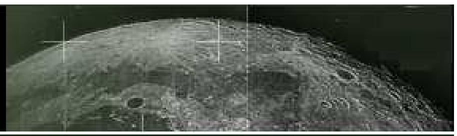
HF 18 MHZ EME EXPERIMENTS
ik3xtv
wsjt software (echo mode)



EME experiment on HF (18 mhz)

doc. 03.31.13.44 date: March 31th, 2010 Flavio Egano, ik3xtv

IMPORTANT NOTE

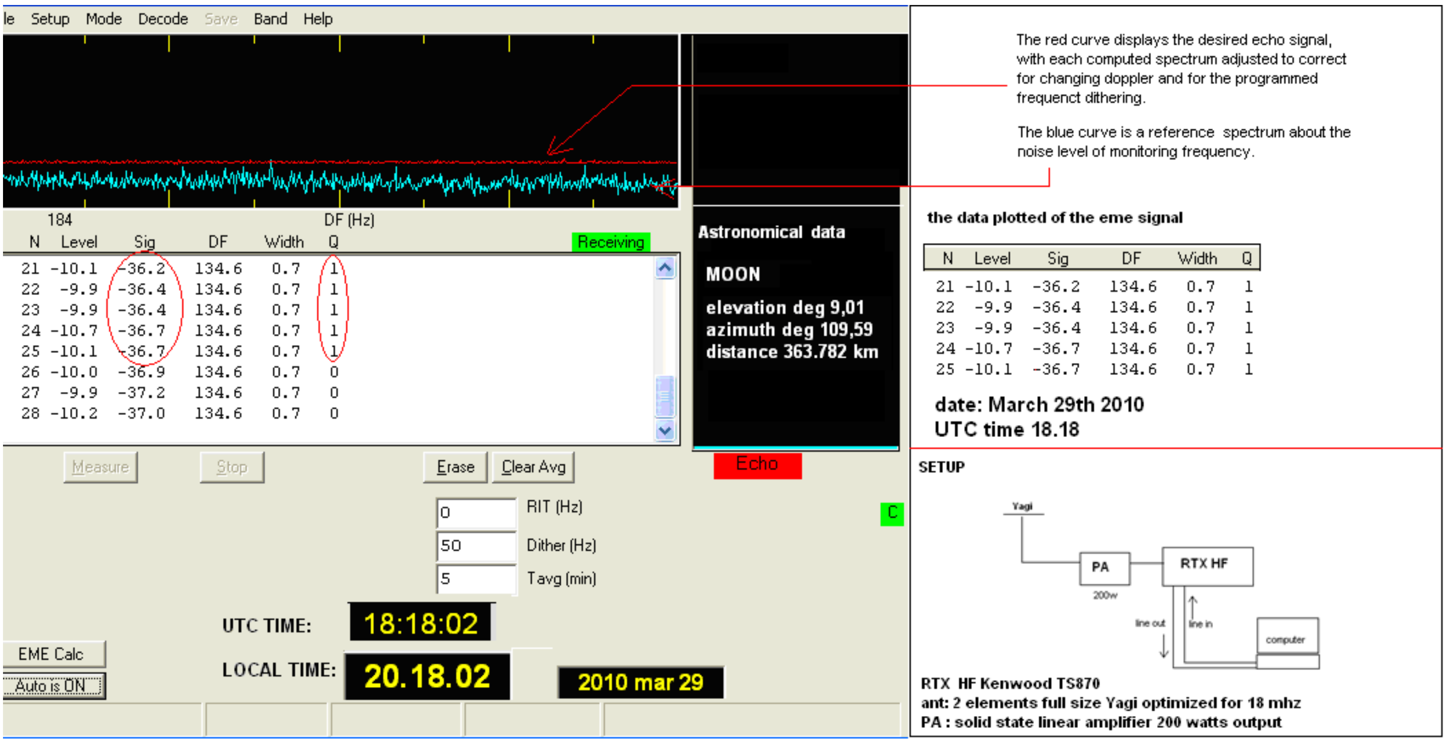
This test is strictly experimental and not have any scientific claim It is not excluded the possibility of a reception error. Need further tests.

Abstract

Using the WSJT software with EME echo mode , I made some EME experiments in the 17 meters HF band. The results are reported in the document below. The software has received a faint echo return from the moon. In the lunar echo experiment , ik3xtv amateur radio station with low power transmitter, launched radio waves toward the moon. The reflected signal, weakened because of the long distance to the moon and back, was detected by receiving antennas and processed by the computer software for digital mode communication. The ionosphere might be focusing the signal in such a way that it hits the moon and returns. HF EME would result in less signal loss from distance attenuation, and HF signals might reflect more coherently than VHF/UHF

The software

EME echo mode is designed to help evaluate the performance of eme station for moonbounce communication.
I used this tool on 18 mhz to detect the radio signal. The program has a cycling transmit loop: transmit a fixed tone for 2 sec, wait about 0,5 sec for the start of returning echo, than record the received signal for 2 sec, analyze, average and plot the results. I repeated this cycle for several time. The EME echo mode can detect signals down to about -38 dB in five minutes. The spectral analysis carried out in EME echo mode provides a frequency resolution and detection bandwidth of 0,67 HZ. The rtx used has a long term frequency stability just to avoid any echo sensitivity degradation. The software is able to carry out some information: LEVEL is the average level of receiver background noise in db. SIG is the average signal strength in db, DF is the measured frequency offset of the detected echo in Hz, after correction for the expected Doppler shift.. WIDHT is the spectral width of the echo in Hz. Q is a relative quality indicator for the echo detection, on a 0-10 scale. Q=0 means the an echo detection has not been achieved , or is very unreliable. Larger values of Q imply increasingly significant echo measurement..



The experiment

The IK3XTV yagi antenna array was "phased" to point about 10 degrees away from the zenith, in order to track and directly illuminate the moon. Its full total power capability, about 200 watts , was used to transmit pulses two seconds over a period of 5 minutes Using such a pulse pattern makes the echo, which arrives back from the moon 2.4 seconds later, and detected by the computer.
In the first test the software detected 5 echoes of quality Q=1 . This is very low quality detection but the echo signal was very weak at about -36 dB. I consider a success in order to evaluate the very qrp station the I managed on HF (tx output power of 200 Watts). The HF signal has affected of ionospheric absorption and reflection and ionospheric condition can change very fast. Some other tests should be doing during the nighttime hours, to reduce as much as possible the ionospheric absorption and reflection on this frequency. Tests were made at moonrise with 9 degrees of moon elevation because I have not the elevation of the HF Yagi antenna . However in this situation we can have the ground gain effect that theoretically should make a increase of about 6 db. Because EME echo mode uses a very narrow detection bandwidth of 0,67 Hz. It can detect signal much weaker than those required for JT65 communication. The threshold signal level for detection of echoes with Q=1 is given by:

Sig= -29,4 – 5 log10 N

Where N is the number of echoes cycles. This equation means that you should be able to detect echoes down to about -34 dB in one minute (N=10) and -38 dB in five minutes (N=50).

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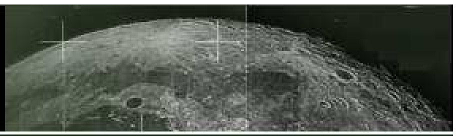

The tests were done for several days without any results (no echoes detected). This is because the conditions of the moon and above the Earth's ionosphere are very restrictive. The Earth's ionosphere very often reflects back or strongly attenuated the HF radio waves.
I also tested the possible errors introduced by the software, I made several test transmission without the moon. They have never been recorded false echoes or decoding errors. To avoid possible ionospheric reflections on 18 mhz I have chosen to make the experiment at a given time interval, just after the sunset when the MUF go down, pointing the antenna in the dark zone of the earth .
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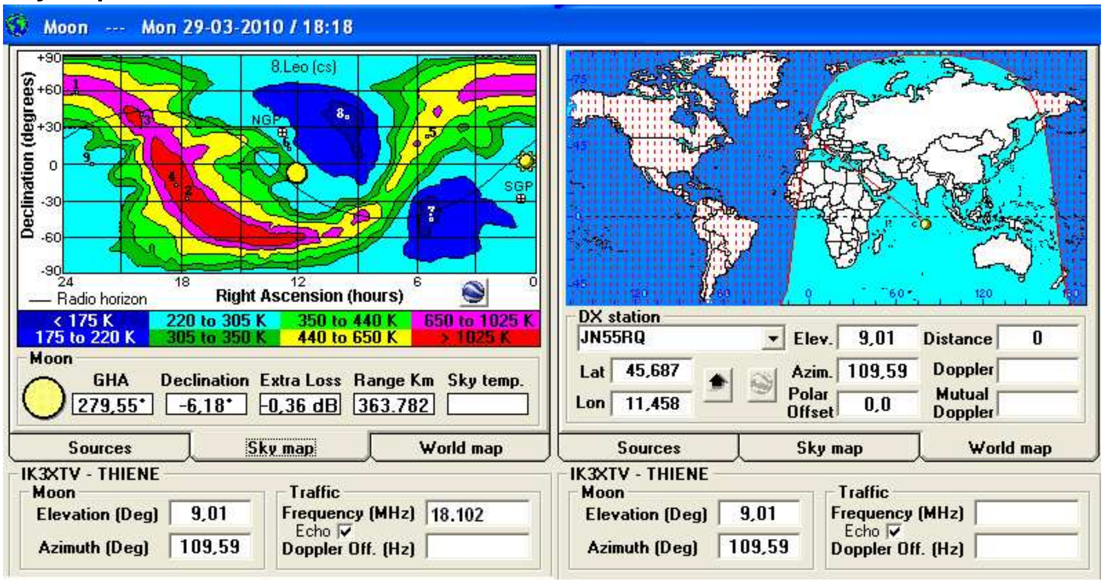
Possible future developments
The ultimate goal of this experiment would be to study the feasibility of EME digital communications on the HF bands.
The idea is to implement the system with greater power and directional antennas with higher gain to increase the quality and level of lunar echoes. Better results could be obtained using HF higher frequencies as 21, 24 and 28 mhz.

Sky map and moon data

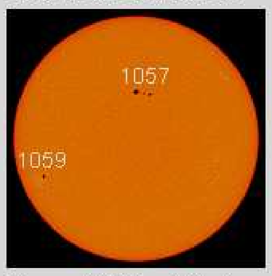


ionospheric and space weather data

Solar wind
speed: **352.5** km/sec
density: **5.5** protons/cm^3

X-ray Solar Flares
6-hr max: **A6** 2310 UT Mar29
24-hr: **B1** 0050 UT Mar29

Daily Sun: 29 Mar. 10



Big sunspot 1057 is quieting down after a weekend of C-class flare activity. Credit: SOHO/MDI

The Radio Sun
10.7 cm flux: **86** sfu

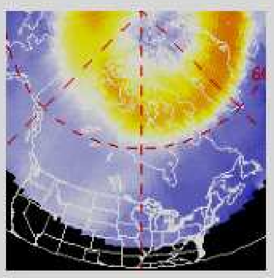
Sunspot number: 33

Spotless Days
Current Stretch: 0 days
2010 total: 6 days (7%)
2009 total: 260 days (71%)
Since 2004: 776 days
Typical Solar Min: 485 days

Planetary K-index
Now: **Kp= 0** quiet
24-hr max: **Kp= 2** quiet

Interplanetary Mag. Field
B_{total}: **4.1** nT
B_z: **1** nT **south**

Current Auroral Oval:



moon phase
full moon march 30th 2010

References
Wsjt by Joe Taylor, K1JT http://www.physics.princeton.edu/pulsar/K1JT/
ESA European Space Agency
NASA United States of America
Ik3xtv Amateur radio propagation studies http://www.qsl.net/ik3xtv
Space weather indices : http://spaceweather.com/