Getting Started On Two Meter EME To Work Lots Of DX

By

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Living here in Southern California, on the West Coast of the United States, presents some geographical challenges towards working DX on two meters (2m). Of course, this applies to living anywhere when operating 2m DX. Propagation via the direct path, tropospheric and meteor scatter and Sporadic-E have distance limitations. Achieving WAS (Worked All States), WAC (Worked All Continents) and DXCC awards is impossible when these are the only propagation modes being utilized on this popular VHF band.

With a half a million mile round trip path, EME (Earth-Moon-Earth) or moonbounce is the ultimate DX. Many weak signal (CW and SSB) operators already have a station capable of limited 2m EME operation. The objective of this article is to, hopefully, inspire & motivate many hams who are already working, or wish to get started working, weak signals on 2m to try EME in order to work a lot more DX including many more grids, states and countries. In addition, the tools needed to be successful with 2m EME will be presented. So, let's get started!

The Nature of EME – Basic Technical Aspects

If two stations have adequate equipment and can simultaneously see the moon, they should be able to make contact via EME. However, several attempts may be required to achieve success. Signals are very weak echoes reflected from the moon's surface. Typically, they are usually at the noise level, or even beneath the noise, occasionally rising from the noise for brief periods. Let's look at some of the technical factors that effect EME communications, particularly as they relate to 2m.

- **Polarization**

The polarization of EME signals is constantly changing which can result in no signal being heard or very deep QSB. There are two basic types of polarization:

Spatial Polarization – This is a function of geometry. The wavefront of an EME signal between two stations can be rotated in polarity. The amount of rotation depends on the relative longitudes of the two stations and the position of the moon in the sky. Most computer moon tracking programs calculate the amount of spatial polarization and can show the optimal times to arrange schedules (skeds).

Faraday Rotation – The earth's magnetic field causes the wavefront from the radio signal to rotate in polarization several times as it passes through the ionosphere on the way to the moon and back. This causes a cyclic fading in the received signal. At 2m, the fade period between signal peaks (i.e., the time to rotate through 90 degrees) is about 30 minutes. Faraday rotation cannot be predicted by computer software at this time.

The adverse effects of spatial polarization and faraday rotation can be minimized by using either fully rotatable linearly polarized antennas such as the collinear array at VE7BQH which can be rotated along the x, y and z-axis or, more simply, by using cross-polarized (x-pol) yagis such as those used by K6PF and many other stations. Successful contacts can be made by two linearly polarized stations by simply "waiting it out" or by trying another time if the combination of spatial polarity and faraday rotation are not favorably aligned.

- **Libration Fading**

As viewed from earth, the moon appears to rock back and forth on its axis. This motion is called "libration". The path lengths of signals backscattered from the various parts of the moon's irregular surface are always changing leading to quite rapid flutter. This flutter causes brief fading and enhancements of the EME signal by several dB. At 2m, a fade or enhancement can last for up to a couple of seconds. When a brief signal enhancement occurs, this can help the small or marginal stations make contacts that otherwise may not have occurred.

- **Doppler Effect**

Because the moon moves in relation to earth, there is a doppler shift on EME signals. On 2m, it is <u>approximately</u> a plus 350 Hz at moonrise, 0 Hz when the moon is overhead, and a minus 350 Hz at moonset. Doppler shift increases with increasing frequency. This shift in a received signal needs to be taken into account by using a RIT (or clarifier) or separate VFO when listening for your own echoes or for stations on a scheduled frequency. A good operating practice on 2m is to tune about 750 Hz on both sides of the expected receive frequency, which is the sked frequency +/- the doppler shift, when listening for a station. It also is best to use a wider receiver filter such as 500 Hz when initially tuning. Once a station is located, the receiver filters can be narrowed as necessary to improve the signal-to-noise ratio.

- **Sky Noise (Noise Temperature)**

As the moon travels in it's orbit during the course of a 28 day lunar month, it passes in front of various celestial bodies, such as our sun and other stars and planets, which generate RF noise. Some sources are noisier than others and any additional noise further degrades communication along the EME path.

Most smaller 2m antenna arrays used for EME have a half power beamwidth of approximately 30 degrees for a single yagi to about 15 degrees for a four yagi array. Since the moon subtends an arc one-half degree as seen from earth, the antenna is viewing a large portion of the noisy sky around the moon.

Sky noise, or noise temperature, is measured in degrees Kelvin (K). On 2m, sky noise varies between a low of about 175 degrees K (rare) to over 3,000 degrees K. The lower the better and if it's much over 400 degrees K, the smaller stations are not likely to hear or be heard by even the bigger stations. Noise temperature goes down in proportion to an increase in frequency.

- **Path Loss**

During the lunar month, the moon travels in a slightly elliptical orbit with a distance to earth of approximately 221,500 miles at perigee (point closest to earth) and about 252,700 miles at apogee (point furthest from earth). This distance results in about a 2.5 second delay of EME echoes. On 2m, the round trip path loss is about 251.5 dB at perigee and 253.5 dB at apogee and the path loss increases with frequency. This 2 dB difference between perigee and apogee is a significant factor in the potential for success by a small station. Therefore, most skeds are setup around perigee.

- **Degradation**

This is a "figure of merit" calculation performed by most computer moon tracking programs that calculates the degradation (dgrd) in the EME signal-to-noise, in dB, at a particular moon position and date. It compares the excess sky noise in the direction of the moon plus the earth-moon separation distance in relationship to the lowest possible sky noise along the moon path and the absolute minimum perigee distance. During a monthly lunar cycle, this factor can vary by more than 13 dB at 2m. Small stations will have the greatest chance for success on 2m EME when degradation is less than 2.5 dB and the lower the better.

- **Declination**

This is the position, measured in degrees above or below the equator, at which the moon appears in the sky. The maximum positive or northerly declination averages around +23 degrees. Best EME operating conditions for northern latitude stations are found at highest declinations because it offers the longest possible common operating window between two stations in the northern hemisphere (such as between the US and Europe or the US and Japan). Also, the sky noise is typically lower at higher declinations. As the moon's declination passes through 0 degrees (directly over the equator) and into negative declination, it rises farther and farther to the south and the operating windows for northern latitude stations diminishes.

- **Ground Gain**

On 2m EME, small stations in particular, with or without elevation of their antennas, can possibly benefit from up to 6 dB of additional antenna gain when pointed on the horizon. Reflections from uncluttered flat ground in front of an antenna cause peaks and nulls at certain elevation angles, which can result in up to 6 dB of additional antenna gain. This assumes that one does not have a marked increase in terrestrial noise level on the horizon. Ground gain is potentially useful when the moon is between 0 degrees up to 10 to 12 degrees on rise and set.

- **Moon Phases**

Of the four phases of the moon (new moon, first quarter, full moon and last quarter), new moon plus or minus one or two days should be avoided due to sun noise. Full moon, with stable nighttime conditions, can be favorable. When the moon is visible during the daytime hours, ionospheric disturbances caused by the sun can degrade EME conditions. Therefore, nighttime conditions are usually better.

- **Activity or Sked Weekends**

Usually, there are only a few days out of every month when EME conditions are favorable. Please refer to the attached chart & related comments page at the end of this article which is labeled "W5LUU Weekend Moondata – 2003". This chart will tell you which Sundays of each month have the best possible conditions and, therefore, the best chance for success. Activity or sked weekends are held during these times.

- **Best Time To Operate**

The best time to operate 2m EME is when perigee, high northerly declination (for northern latitude stations), minimal sky noise, lowest degradation and evening hours all coincide. However, this optimal situation happens only every nine years when the moon is as close to the earth as it ever gets. This last occurred during 1999-2000. During the balance of this nine year cycle, maximum declination and perigee drift apart. Choosing a time when sky noise (noise temperature) is the lowest is usually the best compromise. The next time that degradation should be the lowest and, therefore, EME conditions should be at it's best, will be during the period of 2007-2010. However, many very good EME contacts take place throughout the entire nine year cycle.

What Kind Of Station Is Needed To Work 2m EME?

First, let's look at the minimum station that could work some of the "big gun" or "larger" stations assuming that many of the variables discussed in the preceding section are favorable. We're referring to CW EME where code speeds are usually in the 10 to 15 wpm range with some stations sending up to 20 wpm. Some of the bigger stations can, occasionally, complete contacts via SSB but FM is not used. Also, JT44, a digital mode of communications, will briefly be discussed later. For now, assume CW.

- **Minimum Station**

Antennas – A single yagi, horizontally polarized (not circular) with about 12.5 dBd gain (or about 14.6 dBi gain) with an azimuth rotator should be sufficient. Having the ability to elevate the antenna will give a lot more flexibility as to when you can operate along with a lot of moontime. With no elevation, you will only have about one hour of moontime at rise and set along with the potential for ground gain enhancement. Depending on your QTH, however, terrestrial noise may be worse with the antenna on the horizon. Don't expect to hear your own echoes with this minimum station.

Receiver, Transmitter and Power – Any reasonably good 2m receiver and transmitter or transceiver that can operate CW can be used. Either a receiver RIT (or clarifier) or split VFO will be needed to be able to compensate for doppler shift. A narrow IF filter (such as 500 Hz bandwidth) and/or internal or external DSP capability will help improve the signal-to-noise ratio of any weak EME signal being heard. A "brick" power amp with at least 150 watts output is the minimum power needed.

Preamp and Feedline – A low noise preamp with a noise figure of less than 1.5 dB is needed. At 2m, it can be mounted in the shack as long as good low loss feedline is used. The shorter the length of feedline, the better. With the preamp in the shack, low loss feedline will minimize the degradation of the receiver noise figure and maximize the amount of transmitted power getting to the antenna. Preferably, the feedline should be under 50 feet of Belden 9913, LMR 400 or comparable. For longer runs, consider using heliax. RG-58 should never be used and RG-8 probably shouldn't be used due to losses. Ideally, the preamp will be mast mounted at the antenna. It needs to be protected from transmitting into it either via internal RF sensing and relays when lower power levels are being used or with a sequencer when running higher power levels.

Tracking The Moon – A computer running one of the many commercially available or shareware moon tracking programs will be needed. Examples include "Skymoon" by W5UN, "Z-Track" by N1BUG, "MoonSked" by GM4JJJ, "Tracker" by W7GJ, "EME Planner" by VK3UM, etc. (see reference section). These programs will tell you when conditions are optimal for EME as well as when you and another station have a common moon window and good polarity.

Who Can You Work With A Minimum Station? – The author worked 15 initial stations on 2m EME, during a one year period, using a single horizontally polarized 13 element yagi with about 12.5 dBd gain (KLM 13LBA) with azimuth and elevation rotators. A Yaesu FT-726R transceiver, Timewave DSP-59+ and TE Systems "brick" with internal preamp and running about 180 watts output was used. TE Systems amps for both 2m and 70cm along with an Astron power supply are mounted in a weatherproof box at the base of a nine foot roof mounted tower. This kept the feedline loss between the power amp and preamp and the antenna to a minimum. All stations were worked using either 30 or 60 minute skeds.

The following is a list of some of the stations worked by K6PF and their current antenna configuration. You may want to try to arrange skeds with some of these stations since all of them are either "big guns" or at least are "larger" stations:

K5GW (48 yagis)
VE7BQH (384 element collinear)
W5UN (32 yagis)
IK3MAC (30 yagis)
F3VS (24 yagis – H & 8 – V, no skeds)
SM5FRH (24 yagis)
W5LBT (24 yagis)
I2FAK (24 yagis)
SM5BAE (24 yagis)
W7GJ (16 yagis)
WA9KRT (16 yagis)
W0RWH (16 yagis)
KB8RQ (8 yagis)
K1CA (8 yagis, x-pol)
HB9Q (8 yagis)
K9MRI (8 yagis)
KJ9I (8 yagis, x-pol)
DL5MAE (8 yagis)
OK1MS (8 yagis)
AA4FQ (8 yagis)
SM2CEW (6 yagis, x-pol)
W0HP (6 yagis)
K2GAL (4 yagis, 21 el on 52' booms)
W7FG (4 yagis, 20 el)

- **More Advanced Station**

The following station will have sufficient capability to allow you to hear your own echoes at least some of the time and to hear, and regularly work, via skeds or random, CW stations of similar size as long as EME conditions are reasonably favorable. You may also be able to work one or two yagi stations on occasion.

Antennas – Four yagis with booms of at least three wavelengths long are needed. Five wavelength booms are better. Full azimuth and elevation capability is required and yagis should be either horizontally or cross-polarized. X-pol will result in more contacts, within a given period of time, since faraday rotation will be less troublesome. Antenna gain should be greater than 18 dBd (20.1 dBi).

Receiver, Transmitter and Power – A good HF transceiver and 2m transverter are preferred although a quality 2m or multi-mode transceiver will suffice. Minimum power should be in the 800 to 1000 watt range. More power is better so running the legal power limit is best.

Preamp and Feedline – A low noise GaAsFet mast mounted preamp should be used with a sequencer to prevent "burning out" the GaAsFet during transmit. Usually, separate transmit and receive feedlines are used and a high quality transmit feedline such as 7/8" heliax is used to minimize the loss of transmit power arriving at the antennas. The feedline from the preamp output is less critical but an overall receive system noise figure of about 1.0 to 1.5 dB is a good design goal.

Computer – In addition to running a moon-tracking program, additional programs such as "FFTDSP" by AF9Y, "DSP Blaster" by K6STI, or "Hamview" or "Spectran" by I2PHD and IK2CZL can help locate weak signals (see reference section).

Photo A shows the antennas at K6PF. The two antennas on the nine foot roof mounted tower include a KLM 13LBA for 2m and a KLM 30LBX for 70cm. The box on the tower houses an Astron power supply and TE Systems amps for 2m and 70cm. Both antennas are horizontally polarized and have azimuth and elevation capability. The rear antennas include four M^2 2MXP20's for 2m EME. These are x-pol antennas with elements in the horizontal and vertical planes and the ability to switch between them. Photo B is a close up picture of the four x-pol yagis at K6PF.

Photo A – Antennas at K6PF

Photo B – EME array at K6PF consisting of four x-pol yagis with a mast mounted preamp and relays and TV camera

Selecting The Best Times To Operate And Setting Up Skeds

When starting out on 2m EME, and especially if running a minimum sized station, try to concentrate on weekends that show conditions as “Good” or “Very Good” on W5LUU’s Weekend Moondata chart as long as it’s not within one or two days of a new moon due to sun noise. Skeds can be run anytime, and not just on weekends, as long as a common moon window exists. With any of the moon-tracking programs mentioned, it’s helpful to look at conditions for several days on either side of the best Sundays on W5LUU’s chart. This will identify the days that offer optimal EME conditions. Oftentimes, these occur during weekdays.

There are several ways to go about proposing and setting up skeds. They include posting a message on “Moon-Net”, checking into the 2m EME net on weekends, contacting a potential sked station directly via email, or posting a message in real time on the EME Logger. The EME Directory, which is maintained by W5LBT, can also be helpful (see references). “Moon-Net” is the main reflector being used for 2m EME. Go to http://www.nlsa.com/nets/moon-net-help.html for posting and subscription instructions. You might want to post a message on Moon-Net saying, for example, that you’re just starting out on 2m EME and are looking for skeds with some “big guns” and see who responds. Be sure to mention your station capabilities especially pertaining to antennas, power and whether you have elevation or are limited to your moonrise and moonset. If you are not sure when to try a sked, ask any station replying to your posting for suggestions. “Big gun” & “larger” stations have experienced operators who are always looking for the opportunity to work a new station for a new “initial” contact. They appreciate the challenge of working small stations and you will find them very helpful if you’re just getting started. In fact, you will find many members of the EME community ready to help you with answers to any questions that you post on Moon-Net.

Another way to arrange skeds is by checking into the 2m EME net held every Saturday and Sunday at 1600 UTC when daylight savings time is in effect and at 1700 UTC when on standard time. The net is on 20 meters (14.345 MHz) and Lionel, VE7BQH, is net control. You can also email Brian, W3EME, at w3eme@mtwirefree.net and request his help to arrange some skeds for you. Both Lionel & Brian are excellent at determining times when conditions are potentially most favorable. Again, be sure to let them know your station setup.

The EME Logger at http://dxworld.com/emelog.html is an excellent real time site to monitor and to arrange skeds. Because of the limited length of message you can post on this logger, this probably is not the best place to "get your feet wet" to set up skeds. However, it is an excellent place to go to find out who's on at any given time so you can do some listening.

An excellent shareware program with which to become familiar is SKD 87 which is used by Lionel as net control and by many EME operators. It can be downloaded from AF9Y's website (see references). Usually, one or more files used by SKD 87, such as "vhfsched.skd", are updated weekly & distributed by W3EME. This program is very useful for setting up skeds since it identifies a common moon window, when spatial polarity is best and it also helps prevent frequency and time conflicts with other station's skeds. SKD 87 also has a feature where you can view all stations having skeds on 2m during a given period of time. This feature provides an excellent source of stations to listen for during your common moon windows.

Let's look at an example of how K6PF, from his QTH, would use SKD 87 to determine when the best time would be to propose a sked with I2FAK who uses 24 yagis and also with W5UN who uses 32 yagis. Assume for the moment that K6PF does not have elevation and, therefore, is limited to operating only during his moonrise and moonset (say moon elevations between 0 and 12 degrees). Using any of the moon tracking programs mentioned, it is determined that conditions look very favorable on September 22 and 23, 2003 and that K6PF's moonrise on September 22 is 0951 UTC and on September 23, it is 1056 UTC. Be sure that your computer clock is set to UTC time when running these programs. These dates are chosen since degradation is very low (i.e., only 1.3 dB) and declination is reasonably high. Also, these dates are two to three days before new moon.

Since skeds usually start on either the hour or half-hour, SKD 87 shows us that a sked with I2FAK on September 22 at 1000 UTC will have good spatial polarity and the moon's elevation during a 30 minute sked will be during K6PF's moonrise. SKD 87 also shows information about I2FAK such as his sked frequency (144.061 MHz), his name, grid, equipment, email address, etc. Similarly, a sked with W5UN on September 23 at 1100 UTC looks favorable on his sked frequency of 144.041 MHz.

Armed with this information, K6PF may then choose to email both stations directly to propose a sked. For example, an email to I2FAK may say:

Hello Franco. I'm just getting started on 2m EME and am running 180 watts to a single yagi (12.5dBd gain) with no elevation. I would like to propose a sked with you for September 22, 2003 during my moonrise starting at 1000 UTC and running for 30 minutes on 144.061. I2FAK to start with 2 minute sequences. Would you be available for this proposed sked?

73, Bob, K6PF

Be sure to propose skeds sufficiently in advance to allow time to work out the details via email.

When K6PF actually runs this sked, he will transmit on the sked frequency of 144.061 MHz. Since it is during his moonrise, he will need to listen about 350 Hz higher due to doppler shift. Actually, he will tune about +/- 750 Hz around the expected receive frequency (sked frequency +

doppler shift) to listen for I2FAK. The moon tracking program that will be running during your skeds will tell you the amount of doppler shift as well as the moon's position in azimuth and elevation.

Operating Procedures For 2m EME

Skeds are usually run for 30 minutes but 60 minutes is reasonable when a minimum sized station is involved. This allows for at least one complete cycle of faraday rotation. Sequences are typically two minutes for skeds and one minute when working stations on random although some operators prefer one minute sequences even for skeds. Random contacts are a challenge for a small station. Just be sure both stations agree ahead of time on both the sked duration and sequence length.

By convention, the eastern most station starts if the sked begins on the top of the hour and the western most station begins on the half-hour. In the example of the sked between K6PF & I2FAK starting at 1000 UTC, I2FAK is the eastern station and K6PF is the western station. Therefore, I2FAK would transmit during the first two minute sequence since the sked starts on the top of the hour. It's important that your clock is accurately set when running skeds so that both transmit and receive sequences are accurate. Remember, also, that the mode is CW and you will want to use a code speed in the 10 to 20 wpm range which is the optimum speed considering conditions over the EME path, especially libration fading.

A "Xmit/Rcve Sequence Sheet" is available from W5UN's website at http://web.wt.net/~w5un/sequence.htm and is also included at the end of this article. This is already set up for two minute sequences. It is recommended that you go to this website and download a good quality original form to keep as a master copy and use a copy of it for every sked. This form helps keep track of who transmits when and you also can make notes on it as to what you're copying during each receive sequence. It also provides a good record for each contact when a QSO is completed.

When I'm calling I2FAK, or any other station, I do not send "de" between calls. Although many EME operators do send it, it isn't necessary and only adds unneeded additional information that you are trying to copy from a potentially very weak signal. In my sked example, I would just send I2FAK K6PF I2FAK K6PF for the entire two minute sequence at the start of our sked.

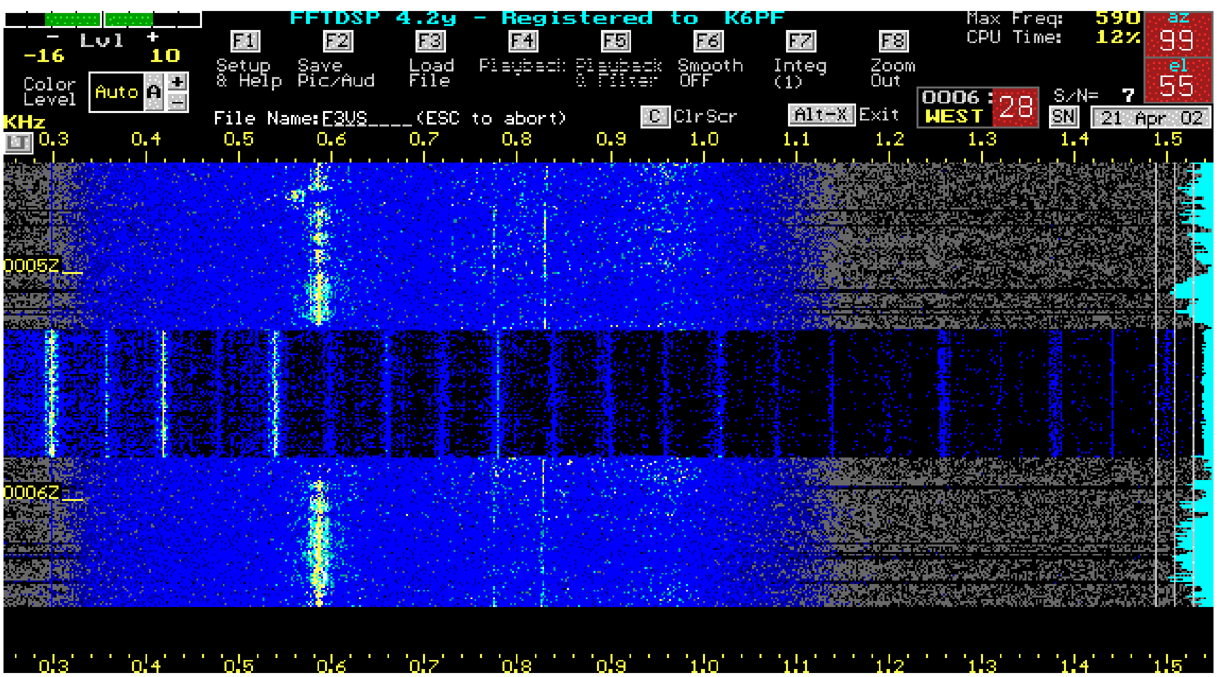
For a successful and valid 2m EME QSO, the only information required is the copying of both call signs by both stations as well as a signal report and acknowledgement which usually consists of O's, RO's and R's. 73's are frequently sent but are not required for a valid QSO. Websites for both W5UN and N1BUG (see references) have excellent discussions on operating procedures for both skeds and random contacts. Due to space limitations here, please refer to those websites for more detailed information.

One operating problem, which many of us have encountered, should be addressed. It is even being done by some experienced EME operators and has kept many QSO's from being completed which should have been successful. With experience, you will have some idea of what has been copied by the other station and what information is still missing. Let's assume you copied both callsigns after a couple of sequences and are ready to send O's. The other station is still sending both callsigns for the entire sequence. Therefore, you know for certain that he has not copied complete calls or he would be sending O's. What you don't know is whether he hasn't heard you at all, is missing only one more letters, or may be somewhere in between. When you go to send O's in such a situation, it is <u>very important</u> that you still send both callsigns for 75% of the sequence and send O's for only the last 25%. For two minute sequences, that means sending callsigns for the first 90 seconds and O's for the last 30 seconds. This will maximize the chance for the other station to hear any missing information. Such a scenario is common and, oftentimes, the other station will send calls only once or twice and, due to all of the excitement of copying both callsigns, they will send O's for the rest of the sequence. Since dashes are easier to copy off the moon than dits, O's come through better than many other letters or numerals in callsigns. Remembering this one important point will, over time, result in a lot more completed EME QSO's.

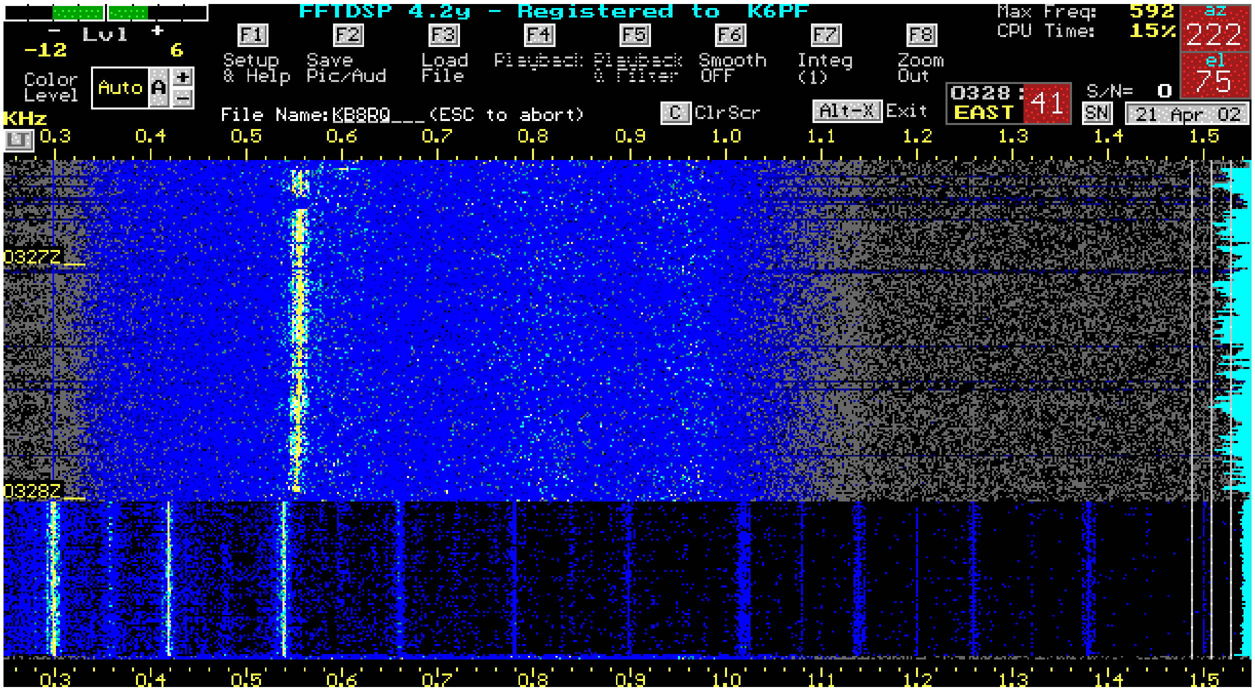
Sample FFTDSP Displays

As an illustration of the wide range in EME signal strengths, four FFTDSP displays follow. These signals were received at K6PF using the four x-pol yagis, a FT-726R transceiver using a 600 Hz CW filter and a DSP-59+ using a fairly wide 250 to 300 Hz audio filter. A brief comment precedes each display. All signal-to-noise ratios (snr) on the FFTDSP displays are referenced to a 100 Hz bandwidth.

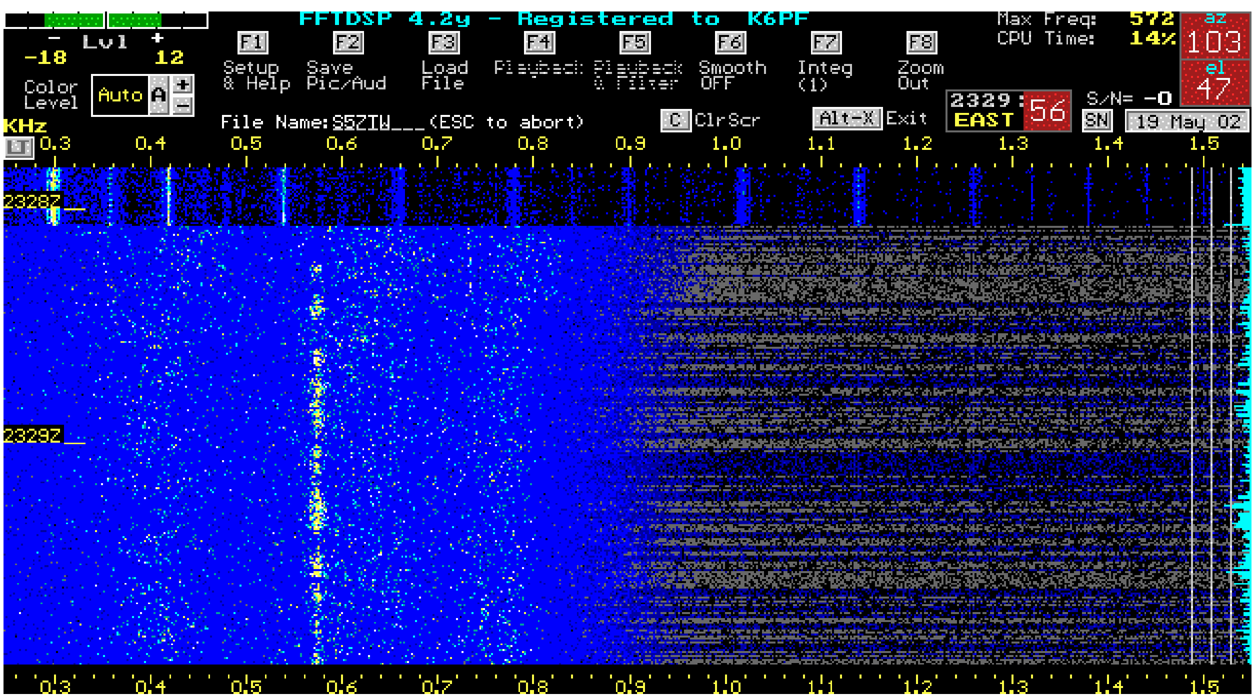
- F3VS (24 yagis – horizontal and 8 yagis –vertical polarization). The signal peaked at 22 dB but averaged about 15 dB snr. Extremely easy to copy this signal.



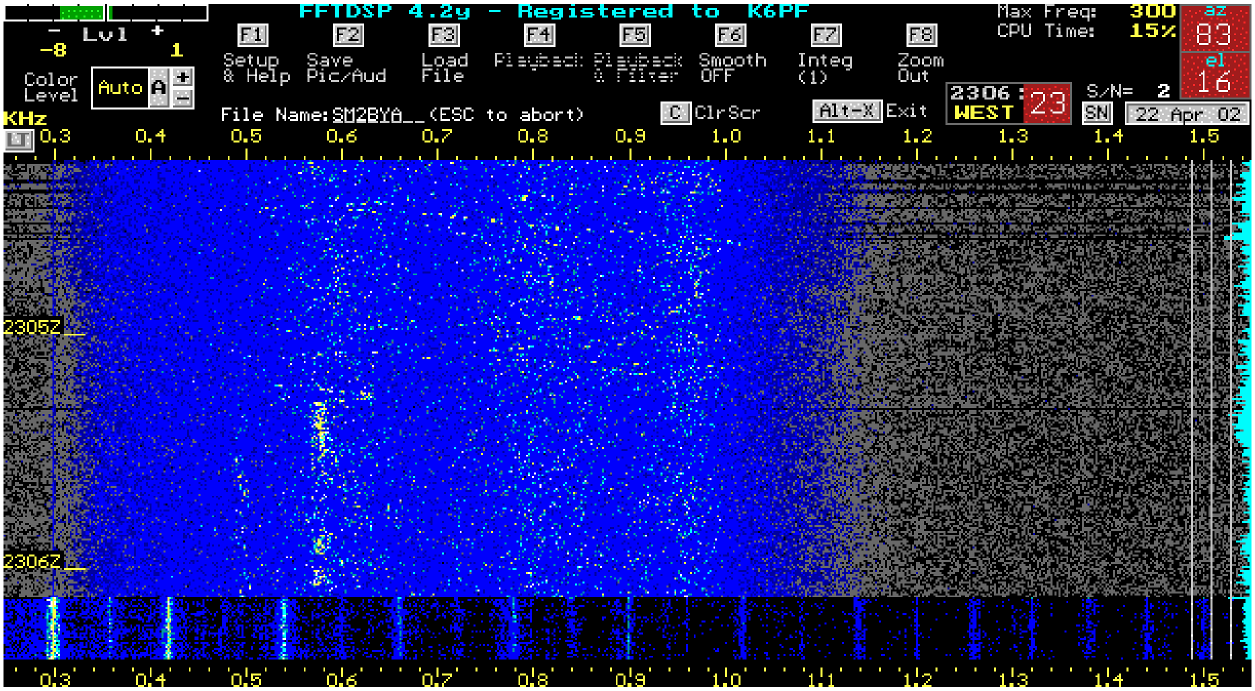
- KB8RQ (8 yagis). The signal peaked at 20 dB and averaged 10 to 12 dB snr. Very easy to copy this signal.



- S57TW (4 x-pol yagis). The signal peaked at 11 dB but averaged about 6 dB snr with lots of QSB. This signal can be copied although it may take more than one sequence to copy complete callsigns.



- SM2BYA (4 yagis). The signal peaked at 10 dB but averaged about 5 dB snr with tremendous QSB. Very difficult to copy this signal.



Digital Techniques

As part of his WSJT software program, Joe Taylor, K1JT, has recently developed JT44 for EME operation as an enhancement to WSJT. Many people have been experimenting with JT44 and are having tremendous success. Please visit K1JT's website at http://pulsar.princeton.edu/~joe/K1JT for additional information. This digital mode of communications apparently has about a 10 dB snr advantage over CW and will make it much easier for a minimum sized EME station to work a greater number of other stations than would be possible on CW except for under the best of circumstances.

At this time, I have not had any personal experience using JT44 but applaud Joe Taylor for his tremendous contribution to amateur radio. Since I get very excited hearing that CW signal being reflected off the moon, my personal emphasis, at this time, is on improving my station so I can work many new initial stations on CW.

Good articles on JT44 appeared in the June 2002 issue of CQ, the Spring 2002 issue of CQ-VHF, and the June 2002 issue of QST.

Conclusions

EME is truly the ultimate DX and 2m EME is the easiest frequency on which to get started. The technical aspects of it are less challenging and there is a much larger pool of operators on 2m than on higher frequencies. Nevertheless, it still is incredibly challenging and rewarding. For the weak signal enthusiast who loves to chase more grids or who strives to earn WAS, WAC and DXCC on 2m, EME is essential.

Hopefully, this article has provided you with the knowledge, tools and resources that will inspire and motivate you to give 2m EME a serious try. You now should have an understanding of some of the technical challenges, know who some of the bigger stations are to try to work, know how to set up skeds during the best possible times, understand the proper operating procedures and have a list of references to further help you become successful. EME is not only the ultimate DX but also the ultimate weak signal form of communications in amateur radio. As with anything new, there will be challenges and there is a learning curve but you need to persevere until you succeed.

One of the most thrilling experiences in amateur radio is to hear the CW from a very weak signal that has traveled a half a million miles with only 7% of it being reflected off the moon. It certainly gets the adrenaline going!

MOONDATA UPDATE-2003 AND RELATED COMMENTS
By Derwin King, W5LUU

While a number of factors affect EME communications, the distance from the earth to the moon and the cosmic noise temperature in the direction of the moon are predictable, cyclical variables that set the basic day to day quality of the earth-moon path. Other things being equal, best EME conditions occur when the moon is: 1) at the best possible perigee and 2) near the RA and DEC. of the coldest sky along its path. Signal to noise degradation (DGRD) from these two variables, in dB referenced to the best possible, are tabulated on the next page along with other pertinent data. These are for each Sunday at 0000 UT to provide a guide to the 144MHz and 432 MHz weekend conditions in 2003.

In 2003 the average DGRD continues to increase as moon perigee occurs at increasing RA and southern declinations where the sky noise (temperature) is generally higher. This trend will continue for the next 2 to 3 years as the position of perigee vs RA proceeds along its near 9 year cycle. DGRD will be very low again in 2007-2010 as perigee occurs within a few hours RA of cold sky. Meanwhile don't give up. There is one VERY GOOD weekend monthly from Jan. –May. In addition there are two (2) good ARRL Contest weekends: Oct. 18, 19 and Nov. 15, 16. We should quickly lay claim to these for the EME Contest. In addition to weekends, there are many GOOD to EXCELLENT days during the week, especially in Jan – June 2003. Enjoy and good luck.

DEC. (deg) : Moon declination north and south (-) of the equator. This is cyclical with an average period of 27.212221 days. The maximum monthly declination is also cyclic with a range of 18.15 to 28.72 and a period of about 19 years. Next maximum is in 9/2006.

RA (hrs) : Right ascension in hours. East-West position of the moon against the sky background. Average period of RA cycle is 27.321662 days but it can vary by a day or so.

144 Mhz Temp (K) : 144 Mhz sky (cosmic) noise in direction of moon expressed as temperature.

Range Factor (dB) : The additional EME path loss, in dB, due to a earth-to-moon separation distance greater than the absolute minimum (348,030 km surface-to-surface) Varies from a low (0 to .7 db) at perigee to as much as 2.43 dB at apogee.

DGRD, (dB): The 144 and the 432 MHz degradation in EME signal-to-noise, in dB, due to the excess sky noise (assuming a very narrow beam antenna) in the direction of the moon plus the earth–moon separation distance at the indicated moon position and date. During a monthly lunar cycle this factor can vary by more than 13 dB at 144 and 8 dB at 432. DGRD is referenced to the lowest possible sky noise along the moon path, to a system noise temperature of 80 K at 144 and 60 K at 432 and to the absolute minimum perigee distance. 144 and 432 DGRD are equally affected by EME distance but at 432 the sky noise varies less.

Moon Phase : Shows new moon (NM) and full moon (FM) along with the number of days (d) Or hours (h) before (-) or after (+) these events. At NM sun noise can be a problem while at FM the stable night time conditions can be advantageous.

Conditions : Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbances, but not better than Indicated. In general 144 MHz DGRD under 1.0 dB is considered excellent, 1.0 to 1.5 is very good, 1.5 to 2.5 is good, 2.5 to 4.0 is moderate, 4.0 to 5.5 is poor, and over 5.5 is very poor. New moon can make conditions very poor.

Date 2003	Dec. deg.	RA hrs.	144 MHz Temp. K	Range Factor dB	DGRD, dB 144 MHz	432 MHz	Moon Phase	CONDITIONS
Jan 05	-21.9	21.0	331	1.37	3.6	1.9	NM + 2d	Moderate
12	11.3	2.3	348	2.23	4.6	2.8		Poor
19	**23.1**	**8.6**	**186**	**1.08**	**1.4**	**1.2**	**FM + 1d**	**VERY GOOD**
26	-14.1	14.8	405	0.73	3.7	1.5		Moderate
Feb. 02	-19.6	21.6	341	1.55	3.9	2.1	NM + 13h	Moderate
09	14.5	2.9	363	2.23	4.8	2.9		Poor
16	**21.1**	**9.2**	**172**	**0.84**	**1.0**	**0.8**	**FM**	**EXCELLENT**
23	-18.2	15.5	455	0.70	4.1	1.6		Poor
Mar 02	-16.8	22.1	269	1.78	3.3	2.1	NM – 1d	Moderate
09	17.6	3.4	359	2.26	4.8	2.8		Poor
16	**18.9**	**9.7**	**185**	**0.74**	**1.1**	**0.8**	**FM – 2d**	**VERY GOOD**
23	-21.4	16.2	588	0.55	4.9	1.7		Poor
30	-13.5	22.7	244	1.97	3.2	2.3	NM – 3d	Moderate
Apr 06	20.5	3.9	365	2.28	4.9	3.0		Poor
13	**16.3**	**10.3**	**194**	**0.77**	**1.2**	**0.9**		**VERY GOOD**
20	-23.8	16.8	817	0.39	6.0	1.9	FM + 3d	Poor
27	- 9.8	23.3	244	2.07	3.3	2.4		Moderate
May 04	22.9	4.6	417	2.25	5.3	3.1	NM + 3d	Poor
11	**13.1**	**10.8**	**206**	**0.87**	**1.5**	**1.0**		**VERY GOOD**
18	-25.3	17.5	1828	0.31	9.2	3.4	FM + 3d	Very Poor
25	- 6.0	23.9	250	2.08	3.4	2.5		Moderate
Jun. 01	24.8	5.2	490	2.16	5.8	3.2	NM + 20h	Very Poor
08	**9.0**	**11.4**	**232**	**0.94**	**2.0**	**1.1**		**GOOD**
15	-26.2	18.1	3064	0.38	11.5	4.9	FM + 1d	Very Poor
22	- 2.1	0.4	266	2.05	3.5	2.5		Moderate
29	25.9	5.9	503	2.01	5.8	3.3	NM – 19h	Very Poor
July 06	**4.4**	**12.1**	**268**	**0.94**	**2.5**	**1.3**		**GOOD**
13	-26.4	18.7	1546	0.58	8.8	4.2	FM	Very Poor
20	1.7	0.9	279	2.03	3.7	2.5		Moderate
27	26.5	6.5	417	1.85	4.9	2.8	NM – 2d	Poor
Aug 03	- 0.6	12.7	313	0.82	2.9	1.4		Moderate
10	-26.1	19.4	658	0.85	5.6	2.6	FM – 2d	Very Poor
17	5.4	1.3	293	2.05	3.9	2.5		Moderate
24	26.5	7.1	355	1.73	4.2	2.4		Poor
31	- 5.4	13.3	319	0.60	2.7	1.1	NM + 3d	Moderate
Sept 07	-24.9	20.1	372	1.11	3.8	1.8		Moderate
14	9.1	1.8	313	2.13	4.2	2.7	FM + 3d	Poor
21	25.9	7.6	274	1.69	3.3	2.1		Moderate
28	- 9.7	13.9	343	0.34	2.7	0.9	NM + 2d	Moderate
Oct. 05	-22.9	20.9	333	1.29	3.5	1.9		Moderate
12	12.7	2.3	345	2.23	4.6	2.8	FM + 2d	Poor
19	**24.8**	**8.3**	**203**	**1.73**	**2.3**	**1.9**		**GOOD**
26	-13.3	14.4	379	0.13	2.8	0.8	NM + 11h	Moderate
Nov 02	-20.0	21.6	339	1.34	3.7	1.9		Moderate
09	16.1	2.9	364	2.31	4.9	2.9	FM	Poor
16	**22.9**	**8.9**	**171**	**1.79**	**1.9**	**1.8**		**GOOD**
23	-16.5	15.0	414	0.08	3.1	0.8	NM – 23h	Moderate
30	-16.8	22.2	266	1.29	2.8	1.7		Moderate
Dec 07	19.2	3.5	358	2.34	4.8	2.9	FM – 2d	Poor
14	**20.2**	**9.5**	**183**	**1.77**	**2.1**	**1.7**		**GOOD**
21	-19.5	15.5	453	0.21	3.6	1.1	NM – 2d	Moderate
28	**-13.4**	**22.7**	**244**	**1.20**	**2.4**	**1.5**		**GOOD**

xmit/rcve sequence sheet

(one sheet per schedule, for notes and comments)

```
Date: ___________________________        Station: ______________Freq:          mhz
Time: _________ to________ GMT           Remarks: ____________________________________

EASTERN transmitting sequence            WESTERN transmitting sequence
stn: __________                          stn: _____
=====================================================================================
0 - 2 minutes                            2 - 4 minutes

=====================================================================================
4 - 6 minutes                            6 - 8 minutes

=====================================================================================
8 - 10 minutes                           10 - 12 minutes

=====================================================================================
12 - 14 minutes                          14 - 16 minutes

=====================================================================================
16 - 18 minutes                          18 - 20 minutes

=====================================================================================
20 - 22 minutes                          22 - 24 minutes

=====================================================================================
24 - 26 minutes                          26 - 28 minutes

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28 - 30 minutes                          30 - 32 minutes

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32 - 34 minutes                          34 - 36 minutes

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36 - 38 minutes                          38 - 40 minutes

=====================================================================================
40 - 42 minutes                          42 - 44 minutes

=====================================================================================
44 - 46 minutes                          46 - 48 minutes

=====================================================================================
48 - 50 minutes                          50 - 52 minutes

=====================================================================================
52 - 54 minutes                          54 - 56 minutes

=====================================================================================
56 - 58 minutes                        | 58 - 60 minutes

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References

1. Website for W5UN is at http://web.wt.net/~w5un/ and it contains a great EME Operating Primer and information on “Skymoon” and “Cwkey5” EME software.

2. Website for N1BUG is at http://www.n1bug.net/ and then click on the EME (Moonbounce) link. Also, under “Miscellaneous VHF ‘How To’ Information”, click on “Getting Started in EME” and “Polarization of EME Signals”. Excellent tutorials. “Z-Track” is a software program that can be downloaded for moon tracking, etc.

3. Website for GM4JJJ is at http://www.gm4jjj.co.uk/ and it contains information on “MoonSked”, a moonbounce scheduling software program for Macintosh and Windows.

4. Website for W7GJ is at http://bigskyspaces.com/w7gj/ and it contains moonbounce operating tips and information on “Tracker”, a moon tracking program.

5. Website for AF9Y is at http://www.af9y.com/ and click on “Moonbounce (EME) Operation”. This contains information on “SKD 87”, an EME scheduling program and also information on “FFTDSP” software and applications.

6. The EME Directory can be downloaded from W5LBT’s website at http://www.qsl.net/w5lbt/

7. To subscribe to “The 144 MHz EME Newsletter” published by Bernd, DF2ZC, send a blank email to eme-news@t-online.de .

8. The weak signal and SETI page for W6/PA0ZN is at http://www.nitehawk.com/rasmit and contains interesting EME information and the “432 MHz and Above EME Newsletter”.

9. For “DSP Blaster” software by K6STI, go to http://www.setileague.org/software/dspblast.htm for information.

10. For “Hamview” or “Spectran” software by I2PHD and IK2CZL, go to http://www.weaksignals.com for information.

11. “The VHF/UHF DX Book” published by RSGB (Radio Society of Great Britain) is available from ARRL.

12. “’To The Moon, Alice!’ – Part 1, 2-meter Moonbounce Basics” by Tim Marek, NC7K (now K7XC), October 1996 CQ-VHF.

13. “More ‘QRP’ EME on 144 MHz” by Ray Soifer, W2RS, October 1990 QST.

14. “QRP EME on 144 MHz” by Ray Soifer, W2RS, February 1989 QST.

Biography of Bob Kocisko, K6PF

Bob Kocisko was first licensed in Tucson, AZ in the late 1950's while in Junior High School. His first callsign was KN7KYQ and then K7KYQ. He let his license expire in the late 1960's but during this ten year period, his primary operational areas of interest included 2m and 70cm weak signal work, 70cm ATV and some HF. He was fascinated even back then by the concept of EME communications.

Bob obtained a BSEE degree in 1969 from The University of Arizona and a MSEE degree in 1974 from The University of Southern California. His career path included two years as a hardware design engineer for radar receivers at Hughes Aircraft Co., then four years selling electronic test equipment for Tektronix, and finally being a commercial and investment real estate broker for the past 27 years.

With a desire to get back into amateur radio, Bob became re-licensed in 1996 and briefly held the callsigns KF6FEV, KQ6JN and AC6YJ and, in February 1997, he obtained the vanity callsign K6PF. Bob holds an Amateur Extra Class license and has resided in Fountain Valley, CA since 1976.

During the past six years, his focus has been on working weak signals on CW and SSB, predominately on 2m and 70cm along with some of the analog satellites. During a one year period from late 1997 to late 1998, he worked 15 initial stations on 2m EME using a single 13 element yagi and only 180 watts of power.

In June 2000, Bob started operating on 2m EME using four cross-polarized (x-pol) yagis with a mast mounted preamp and a AM-6154 power amp running 425 watts output along with a FT-726R and Timewave DSP-59+. During the past two and one-half years, he worked an additional 129 initial contacts on 2m EME while still operating QRP.

Bob's goals for 2m include achieving VUCC, WAC, WAS and DXCC. As of April 15, 2003, he has 165 confirmed grids towards VUCC + an endorsement (just needs to submit QSL cards for verification) and has 42 states towards WAS of which 19 were obtained via tropo and meteor scatter and 30 via EME (some states were worked via EME and tropo or meteor scatter). He has 33 countries towards the 100 needed for DXCC of which 32 were obtained on EME. Bob now has 150 initial contacts on 2m EME.

For questions or comments, you can reach Bob at k6pf@ix.netcom.com .