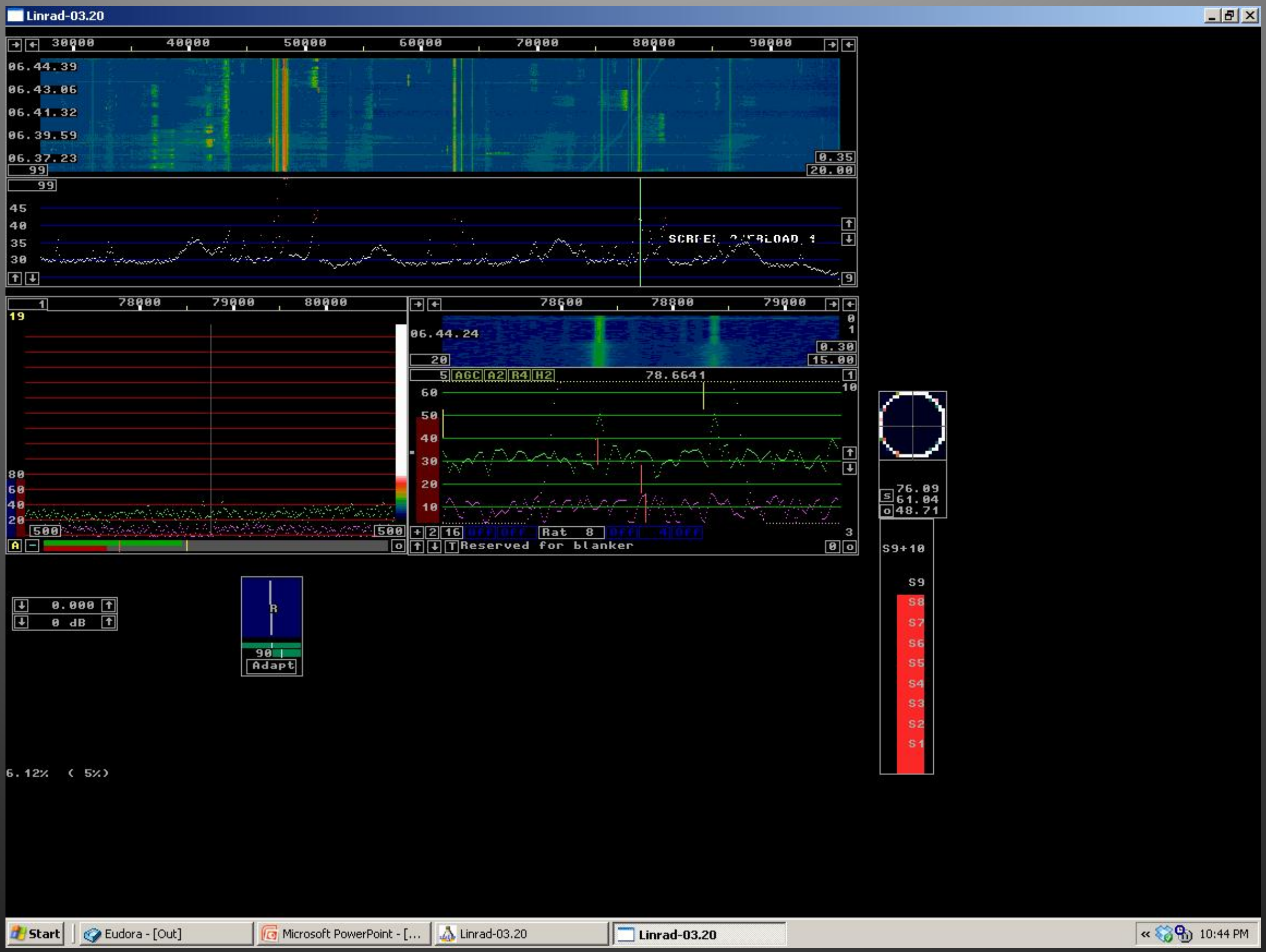
Adaptive Reception of Dual Polarity EME Signals Using Linrad

By Ed Cole – KL7UW



Introduction

- This paper explores receiving eme signals into two polarities simultaneously, and using the Linrad (**Lin**ux **rad**io) program for determining the polarization angle and peaking the signal in the direction of polarity. http://www.kl7uw.com/LINRAD.htm

- Linrad is a software defined receiver (SDR) program, so it uses appropriate hardware that can supply I and Q signals that all SDR require for operation.

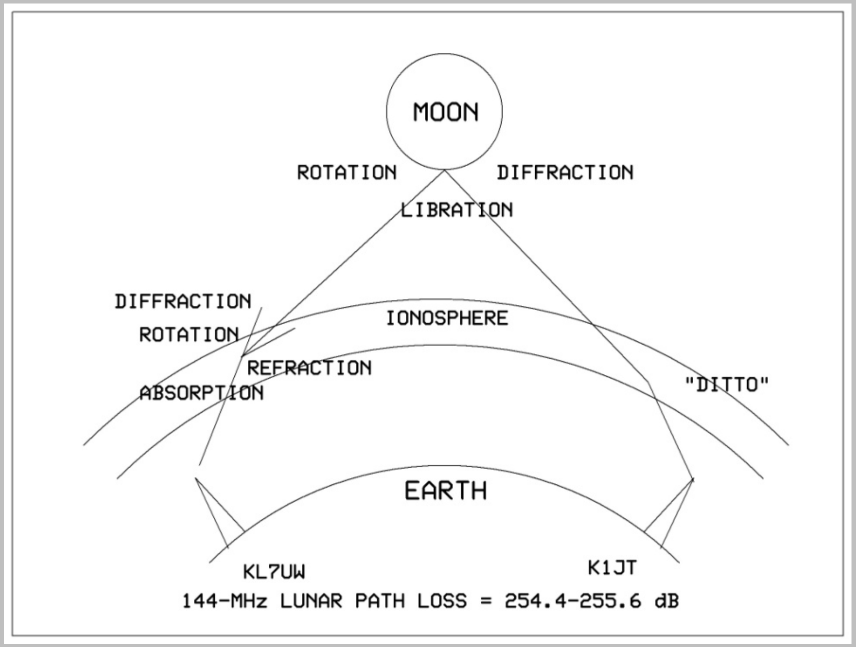
- My particular application converts 144-MHz signals down to audio base-band for input to Linrad by use of a high-performance soundcard.

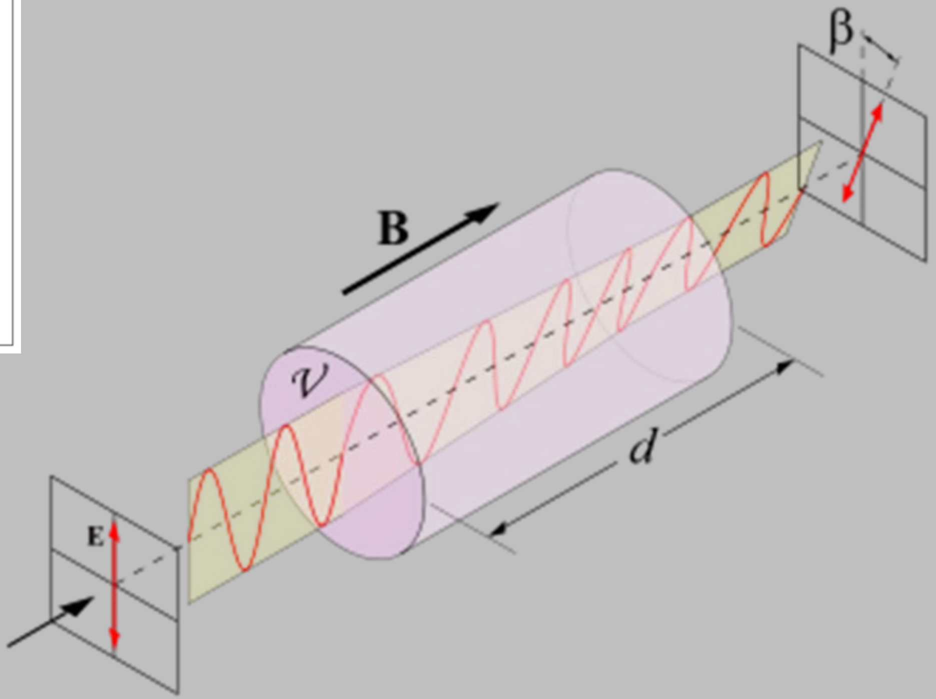
- But before getting into the specifics, lets review some basics about eme reception.

Signal Polarity and EME:

- EME stands for earth-moon-earth or more commonly “Moon-bounce”.
- RF signals travel thru the ionosphere in transit to the Moon, twice.
- Electrically charged plasma in the Ionosphere interacts with the electromagnetic field of the radio signal to absorb, refract, diffract, and twist it.
- This affects signal reception after it travels to and reflects from the Moon and returns to Earth.
- Not much can be done about most of these effects.
- The one that causes “twisting” (called the Faraday Effect) results in the polarity of a radio signal being rotated and there is something we can do to minimize its effect.
- Faraday varies in strength with solar and geomagnetic activity and affects signal differently with frequency.
- The effect is stronger at lower VHF frequencies such as 50-432 MHz.

Signal Polarity and EME:



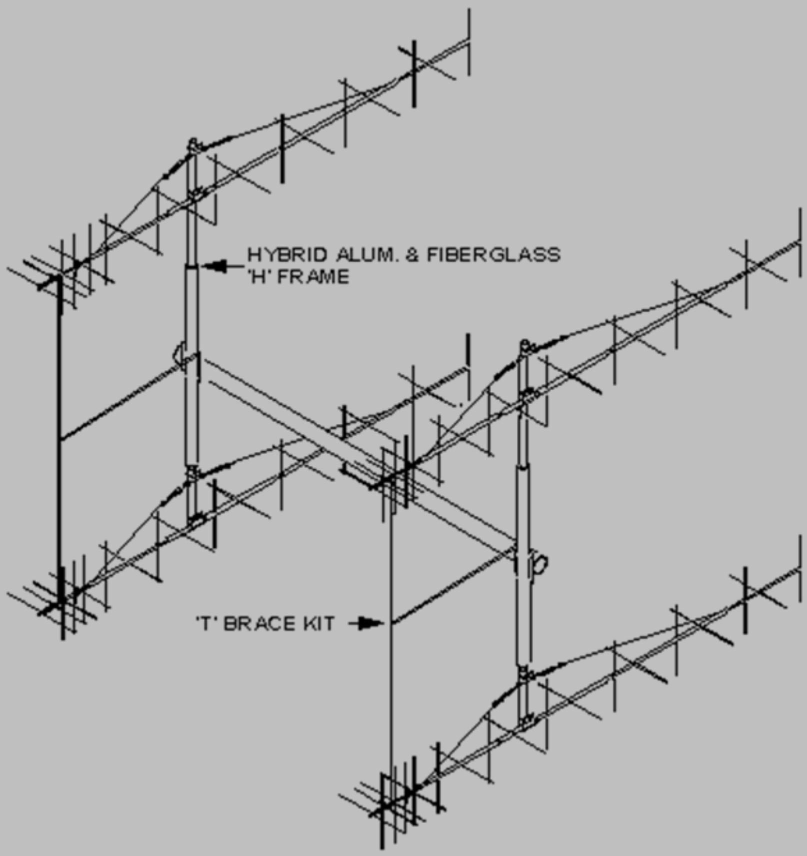


Signal Polarity and EME:

- At 6m an eme signal will twist very rapidly.
- At 2m typically it will rotate up to 90-degrees in a few minutes.
- At 432-MHz the effect slows to part of an hour up to several hours.
- Above 1000-MHz Faraday is not significant and can be ignored.
- Results in the eme signal returning to Earth at a different polarity angle which results in signal loss called cross-polarity loss.
- At 90 degree rotation loss is >20 dB. At 45 degree it is 3 dB.
- EME is extreme weak-signal operation so loss is to be avoided.
- Early years of eme they just accepted Faraday.
- In the last decade dual-polarity antennas have become popular.
- On 432 some even physically rotate the whole array.
- 1296 and some higher microwave bands circular polarity is used.
- Even using dual polarity loss can still reach 3-dB.
- Is there a better way to handle this?

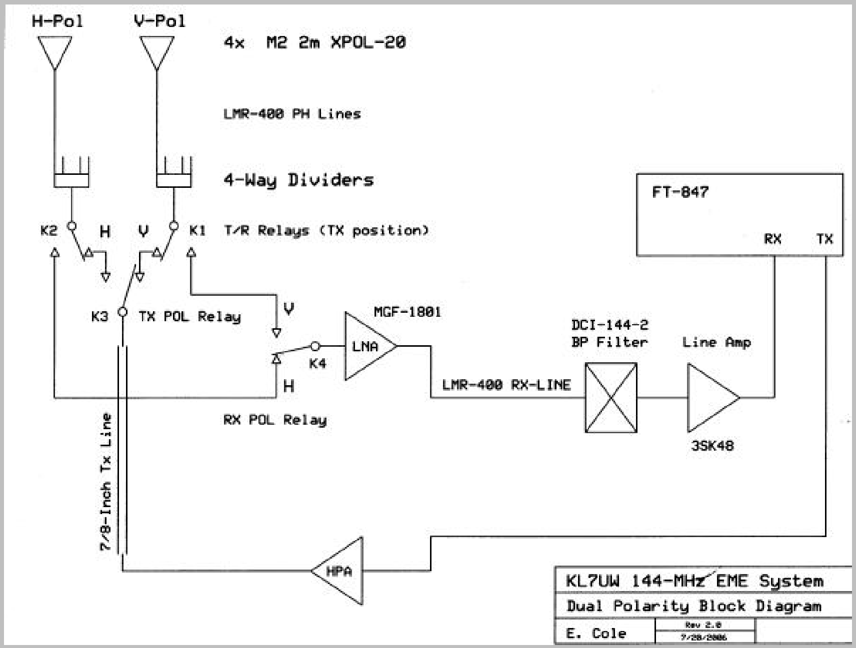
Hardware of the Dual-Pol Adaptive System

- At KL7UW the M2 2mXpol-20 dual-pol antenna was chosen.
- Each antenna has ten elements in each pol with 13.2 dBd (15.3 dBi) gain. The array has 19.2 dBd (21.3 dBi) gain.
- This array has the minimum gain required for CW-eme using 600w RF output.
- I chose this antenna because it was physically smaller than the typical antenna used for 2m-eme.



Hardware of the Dual-Pol Adaptive System

- I started building my eme station in 1998 and acquired a FT-847 for my main radio.
- Initially the eme station was fairly simple as I used a 170w amplifier which resulted in about 100w at the antenna. This was QRPp –very weak for CW (I only worked four very-big stations in the first years).
- In 2003 a new digital mode (JT-44) was introduced and I quickly added another 120 contacts.



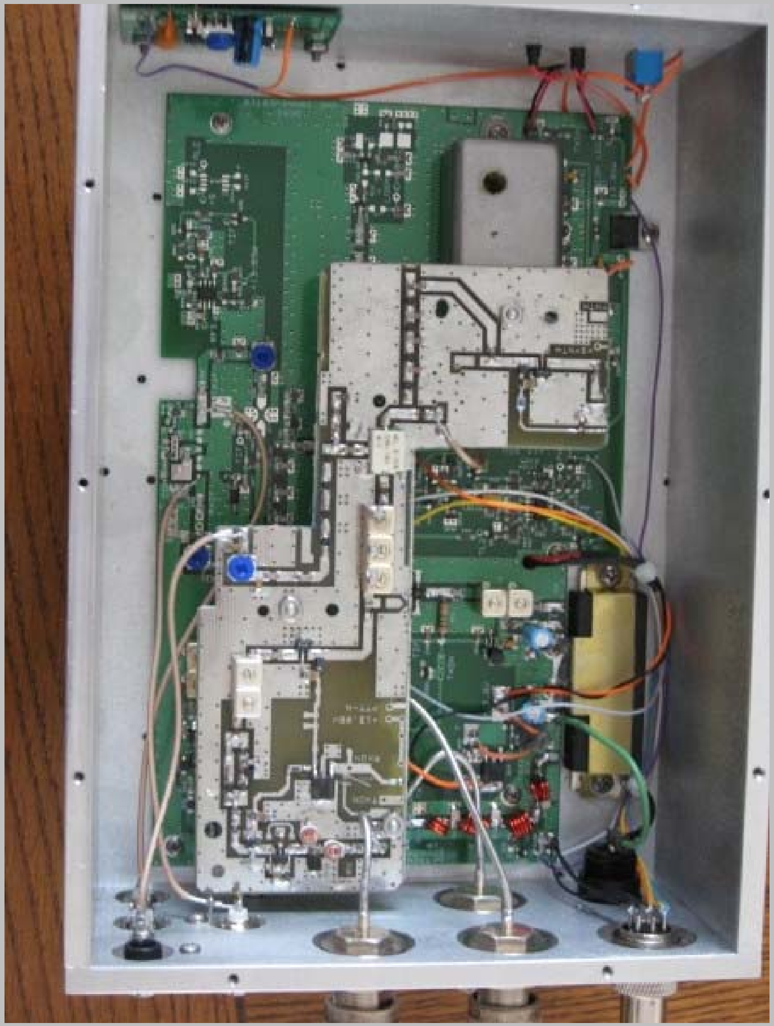
JT-44 (now JT-65) increases station performance about 10-dB over CW making eme possible with a small antenna system.

Hardware of the Dual-Pol Adaptive System

- I decided in spring of 2010 to switch from the multi-mode VHF transceiver to using a well-designed HF transceiver with a VHF transverter.
- I chose the Elecraft K3 which has a reputation for superb CW reception.
- It is a hybrid dual-conversion radio with a SDR core.

- Elecraft uses an identical second receiver which could be phase-locked to a single digital VFO for diversity reception.
- K3 offers a transverter interface which provides separate Rx and Tx connections.
- Direct frequency readout for up to nine transverters and 10-MHz external frequency reference for very high frequency accuracy.
- K3 exhibits 2-Hz accuracy at 28-MHz.
- I ordered a custom-made DEMI Transverter with two Rx converter.

Downeast Microwave dual-Rx Transverter

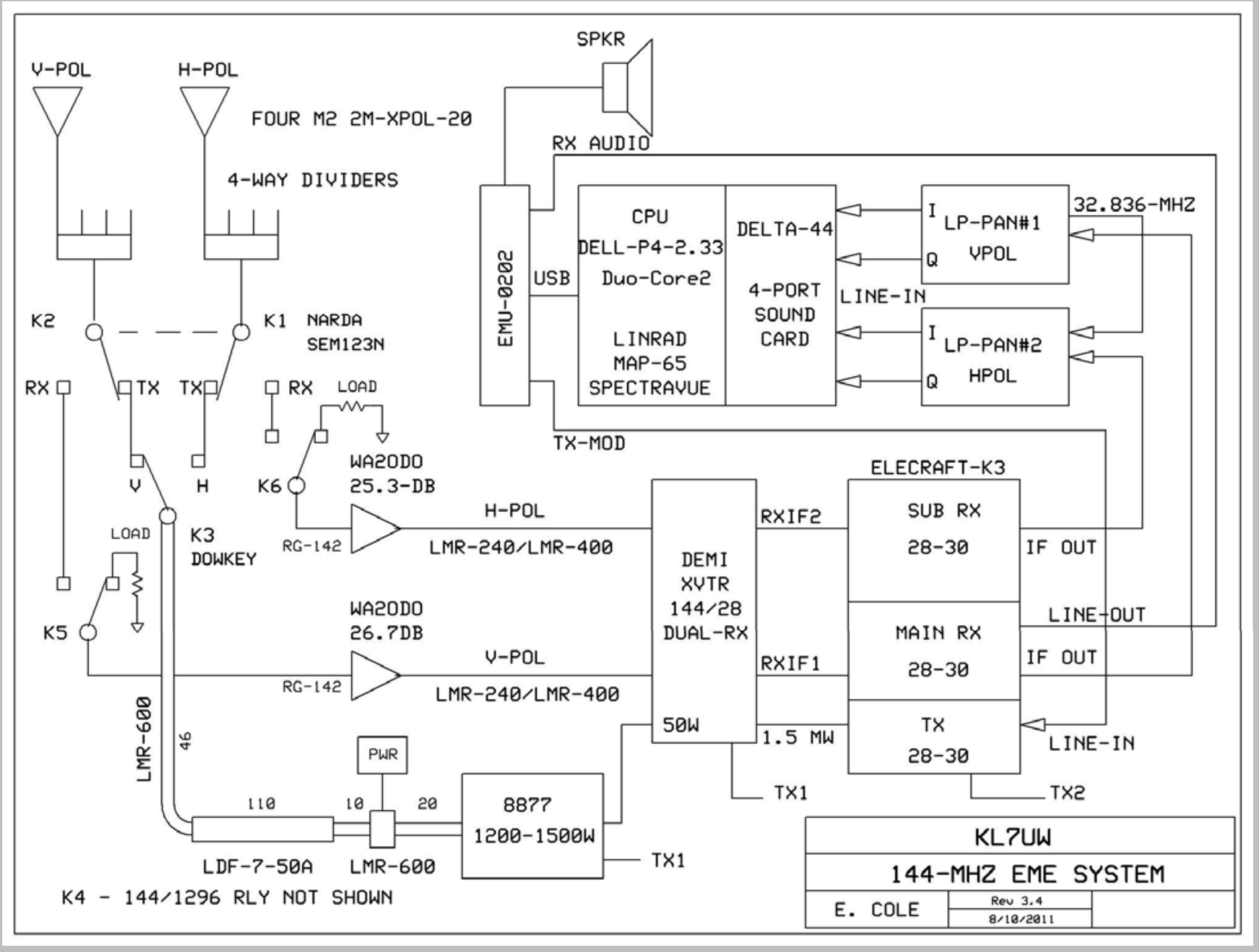


Downeast Microwave dual-Rx Transverter

- I was approached by DEMI at the 2010 International EME Conference with a proposal to make me the custom-build dual-Rx transverter I had inquired into earlier in the year.
- I would get the dual-Rx transverter for the standard price in turn for being a test-bed for the prototype.
- The transverter is their new-design series for 2010.
- A second Rx was created from a cut-down pc board.
- A custom enclosure was made to accommodate the extra coax connectors that are required.
- I chose the 50w model to directly drive my 8877 linear amplifier.
- Full test specs are on my website:

  http://www.kl7uw.com/DEMI144-28DRX.htm
- The dual-Rx in the transverter are fed by two identical preamps made by WA2ODO that exhibit extremely low NF.

Hardware of the Dual-Pol Adaptive System



Hardware of the Dual-Pol Adaptive System

- The K3 is an SDR, but audio is limited to a maximum bandwidth of 4-KHz.
- My objective is to use MAP-65 (a variant of JT-65) at 90-KHz of bandwidth.
- Another limitation is the K3 does not provide access to the I-Q signals.
- A different approach suggests using the 8.215 MHz 1st-IF of the K3 to feed an external SDR which would offer I-Q output.
- The LP-Pan, made by Telepost, inc., is perfect since it is specifically designed to operate from the 1st IF of the K3.
- The LP-Pan was intended to be used as a panadaptor but is a simple SDR and provides both I and Q at audio baseband for input to a stereo soundcard.
- For the dual-receiver system two LP-Pan are required one for the main K3 receiver IF and one for the K3 sub-receiver IF.
- But two modifications were required:

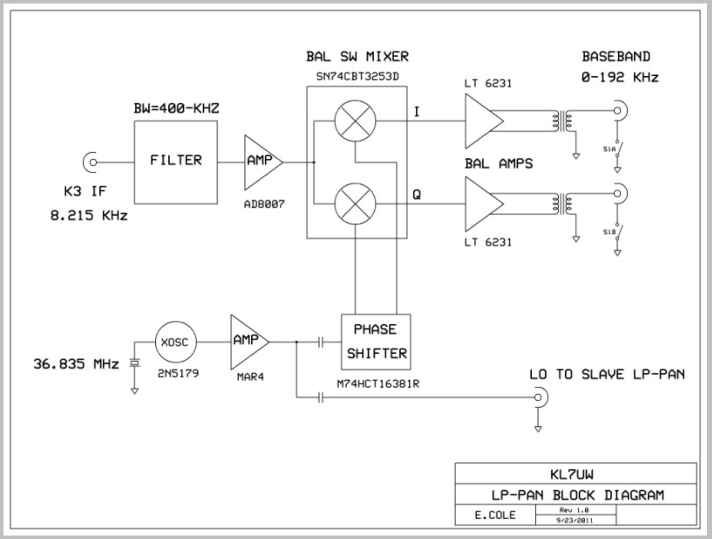
1. Access to the IF of the sub-receiver in the K3
2. Running both LP-Pan from a single master LO

Hardware of the Dual-Pol Adaptive System

- The IF simply requires use of a .001 uF coupling capacitor and a run of RG-174 to a BNC connector on the back of the K3.
- I disabled the LO of one LP-Pan and ran both from the LO in the other LP-Pan (see diagram):

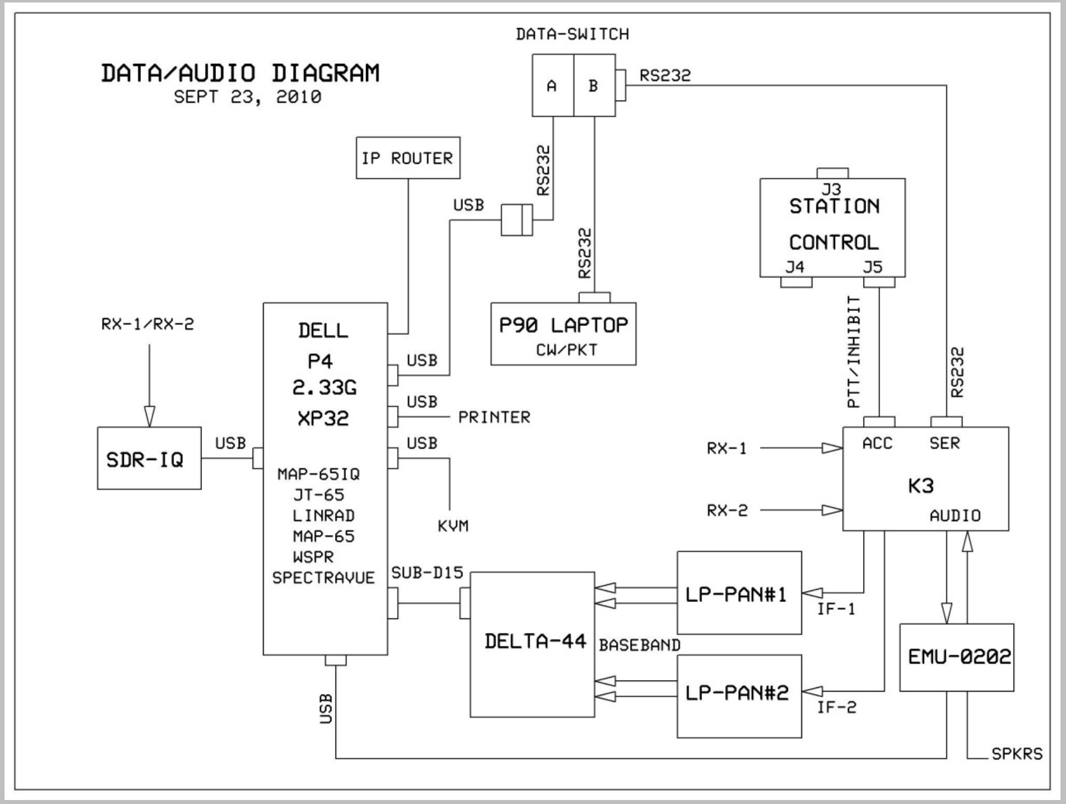
http://www.telepostinc.com/LPAN.html

- The I and Q audio were connected to a four port soundcard.
- I chose the M-Audio Delta-44 which can support 96 KHz bandwidth.



Software of the Dual-Pol Adaptive System

- Two programs are used:
  1. LINRAD http://www.sm5bsz.com/linuxdsp/linrad.htm
  2. MAP-65 http://physics.princeton.edu/pulsar/K1JT/
- Linrad performs the SDR operation of digital filtering, and displaying a spectrum and waterfall screen.
- Linrad is also able to take the input of the two Rx and computes the vector angle of polarization which is displayed and also peaks the output accordance with that polarity, completely eliminating polarity loss.



Software of the Dual-Pol Adaptive System

- Linrad is the creation of Leif Asbrink, SM5BSZ, a radio engineer from Sweden. Originally written in Linux it is now available in windows.
- MAP-65 is a variation on the popular digital-eme mode, JT-65. This is the creation of Joe Taylor, K1JT, an Astronomy Professor of Princeton, University. Joe has produced a suite of digital modes called WSJT.
- Linrad performs the SDR processing to provide any mode: CW, SSB. AM, FM, etc. For use with MAP-65 (or JT-65) Linrad is run in USB mode. The output data stream is sent to Map-65 for decoding all JT-65 signals in the 90-KHz baseband. MAP-65 is able to discriminate between valid digital signals and interference (birdies).
- The result is a map of all JT-65 signals listing time, freq., callsign, and signal level for all stations calling within the 90-KHz passband. This is a powerful contest tool and very useful for random eme operation.
- The rest of this presentation are examples of Linrad and MAP-65.

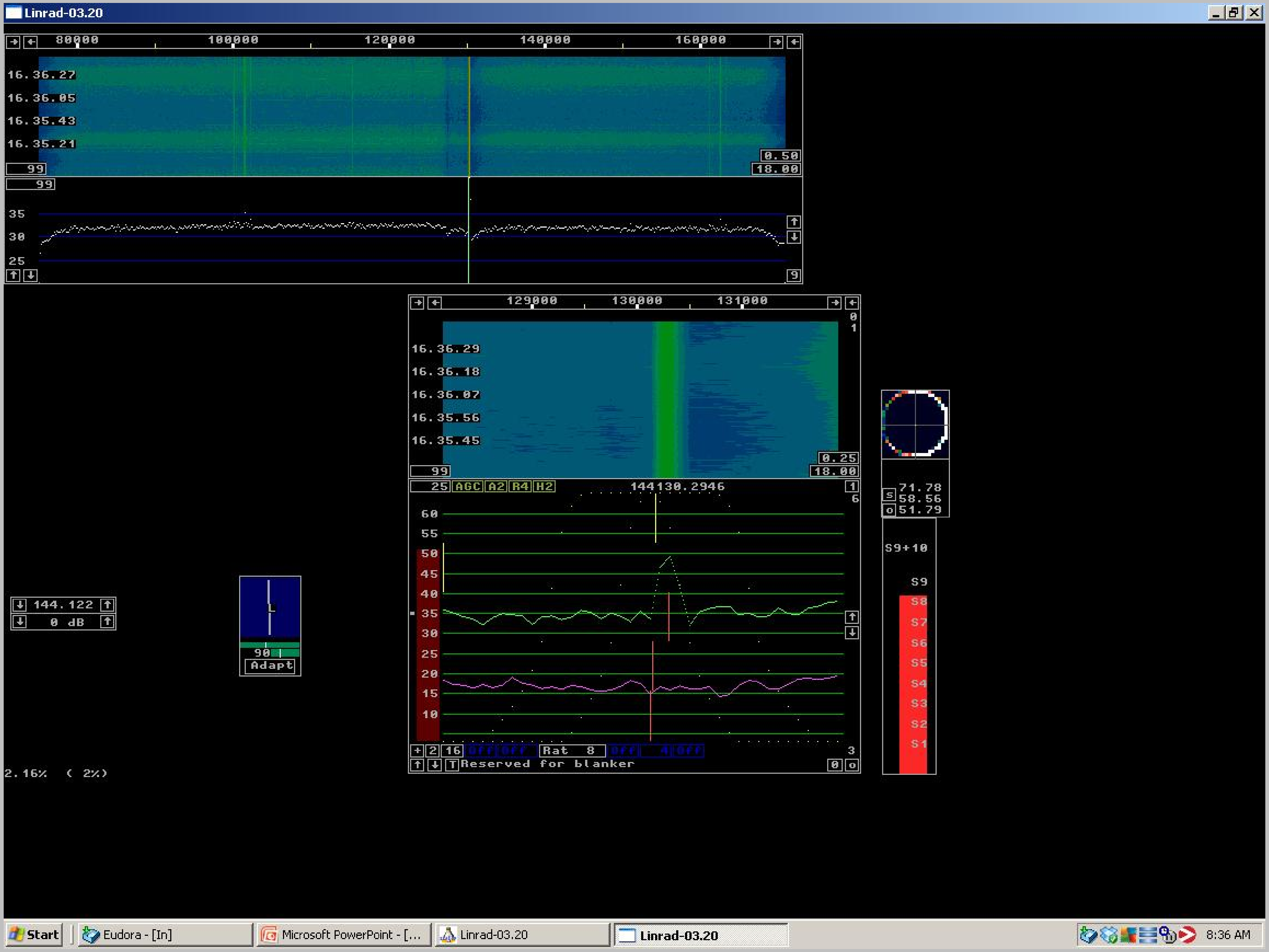


Fig. 1 – Linrad with Adaptive Polarity = 90

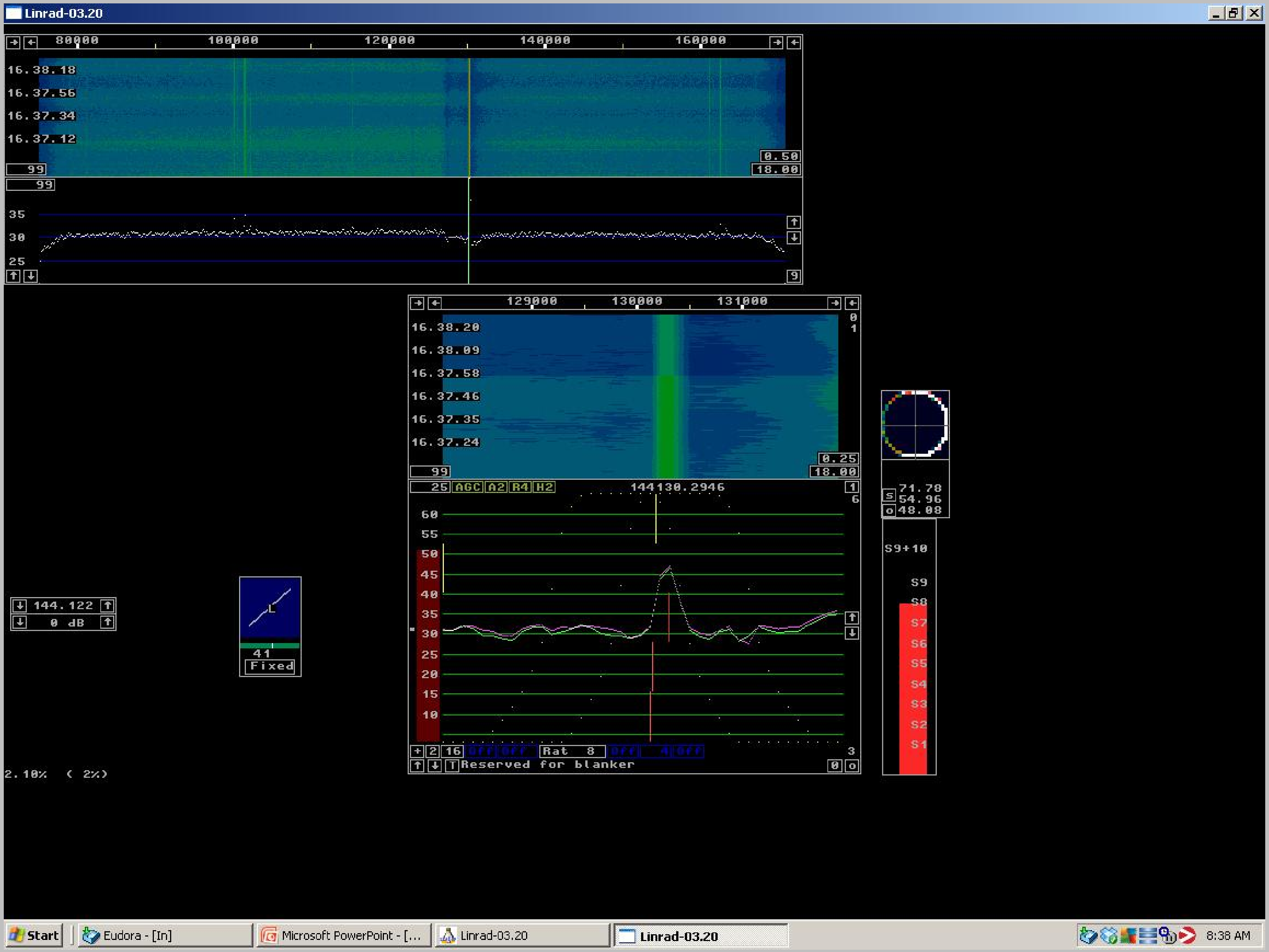


Fig. 2 – Linrad with Adaptive Polarity = 41

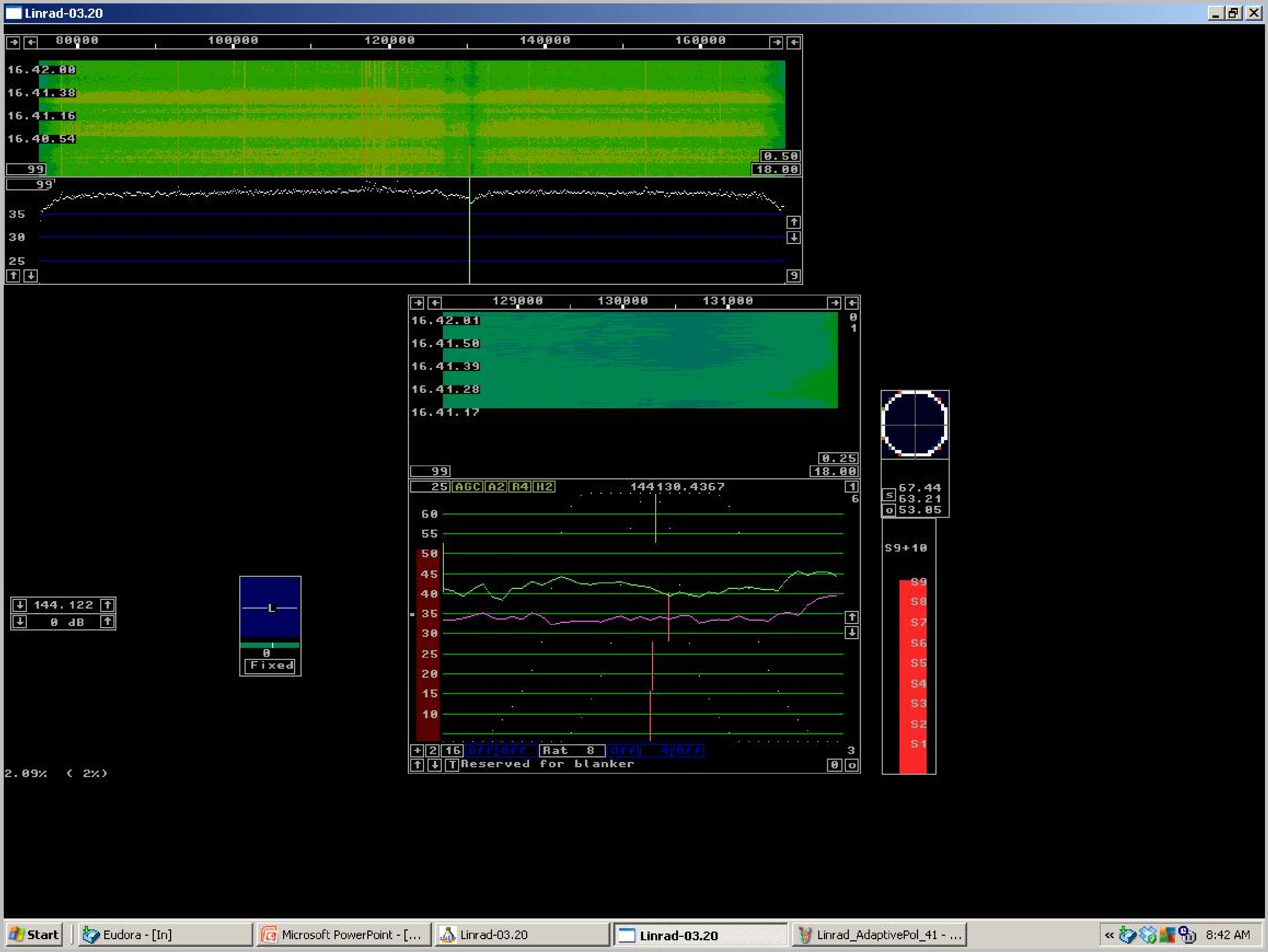


Fig. 3 – Linrad with Adaptive Polarity = 00

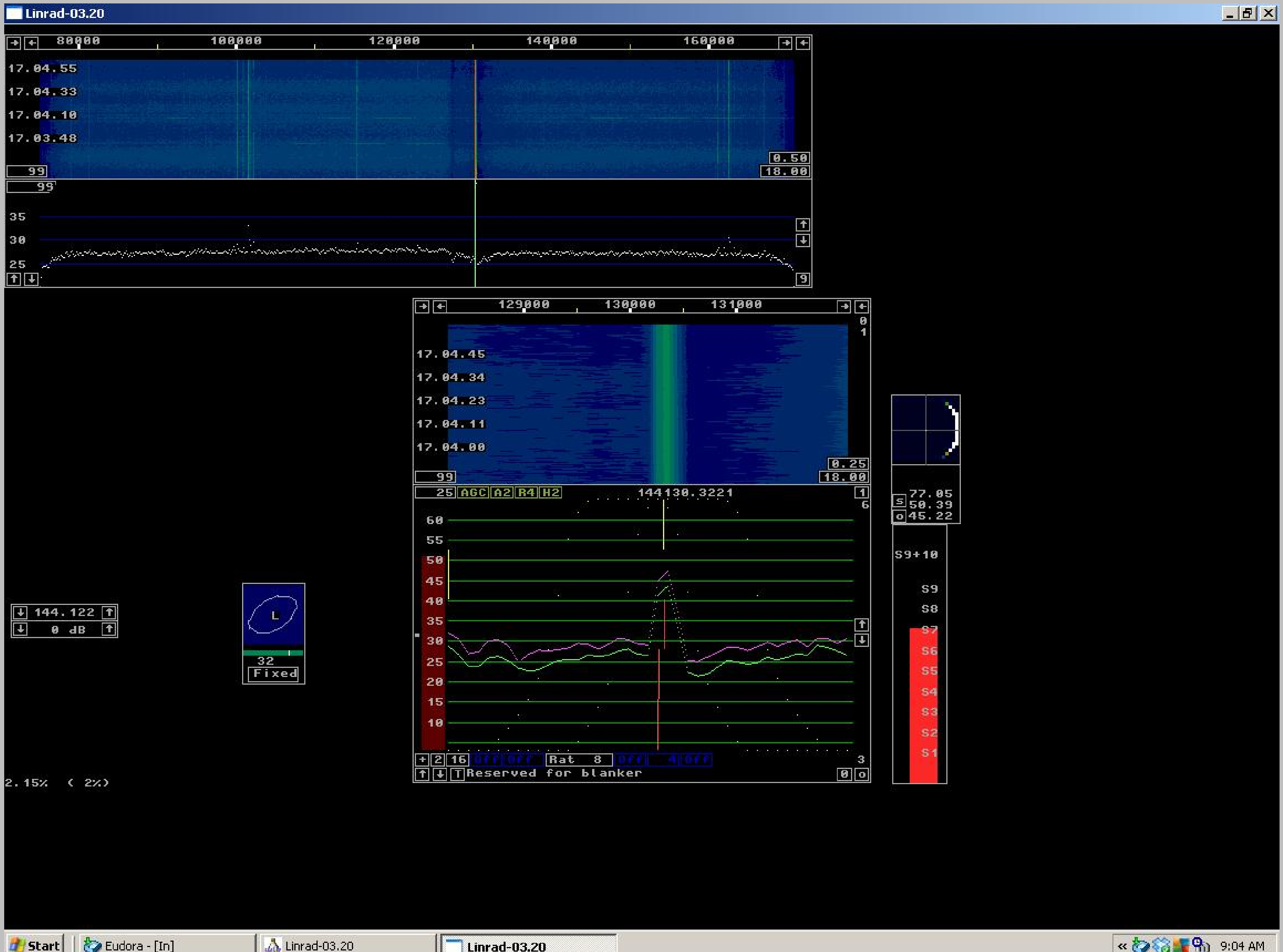


Fig. 4 – Linrad with Adaptive Polarity = Elliptical, 32

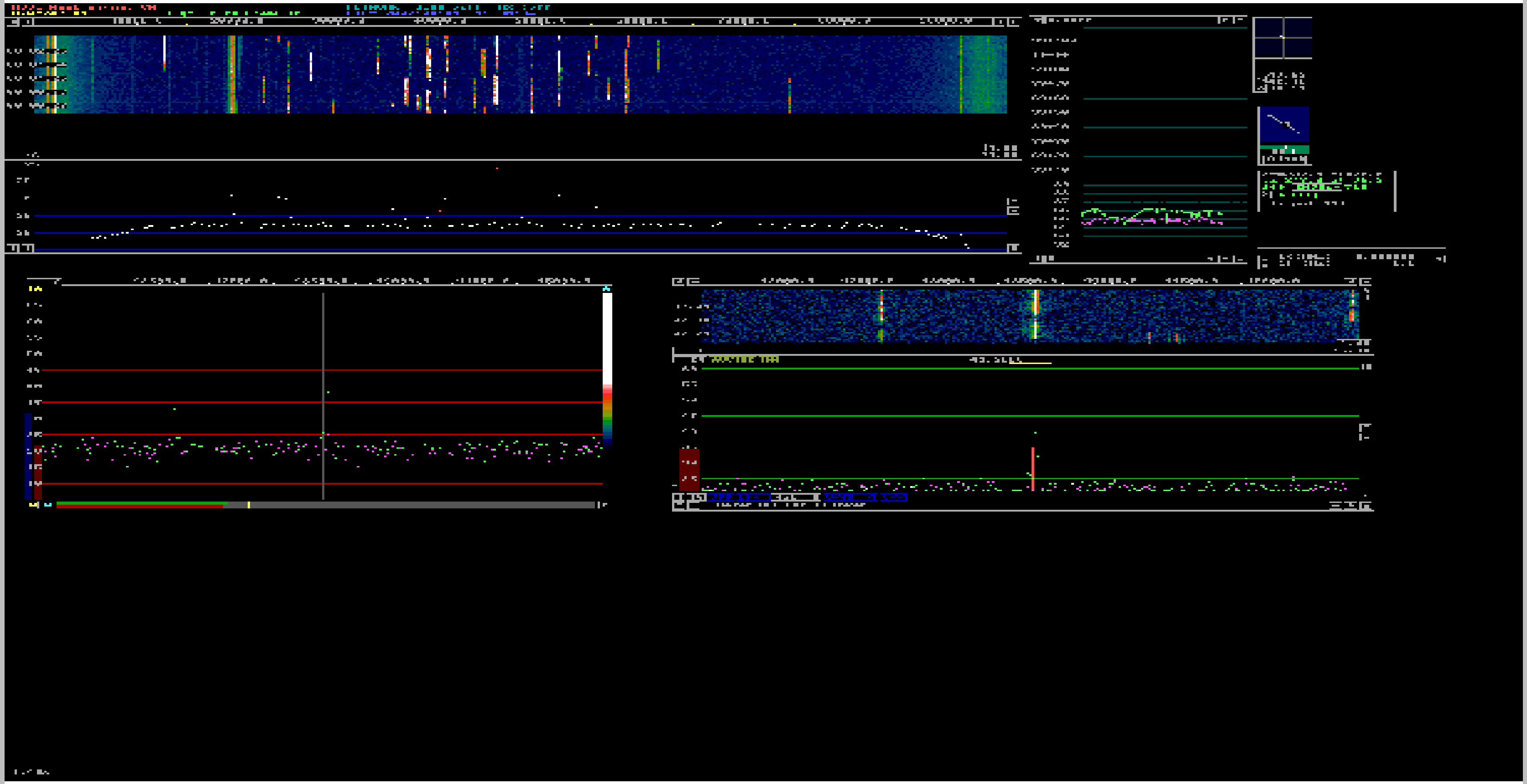


Fig. 5 – Linrad showing 2 meter EME

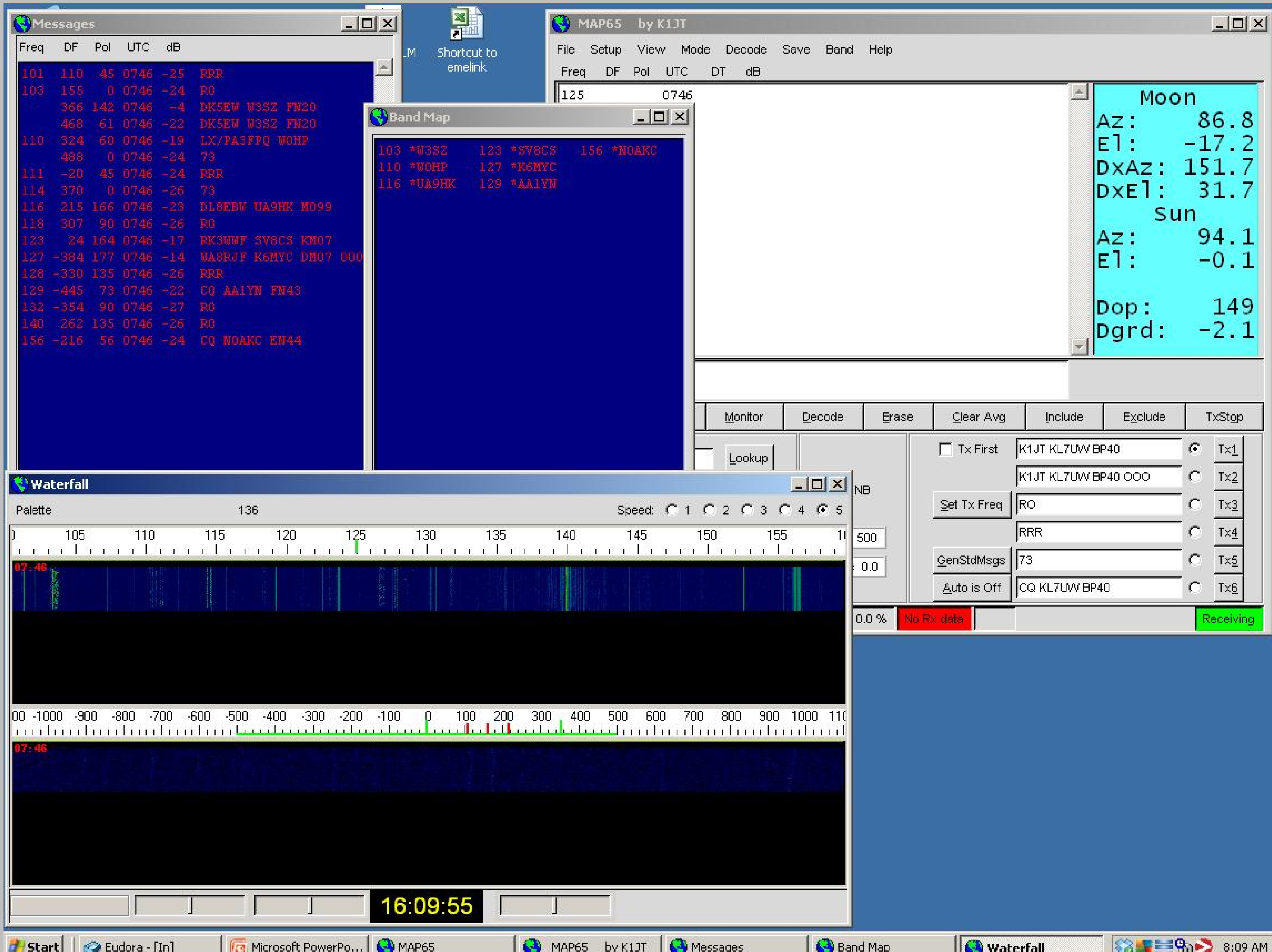
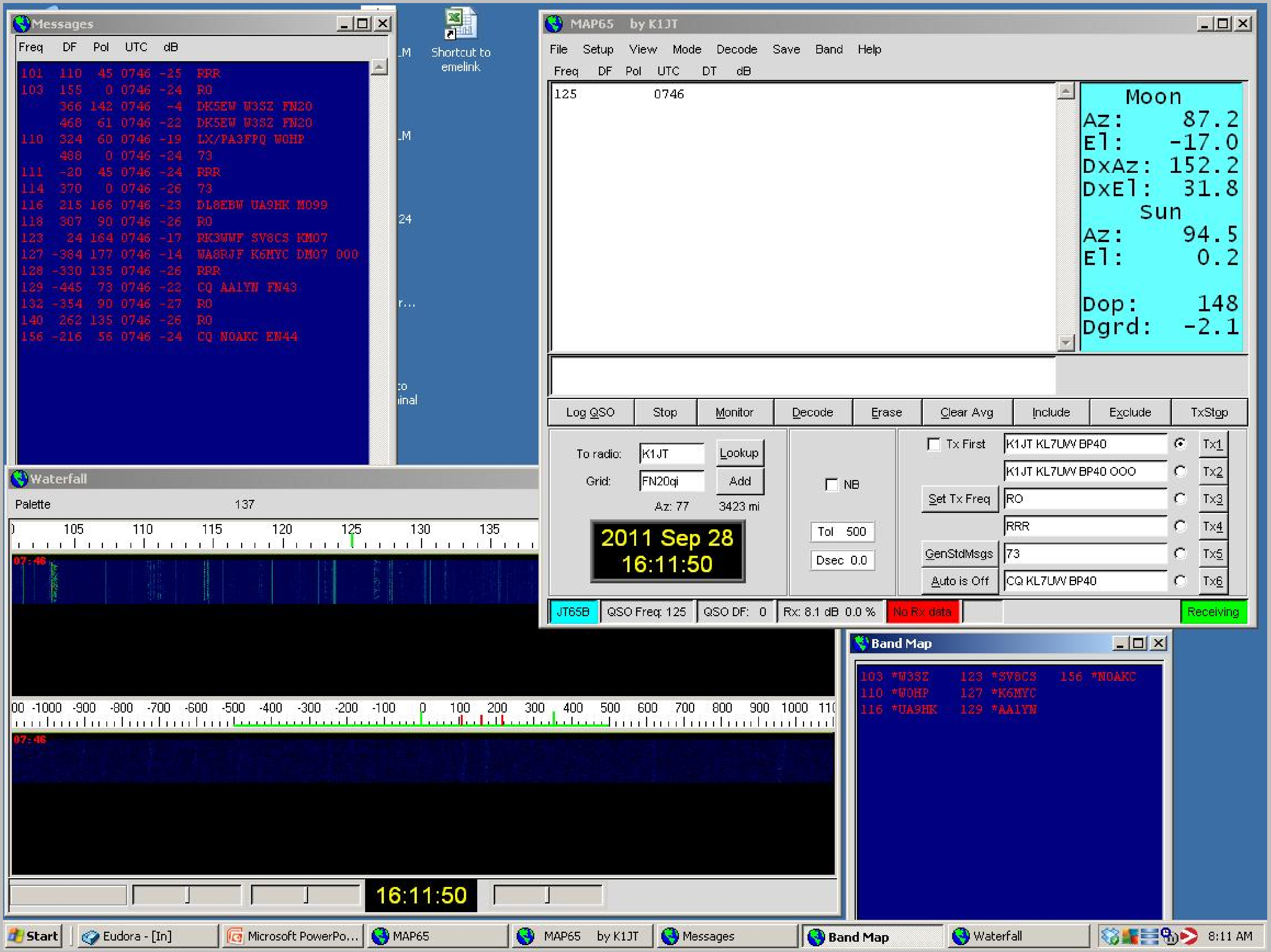

Messages
Freq DF Pol UTC dB
101 110 45 0746 -25 RRR
103 155 0 0746 -24 RO
366 142 0746 -4 DK5EW W3SZ FN20
468 61 0746 -22 DK5EW W3SZ FN20
110 324 60 0746 -19 LX/PA3FPQ W0HP
488 0 0746 -24 73
111 -20 45 0746 -24 RRR
114 370 0 0746 -26 73
116 215 166 0746 -23 DL8EBW UA9HK MO99
118 307 90 0746 -26 RO
123 24 164 0746 -17 RK3WWF SV8CS KM07
127 -384 177 0746 -14 WA8RJF K6MYC DM07 OOO
128 -330 135 0746 -26 RRR
129 -445 73 0746 -22 CQ AA1YN FN43
132 -354 90 0746 -27 RO
140 262 135 0746 -26 RO
156 -216 56 0746 -24 CQ N0AKC EN44
Shortcut to emelink
Band Map
103 *W3SZ 123 *SV8CS 156 *N0AKC
110 *W0HP 127 *K6MYC
116 *UA9HK 129 *AA1YN
MAP65 by K1JT
File Setup View Mode Decode Save Band Help
Freq DF Pol UTC DT dB
125 0746
Moon
Az: 86.8
El: -17.2
DxAz: 151.7
DxEl: 31.7
Sun
Az: 94.1
El: -0.1
Dop: 149
Dgrd: -2.1
Monitor Decode Erase Clear Avg Include Exclude TxStop
Lookup
Tx First
K1JT KL7UW BP40
K1JT KL7UW BP40 OOO
RO
RRR
73
CQ KL7UW BP40
Tx1 Tx2 Tx3 Tx4 Tx5 Tx6
Set Tx Freq
GenStdMsgs
Auto is Off
NB
500
0.0
0.0 %
No Rx data
Receiving
Waterfall
Palette 136
Speed: 1 2 3 4 5
105 110 115 120 125 130 135 140 145 150 155
07:46
-1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0 100 200 300 400 500 600 700 800 900 1000
07:46
16:09:55
Start
Eudora - [In]
Microsoft PowerPo...
MAP65
MAP65 by K1JT
Messages
Band Map
Waterfall
8:09 AM

Fig. 6 – MAP-65



Messages
Waterfall
MAP65 by K1JT
Moon
Sun
Band Map
2011 Sep 28
16:11:50

Fig. 7 – MAP-65

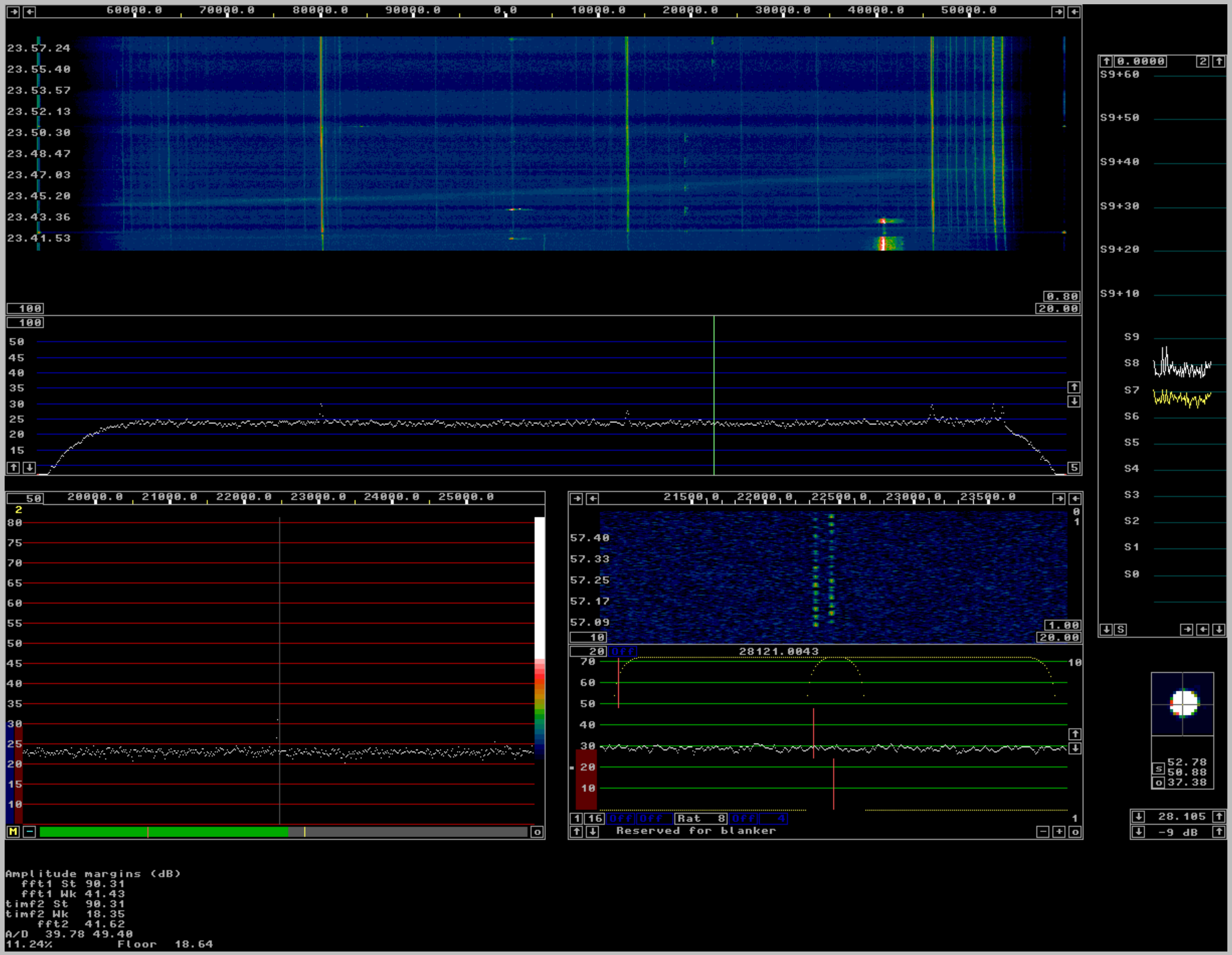


Fig. 8 - Linrad showing EME signal.

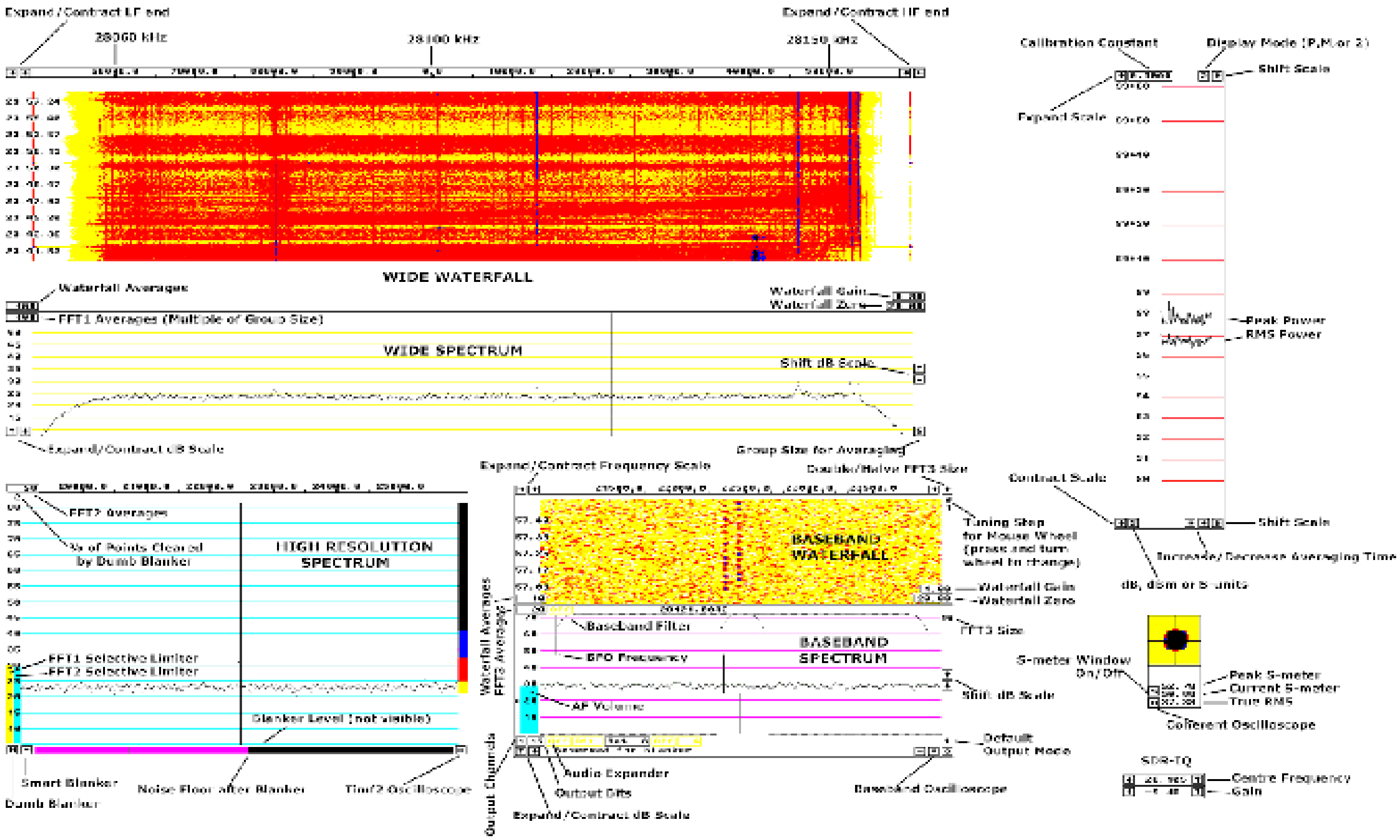


Fig. 9 – Key to Linrad Screen

Fig. 10 – KL7UW, Spring 2011