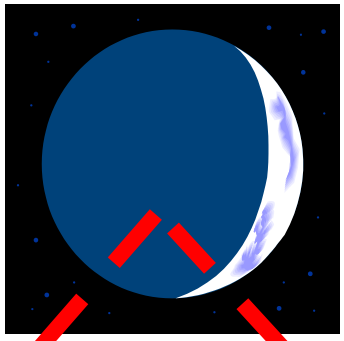
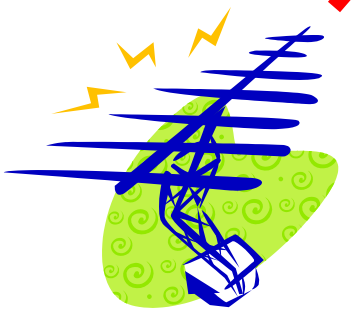


Beginner's Guide to Small-station EME



Paul Bock, K4MSG

phbjr@aol.com

EME (Earth-Moon-Earth)

Two-way radio communication on VHF and above using the Moon as a passive signal reflector. Commonly referred to as "moonbounce".

Amateur EME, 1960-'90s

EME shack?

- Technically challenging
- Required substantial investment
- Definitely *NOT* "plug and play"!

W5UN “Mighty Big Array” (MBA)

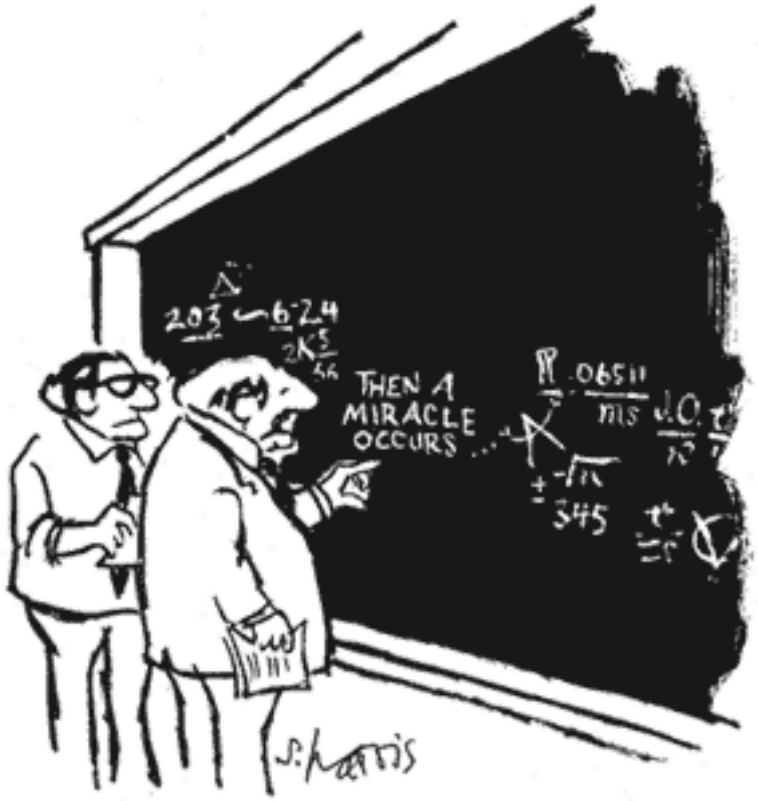
W5UN EME Array with 32 2M5WL horizontal antennas, and 32 front mounted ten element vertical antennas

But - Why so difficult & expensive?

- Path loss >250 dB
- Spatial Polarization Offset – "Your horizontal isn't my horizontal"
- Faraday Rotation (random pol. shift)
- Galactic & Solar noise
- CW was "mode of choice"(signals had to be "hearable")
- Equipment limitations (NF, coax, etc.)

Amateur EME, 2003

"Then a miracle occurs"



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Amateur EME, 2003 – "The Miracle"

- First release of JT65 software designed specifically for EME
- Decodable to <-27 dB relative to noise floor on VHF/UHF
- By contrast, CW is only copyable to about -12 dB with "good ears"

BUT be realistic!!

If you have 1 or 2 modest-size antennas and <500w:

- You will likely never be able to see (or hear) your own echoes!
- You will generally only be able to work stations larger than yours
- Some days you will make no QSOs due to EME propagation conditions

So, how do I try a few EME contacts using this digital mode, but without breaking the bank account??

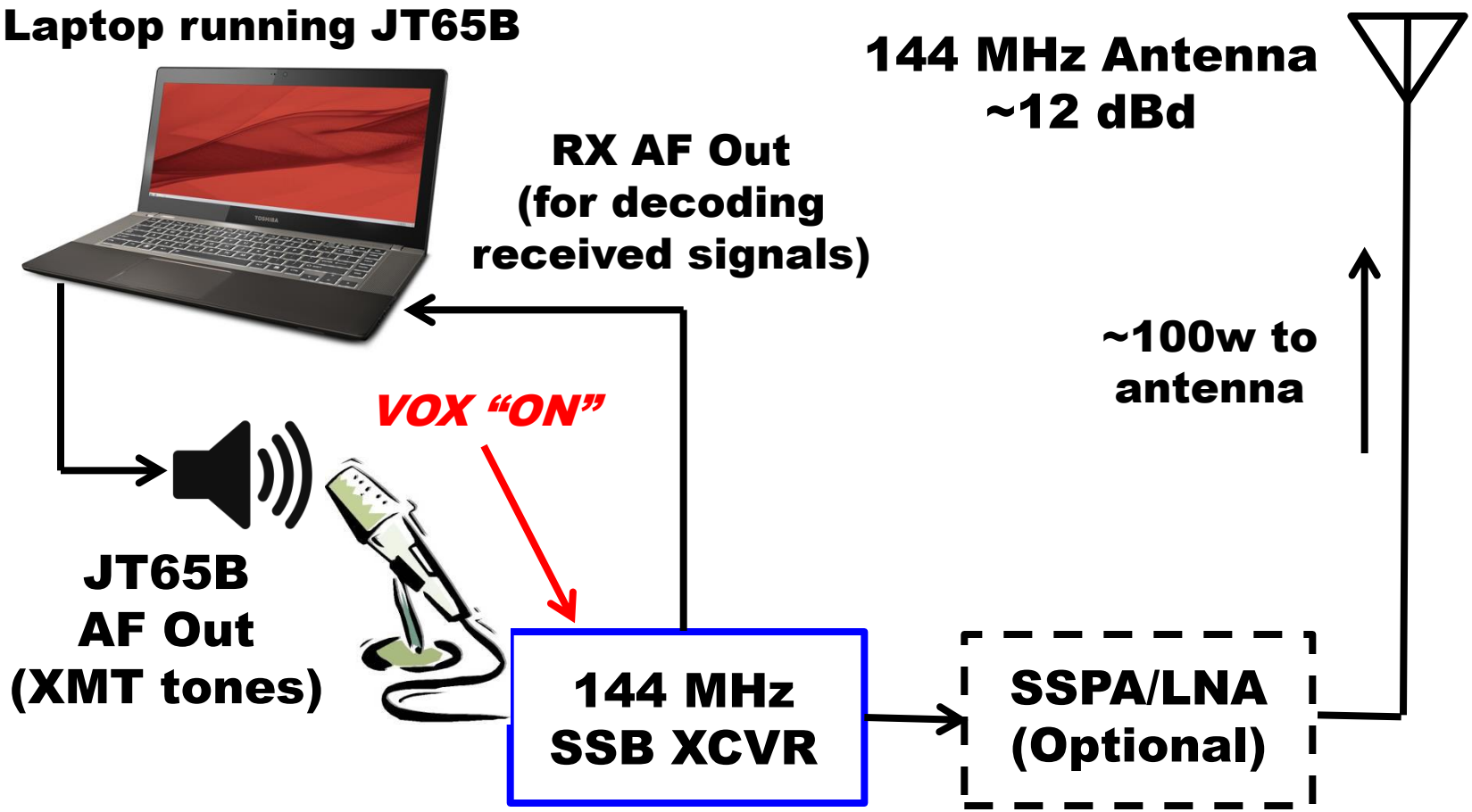
Suggested Station Set-up for 144 MHz EME w/VOX

- ***Multimode 144 MHz XCVR***

  ****OR****

  HF XCVR w/144 MHz XVTR
- ***At least 100w @ antenna***
- ***Low-noise (<1 dB NF) preamp***
- ***144 MHz Yagi (>10 dBd gain)***
- ***Low-loss coax, as short as possible***

Quick & Easy 144 EME: JT65B using VOX



VOX Method

Advantage

Low-cost, “plug & play”

Disadvantage

- Extraneous noise may trip VOX
- Built-in JT65 delay is ignored, only a fast SSPA relay will protect LNA
- No future capability for sequencing mast-mounted LNA relays

Suggested Station Set-up for 144 MHz EME Using PTT

- ***Identical set-up to VOX approach***

****PLUS****

- ***External rig controller such as a RigBlaster (or equivalent)***

****OR****

- ***USB interface (if available on transceiver)***

EME Using PTT

144 & 432 MHz

M2 2M9SSB (144)
Innov 18LFA (432)

JT65B
AF Out

USB to
RS232
(PTT)

RX AF
Out

60’ EcoFlex
10+, -0.9 dB

IC-706
144/432
MHz

**SSPA/LNA
200w/0.8 dB

(OPT.) Use
PTT to
To drive a
sequencer!

Amp PTT

RigBlaster Plus

PTT &
JT65B In

** SSPA/LNA
100w/1.1 dB
on 432 MHz

PTT Method

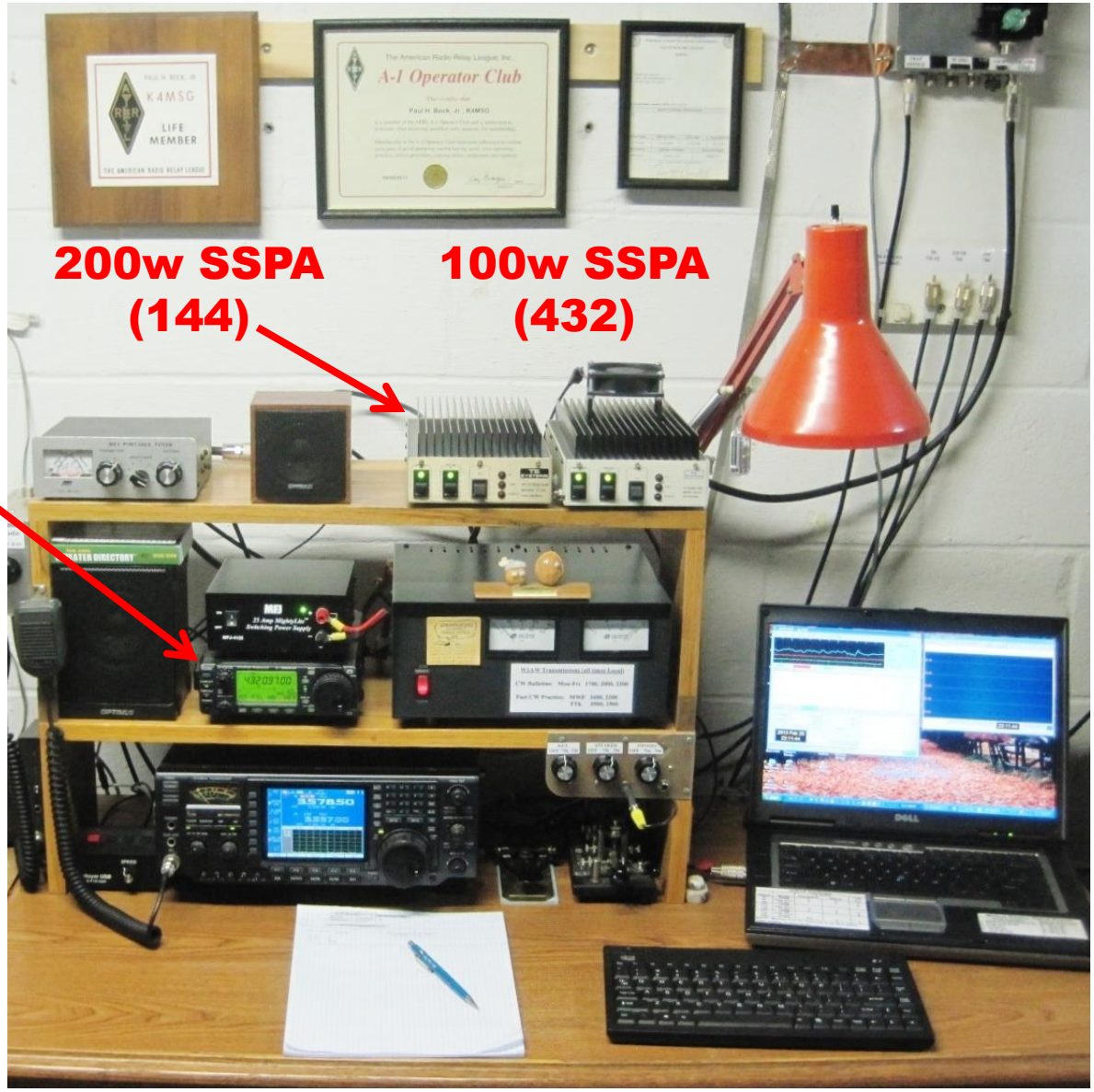
Advantage

- Immune from noise “tripping” VOX
- PTT uses JT65 delay (~0.5 sec) to switch SSPA before modulation
- Expandable using a sequencer

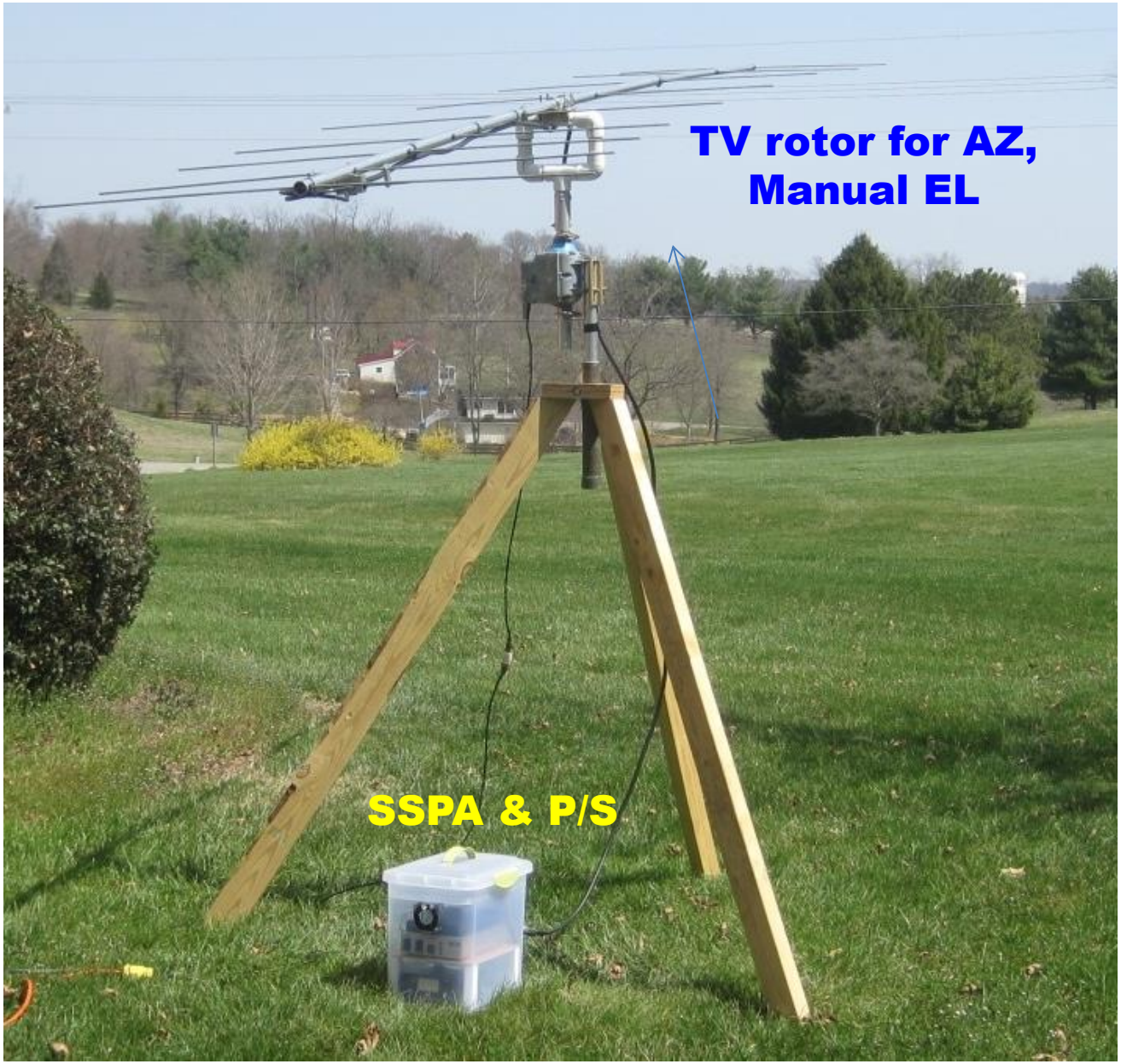
Disadvantage

- More complex, more equipment
- Extra cable (PTT line) to SSPA

K4MSG, March, 2013



144 MHz EME Single-Yagi Set-up



How to set elevation when Moon isn't visible

Clinometer adjusted to re-position "zero" with new scale (old scale is 45-30-15-0-15-30-45)

432 MHz EME Single-LFA Set-up

144/432 MHz EME Low-power SSPAs

144 *OR* 432 MHz SSPA/LNA w/30A switching power supply, located @ antenna

144 MHz - 170w out
432 MHz - 90w out

Both operated at reduced power due to JT65B duty cycle (40% TX)

144 MHz Station Evolution

3/2013: Single Yagi, 170w @ antenna

8/2013: Single Yagi, 260w @ antenna

9/2014: Dual Yagi, 260w @ antenna

1/2015: Transceiver TS-2000X

432 MHz Station Evolution

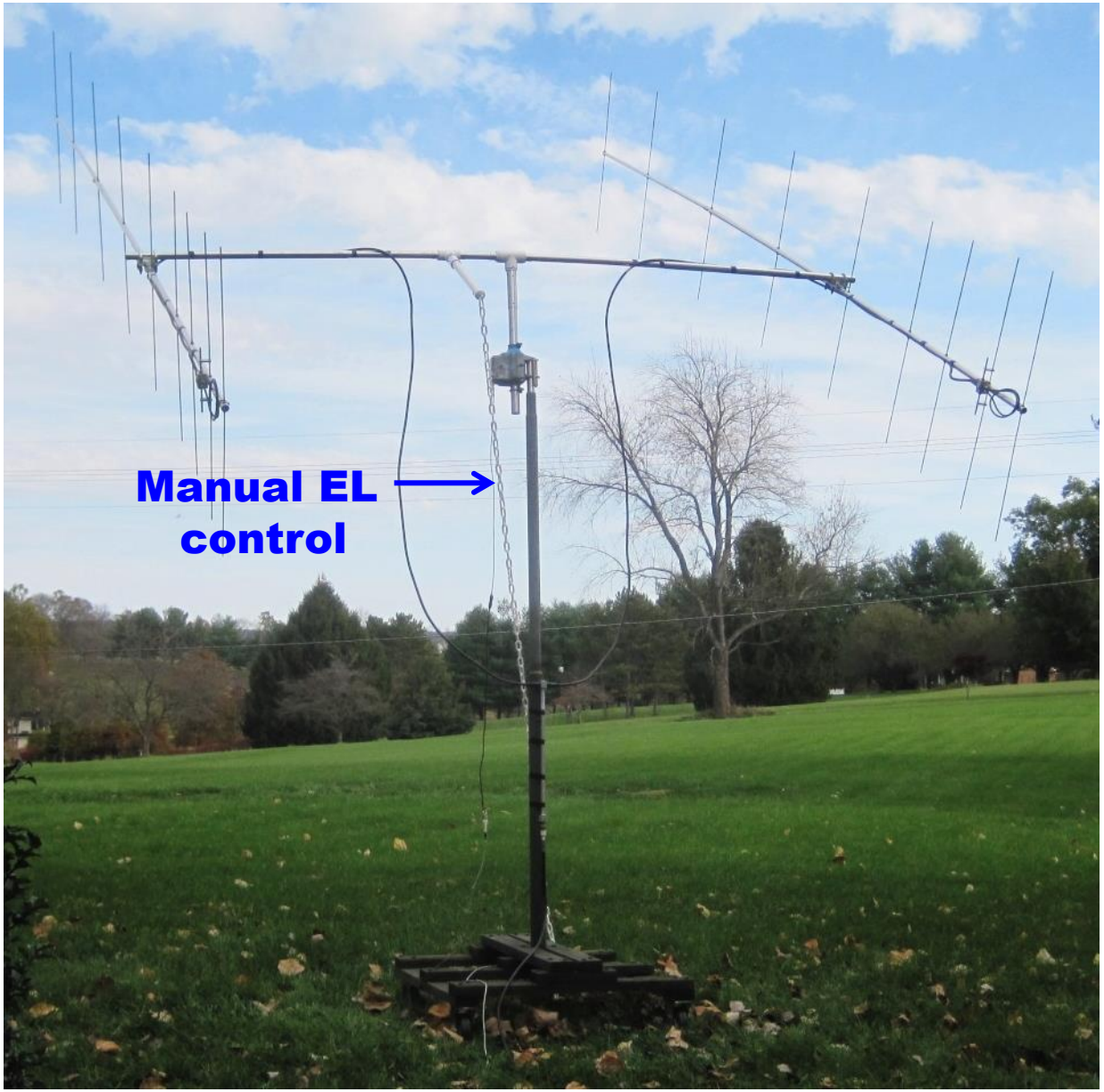
5/2013: Single LFA, 90w @ antenna

8/2013: Single LFA, 160w @ antenna

5/2014: Dual LFA, 160w @ antenna

1/2015: Transceiver TS-2000X

144 MHz EME Dual 9-el. Yagi array, 350w SSPA in shack (9/2014 – present)

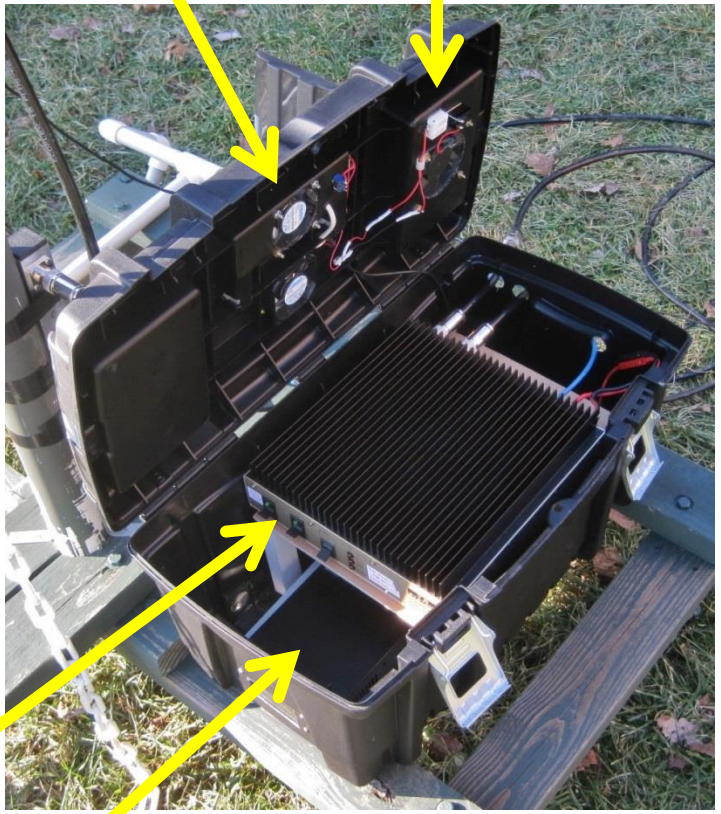


432 MHz EME Dual 18-el. LFA array, 160w SSPA @ antenna (5/2014 – present)

432 MHz. 180w amp & switching power supply (160w @ antenna)

Power Supply Meter

Cooling fans
Inlet Outlet



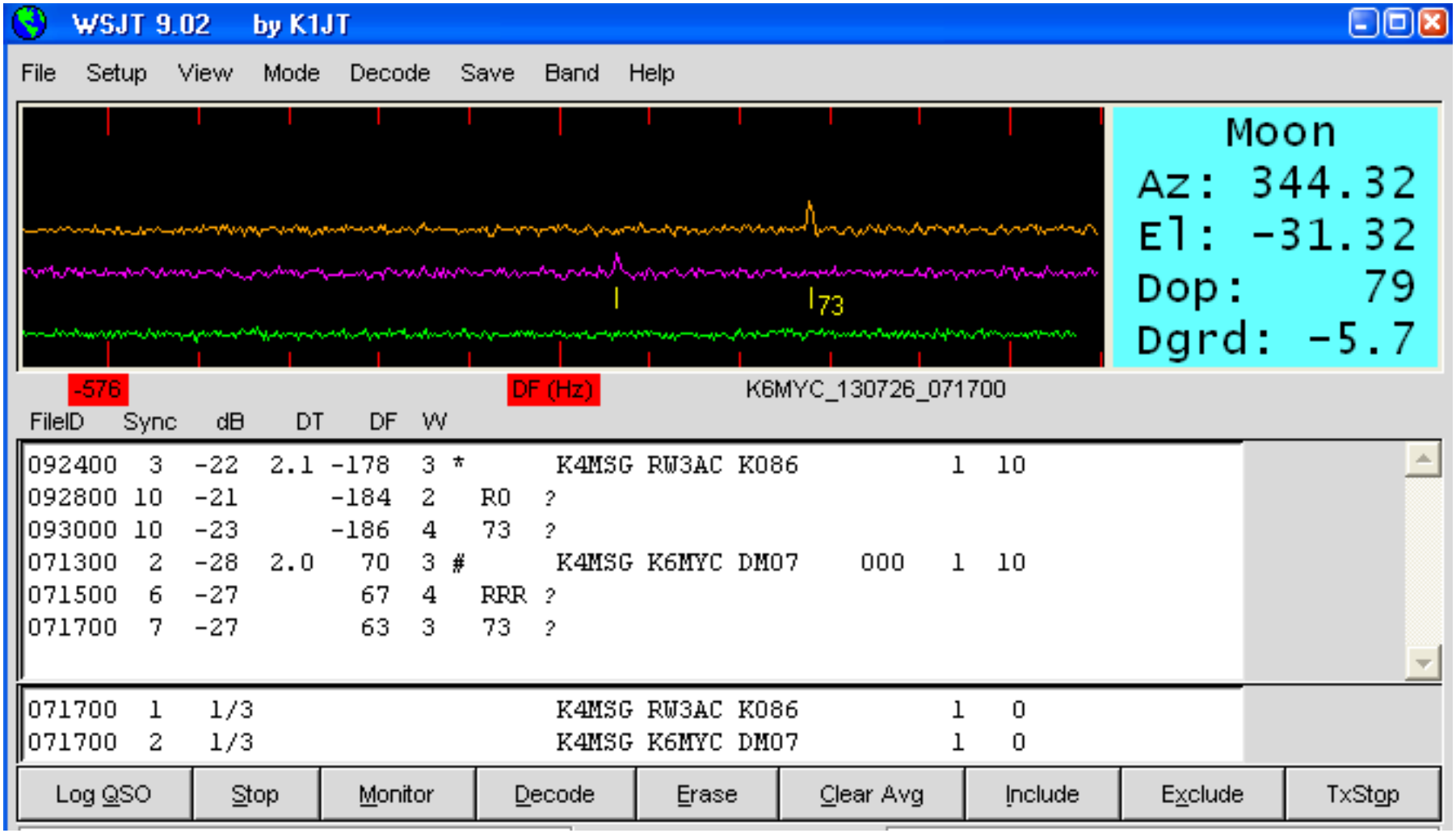
Amp

Power Supply

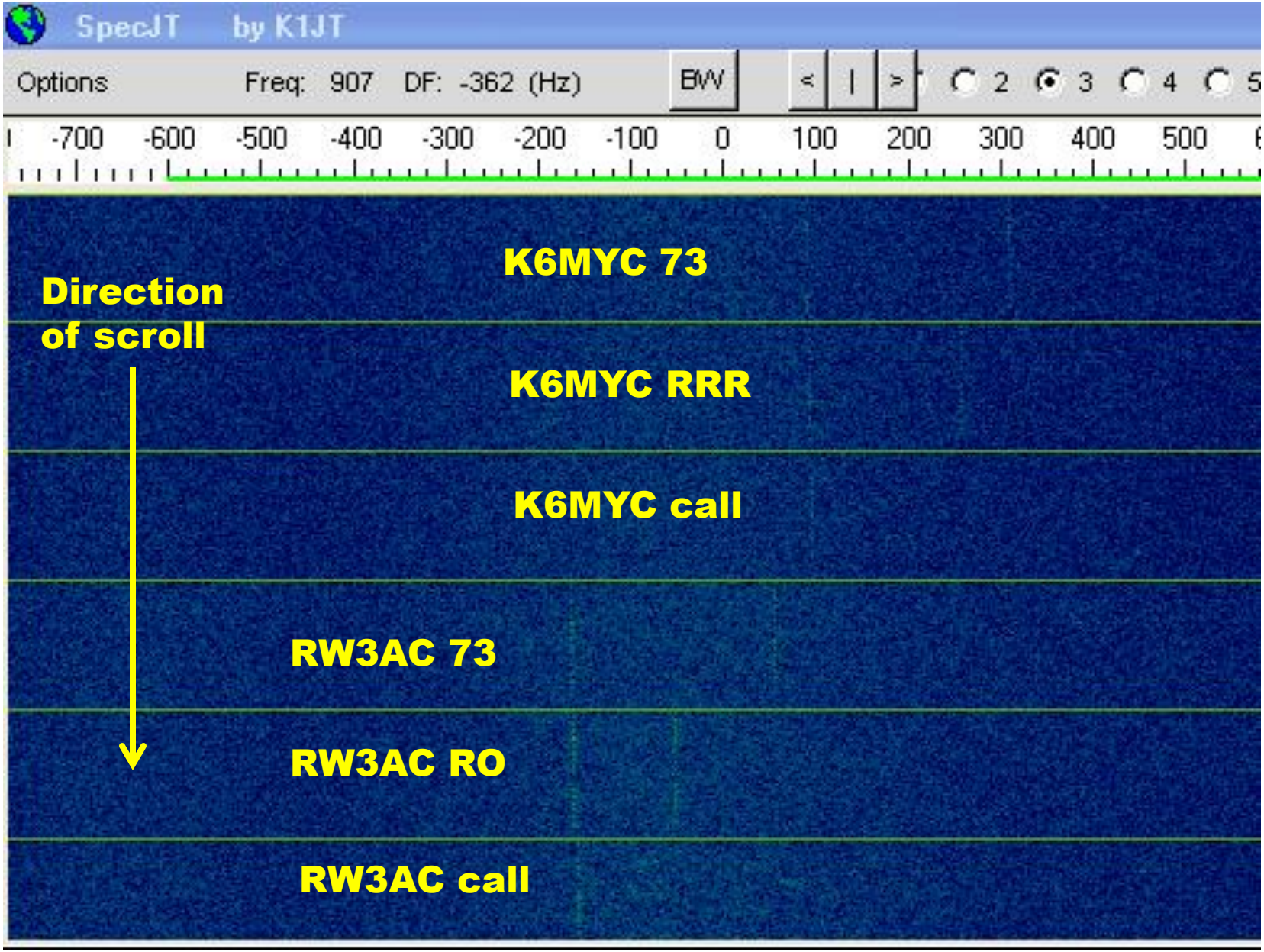

PA7MDJ 144 MHz EME
(100w @ antenna)

Appendix A:
Operating EME

Some typical QSOs



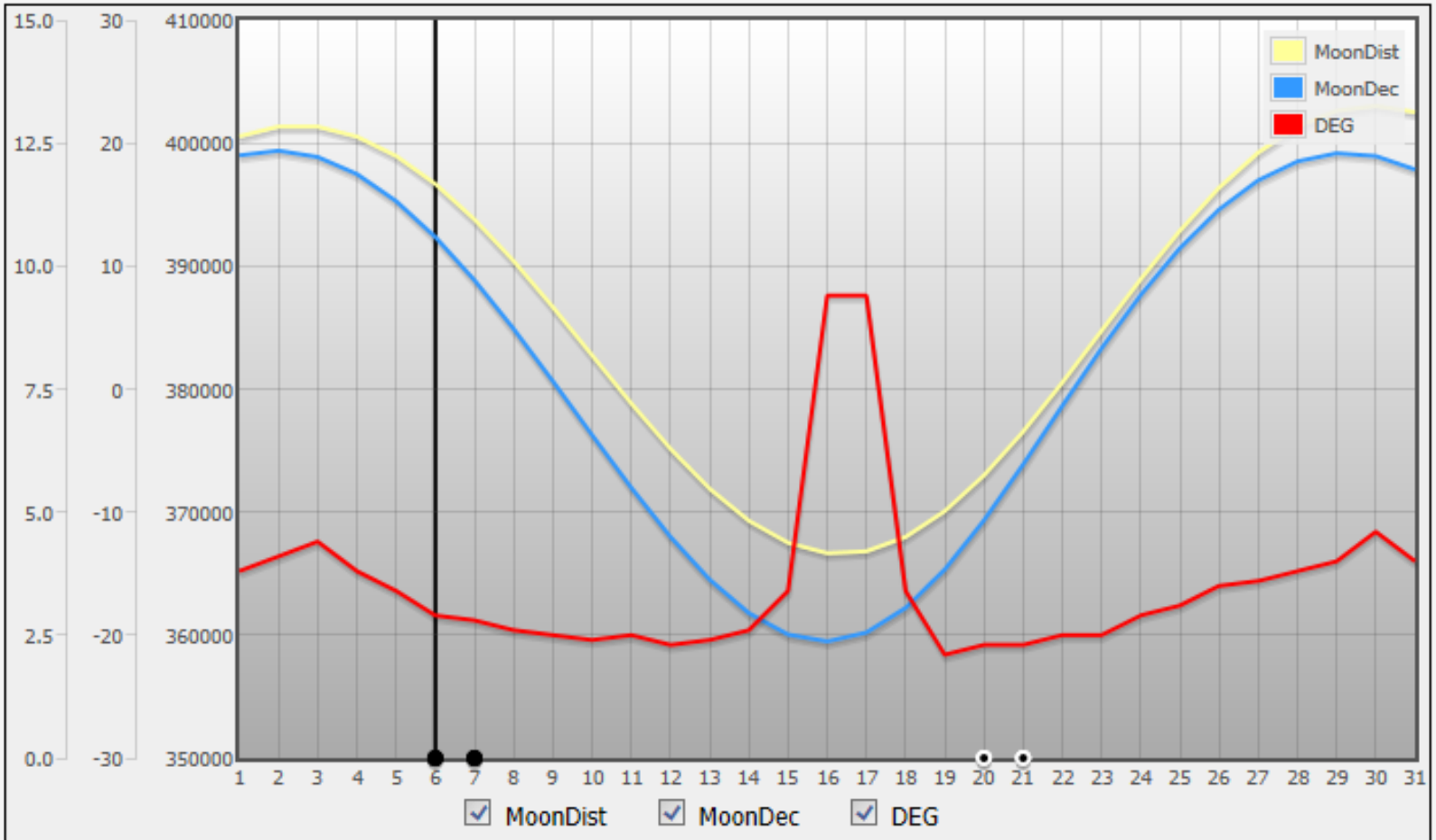
A Picture is Worth.....



Monthly Moon Chart

Earth Moon Earth (EME)

Moon Data - August 2013



August 2013 Go

Todays 144MHz EME conditions: Degradation = 2.9 dB
=> Fair

Whither the Moon?

Rising and setting times for the Moon

			Azimuth		
Date	Moonrise	Moonset	Moonrise	Moonset	Phase
Aug 1, 2013	1:46 AM	4:27 PM	65° ↗	296° ↖	
Aug 2, 2013	2:31 AM	5:15 PM	64° ↗	296° ↖	
Aug 3, 2013	3:21 AM	5:59 PM	64° ↗	295° ↖	
Aug 4, 2013	4:13 AM	6:39 PM	66° ↗	292° ↖	
Aug 5, 2013	5:08 AM	7:16 PM	69° ↗	289° ↖	
Aug 6, 2013	6:04 AM	7:50 PM	73° ↗	285° ↖	New Moon at 5:51 PM
Aug 7, 2013	7:02 AM	8:21 PM	78° ↗	280° ←	
Aug 8, 2013	8:00 AM	8:52 PM	83° →	274° ←	
Aug 9, 2013	8:59 AM	9:22 PM	88° →	269° ←	
Aug 10, 2013	10:00 AM	9:53 PM	94° →	263° ←	
Aug 11, 2013	11:01 AM	10:26 PM	100° →	258° ↙	
Aug 12, 2013	12:04 PM	11:03 PM	105° ↘	253° ↙	
Aug 13, 2013	1:09 PM	11:44 PM	110° ↘	248° ↙	
Aug 14, 2013	2:13 PM	-	114° ↘	-	First Quarter at 6:57 AM
Aug 15, 2013	- 3:17 PM	12:31 AM -	- 116° ↘	245° ↙ -	
Aug 16, 2013	- 4:18 PM	1:25 AM -	- 116° ↘	244° ↙ -	
Aug 17, 2013	- 5:13 PM	2:26 AM -	- 114° ↘	244° ↙ -	
Aug 18, 2013	- 6:03 PM	3:34 AM -	- 111° ↘	247° ↙ -	

Who's calling CQ?

LiveCQ 144 432 1296

Menu

- All spots
- Latest spots
- Who is online
- Add your CQ spot here
- User config
- Contest style
- Simple design all spots
- Mobile

Search

callsign

Latest 25 spots

Freq	Date	Time	Signal	DF	DT		Call	Loc	Pol	M	Spotter
144.125	21-Jul	214800	-21	+059	1.3	CQ	SP2OFW	JO82	H	B	SV6KRW
144.110	21-Jul	213600	-21	-066	2.4	CQ	S52LM	JN65	166	B	OK1IL
144.125	21-Jul	212800	-20	-095	1.9	CQ	SP2OFW	JO82	19	B	OK1IL
144.140	21-Jul	213000	-20	-168	2.4	CQ	SV6KRW	KM09	175	B	OK1IL
144.129	21-Jul	205400	-19	-269	2.3	CQ	UA4LCF	LO44	133	B	OK1IL
144.132	21-Jul	204600	-23	-038	2.9	CQ	UX0FF	KN45	59	B	OK1IL
144.136	21-Jul	203000	-20	+046	2.2	CQ	OZ1CT	JO75	26	B	OK1IL
144.123	21-Jul	202800	-24	+044	2.5	CQ	SM4GGC	JO69	2	B	OK1IL
144.114	21-Jul	200800	-18	+129	2.2	CQ	EA5CJ	IM99	73	B	OK1IL
144.117	21-Jul	200000	-19	-146	1.2	QRZ	UR3EE	KN88	172	B	OK1IL
144.114	21-Jul	000		000		CQ	EA2BDA	IN82	H	B	EA2BDA
144.129	21-Jul	195600	-25	-301	2.2	CQ	UA4LCF	LO44	H	B	UA3PTW
144.117	21-Jul	195600	-21	-237	1.3	CQ	UR3EE	KN88	H	B	UA3PTW
144.114	21-Jul	195400	-24	+042	2.2	CQ	EA5CJ	IM99	H	B	UA3PTW
144.136	21-Jul	195400	-21	-003	2.1	CQ	OZ1CT	JO75	H	B	UA3PTW

Log on to N0UK JT65 EME-1

JT65 EME Link by NØUK

New T

JT65 EME - 1.

PingJockey Central	JT65 Terrestrial	JT65 EME - 2	CW EME	Who's Earwigging?	
Distance/Bearing Locator	Refresh	Look back	Update User details	Paul, K4MSG FM19ee	Refreshed 07/21 23:15

Exchanging any contact details on here before you're complete, invalidates the contact, and, if it's not JT65 via Moonbounce it doesn't belong here!

Enter your message here Go!

```
MM/DD  UTC
07/21 23:13 Enzo very good ......here qro, but in qso 850 :-)  ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.73.113}
07/21 23:11 1500  THERE.....thank you ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 23:11 OK  :-) ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 23:10 Enzo was up 850w ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.73.113}
07/21 23:09 GEORGE HOW MANY watts you have ? ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 23:07 73 george ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 23:03 === Stop CQ === ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.73.113}
07/21 22:59 225400  1  -31       -25  2   RRR ?             ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:59 225300  3  -29      -110  3   RO  .............225500  5  -28      -114  3   73 qsb but all ok 73s ====== {SV6KRW/4X
07/21 22:59 225800  1  -29  1.0  -30  3 *      CQ SV6KRW KM09            0  10  ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.19
07/21 22:58 225600  5  -28       -26  3   73  ?              ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:58 I8KPV Enzo many qsb tonight here ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.73.113}
07/21 22:58 73,S GEORGE ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:58 SORRY  -28 ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:57 TNX QSO  -20 THERE ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:56 224500  0  -26  3.1  -94  3 *      SV6KRW I8KPV JN70         0  10  ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.7
07/21 22:56 I8KPV Enzo many tnx for first EME qso best you here -26 73 and GL!! Ciao ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.
07/21 22:55 73----------TNX ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
07/21 22:44 see again ====== {SV6KRW/4X7V4X8H George xx KM09kp 89.210.73.113}
07/21 22:43 calling now ====== {I8KPV/2X20/1500 Enzo xx JN70ko 79.1.25.194}
```

Appendix B:
Lunar Propagation

Lunar Propagation Basics

- Path loss ~253 dB @ 144 MHz, ~263 dB at 432 MHz
- Spatial Polarization Offset
- Faraday Rotation
- Galactic & Solar noise
- Doppler shift

Spatial Polarization Offset

- Occurs due to location, e.g. my "horizontal" not the same as yours
- Mismatch loss is 3 dB @ 45 degrees, 6 dB @ 60, >20 dB @ 90
- Avoidable by using either "brute force" *OR* circular polarization (*BUT* one station must use RHC while other uses LHC)

Faraday Rotation

- *Random polarization shift, variable (and unpredictable) rate of change*
- *Different for stations at different locations, dependent on ionization*
- **BUT* can mitigate Spatial Polarization Offset problem!!!*
- *Without it, most EME QSOs between small linearly-polarized stations would never occur!!*

Galactic Noise

- *Moon is in front of Milky Way for 3-4 days every Lunar month*
- *Background noise rises ~6-8 dB*
- *SOLUTION: "Brute force" or just don't operate on those days*

Doppler Shift

- Occurs because of relative motion between Earth and Moon
- Maximum ~300 Hz at 144, 1 kHz @ 432, 3 kHz @ 1296, etc.
- Operating procedures have been developed to mitigate the “missed QSO” problem due to not tuning correctly

Appendix C:
EME History

1946, U. S. Army Project Diana

Bounced a RADAR signal (111.2 MHz) off of the Moon!

1954, U.S. Naval Research Laboratory

First successful voice transmission via the Moon.

1960, U. S. Navy Communications Moon Relay (CMR)

The USS Hancock (CVA-19) was the subject for the first official photograph to be transmitted by radio facsimile via moon-bounce.

1960's Navy EME

- **TRSSCOMM EME communications from Technical Research ships (AGTRs), 1961-71.**

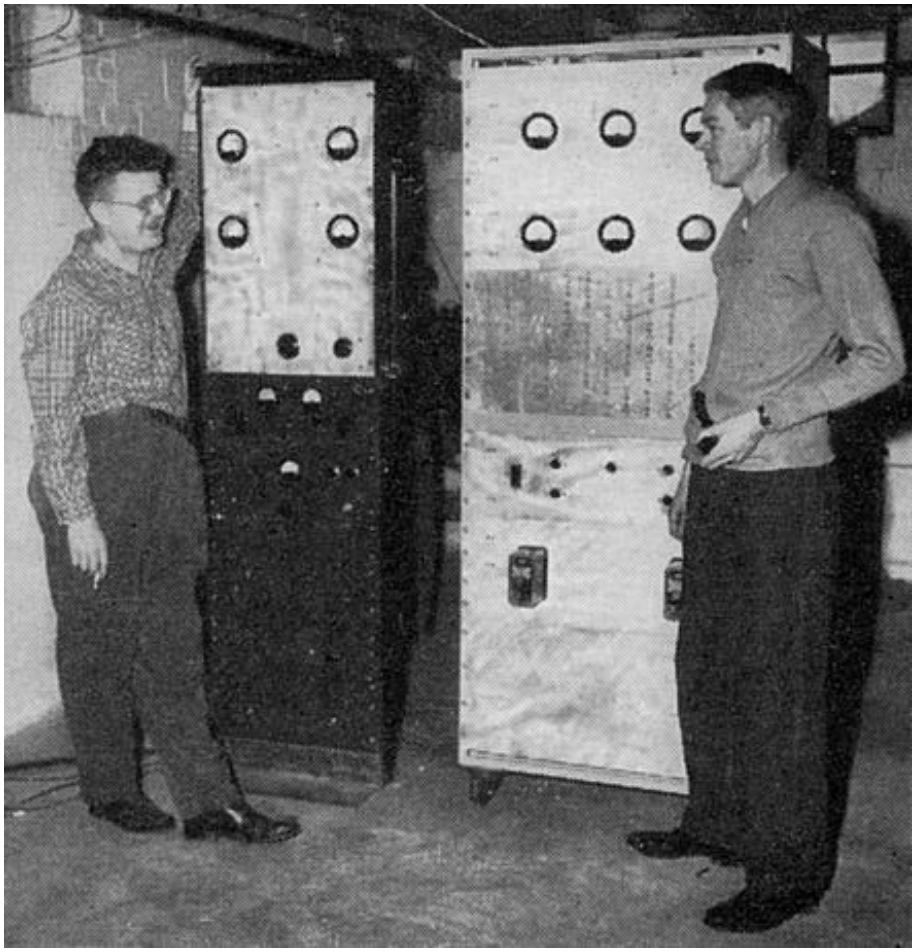
TRSSCOMM for AGTR-4, -5

1800/2200 MHz
10kw output
Paramp front end
LHC/RHC/Linear

100 wpm RATT
Encrypted
Full Duplex

Can you hear me now?

Amateur Radio Moonbounce



1953: Ross Bateman, W4AO, and Bill Smith, W3GKP, recorded first amateur radio signals bounced off of the Moon.

- 144 MHz
- 1 kw
- <4 dB NF
- stacked rhombics

Amateur Radio Moonbounce

First Amateur Two-Way EME, 1960

Sam Harris, W1FZJ (operating W1BU)
Hank Brown, W6HB
1296 MHz