

432 MHz EME with a small antenna

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A lot of people would like to do EME but think they need a big antenna for this. In this article I show how to build up a small but competitive EME antenna, and what is important for success with a small station.

I chose:

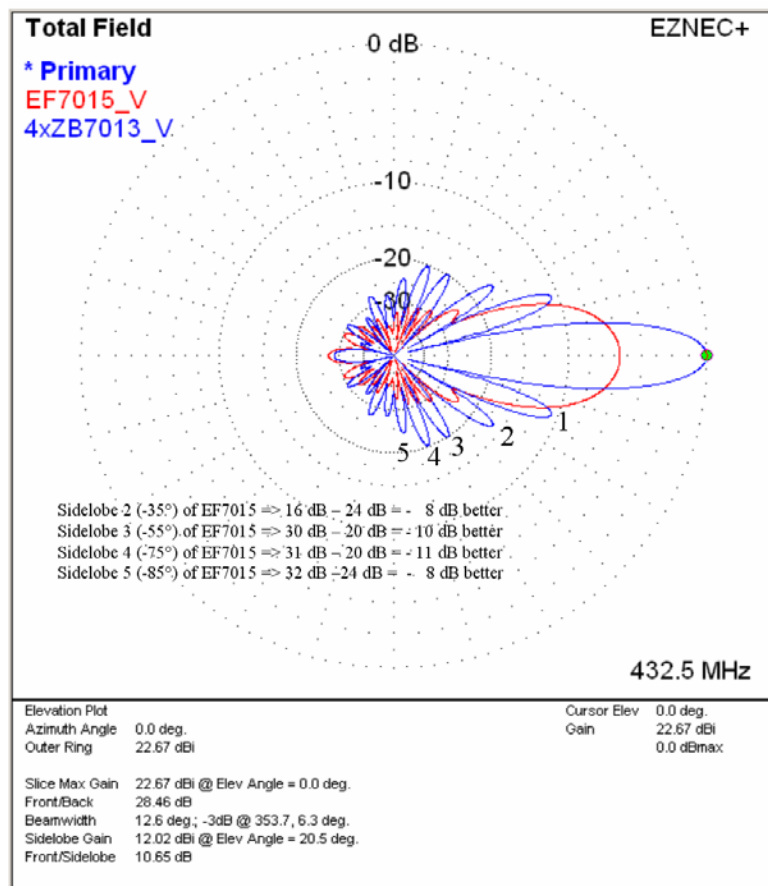
1. The maximum possible boom length without mechanical support which I decided 3.4m (4.9 λ) with a 20 mm x 20 mm x 1.5mm boom.
2. Solid aluminium elements of 6mm diameter to reduce the wind load and allow easy screw fixing.
3. Elements mounted on top of the boom with commercial element holders.
4. Z = 50 Ohm to use an easy to build straight dipole.
5. Symmetrical dipole made from 1/2" cellflex cable.

Which antenna design was my first choice?

I started with a well known design from Martin DK7ZB. I built 4 x 13 element ZB7013 yagis with a boom 3m (4.32 λ) long and about 20.5dBD gain. Stacking distances were 1.45m horizontally and 1.2m vertically. I could work some big guns like DL9KR, VK3UM and HB9Q but was not able to copy stations using 8 yagis or less or my own echoes.

Checking RX performance by sun noise

I started to check my RX performance by measuring sun noise. With my 4 x ZB7013 yagis and very short cables to the 4-way splitter I could measure 4.5dB sun noise at a solar flux index (SFI) of 68 and elevations > 30°. This is a very low figure for a 4 yagi system on 70cm. If you use the VK3UM EME Calculator and select a 4 yagi group with a gain of 20dBD and a preamp of 0.5dB NF you will get a result of about 8dB sun noise. So what is the reason for losing 3.5dB of Rx performance?



How to find the reason for poor Rx performance

I was looking for the reason for this low sun noise and ran a simulation of my 4 x ZB7013 compared to a single EF7015 yagi. In fig. 1 you can see the vertical diagram of the 4 x ZB7013 compared to 1 x EF7015. As you can see the 1 x EF7015 has 5.5dB less gain but on the other hand it has a 8 to 11dB better side lobe suppression for side lobes above 30°. This is the reason, why the single yagi has a much lower antenna temperature. There is much lower ground noise pickup with this antenna. This means that with one EF 7015 you can copy EME signals with nearly the same signal strength as with the 4 x ZB7013 just because its cleaner pattern.

Fig. 1: Elevation pattern of 4 x ZB7013 with less suppressed sidelobes no. 1 to no. 5 vs. 1 x EF7015

I built up a single EF7015 (Fig. 2) and could measure a sun noise of 4dB at SFI 70 with the same preamp I used before (DJ9BV MGF1302, 0.5dB NF, 19dB gain). After that, I was listening to OH2PO via the moon and got a very nice CW audio copy with very low audio noise and much lower QRM from cable TV than before. See fig. 3.



Fig. 2: Single EF7015 for EME

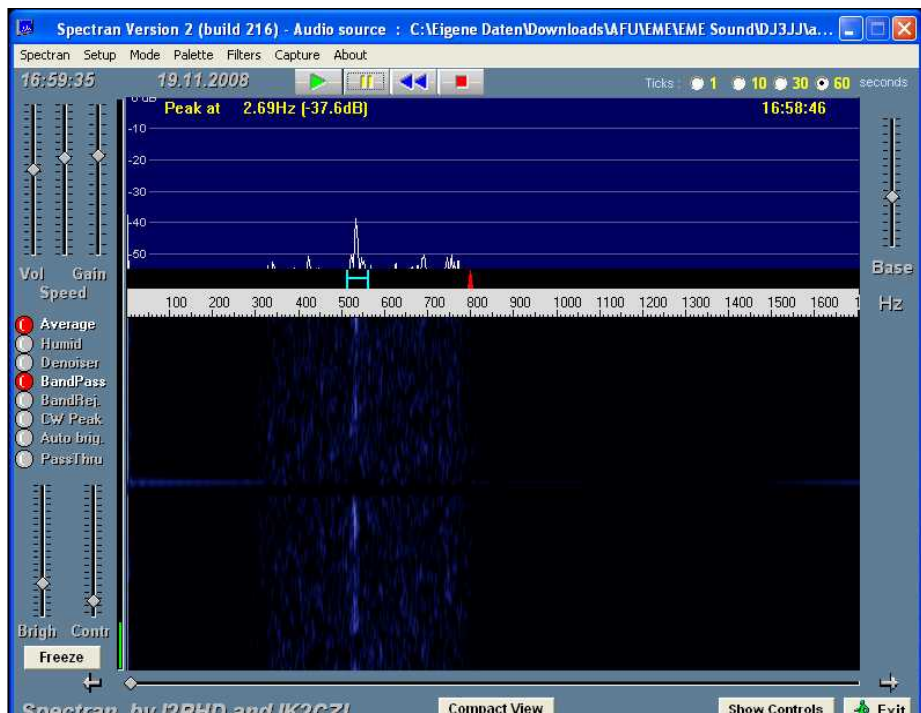


Fig. 3: 70cm EME signal from OH2PO on Spectran received with a single EF7015 yagi

Further increasing the RX performance

After this good result I built 3 more yagis to form a group of 4 x EF 7015 antennas. The vertical stacking distance was 1.4m and the horizontal was 1.45m. As you can see in fig. 4 this increases the gain by 5.81dB from 17.13dBi (15dBd) to 22.94dBi (20.8dBd). The suppression for sidelobes 3 to 5 reduces from -30dB to -25dB which is not an issue as long as the sidelobes are below -25dB. If you reduce vertical stacking from 1.4m to 1.2m you will have only 0.24dB lower gain but the first sidelobe will be reduced from -11.5dB to -16dB and sidelobes 3 to 5 will be again at the -30dB level. This is interesting if you have QRM from below (PC, WLAN etc.) and need better QRM suppression.

If you check your Rx performance with 4 of these yagis you should end up with a sun noise of 10dB with an SFI of 70. This is really a very good result for such a small antenna group and gives you the possibility of copying your own CW echoes with about 500W at the antenna under fair conditions at moon perigee. More details of this antenna can be found at: <http://www.yu7ef.com/ef7015.htm>

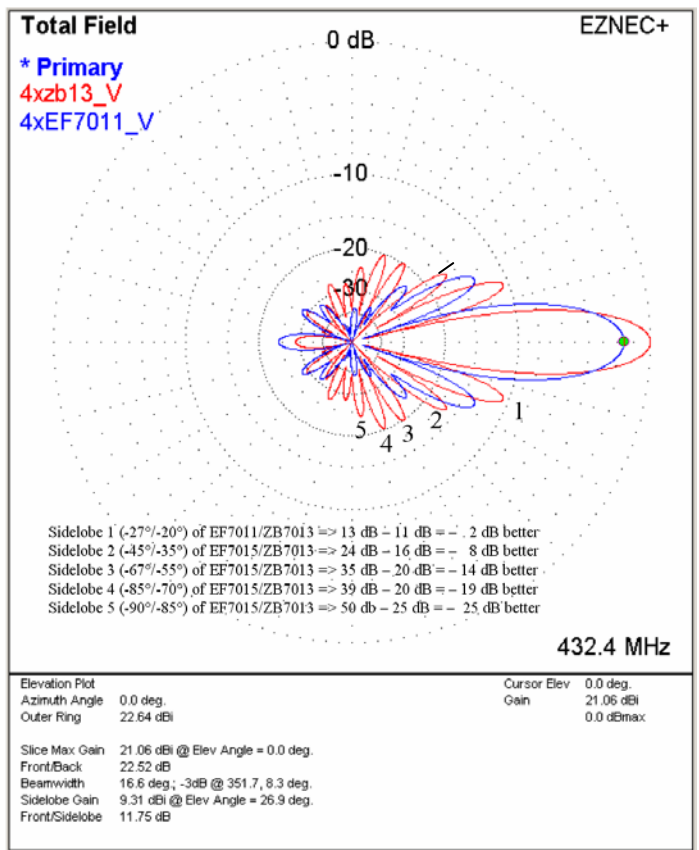
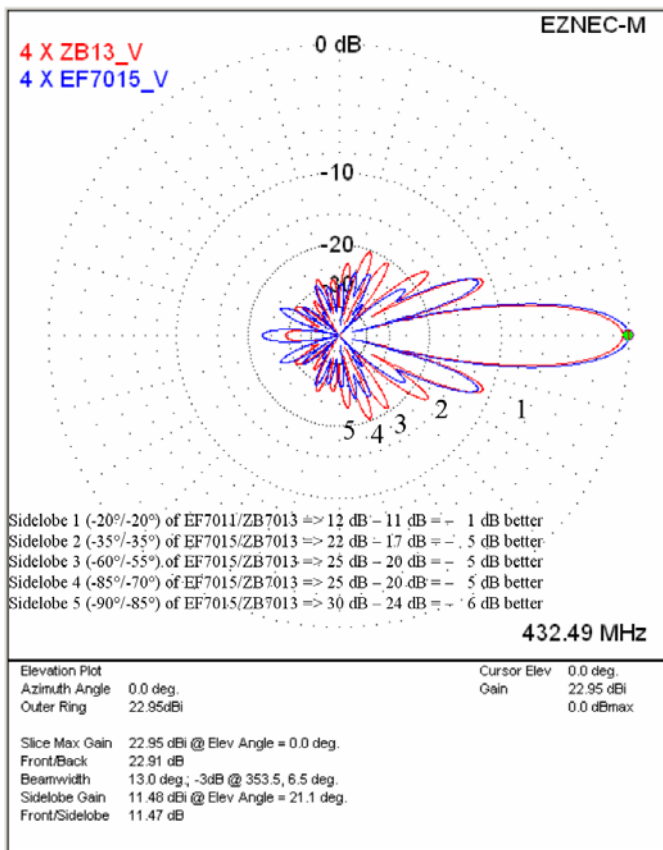


Fig. 4 (left): Elevation pattern of 4 x ZB7013 with larger sidelobes no. 1 to no. 5 vs. 4 x EF7015

Fig. 5: Elevation pattern of 4 x ZB7013 with larger sidelobes no. 1 to no. 5 vs. 4 x EF7011

A 1.4m x 1.45m x 3.4m EME array still too big?

If this antenna is still too big for your own situation there is another smaller design available. This has the dimensions 1.18m x 1.12m x 2.17m and is a group of 4 x EF7011 yagis with an antenna gain of 21.07dBi (18.92dBd). This group delivers about 8dB of sun noise at SFI 70 and because of the short boom the antennas can be mounted from the rear. To copy your own CW echoes you will need about 1kW at the antenna. Fig. 5 shows the difference in the elevation pattern between 4 x ZB7013 and 4 x EF7011. Again you can see the very good sidelobe suppression of the EF7011 in the vertical plane.

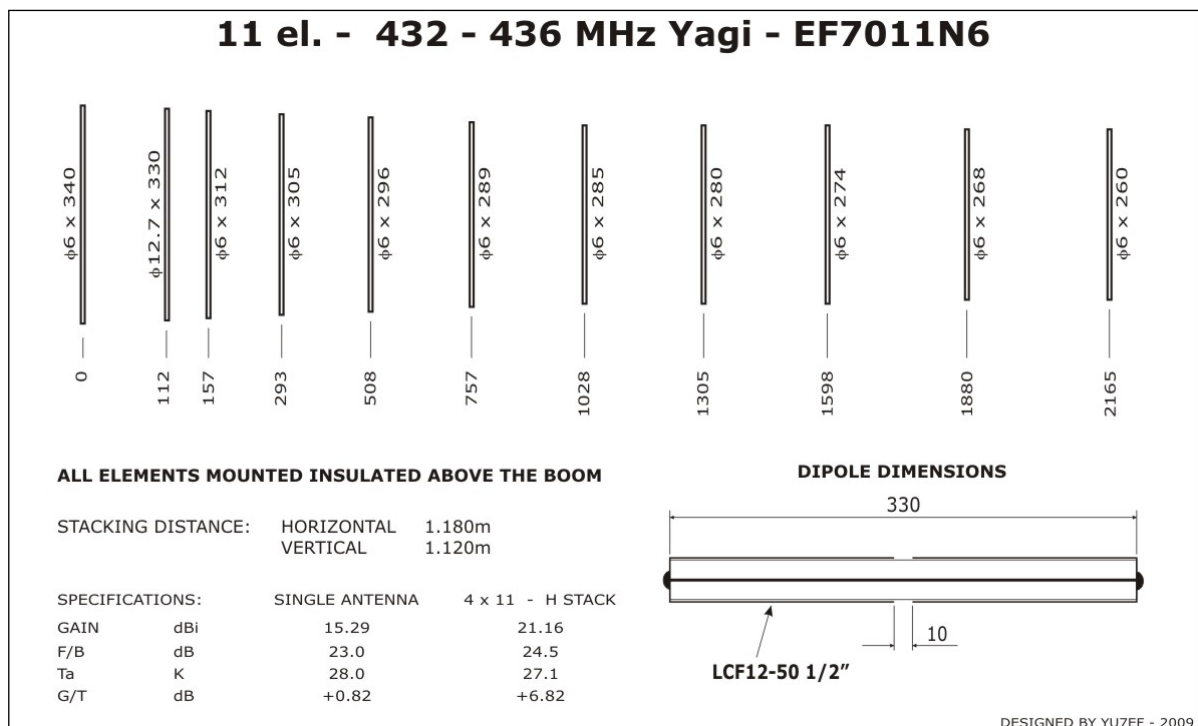


Fig. 6: EF7011 Yagi – details of construction

How to assemble the EF7011 Yagi

In fig. 6 you can see the dimensions of the EF7011 yagi. All elements are made of 6mm solid aluminium. A 2.5mm hole is drilled in the centre of the element, which is then tapped to suit the M3 fixing screw. To fix the elements on the boom I use polyamide element holders from Konni antennas. See www.konni-antennen.de/html/ersatzteile.html (Elementhalter-Polyamid, nur Unterteil 15er oder 20er Boom, 0,45 €). You can see a 6mm element on a polyamide holder in fig. 7.

Fig. 7: Polyamide element holder with 6mm element



The dipole is made of 1/2 inch cellflex cable like LCF12-50. As you can see in fig. 6, fig. 8 and fig. 9 you only have to cut the coax cable to 330mm. Then you connect the inner and outer of the coax at each end with a copper wire and tin the whole area between inner and outer line. The next step is to mark the centre of the dipole and cut the through outer copper sheath 5mm either side down to the foam. Now you will have a 10mm gap between the left and right side of the dipole (see lower part of fig. 6). After fitting this dipole into a housing you can directly connect one end of the coax cable to the dipole (see fig. 9) and the other end with a N male connector to the 4-way power splitter (fig. 11). It is very important that the coax runs across the reflector to the power splitter (fig. 10).

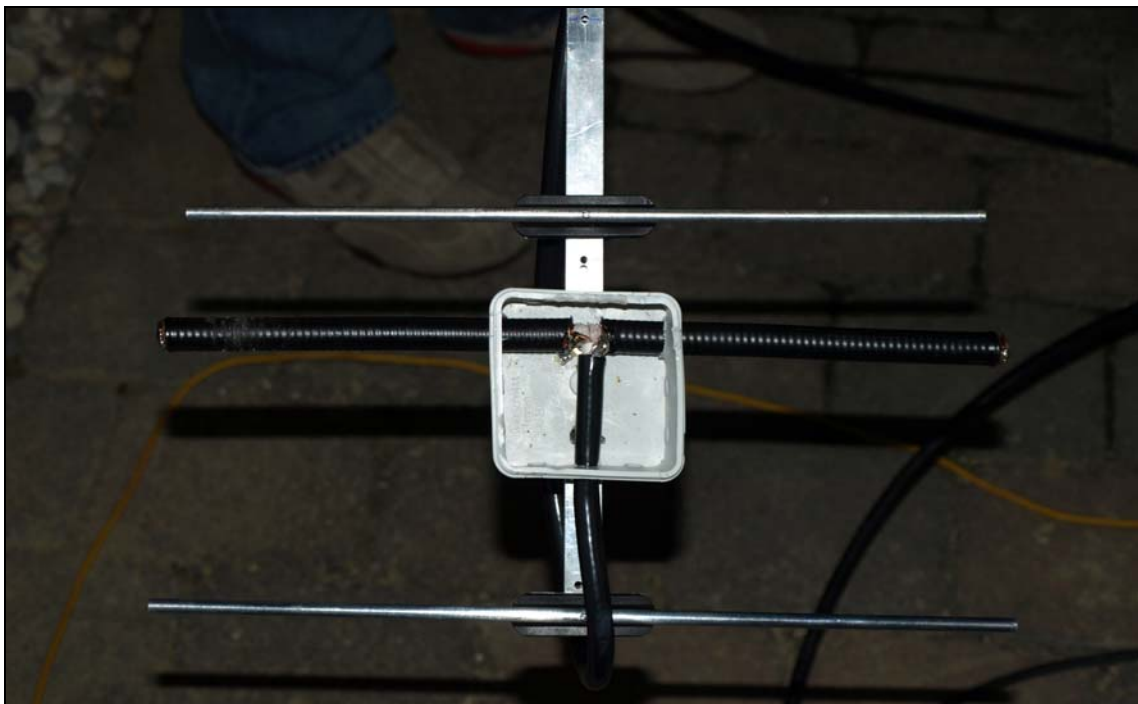


Fig. 8: Dipole made from 1/2" coaxial cable



Fig. 9: Close up view of the connections **Fig. 10: Finished antenna with feeder above the reflector**

How to reduce losses between the antennas and preamp (LNA)

To for optimum Rx performance the coax relay should be connected directly to the power splitter. This is possible by using a male N connector at the input of the splitter. See fig. 11. You should not use coax cable inferior to Ecoflex 10 (8.9dB loss per 100m at 432MHz) If you use Ecoflex 10 or 15 there is a solderless N connector available. If you use a male N connector at the input of your preamp you can reduce input losses by another 0.05dB compared to a male/male adapter. A very good but expensive coax relay is the HF-400. It only has about 0.03dB insertion loss compared to the CX520D or CZD3500Z with 0.2dB loss. An interesting surplus alternative is the RelCom RDL-2N1D4, which has an insertion loss of about 0.05dB on 432MHz and about 80dB isolation. Preamps like the SP7000 from SSB Electronics with built-in CX120 relays have a NF of about 1.2dB. Compared to a 0.5dB NF preamp with an external relay you lose $1.2\text{dB} - 0.5\text{dB} = 0.7\text{dB} \times 3 = 2.1\text{dB}$ of RX performance! If you don't believe it, measure the sun noise with both setups and you will see the difference.

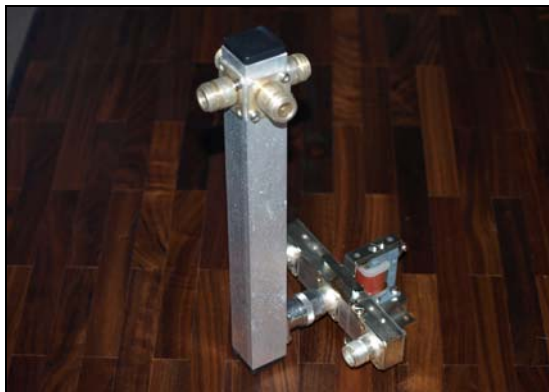


Fig. 11: 4 port splitter directly connected to HF 400 coaxial relay

When you have assembled the 4 yagis on an H frame you should test your RX performance by sun noise measurement. Download the software NoiseMeter from G8KBB from the following link:

<http://g8kbb.roberts-family-home.co.uk/NoiseMeter.zip>

After installing on your PC and setting up your soundcard click on "Measure Noise". See fig. 12. Next tick the enable box under Averaging and set the number to 10. Connect the audio out of your transceiver to your soundcard and set the audio to a low level so that there will be no distortion generated in the soundcard (< -50dB). Then switch off the AGC of your transceiver or if this is not possible reduce the RF gain by about 10dB. Use the Averaged Reading display when doing this.

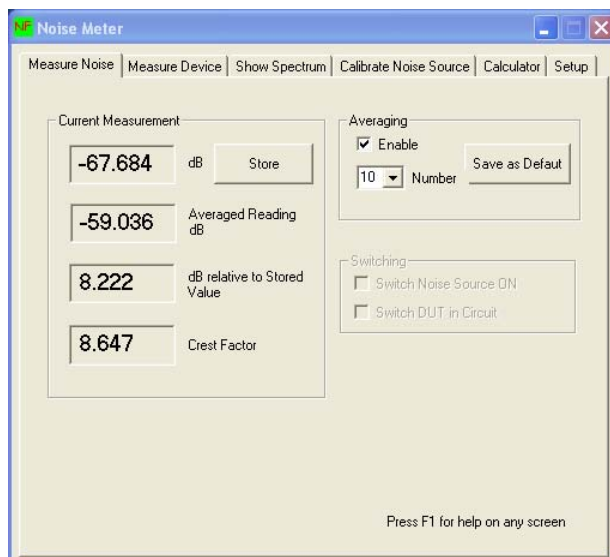


Fig. 12: Screenshot NoiseMeter software

Now elevate your antenna to >30° into the sky and look for the point with the lowest noise you can find using the NoiseMeter display. When have found it press "Store". Finally turn the antenna into the sun. The antenna is pointing at the sun when see an increase in noise reading on the display. Now you can see your sun noise at "dB relative to Stored Value". It is very important that the sun is also >30° up in the sky

to be sure you are not including any noise from the ground. From fig. 5 you can see that the second vertical sidelobe is at 35° , so you should have an elevation greater than 35° to overcome the noise from this sidelobe. If the sun is shining and you have some warm roofs you will also have an increase in noise if your antenna is pointing into this direction.

To check the influence of losses in front of your preamp you can try coax relays with different losses or an adapter cable between splitter and preamp. With every increase of 0.1dB loss you will see a reduction in sun noise of about 0.3dB! So the sun noise test always gives you a quick check that your system is working correctly even if there are no other stations available. You do not need a clear blue sky to measure sun noise. Not even large clouds will change the measurement significantly.

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