe is reduced. It makes clear that the ideal configuration for EME is a bay of 4 antennas, because this reduces the radiation lobe in both planes, concentrating much more energy, to hit a target as small as the Moon. But in this article we are only going to design a two antennas system!.

The next question is what is better to install 2 antennas stacked in the horizontal or vertical plane? We could do many lucubrations, but the reality is that we choose one formation or another depending on the mechanical simplicity. For this reason for terrestrial communications on the same mast one yagi is installed on top of another. But if we have to elevate the antennas to work EME or Satellites, they must be installed one next to another. I repeat, it is purely a mechanical issue.

3.2.- TWO ANTENNAS BAY

I will not go into the robustness of the structure, because like everything, this depends on the compromise between weight and robustness. There are people who like steel tubes, some aluminum, some prefer round profiles and other square. . .

What we have clear is that we will put one antenna next to another, in the same horizontal plane, because this configuration allows, in a simple way, to make the system has elevation.

Normally a formation of two antennas is not very heavy and the commercial rotors like the G550 or AlfaSpid can manage it themself. But the EME group' experience is that you must avoid using these rotors by passing the main cross-boom of the structure through them. The reason is that if the rotor breaks down, the structure must be completely dismantled and this is cumbersome.

For this reason, it is always necessary to install a system of bearings, hinges or teflon sleeves on which the structure rotates, and to move up and down this structure we need an indirect system. The most used are the mechanical actuators that parabolic dishes use, which are based on a worm gear driven by a small motor, as you can see in PHOTO 2. You can also use a G550 or AlfaSpid rotor that moves the system using a system of pinions/chain PHOTO 3, or by means of connecting rods PHOTO 4.

PHOTO 2.- ELEVATION SYSTEM BY MEANS OF A PARABOLIC ACTUATOR OF PA5MS

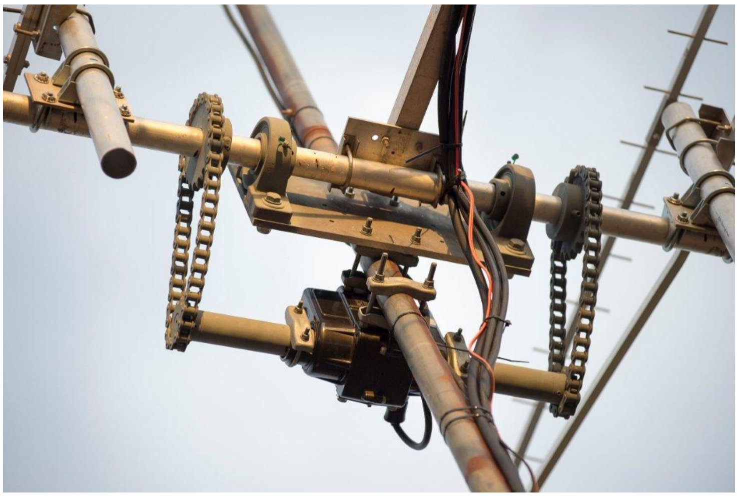


PHOTO 3.- ELEVATION SYSTEM BY MEANS OF PINIONS AND CHAIN OF EA5DF (RELATION 2:1)

PHOTO 4.- ELEVATION SYSTEM BY MEANS OF CONNECTING-RODS OF EA4CYQ (RELATION 1:1)

To know the angle of elevation of the antennas, some of the following systems are usually used:

- The indication of the rotor itself, in the case of Yaesu or AlfaSpid.
- By means of a pendulum system, this moves a potentiometer indicating us, by a voltage divider, the position.
- A system of accelerometer, encoder or similar. Lately the technology allows it and they can send information to the shack, in some cases even by Wi-Fi. They are usually fairly accurate.
- Using a video camera that we will see on a small monitor, it will not indicate the elevation, but when we see the

Moon in the center of the screen, we will be in the target. This system will not be useful on cloudy days or new moon.

We will choose our system according to our possibilities. For EME, an automatic tracking system is not necessary because the Moon moves so slowly that correcting the orientation every 5 degrees or 10 minutes will suffice for the system we are dealing with.

We have just two things clear, the stacking distance and that the structure should allow the elevation turning on bearings or similar, moving it by an indirect system.

3.3.- HOW TO PHASE ANTENNAS ELECTRICALLY

Not only the mechanical part is important, the electrical part is fundamental. A phasing line has two missions, adapting the impedances and adding the signals in phase. For this reason the following three sections are inviolable axioms:

A) Whichever method we choose, it is MANDATORY that the two phasing lines are EXACTLY the same length, because what is intended is that the signal of each of our antennas meet with the same phase at the point of connection to the main line, as a result the sum will be perfect. If it differs even some millimeters, the two signals will not be added in phase and we will lose gain.

B) Another important issue of the phasing lines is that they are between the antenna and the LNA, this means that this line will attenuate the weak signal that our antennas receive, and we cannot allow this. Therefore the phasing lines must be the best cable that WE CAN ACHIEVE and as short as possible.

C) The phasing lines must support the power circulating through them. In EME we work with relevant power and we should never ignore this data.

To carry out the electrical phasing of two antennas, we can find two methods:

METHOD 1:

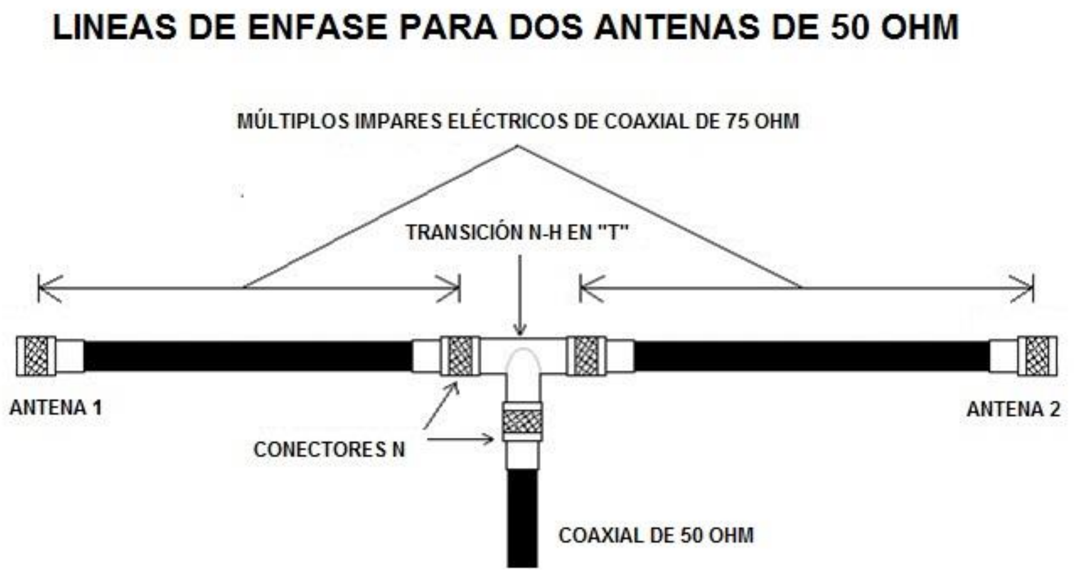


PHOTO 5.- CLASICAL PHASING SYSTEM

For terrestrial communications is the classical system of phasing used, by means of two 75 Ohm coaxial of a length equal to odd multiples of an electrical quarter wave, that is to say:

75 Ohm Cable length (in meters) = odd multiples of [[300 / f (MHz)] / 4] x FV

FV: Cable velocity factor, data given by the manufacturer.

This method is even used in some expeditions, provided that the cable we have is of excellent quality and low losses. It has been detected that some T-connectors are broke-down with high power, so to EME is a provisional system, PHOTO 5.

<u>METHOD 2</u>:
This is the most spread system, a power splitter. This system allows us to use all phasing lines of 50 Ohm, but we have to respect axioms A), B) and C). The phasing lines will have the unique mission of adding the signals in phase, and the splitter to adapt the impedances.

In this case it would be essential and sufficient, that the two lines are exactly equal in length, and any length would be right. BUT it is advisable to use the length obtained from the following equation:

50 Ohm Cable length (in meters) = multiples of [[300 / f (MHz)] / 2] x FV

FV: Cable velocity factor, data given by the manufacturer.

That is, two 50 Ohm coaxial of a length equal to multiples of an electric half wave. The reason is that a half wave has the singularity that at the output it REPLICATES the impedance that is at the input.

If our antenna is 50 Ohm exact, at any length of the cable we will find 50 Ohm and you will not need the above formula. But experience shows that if we use this formula, we can do measurements in the input of the splitter and the data obtained will be a reliable image of the impedance data in the antenna connector. This will help us to find future fails in our system.

We can see as a power splitter is in PHOTO 6 and PHOTO 7. There are wrong called ¼ λ (short) and ½ λ (long), I say misnamed because the two of them are based on the features of the ¼ wave impedance transformer and should always be called 1/4 λ. Both of them work in the same way and it is only a mechanical question that we decide for one configuration or another. There are several commercial brands and no large differences in the losses they introduce, although mechanically some are more robust than others. But if we are skilled we can built them, on the net there are calculators of the construction details, depending on the impedances we want to adapt.

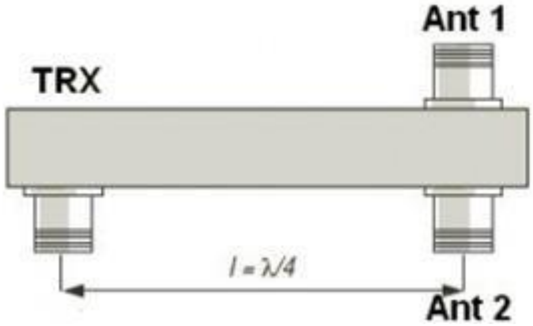


PHOTO 6.- SHORT POWER SPLITTER

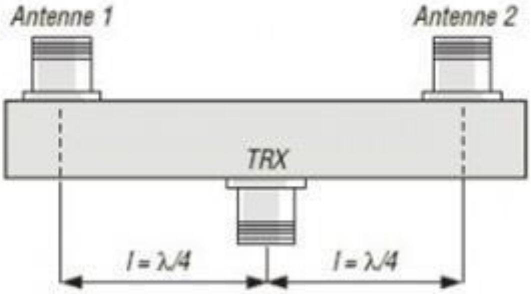


PHOTO 7.- LONG POWER SPLITTER

3.4.- NOT TO DISTORT THE RADIATION LOBE

A very important issue is to respect the radiation lobe that the manufacturer designed or we have obtained in our design, it is a theoretical lobe in the free space, with nothing to disturb it. In our assembly we have to try that this lobe is interfered as little as possible by any "conductive element". Note that I said "try", because in the real world we have masts, crossbars, power cables, coaxial cables, etc.

At first we have just stated that in a horizontal antenna, any metallic part in the vertical plane that passes through the antenna boom will not affect practically its lobe, for the simple reason that this plane is at ZERO potential, and therefore it will not be induced by any V and I, so it will not affect our antenna radiation pattern.

As a consequence the radiation lobe will not be affected by:

- A vertical mast.
- A lower strap that reinforces the boom.
- A steel wire above that will keep the horizontal boom.
- The coaxial cable if is routed along to the boom (under it, away as much as possible from the elements), and routed along the vertical mast.

To a better understand if we see the radiation lobe of an antenna would be something like the PHOTO 8, and seen from behind towards the directors, it would be like PHOTO 9.

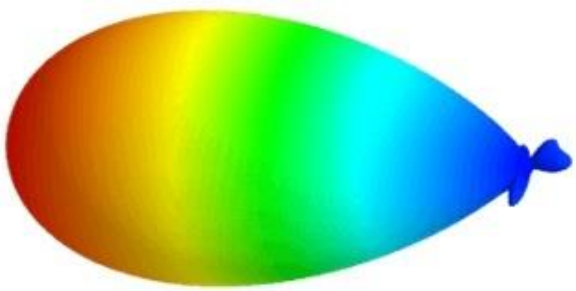


PHOTO 8.- THREE-DIMENSIONAL RADIATION LOBE

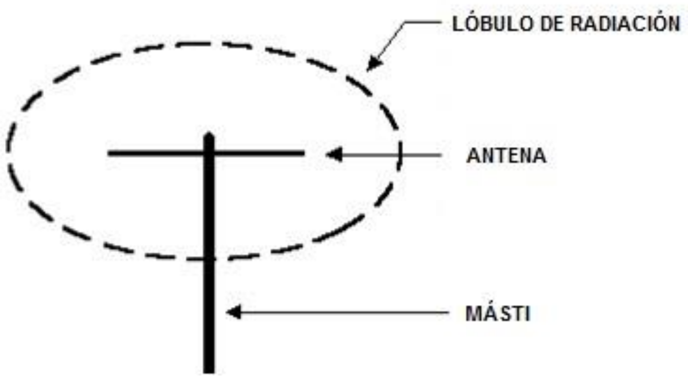


PHOTO 9.- ZONE OF INFLUENCE, DELIMITED BY THE MAIN RADIATION LOBE

As I said before, any metallic element will affect the radiation lobe, with less influence those contained in the vertical plane that passes through the boom. But any metallic element that is not found in the vertical plane will be very noticeable in the radiation lobe, especially if it is within the zone of influence that defines the radiation lobe itself, and we can see it in the PHOTO 9.

Having this clear and that we are forced to install an antenna next to the other, to be able to elevate the system, we only have two options for what our structure does not affect irreparably to the radiation lobe:

3.4.1.- MAIN CROSS-BOOM INSULATED

An example of this system can be seen in the PHOTO 10, which are the Antonio EA7IQM EME antennas.

As you can see the structure is minimal, reducing the weight and surface to wind, which is a very important issue. But the insulated main cross-boom has to be very robust to support two antennas of 7 meters of boom length separated 3.5 meters. In addition it is necessary to install a tube centered and parallel to the booms, where to support the splitter, LNA and routes the coaxial, which have to leave from behind the antennas.

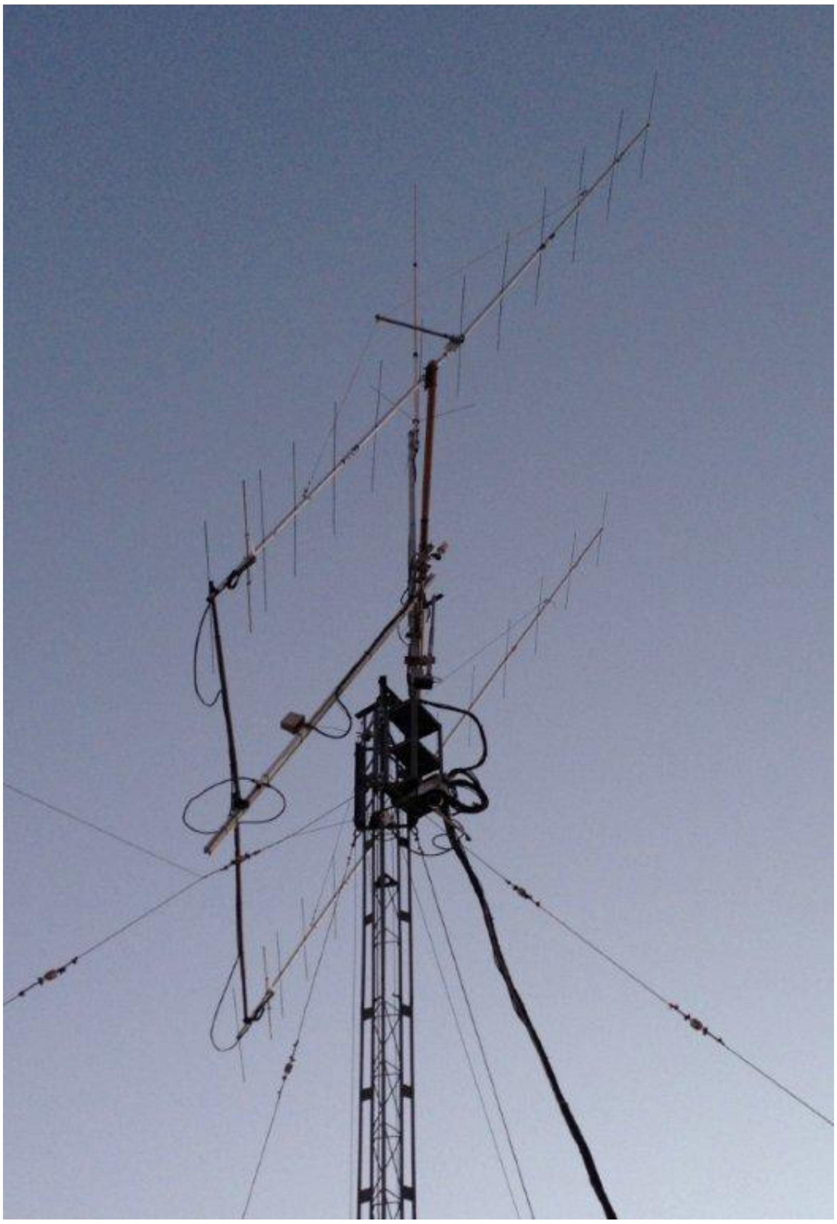


PHOTO 10.- INSULATED CROOS BOOM AND COAXIAL ROUTED FROM BEHIND EA7IQM

3.4.2.- U-SHAPE STRUCTURE

This is the most used assembly method, because round or square metal pipes are easier to get than insulated ones. As you can see, it is an "H" type structure in which the bottom part has been removed. It usually has two horizontal cross-booms to give it robustness, as you can see in PHOTO 12 of Jesus EA7HLB.

In this type of structure is usually committed one of the following mistakes, which would interfere in the radiation lobe:

- Do not install the upper cross-boom insulated (which acts as reinforcement for the structure).
- Not to give sufficient length to the vertical part of the "U", to separate the antenna from the metal cross-boom.

The distance from the antenna to the nearest metallic cross-boom should be at least a half of the vertical stacking distance, which in the table of VE7BQH is defined by column "H", in meters.

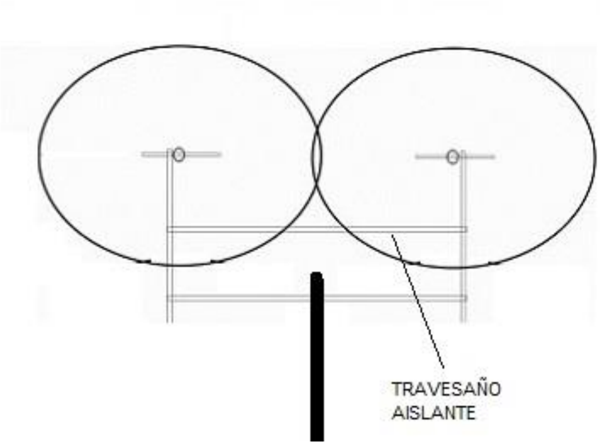


PHOTO 11.- U-SHAPE STRUCTURE

PHOTO 12.- EA7HLB U-SHAPE STRUCTURE

4.- INSTALLATION BETWEEN THE POWER SPLITTER AND THE TRANSCEIVER

Several variants could be established, but as this article tries to clarify the ideas and not to discourage you, I am going to propose only one option, that we can see in the SCHEME 1. We cannot avoid any of the parts here related to achieve an EME communication.

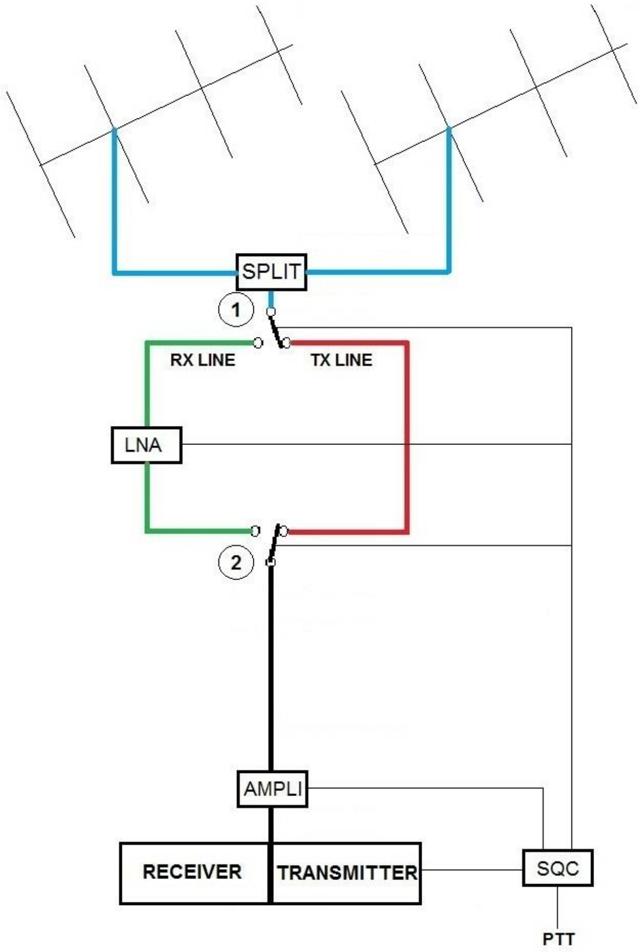
This scheme is a familiar one, since it is similar to that you already use in terrestrial communications, just a LNA with its isolation relays and an amplifier. But since in EME we have to compensate part of the way losses with power for both stations that pretend to make a contact, we will have to choose these components carefully.

For the amplifier, I would recommend between 500 W and 1 kW, the current technology allows us to choose between valves, transistors or MOSFET, all of them will give us good results.

To eliminate the losses between the power splitter and the receiver, a LNA (Low Noise Amplifier) is essential. For this high power, there are some LNAs with commercial relays. My recommendation is not to buy the set, but to do it ourselves, buying an LNA without relays, which are of prestige recognized Khune, SSB Electronic, F1OPA, etc. And to install two high isolation relays type Tohtsu CZX3500, which give more confidence than those included in the commercial sets. The advantage of mounting it, if the LNA or any of the relays fails, you only have to replace the damaged part, and not the whole set.

Finally, and we cannot avoid it when working with high power, the installation of a "Sequencer", which will allow us to establish times in the transient steps from reception to transmission and vice versa, between the transmitter, amplifier and LNA. There are several commercial sequencers that will give you good results.

Needless to say, that the connectors and coaxial cable must be of excellent quality, I would recommend ECOFLEX-15 to pass the rotor, and ½ "coaxial cable for phasing lines and main line, the connection between parts into the shack, minimum LMR400.



ESQUEMA - 1

SCHEME 1.- CONNECTION BETWEEN THE SPLITTER AND TRANSCEIVER

With this article we tried to establish a minimum constructive performance in the assembly of two antennas, to install in an elevation system, so that the assembly has the sufficient quality that can be used in EME with enough guarantees.

I hope to have fulfilled the expectations, if you already have antennas for satellite communications you will be familiar with the elevation systems, and if you have an installation for terrestrial communications with a yagi, you already have ideas to make the necessary modifications and cover another facet of the communications of VHF up, which will give you many satisfactions.

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