432MHz:

Polarization experiments

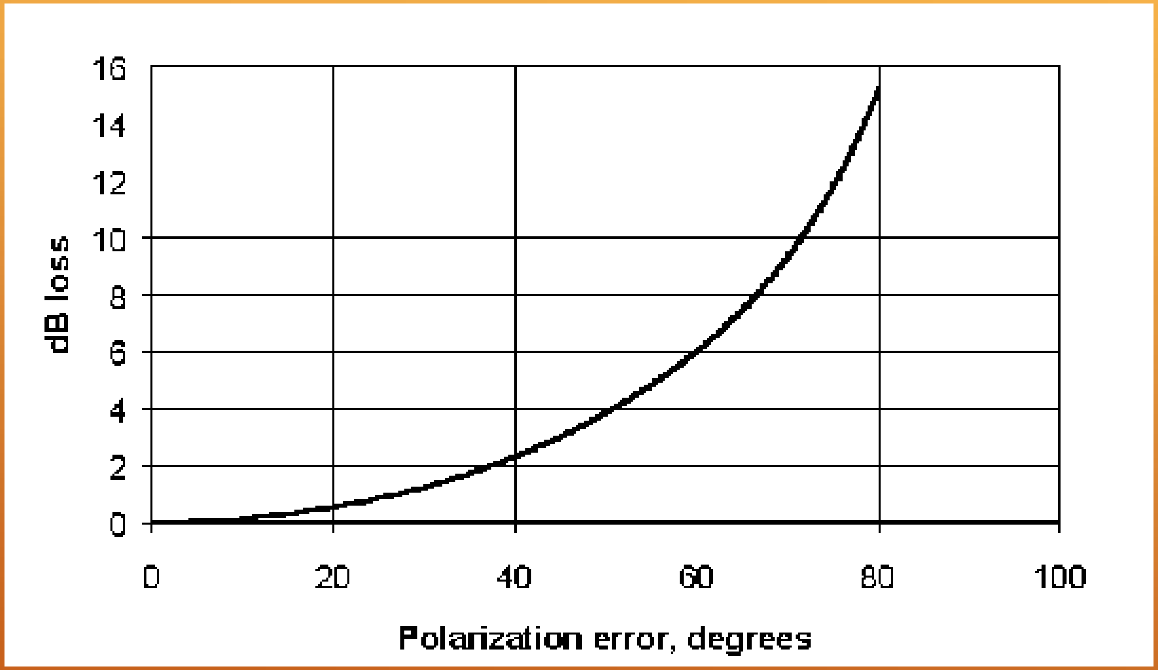
PA0PLY - JO22IH

Fundamentals

FARADAY ROTATION

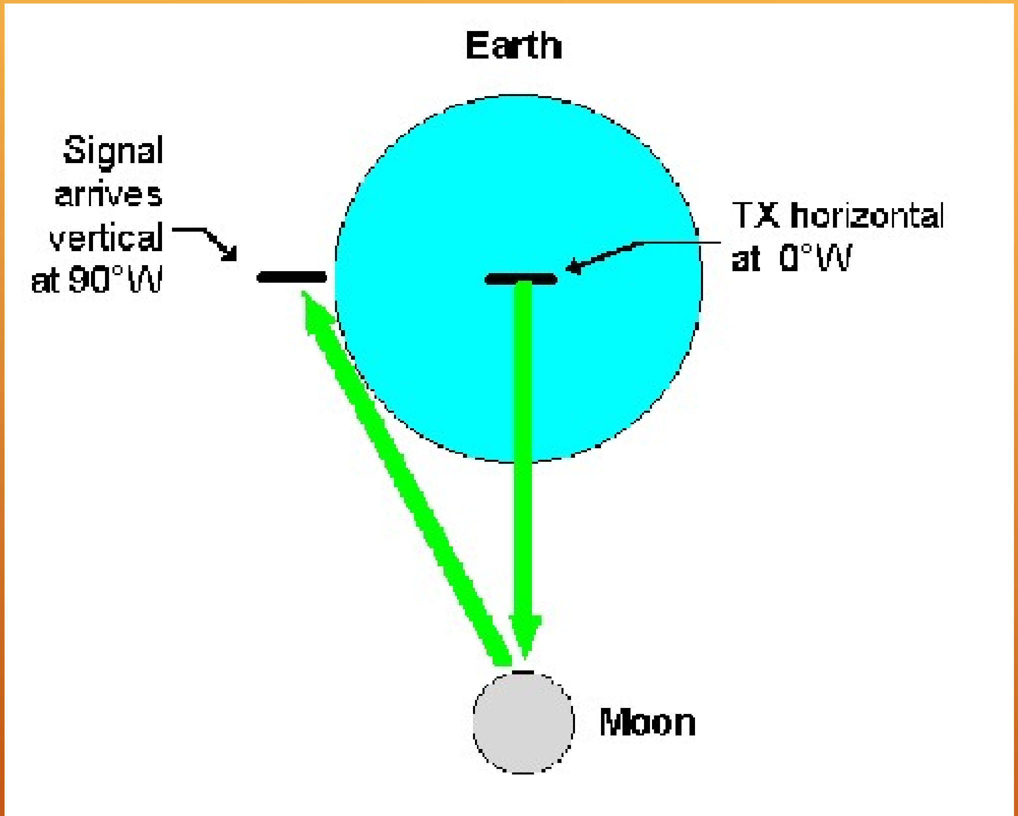
- Linearly polarized signals rotate when they pass through the ionosphere.
- EME signals pass through the ionosphere twice
  - First on its outward journey
  - Secondly the returned signal reflected from the moon
- It's speed of rotation is a function of : $1/(freq)^2$
- Thus at 144MHz it rotates 9x faster than on 432MHz.
- On 432MHz signals can be 'locked out' for a longer period.

Polarization errors



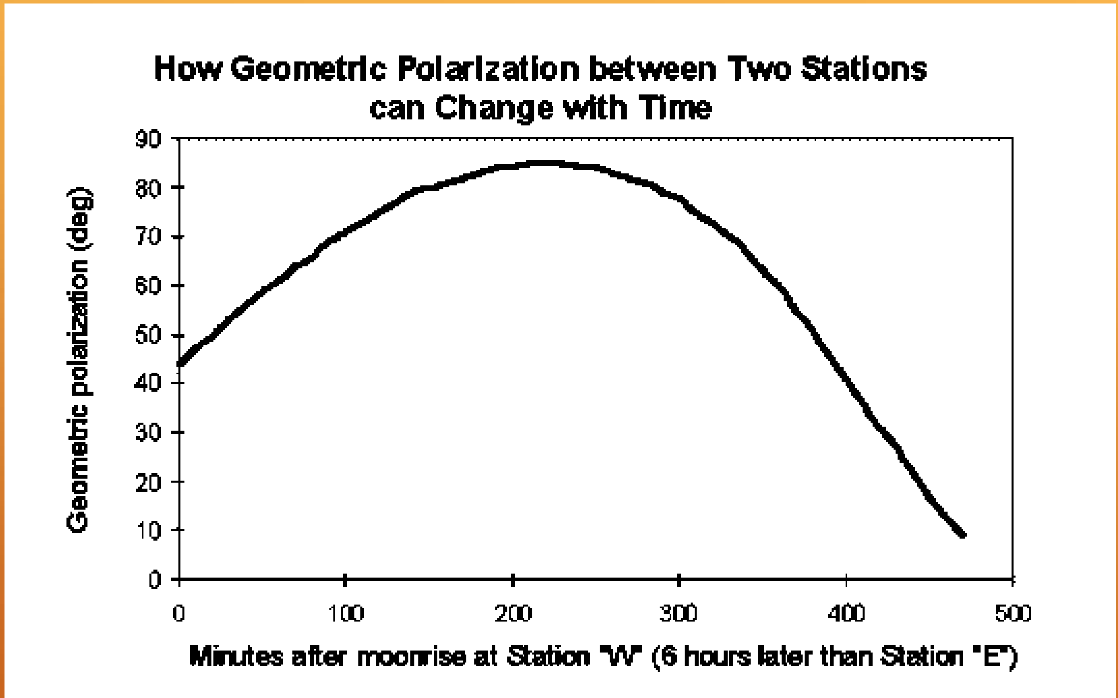
- **Polarisation offsets in excess of 27 degrees have more than 1dB loss**
- **An offsets of 45 degrees will introduce a loss of 3dB**
- **Offsets of 20 degrees or less will introduce negligible loss**

Geometric effects



- The relative position of two stations on earth causes a polarisation offset, called spatial polarization.
- For example horizontally polarised signals from EU can arrive close to vertical in the USA

Geometric effects



- Furthermore the error will also depend on the position of the moon.
- Polarization changes may vary from 0 to 90 degrees between an East and West station from moonrise to moonset.

Signal ROTATION

Key to table below:

White background	=	can hear – polarizations are aligned
Grey background	=	can hear, but with loss due to polarization mis-alignment
Black background	=	can **not** hear – cross-polarized!

Fixed horizontal polarization		Geometric Rotation (station positions + moon position)				
		–90°	–45°	0°	+45°	+90°
Faraday Rotation (iono-sphere)	+90°	E hears W W hears E	E hears W W hears E		E hears W W hears E	E hears W W hears E
	+45°	E hears W W hears E	W hears E	E hears W W hears E	W hears E	E hears W W hears E
	0°		E hears W W hears E	E hears W W hears E	E hears W W hears E	
	–45°	E hears W W hears E	E hears W	E hears W W hears E	E hears W	E hears W W hears E
	–90°	E hears W W hears E	E hears W W hears E		E hears W W hears E	E hears W W hears E

1. Faraday rotation
2. Geometric rotation
3. Moon position influence

Antennas – pa0ply

PA0PLY

- DL6WU 4.2 λ - modified
- 8 X HORIZONTAL
- GAIN: 23dBD

PA0PLY

- Severe storm damage created the opportunity to prepare a different set-up.

PA0PLY – 2nd generation

- DL6WU 4.2 λ
- 4 X HORIZONTAL
- 4 X VERTICAL
- DIRECTLY COUPLED
- GAIN: 20dBD (each section)

PA0PLY 3rd Generation

- **SWITCHABLE BETWEEN HORIZONTAL & VERTICAL**

- Antenna pattern will be pure Hor or Ver
- RX will improve since noise from other section will not contribute
- TX power will increase to individual section

TEST PROGRAM

Test program

- During QSO's compare signal reports between PA0PLY and PA2V / PD7RKZ.
- As we are in the same geographic area the arrival of signals will have very similar polarisation.
- Test sequences with Frank NC1I to have some indication on the polarity change between EU and USA.
- Signal comparison to single polarized stations.

Test program

- Measure the antenna diagram for the coupled antenna situation.
- Or
  - Predict the antenna diagram from simulation.

Practical reports

Practical reports – PA2V

- Unfortunately Peter lost his array before we were able to run these tests.
- During previous QSO's we confirmed that the arrays have similar performance (my 8 ant array & Peter's 4 ant array.)
- Peter used: 4 x 24el LFA antenna's.
- Gain: 22.35dBD

Practical reports – PA0PLY

- In parallel with PA2V I checked signal reports to other stations.
- My signal was -3dB compared to Peter most of the time.
- Some contacts with ES3RF show the signal strength H- versus – V.
- My impression is that I lost gain compared to the original set-up.
- I rarely observed any advantage with V pol due to Faraday rotation.

Practical reports – PD7RKZ

- With Rob PD7RKZ we checked the difference in signal strength on the GB3UHF beacon.
- My signal level was -3dB when compared to Rob's, most of the time.
- This confirms the decrease in antenna gain for a horizontal signal, due to my set-up.

Practical reports – NC1I

- Over a long period Frank noted the polarisations during his QSO's.

- From his log:
- Quite often in USA: H-H contacts
- Quite often USA-EU: V-H contacts
- Contact USA – JA: [Insufficient data available for good comparison]
- Sometimes contacts under 45Degr.

Antenna: 48x15el K1FO Gain: 31.5dBi

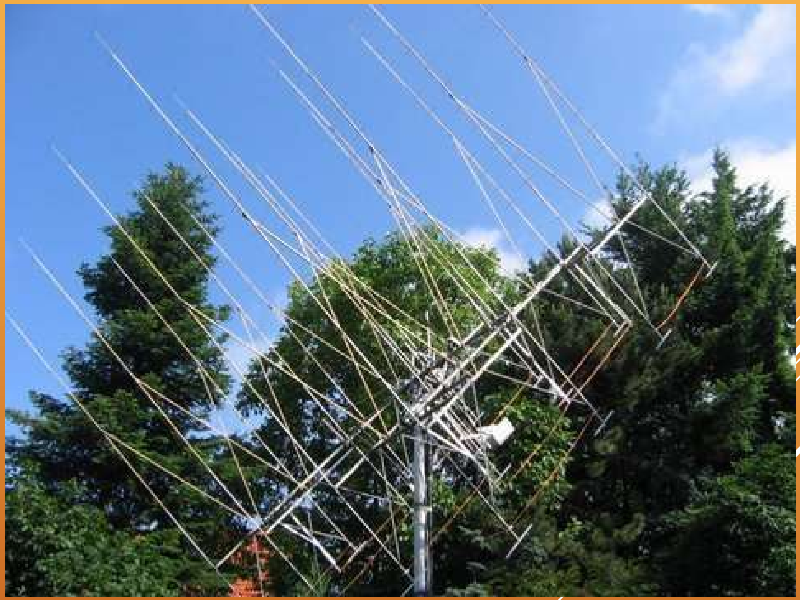
Practical reports – DL9KR

Jan:

There's the community of "yagi-polarization-changers" by means of mechanically turning the whole yagi group. This needs construction in front of the supporting mechanism and hence relatively short yagis.

Exponents are NC1I and G3SEK. Their rate of change of polarization is slow and will only work with the slow changes of Faraday, but not with one-way effects.

Then there's the group of cross-yagi users that has to rely on the quality of their antennas and the quite complicated switching of the pertinent relays.

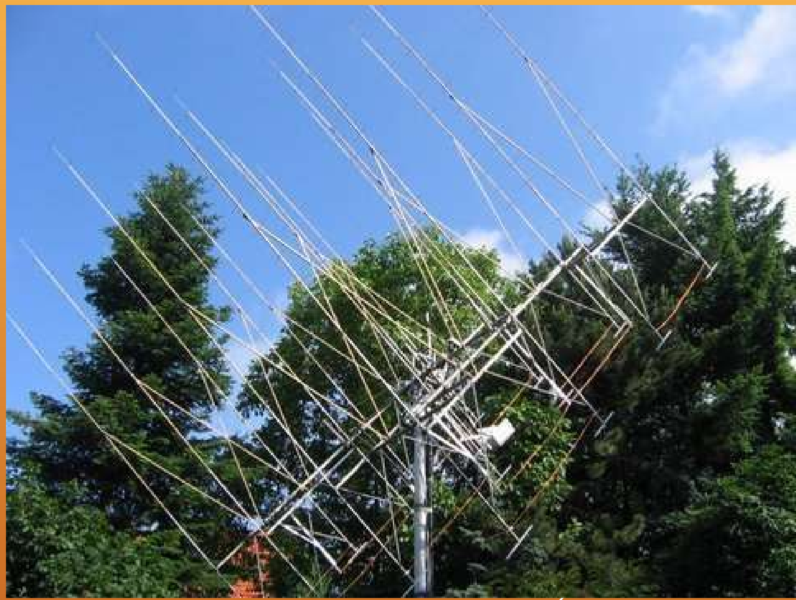


Antenna 16x8.5wl DL6WU Gain: 28,3dBD

Practical reports – DL9KR

Jan’s opinion:

It's best to put ALL yagis of a group into ONE polarization to maintain max. antenna gain for RX and TX. I certainly had to stand hard times in contests waiting for Faraday to do a good job.



My own high contest scores in the past were also a matter of patience.

Practical reports – DL7APV

Bernd:

70-90% of the incoming signals are H or close to that. Means with V it would not be much better.

I have an small 8x11 V pol. since ARRL last year and that confirms it a bit.

My first plan was to use 64H+64V, but then I changed the plan.

Look at spatial offset: Europe is H, VK is H and only JA is V. But luckily they use V pol. So if no Faraday is active (most of the time at quite sun) only the US boys in the west and northwest are V.

The perfect solution would be a cross yagi, but combined with open feed.

Antenna: 16 x 13λ l DJ9BV Gain: 29.7dBD

ANTENNA Set-up overview

PA0PLY

- 4 x 13el DL6WU – Hor. Pol
- 4 x 13el DL6WU – Ver. Pol
- Gain: 20dBD / section

PA2V

- 4 x 24el LFA
- Horizontal Polarisation
- Gain: 22.35dBD

PD7RKZ

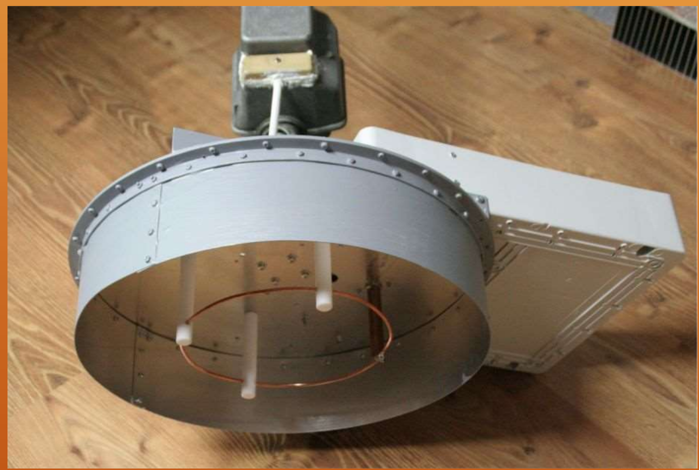
- 8 x 11el DG7YBN
- Horizontal polarization
- Gain: 21.7dBD

NC1I

- 48 x 15el; [4λ] K1FO
- Full rotation capability
- Gain: 29.2dBD

“Rich” men solution

- OK1DFC 10m Dish with quick polarisation change



“Rich” men solution

- DL7APV new array
- 128 x 11el DG7YBN (H)
- Gain: 33.7dBD

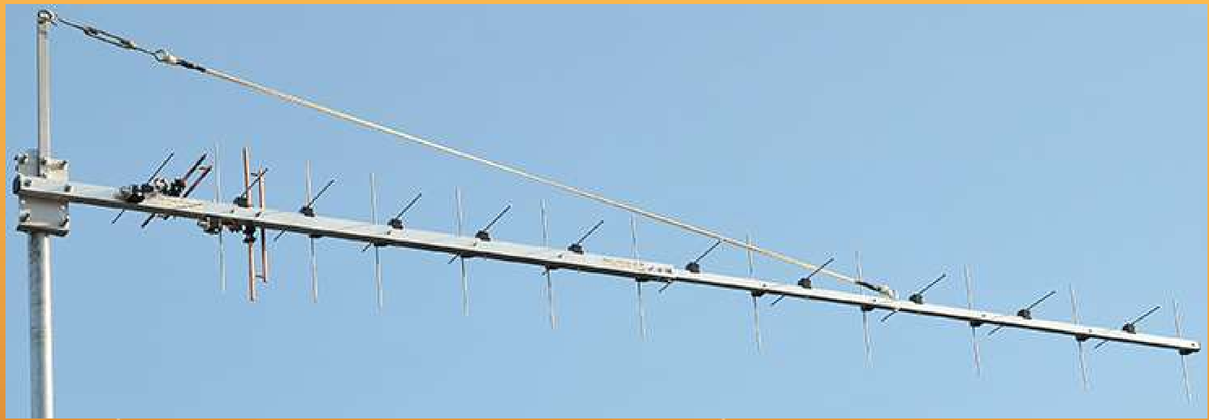
“Poor” men solution

- PATIENCE!
- Keen operation!

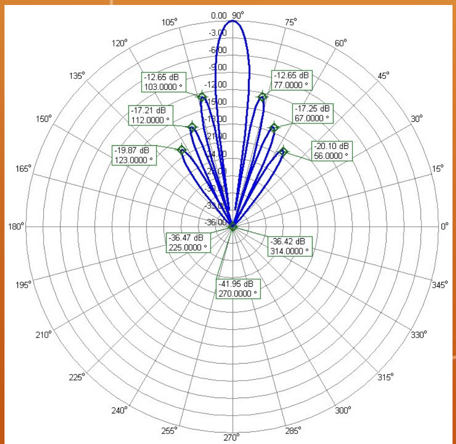
“Poor” men alternative solution

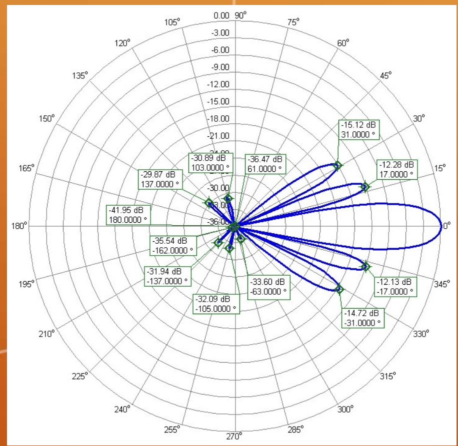
- Combined X-Y yagi design
- Example: ZS6JON

- based on SM7THS / DG7YBN idea’s



Cross pol yagi YU1CF





PA5Y is constructing his array based on this design.

CONCLUSION

Conclusion

- The individual antenna set-up should have a minimum of 23dBD gain.
- Polarization changes on 432MHz are reasonably slow and can influence performance for TX and RX differently.
- A slow polarization rotation system does have some advantages, but for maximum advantage a quick change system is better.
- Coupling 2 antenna groups with H and V polarization is not a good idea unless sufficient gain is available for each polarization.
- Once a good X-pol 432MHz antenna becomes available an adaptive RX system can be installed with CP TX mode, like used on 144MHz.

CONTRIBUTIONS

- PA2V
- NC1I
- PD7RKZ
- OK1DFC
- DL7APV
- DL9KR
- SM7THS
- ZS6JON
- N1BUG
- G3SEK
- PA5Y

TNX ALL & CU Off the Moon

Jan PA0PLY