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North Texas NTMS Microwave Society

Earth-Moon-Earth (EME) Communications from 902 MHz to 78 GHz

by

Al Ward W5LUA

presented at

HAMCOM

June 10th, 2011

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The Microwave Bands

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Band	Frequency Range	Weak signal work in NA
33 cm	902 to 928 MHz	902 MHz
23 cm	1240 to 1300 MHz	1296 MHz
13 cm	2300 to 2310 MHz	2304 MHz (2301, 2320 and 2424 MHz used outside NA
	2390 to 2450 MHz	
9 cm	3300 to 3500 MHz	3456 MHz (3400 MHz used for EME)
6 cm	5650 to 5925 MHz	5760 MHz
3 cm	10000 to 10500 MHz	10368 MHz (10450 MHz used by JA
1.25cm	24000 to 24250 MHz	24192 MHz (24048 MHz used for EME)
.6 cm	47000 to 47200 MHz	47088 MHz
.35 cm	77000 to 81000 MHz	78192 MHz

The problem…Not all countries have same allocation as us…….

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How long have hams been doing EME on the upper bands?

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- First 902 MHz EME QSO on January 22, 1988 between K5JL and WA5ETV
- First 1296 MHz EME QSO in 1960 between W1BU and W6HB
- First 2304 MHz EME QSO in 1970 between W4HHK and W3GKP
- First 3456 MHz EME QSO on April 7, 1987 between W7CNK and KD5RO
- First 5760 MHz EME QSO on April 24, 1987 between W7CNK and WA5TNY
- First 10368 MHz EME QSO on August 27, 1988 between WA7CJO and WA5VJB
- First 24192 MHz EME QSO on August 18, 2000 between W5LUA and VE4MA
- First 47088 MHz EME QSO in January 2005 between RW3BP and AD6FP
- First 78192 MHz EME QSO TBD but being actively pursued by VE4MA and W5LUA – 2012?

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Path Loss

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- According to the Radar equation, the path loss increases by 6 dB every time the frequency is doubled
- However dish gain also increases by 6 dB every time frequency is doubled
- Since we gain the same 6dB on both receive and transmit and assuming we use the same power and the same NF as we go up in frequency, our echoes will improve as frequency is increased – this is in fact what we see!

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VK3UM EME Performance Calculator

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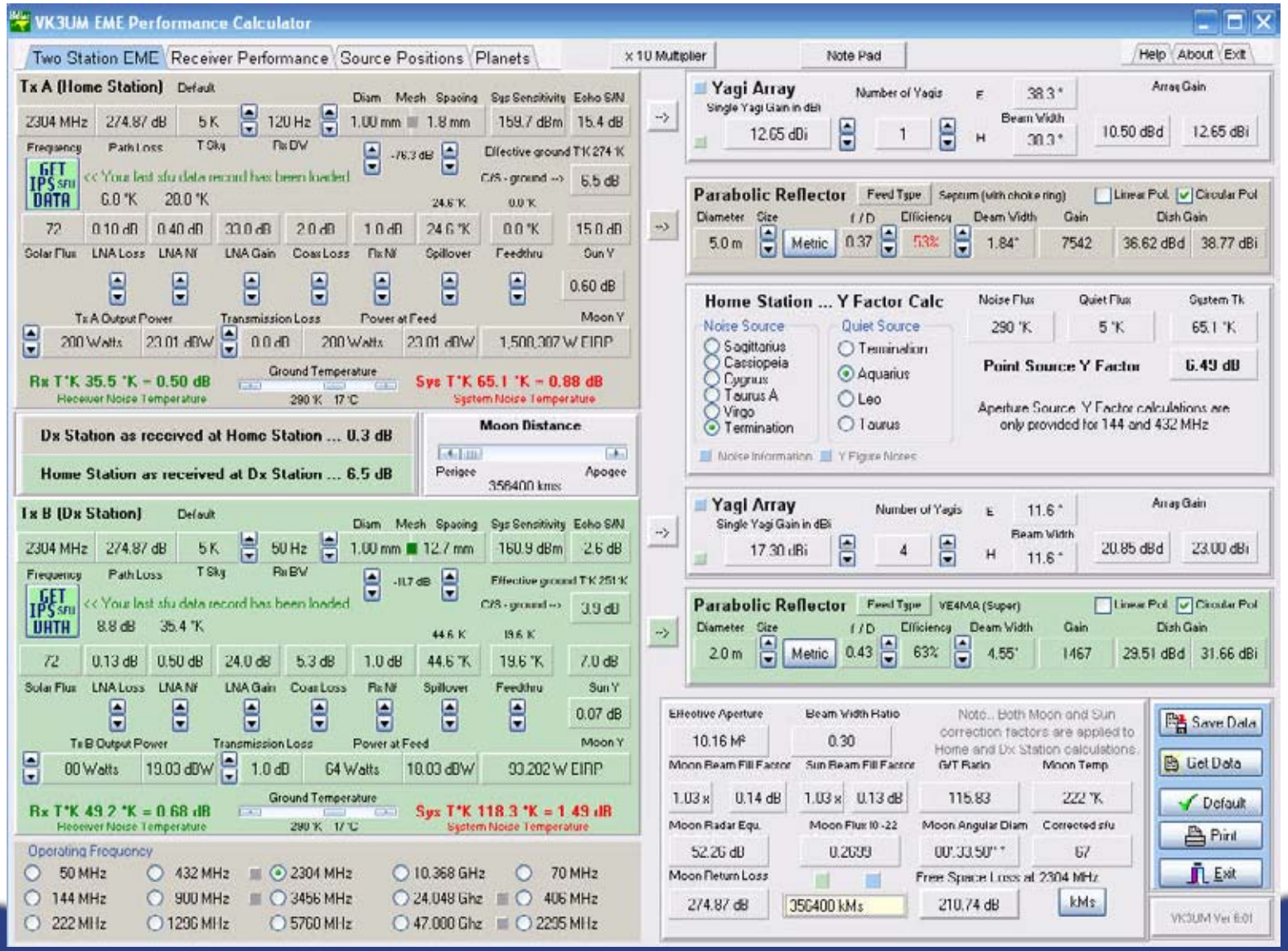

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Doppler

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- The doppler shift is a change in frequency of the signal reflected off the moon and received back on earth.
- Doppler scales with frequency and is an indication of the relative motion of the moon with respect to the earth.
- When the moon is rising the doppler will be positive and when the moon is setting the doppler will be negative. The doppler is at a maximum when the moon is on the horizon and at a minimum at zenith.
- While doppler may be several hundred Hz at 2M, it is over 3 kHz at 1296 MHz and greater than 100 kHz at 47 GHz

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Faraday Rotation

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- According to Skolnik's Radar handbook.."The Faraday rotation of the plane of polarization can be 2 to 5 revolutions in the UHF range, but since it scales as $1/f^2$, is negligible at and above L band" L band is defined in Skolnik as 1000 MHz to 2000 MHz and UHF is defined as 300 to 1000 MHz
- If we scale from 144 to 432 MHz the effect is 1/9
- If we scale from 432 to 1296 MHz it is another 1/9
- We know that time between signal peaks on 6M can be about 5 minutes, and 15 to 20 minutes on 2M and up to hours or days on 432 MHz so….
- In terms of what we hear, does this scale the time in between max and min signal strength or the level in dB between max and min or both?
- Most likely it is scaling the amount of rotation of a linear polarized signal and decreases significantly at 902 MHz and higher

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The transition from 1296 to 2304 MHz

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- Noise figures are very comparable – most sub 0.4 dB.
- Power levels of 200 watts are easily obtainable at 2304 MHz and can be more easily mounted at the feed offering a bonus on 2304 over 1296 – minimal feedline loss.
- Very efficient feeds from OK1DFC, RA3AQ and WD5AGO
- Easier to track the moon because now we are able to see moon noise – why is this?
- VK3UM program to analyze path loss

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Bottom Line

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- With similar equipment on 13 cm and the same size dish, the echoes will be nearly 5 dB stronger on 2304 MHz than they were on 1296 MHz plus we can now track the moon better because we can now see noticeable moon noise
- And it gets even better as we go higher in frequency!

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WD5AGO 8ft Dish for 2304 MHz

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WD5AGO 3.1M Expanded TVRO Dish

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Tommy uses this dish on 1296, 2304 and 5760 MHz from Tulsa, OK.

Tommy has done a lot of work on optimizing feed horns and LNAs

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WD5AGO & Student using a Horn to make EME QSOs on 1296 MHz

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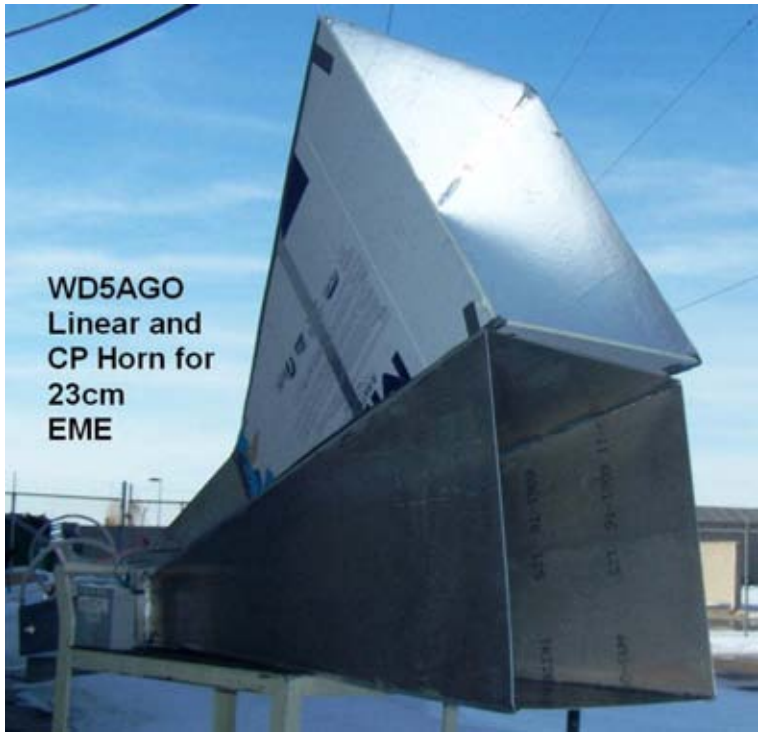

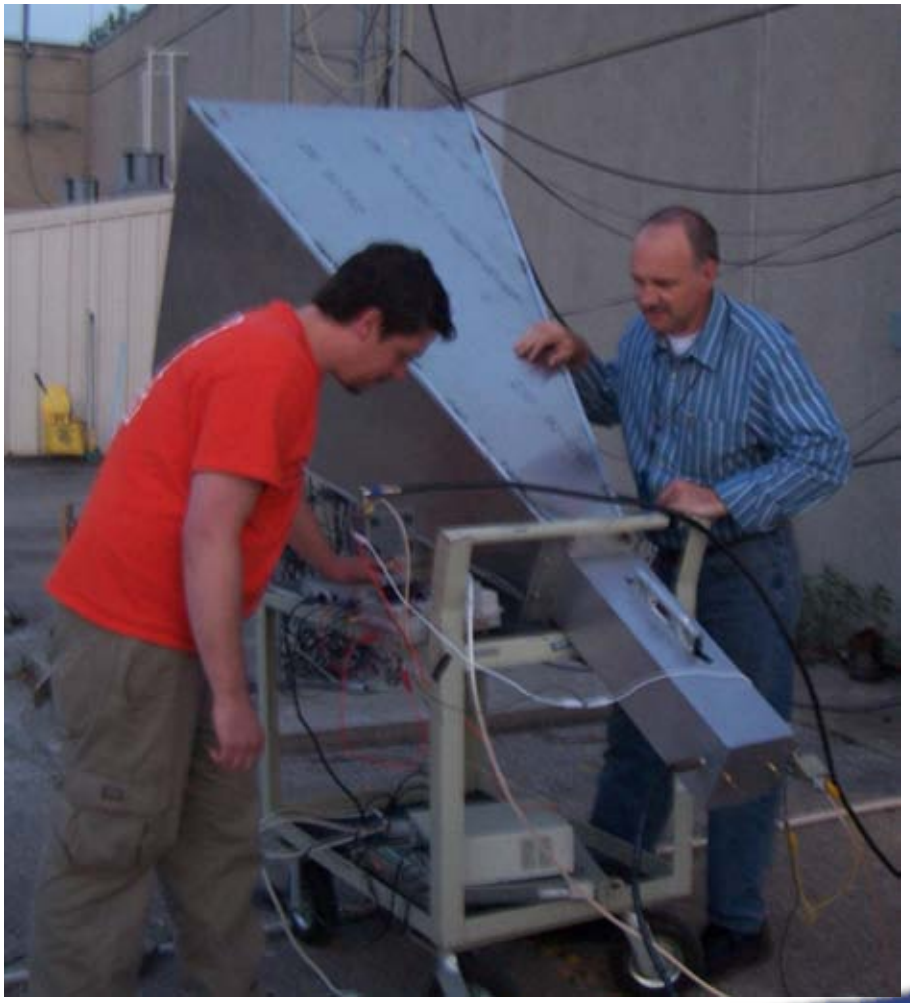

Large aperture horns can also be used to make QSOs via the moon. Horns have very clean patterns with low side lobes

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VK7MO 3M Dish on 1296 & 2304 MHz

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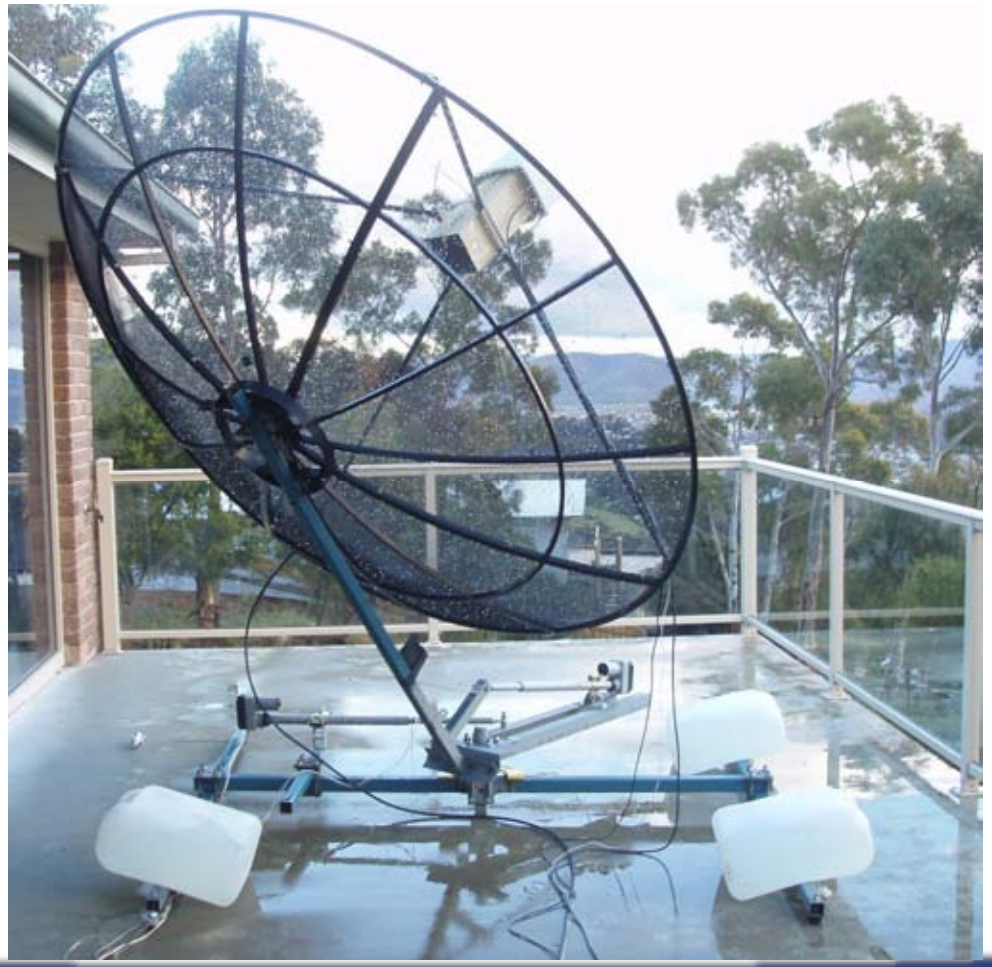

WA5WCP/1 Four States on 1296 EME in 16 Days Aug 2006

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3M (10ft) Diameter Dish

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- 1296 MHz
- 3dB BW 5.3 degrees
- 1 dB BW 3 degrees
- First null at +/-9 deg.
- Gain 30 dBi at 55% efficiency
- Need to be within a couple of degrees

- 2304 MHz
- 3dB BW 3 degrees
- 1dB BW 1.7 degree
- First null at +/-5 deg.
- Gain 35 dBi at 55% efficiency
- Need to be within a degree
- Less is always better!

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Azimuth Rotator Options

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- Ham-M and Tailtwister can only get you with 4 to 5 degrees due to the break wedge – not good enough
- Yaesu G-2800DXA or equivalent with friction break is an option
- M2 2800 with readout to 0.1 degree
- Alpha Spid Rotator
- Prosistel Rotator
- Old prop pitch rotor
- Motor and gearbox
- Linear actuator

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Knowing Where We Are Pointed

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- Potentiometers used in bridge circuit with a regulated 5V supply – pot linearity a big issue – 10 turn pots a better solution – WW2R has a digital readout board that will work with potentiometers
- US Digital Absolute Encoders are a very good solution but pricey – use a shaft encoder for AZ and an inclinometer for EL – connect to pc through the USB or RS-232 port – read by programs like K5GWs and F1EHNs – resolution as high as .01 degree
- Less expensive option is US Digital's incremental encoders which can be read by W2DRZ's controller board – K1RQG and K2DH use this setup with excellent results

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WA8RJF Digital Level Modified for Elevation Readout

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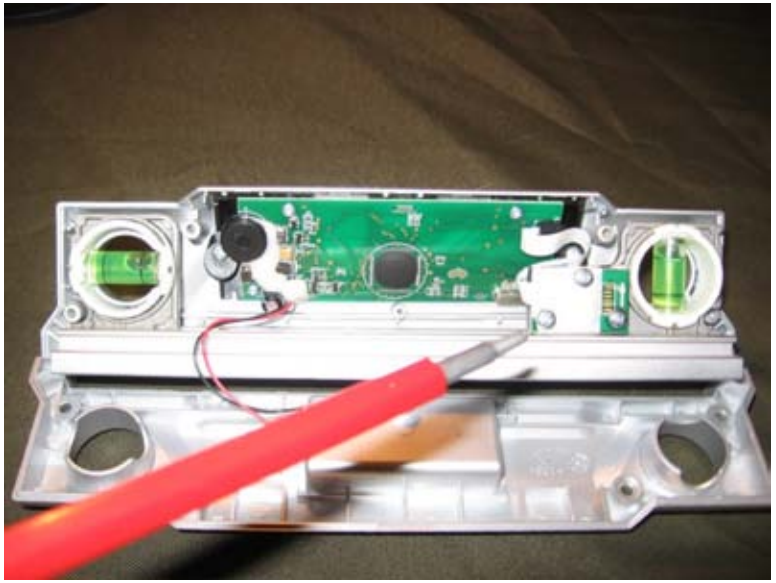

Unmodified

Modified for remote operation
Will read to 0.1 degree

Proceedings of Microwave Update 2008, Bloomington, Mn; page 206

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5 Meter Dish at W5LUA

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Used for EME on

432 MHz
902 MHz
1296 MHz
2304 MHz
3456 MHz
5760 MHz
10368 MHz

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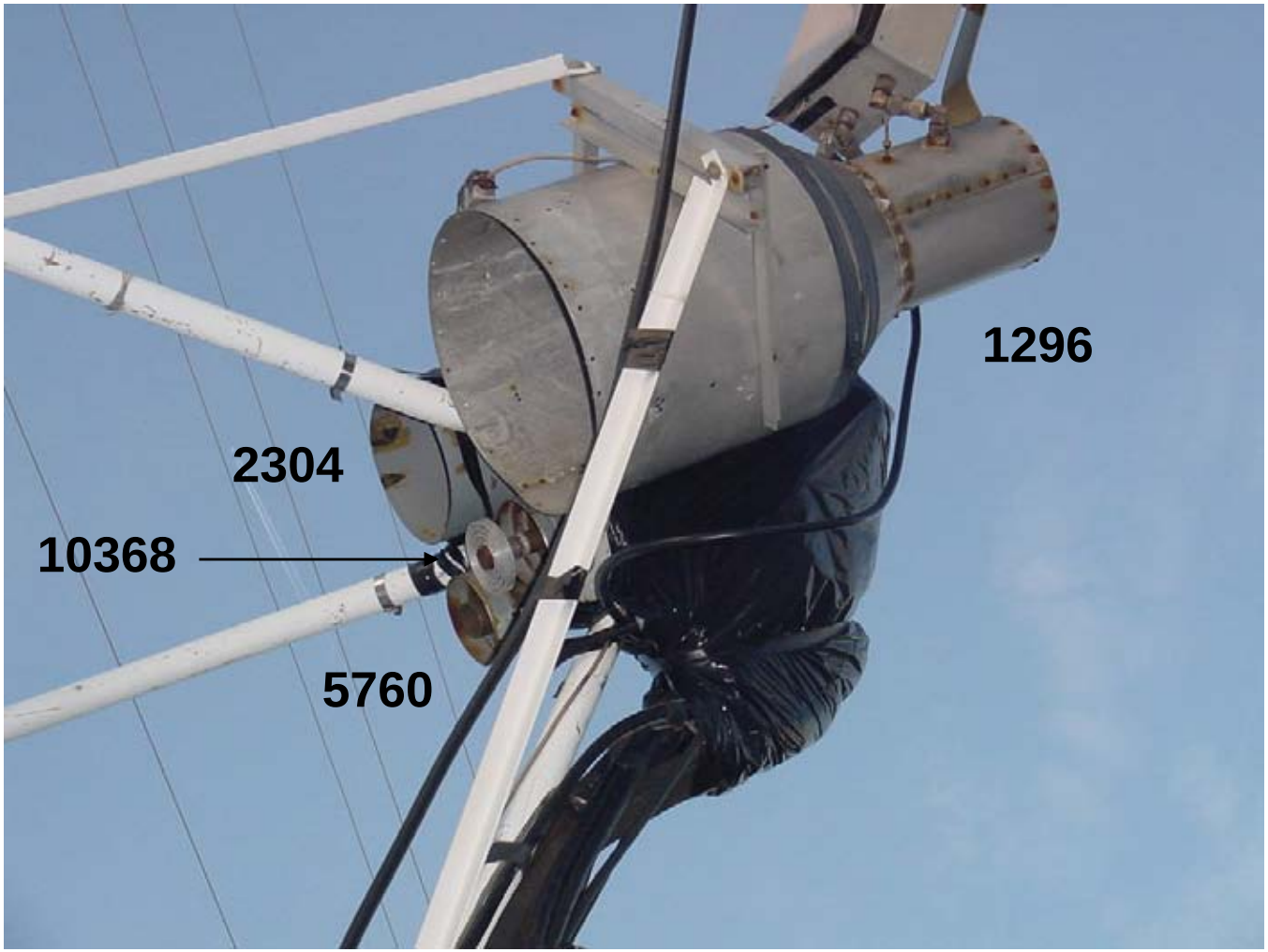
Multi-Band Feed System



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AZ EL Mount for 5 Meter Dish

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Hydraulics for elevation drive
Prop pitch rotor for azimuth drive
US Digital Absolute Encoders for readout and K5GW tracking program

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Prop-Pitch Motor for Azimuth

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IW2FZR on 1296 and 2304

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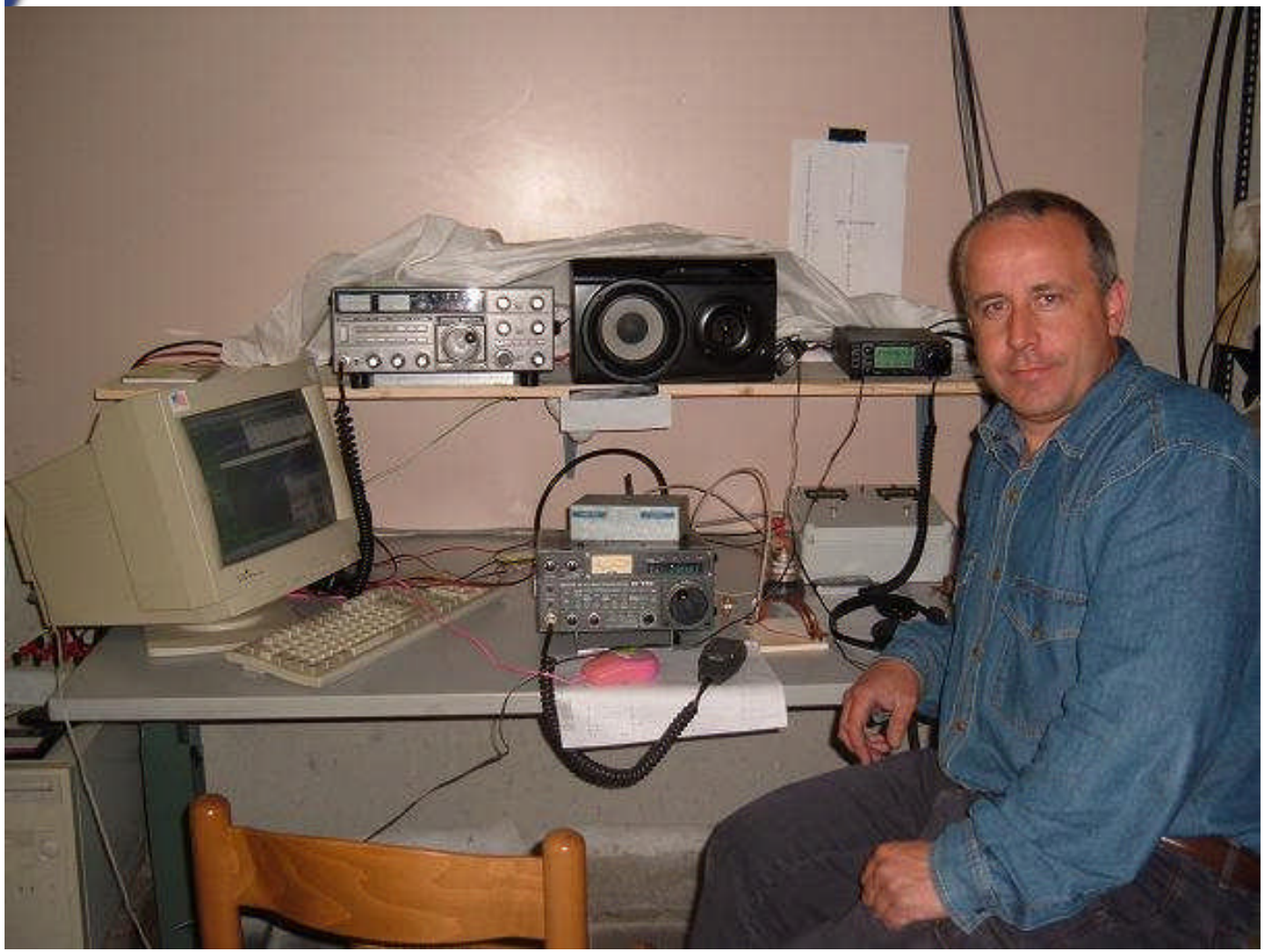

So you don't think you are good enough at CW? Check out Dario's hand key!

Now look closer!

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IW2FZR Homebrew Key

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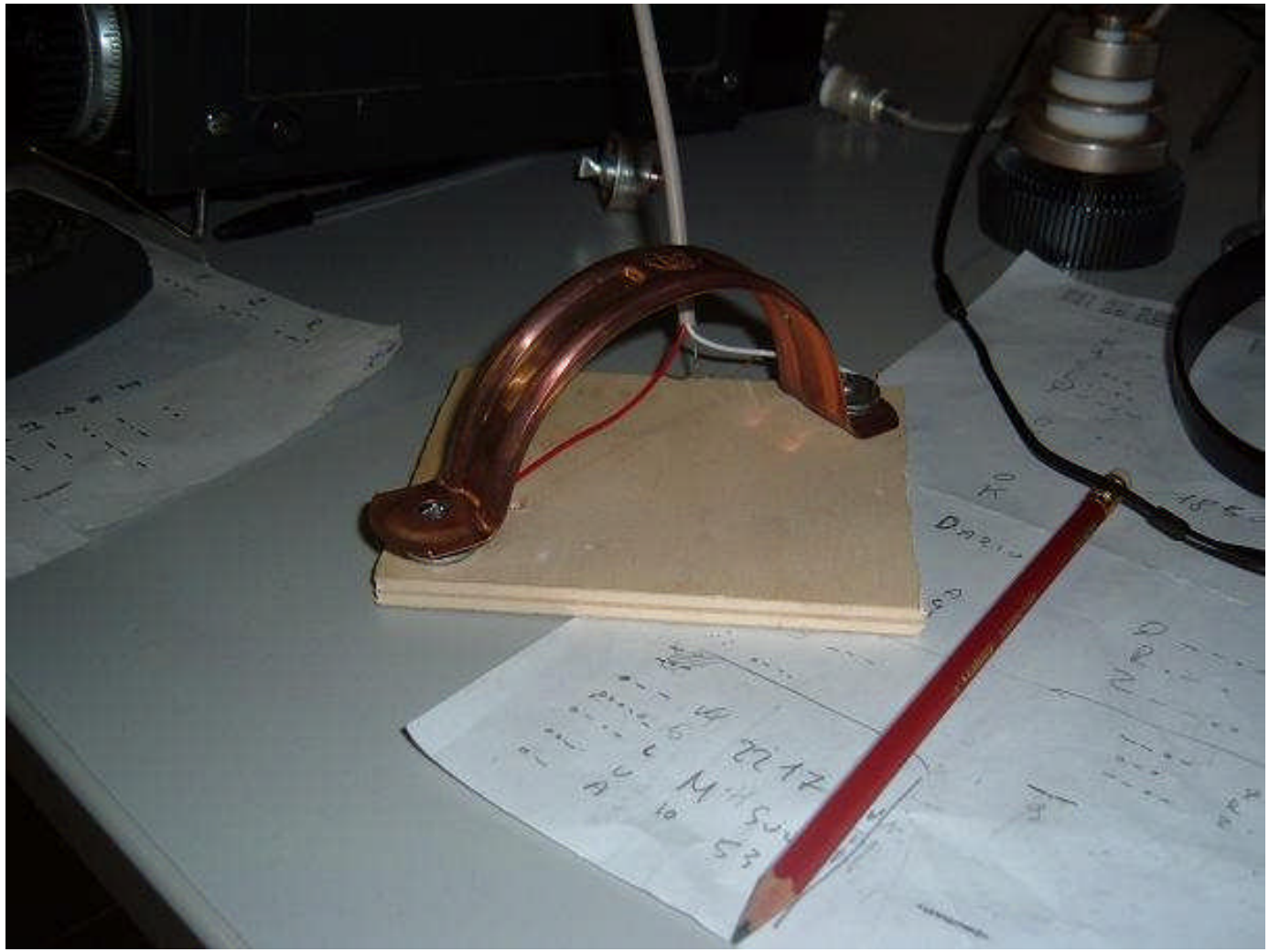

Now this is dedication! … by doing what you have to do to make the contact!

And Dario is still very active with great signals on 1296 and 2304 MHz!

OH3MCK on 1296 MHz JT-65C

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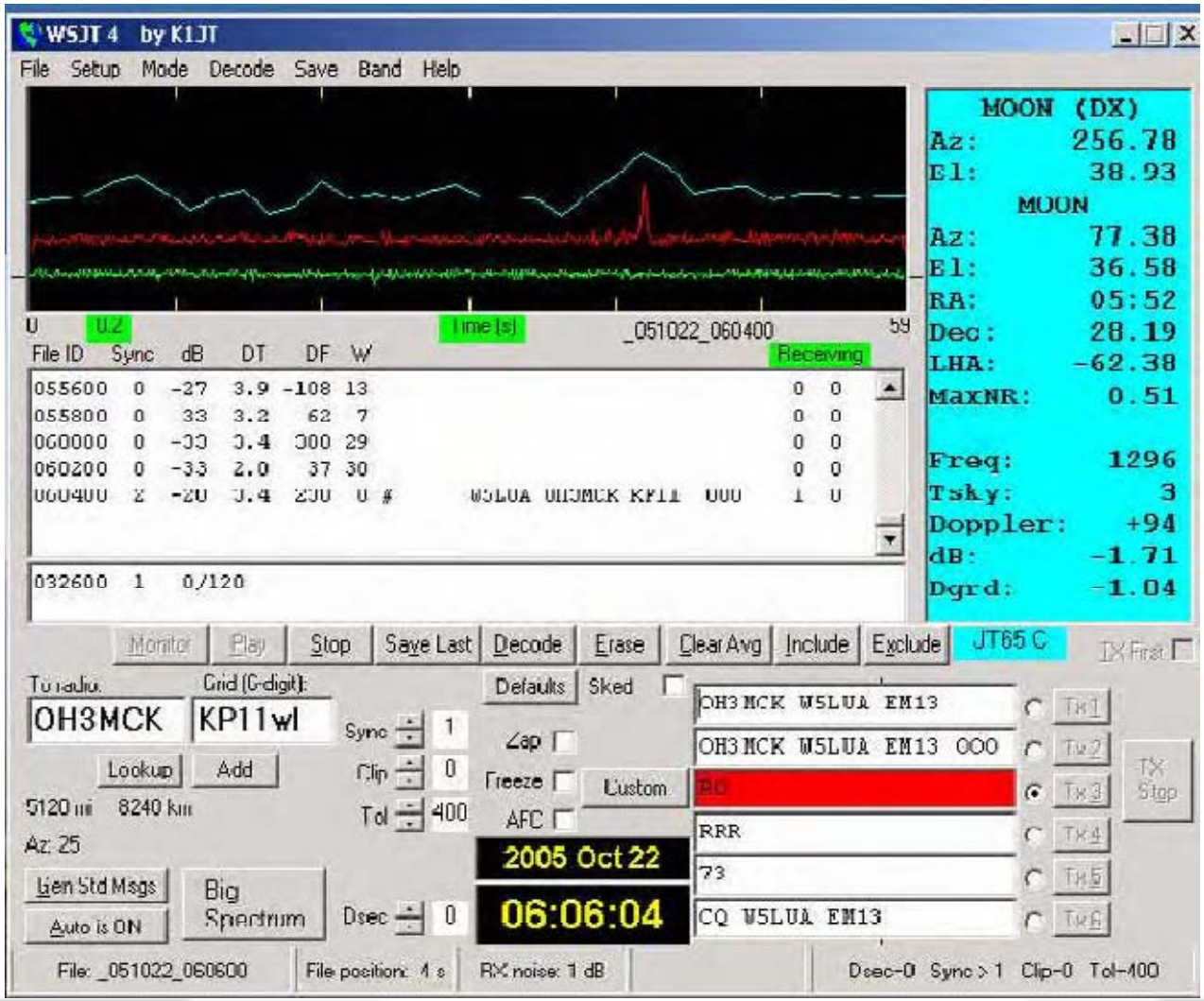

4 Yagis 27 dBi
200 watts

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DL3OCH/DU on 1296 MHz JT-65C

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110 Watts and 55 ele Yagi on 1296 MHz EME!

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DL3OCH Bodo / 5N0 (Nigeria) EME

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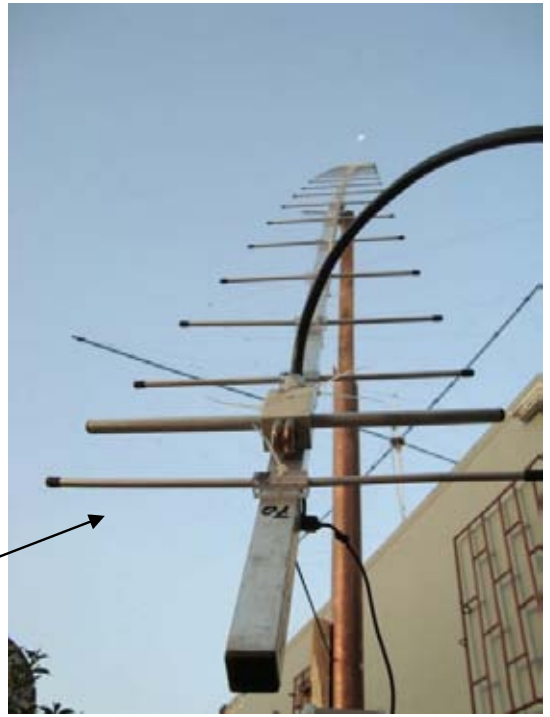
2M EME



432 MHz EME

1296 MHz EME

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2.4M Offset Fed Dish at W5LUA

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Dish used on 24 GHz and 47 GHz
EME and tested on 78 GHz

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47 GHz System for 2.4M Dish at W5LUA

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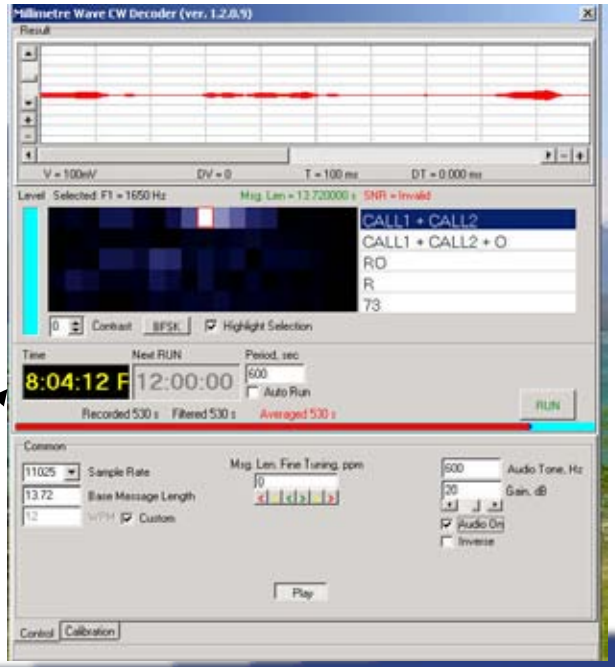
Feed LNA 30 W TWT



Special software designed by RW3BP to do 10 minute averaging to improve S/N

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78 GHz Converter

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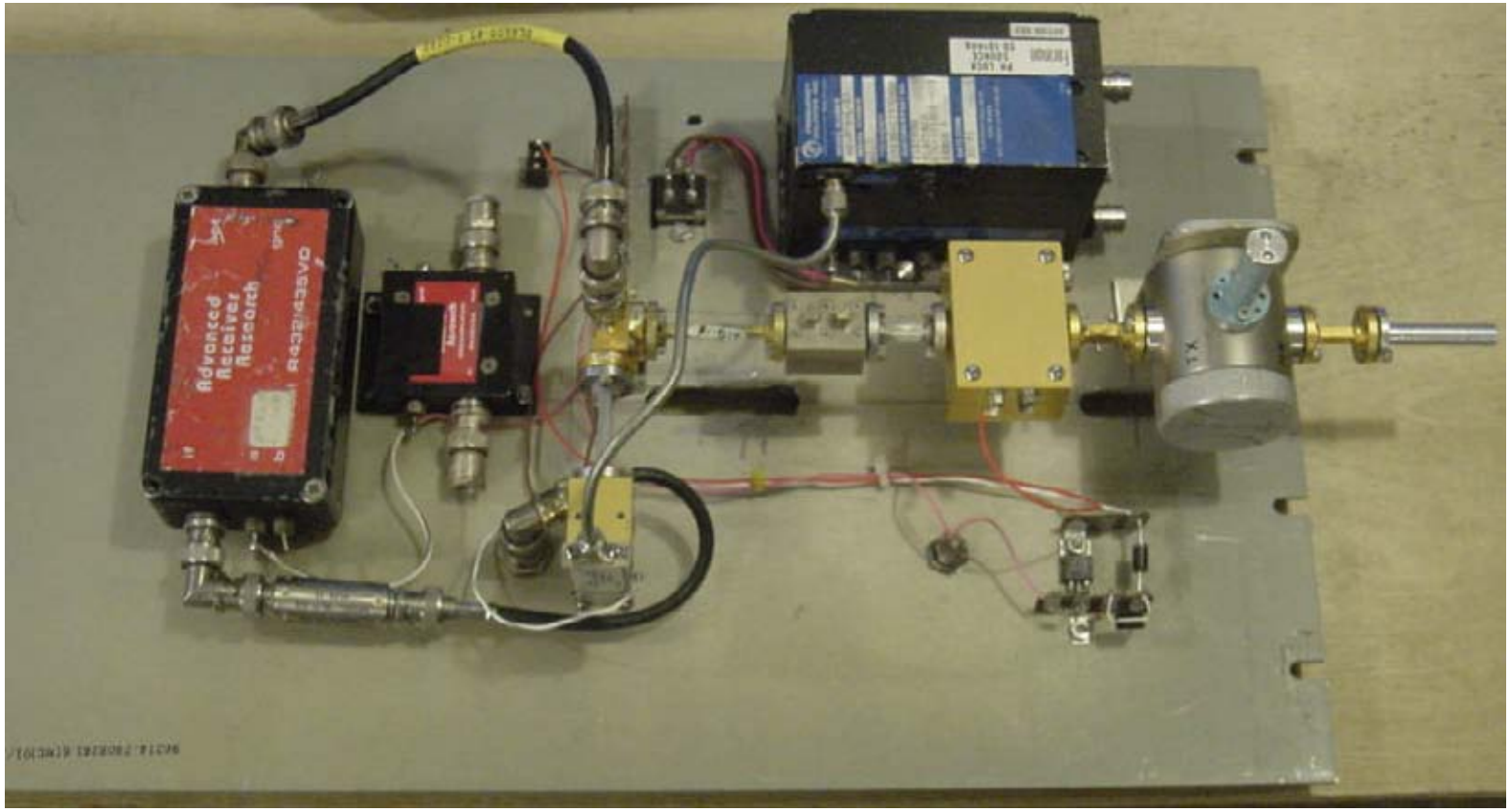

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1 m Winegard Offset Fed Dish with W2IMU Feedhorn built by WA5JAT

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System NF = 3.5 dB (359K)

Sun Noise / cold sky =
7.2 dB w / W2IMU Feedhorn
SFI = 87, 3, 0

Moon Noise / cold sky =
0.75 dB

50Ω / cold sky = 1.2 dB,
NF = 3.5 dB, Ta = 133 K

Feed position still not optimized!

Dew point is quite a factor in the measurements = moisture and oxygen absorption!

International EME Conference

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- Premier EME Conference for EME Enthusiasts
- Semi-Annual Conference held at various locations through out the world
- The North Texas Microwave Society sponsored the 14th International EME Conference in Irving, Texas in August of 2010
- The 15th International EME Conference will be held at Churchill College, Cambridge in the UK August 16th through the 18th in 2012.
- Check http://www.eme2012.com/ for conference schedule and updates

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F1EHN Tracking Software with Doppler Calculation & RX Tuning

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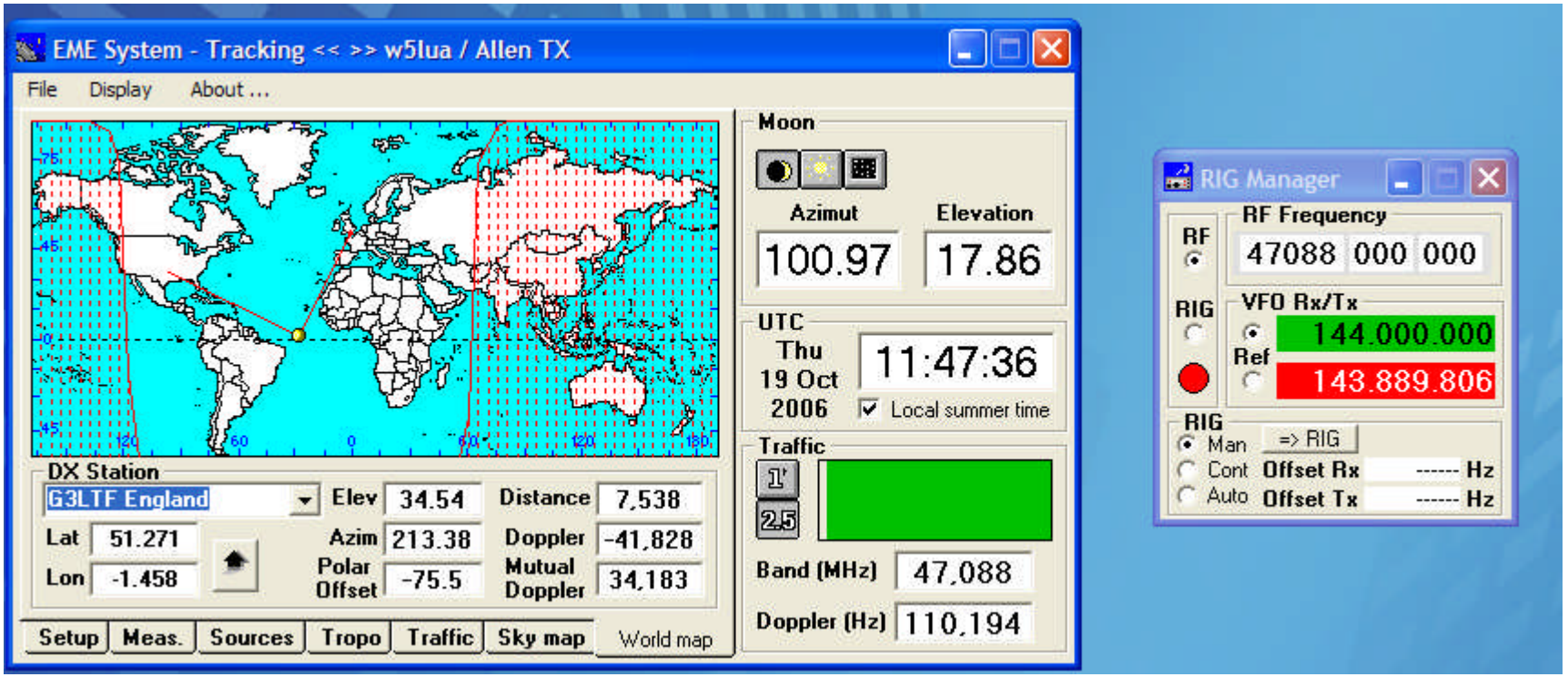

- http://www.f1ehn.org/

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VK3UM EME Planner and Tracking Software

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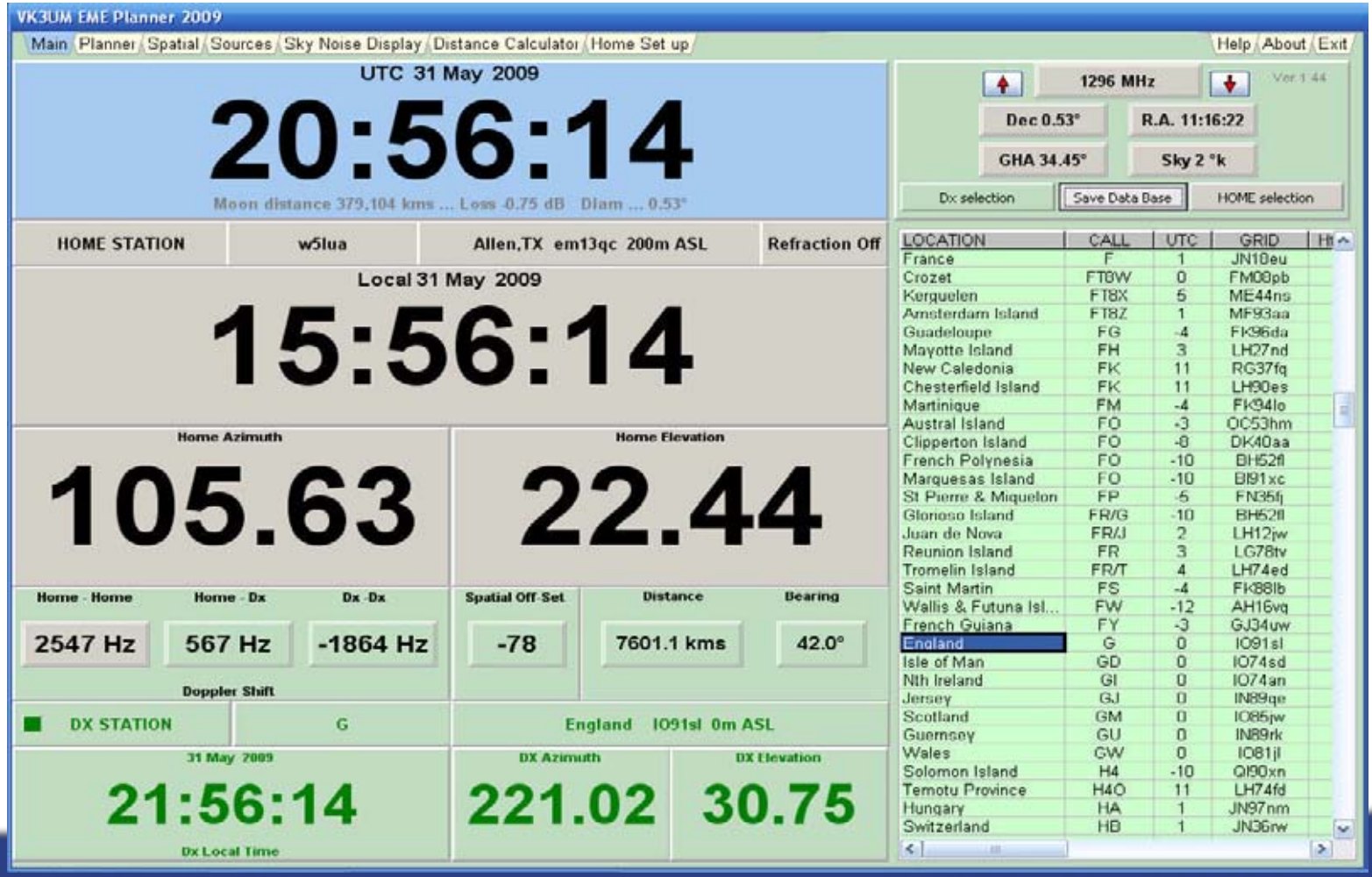
http://www.ve1alq.com/vk3um/



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K5GW Tracking Software

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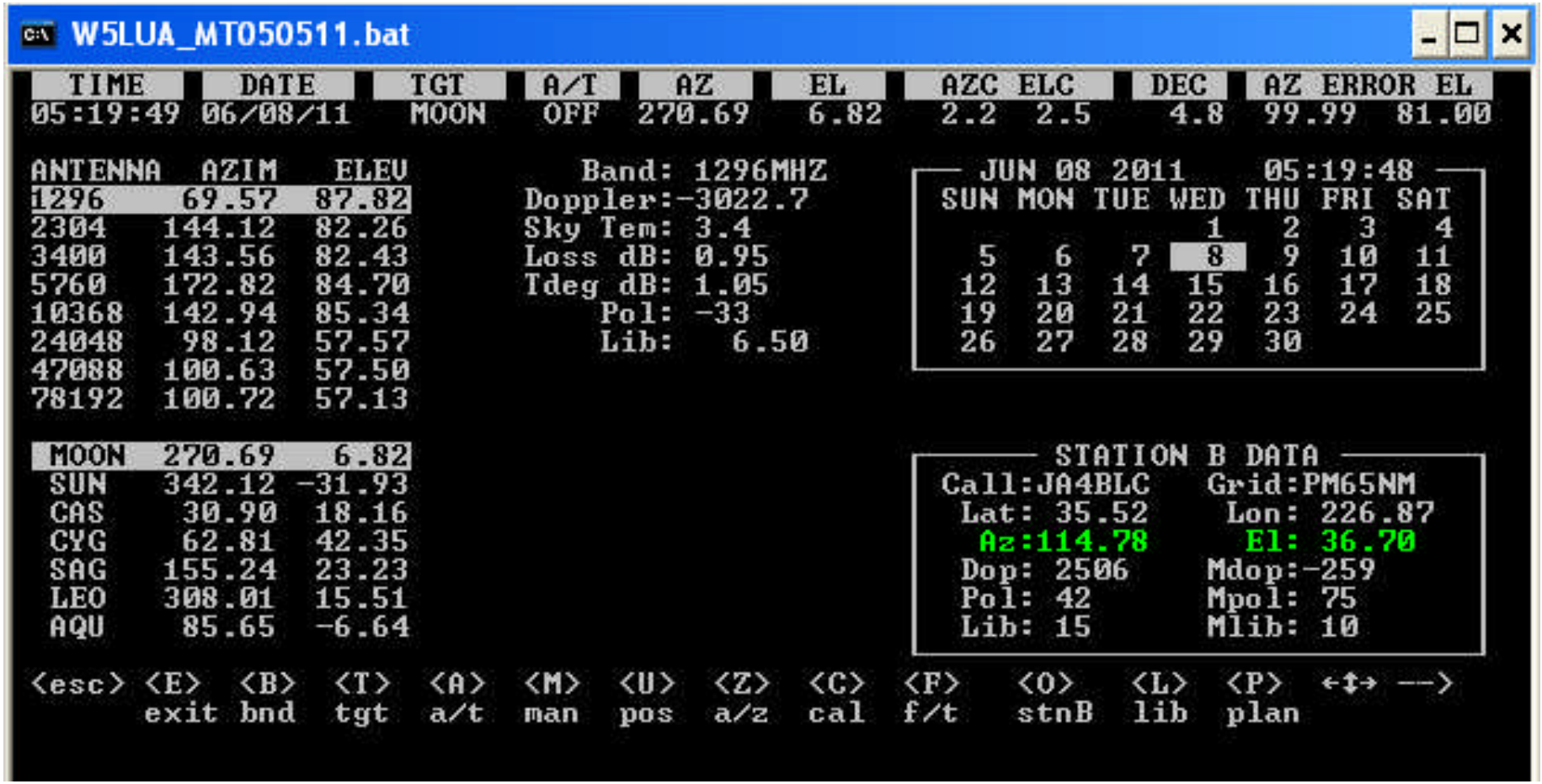

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When is the Best MW EME Activity?

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- Perigee when the moon is closest to the earth
- High declination best for northern hemisphere activity – most hours of moon
- Perigee and High declination not always occurring at the same time of the month –
- Stay away from new moon
- Mainly weekend activity unless retired

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Coordination of Activity

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- Band by band activity weekends and many contests during the year – best to stay tuned in to the newsletter, net notes, reflectors and the 20M net.
- Bands like 1296 MHz have considerable activity each month.
- Improved random activity on 2304 and more recently 3400 MHz.
- Best to coordinate other bands with individual operators known to be active

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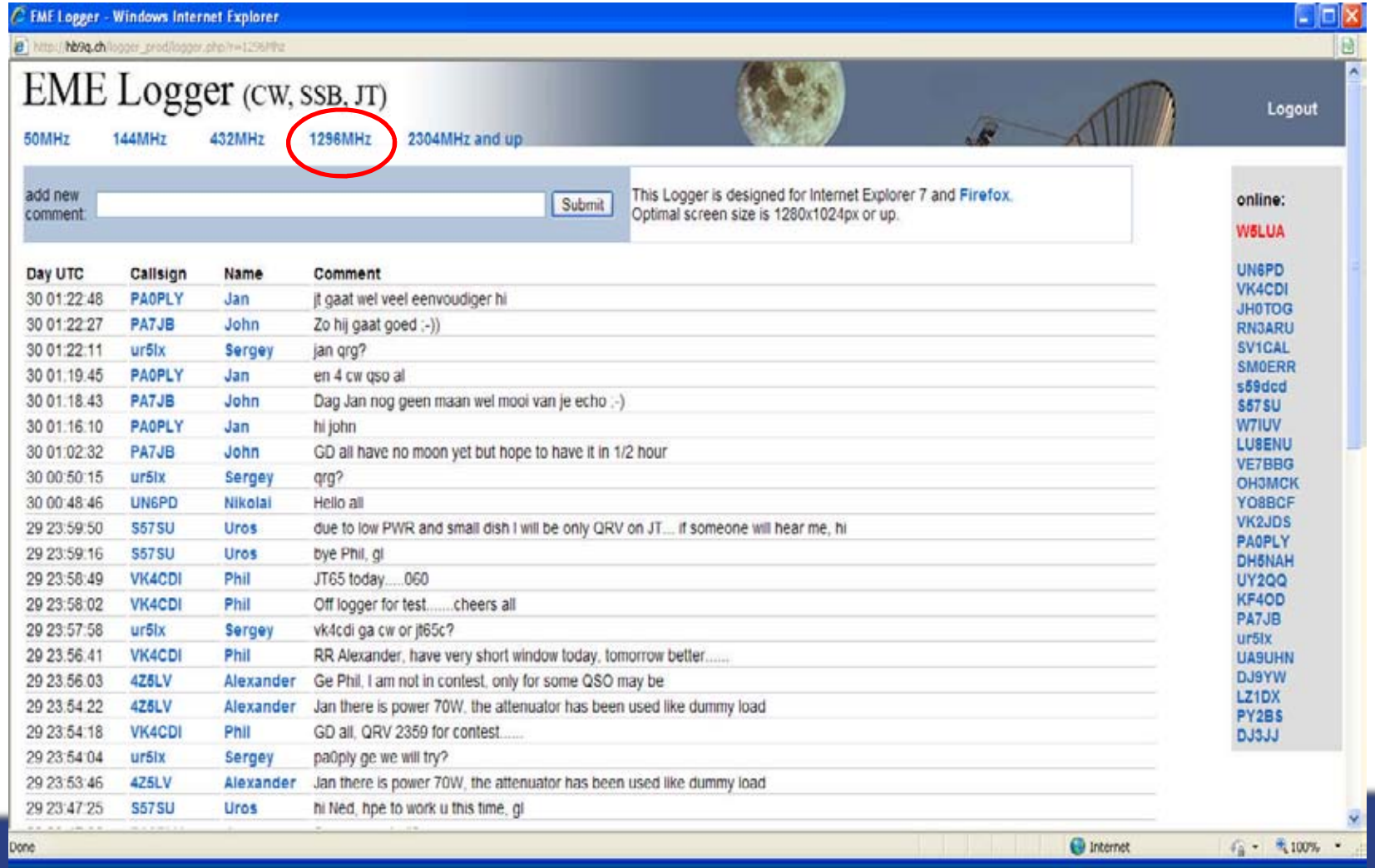
HB9Q Logger for real time chat

http://hb9q.ch/joomla/index.php



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Moonbounce Reflectors

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- Moon-Net - http://www.nlsa.com/nets/moon-net-help.html
- Moon - http://www.moonbounce.info/mailman/listinfo/moon

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EME Net

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- Meets Saturday and Sunday Mornings at 9AM Central time on 14.345 MHz – NET Controls are N4PZ & K1RQG
- Also informal activity during the week on 14.345 MHz starting at 9AM Central

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432 MHz and Above EME Newsletter

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- Edited and distributed monthly by Al Katz, K2UYH since 1972 – send reports to a.katz@ieee.org
- Available from Rein W6/PA0ZN now W6SZ via the internet at http://www.nitehawk.com/rasmit/em70cm.html
- Available from Warren Butler wbutler@comcast.net in .pdf format

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Websites for more Information

North Texas NTMS Microwave Society

- NTMS – http://www.ntms.org/
- VE1ALQ - http://www.ve1alq.com/
- F1EHN - http://www.f1ehn.org/
- W2DRZ - http://www.w2drz.ramcoinc.com/index.htm
- W1GHZ – www.w1ghz.org
- DEMI - http://www.downeastmicrowave.com/
- A Short Primer on Getting Started on 13 cm EME By Al Ward W5LUA http://www.ntms.org/files/2304EME-primer.pdf

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Using the Flex 5000 Software Defined Radio at W5LUA

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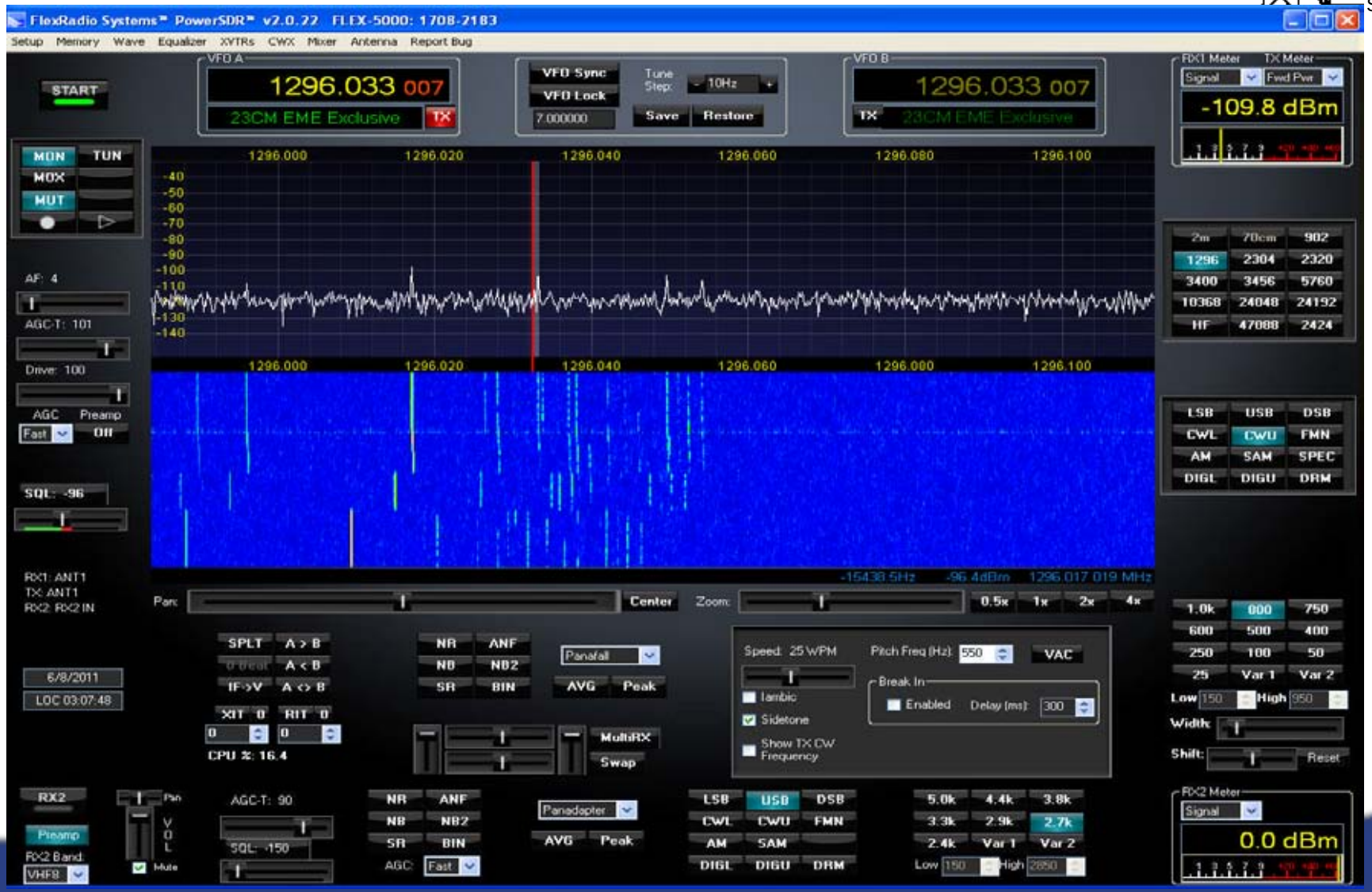

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Schedule

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1:00 PM Introduction to Microwaves and the NTMS
by Al Ward W5LUA and Bob Gormley WA5YWC

1:30 PM Building equipment and operating on 10 GHz by
Bob Gormley WA5YWC and Al Webb W5RLG

2:15 PM Microwave EME from 902 MHz to 78 GHz by
Al Ward W5LUA

2:45 PM Wrap up & Q&A

Questions?

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