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Moon-bounce: A Boon for VHF Dxing

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Abstract:- Amateurs Radio operator, also known as HAM communicates with other HAMs through Radio waves. Wireless communication in which Moon is used as natural satellite is called Moon-bounce or EME (Earth -Moon-Earth) technique. Long distance communication (DXing) using Very High Frequency (VHF) operated amateur HAM radio was difficult. Even with the modest setup having good transceiver, power amplifier and high gain antenna with high directivity, VHF DXing is possible. Generally 2X11 YAGI antenna along with rotor to set horizontal and vertical angle is used. Moon tracking software gives exact location, visibility of Moon at both the stations and other vital data to acquire real time position of moon.

Keywords:- Amateur Radio, HAM, Moon-bounce, Earth-Moon-Earth, EME, Yagi Antenna

I. INTRODUCTION

HAM Radio operators are making two way radio communications with other HAMs in distant countries or with far away Dx stations are referred to as "DXing". Generally they use High Frequency (HF) on amateur bands. But it is difficult to make a long distance QSO (communication) using VHF frequency, without using repeater, satellite, computer base software and when Sporadic-E phenomena occur (probability of its occurrence is more during Summer season i.e. May to August) or Duct propagation. In this paper, Moon Bounce method for VHF DXing is elucidated.

II. THE MOON

The Moon, nearly spherical in shape, is the only natural satellite of the Earth. It is in synchronous rotation with the Earth. After the Sun, it is the second brightest regularly visible celestial object in Earth's sky. As the Moon orbits around the Earth once per month, the angle between the Earth, the Moon and the Sun changes; we see this as the cycle of the Moon's phases. The time between successive new moons is 29.5 days (709 hours), slightly different from the Moon's orbital period (measured against the stars) since the Earth moves at a significant distance in its orbit around the Sun in that time.

The Moon Profile:
Orbit: 384,400 km from Earth (Orbits the Earth)
Length of the orbit: 27.3 Earth days
Diameter: 3475 km
Mass: 7.35e22 kg
Average distance from the earth: 384400 km
Surface temperature: -233 to 123o C
Moon is ~ 1 degree wide when seen from earth

III. MOON BOUNCE

Moon Bounce is a peculiar mode of communication. It is a radio communication technique in which radio waves transmitted from the Earth based transmitter located at one place are reflected off the moon surface and received back at another location on the Earth based receiver. This technique is also known as Earth - Moon - Earth (EME) Communication. EME technique was developed by US Military during year 1945-46. Now, Amateurs are using this technique for DXing and also for research work.

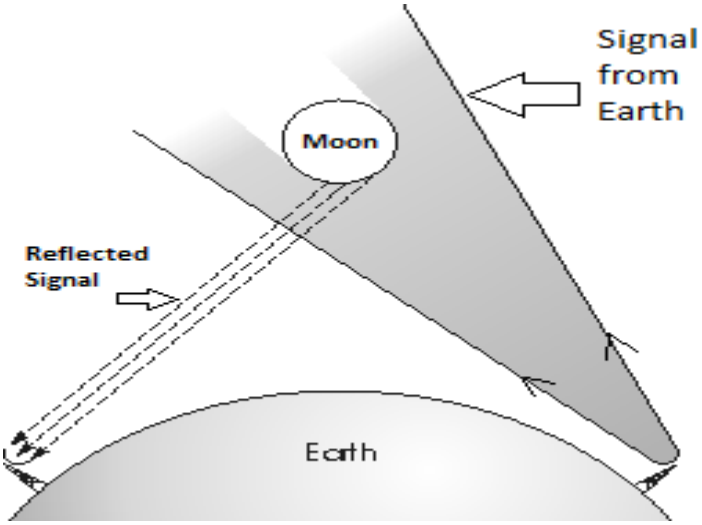

Fig 1. Conceptual model of EME

IV. RATIONALE

In the EME technique, The Moon is used as a passive satellite. It is approximately 384400 (d) km away from the earth (distance varies as Moon's orbit is not perfectly circular). This distance is the mean of apogee and perigee. Radio waves propagate at the speed of light c, exactly 299,792,458 m/s. Propagation time to the Moon and back is therefore 2d/c

d is distance (average distance at any given time)
or about 2.4 s at perigee
or about 2.7 s at apogee
or about 2.56 s on average, but for message coding 2.25 s time is measured.

Thus the lag time is 2.25 second. It means that a signal sent to the moon does not return until 2.25 seconds have elapsed. If two people are engaged in a conversation and one person asks a question, that person cannot expect a reply until at least 4.50 seconds have elapsed. The Moon is nearly spherical, and its radius corresponds to milliseconds of wave travel time. The trailing parts of an echo, reflected from irregular surface features near the edge of the lunar disk, are delayed from the leading edge by as much as twice this value.

V. EXPERIMENTS

Amateur radio operators (HAMs) use EME technique for two-way communication. Here, HAM has to work in challenging situation as they have to decipher weak signal, but it is a fun to make difficult, unusual and exceptional contact. Amateurs generally use VHF and UHF to communicate through EME. In this mode of communication, Amateurs can use their own basic setup, no high end equipment or antennas are required. In this paper, mode of communication is restricted to VHF (CW) on 2 meter.

V.1 EQUIPMENTS:

Amateur-radio moon bounce generally requires the following:

- A transceiver having sensitive receiver with a narrowband filter. (Fig.2)
- A transceiver, capable of operating on amateur band above 144 MHz, and capable of producing high watts of continuous radio-frequency output. (Fig.2)
- A power amplifier. (Fig.3)
- Antennas with high directivity and gain, capable of being rotated in both the azimuth and elevation planes. (Fig. 4).
- Rotors. (Fig. 5).
- Computer / Notebook
- Moon Prediction software
- A location in which the moon can be seen without obstruction for extended periods
- A location where QRM and QRN are minimal

V.2 TRANSCEIVER:

A transceiver is capable of operating on amateur band (2 meter) and is also capable of transmitting high power. Receiver of the transceiver must have high sensitivity and narrowband filter.

For experiment, FT2800M is used (Fig.2)

Fig. 2: A typical VHF Transceiver device

V.3 POWER AMPLIFIER:

B-2518-G amplifier gives 160 Watts of output power for just 25 W in from base/mobile rig As shown in figure 3.

Fig. 3: A typical VHF Power Amplifier device

This amplifier contains an internal receiving amplifier (also called a pre-amplifier or pre-amp) that "boosts" weak signals. It has a noise figure of about 1 dB, and about 14dB maximum gain.

V.4 ANTENNA:

Homebrew, high gain and high directivity 2X11 element Yagi array antenna having following specifications is used as shown in (Fig. 4).

Specifications are as follows:
1. Forward Gain (dBi): 13.2
2. Front to Back (Ratio): 28
3. Power Ratings (Watts): 300
4. Boom Length (in.): 39 3/8
5. Turning Radius: 72
6. Mast Range (in.): 1 1/2 - 2 1/8 "
7. Wind LOAD (sq .ft): 1.12
8. Weight (lbs): 6

Hardware: All stainless steel, except mast mount U bolts.
Gamma Match: 50 Ohm feed
Connector: Std. SO-239 UHF female connector.
Coax RG214 and N type connections are used for Tx and Rx.

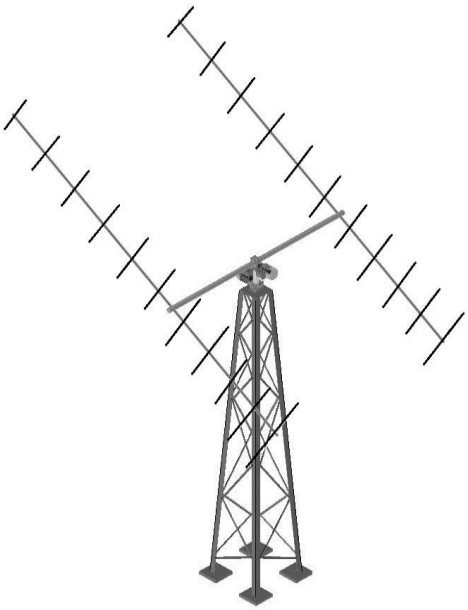

Fig. 4: Schematic view of Yagi Antenna

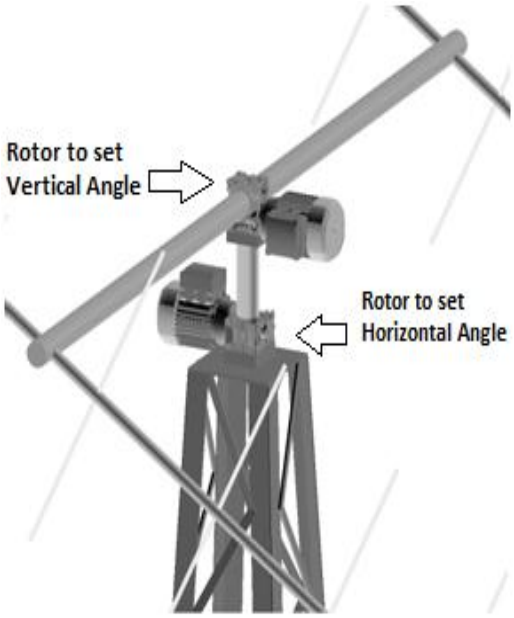

Fig. 5: Schematic view of Rotor

V.5 ROTORS:

A mechanism (Rotors) to set horizontal and vertical angle of both antennas are fabricated and used (Fig. 5). In fact, two rotors are used, one at base and one at top of the mast. These angles are digitally displayed and can be adjusted from the radio sack. These rotors use stepper motors and can be set from the radio sack.

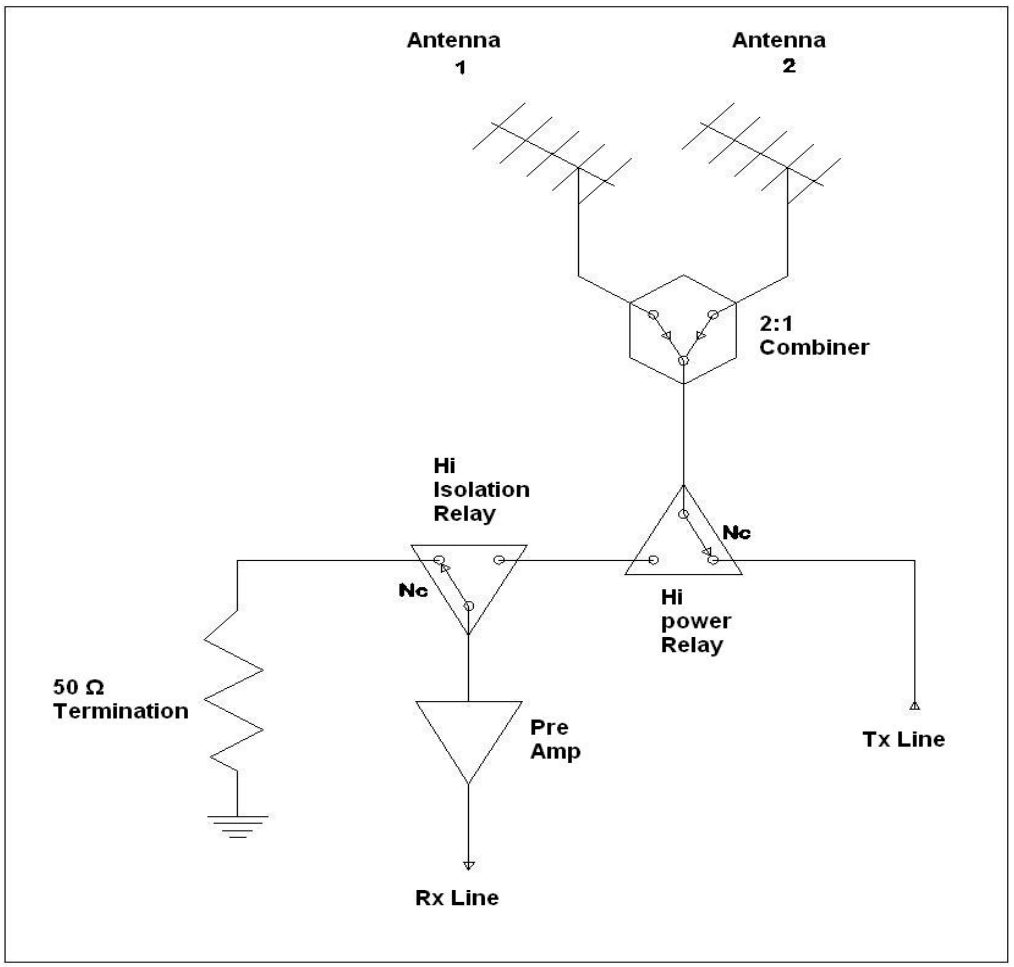

Fig. 6: Schematic diagram of EME transceiver station

V.6 MOON PREDICTION SOFTWARE:

Generally speaking EME communication is not possible round the year. As the Moon travels around the earth in a cycle of about 29.5 days, at the same time the Earth moves at a significant distance in its orbit around the Sun in that time. In order to establish solid contact, it is inevitable to have good Moon predictable software which provides moon calendars and detailed information about moon data. A few such software's are - Quick Phase, LunarPhase Pro, PREDICT (Open source), Moonphase 3.3 (Freeware) etc.

V.7 QSO (Communication):

To establish contact,

1. Make sure that Moon conditions are very good,
2. Moon is visible from both the stations
3. Use moon tracking software to locate moon and its data
4. Set elevation and azimuth angle of antenna
5. Ensure that there is no QRM, QRN or high sky noise
6. Switch on the equipment for DXing.

VI. OUTCOME OF EXPERIMENTS

The following factors affect DXing:

1. Earth's magnetic field
2. Spatial offset
3. Signal fads as moon rotates.
4. Signal also fads as the surface of the moon is uneven. Higher the frequency, more rapid fading
5. Polarization shift due to ionosphere
6. No communication when the Sun and the moon are at 180^o
7. Celestial noise.
8. Communication is not possible between stations having 90^o polarisation offset.
9. Moon condition

VII. CONCLUSIONS

QSO in Moon-bounce communication is slightly difficult but gives thrilling experience to HAMs and that too with existing modest set-up and passion. It is fun to decipher weak signal and make unusual QSO. It is observed that during Sporadic-E phenomena, HF communication is not possible. At that time Moon bounce communication proves to be useful.

VIII. FUTURE SCOPE

In this paper, only CW Mode is taken into consideration. Amateur can modify the setup and use for other modes of communication. Apart from the work carried out in this paper, there is a space for research in other domains as well such as Propagation characteristic, Noise level at different time, Antenna phasing, Polarization, Study of reflection pattern and thereby that of Moon surface etc.

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