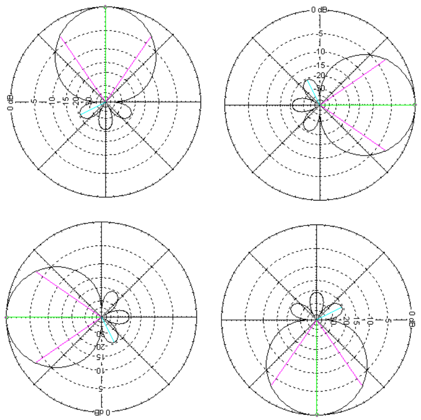


-antenna (hash)

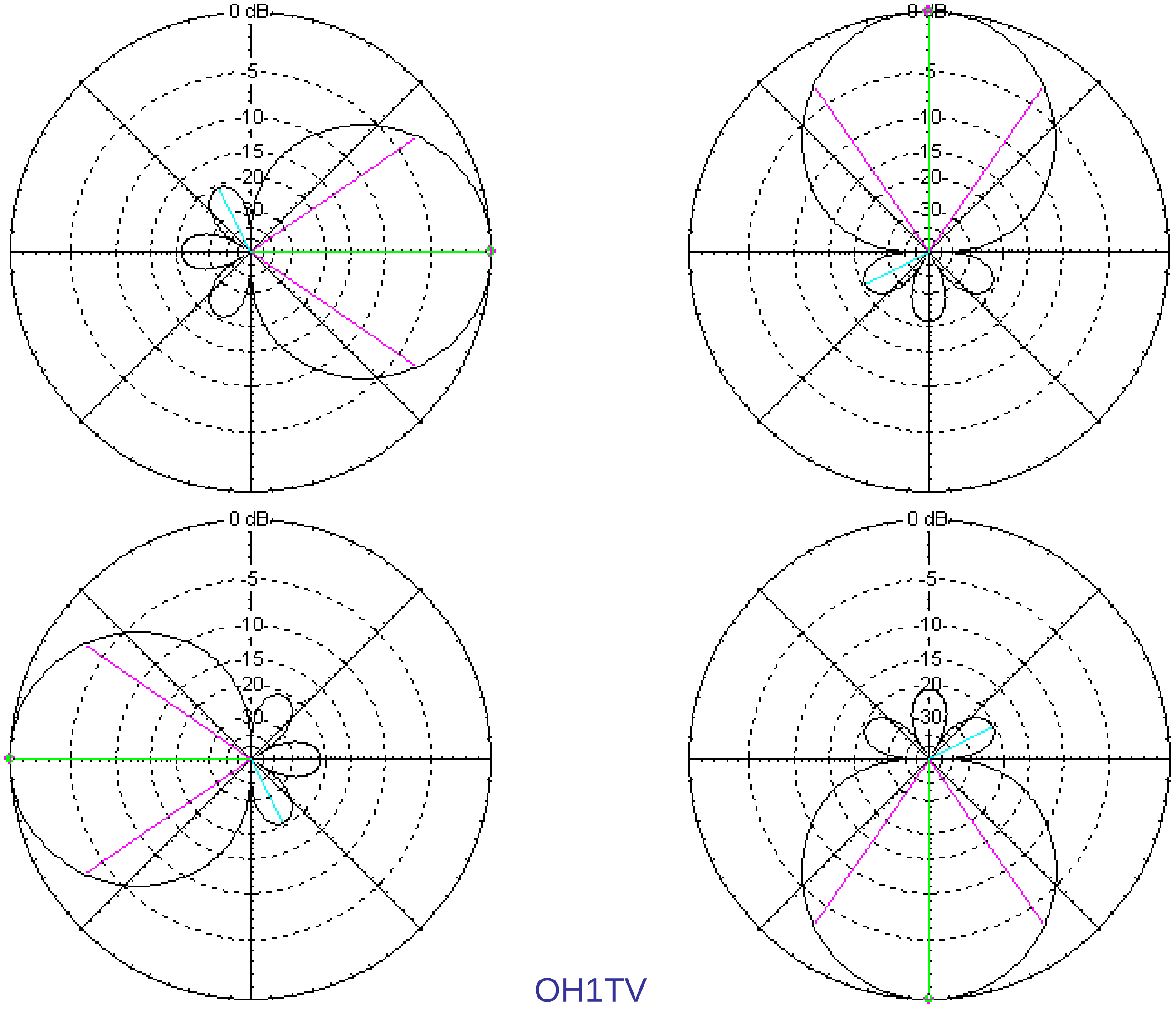
4 direction switchable array

Feasibility study

Paper on CCF & OHDXF cruise 4.1.2012

Pekka Ketonen

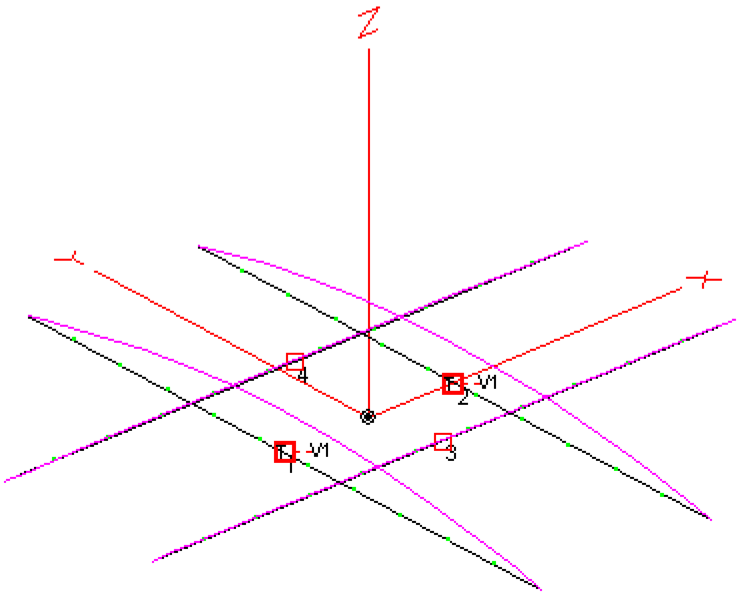
4 direction, instant switching



Features

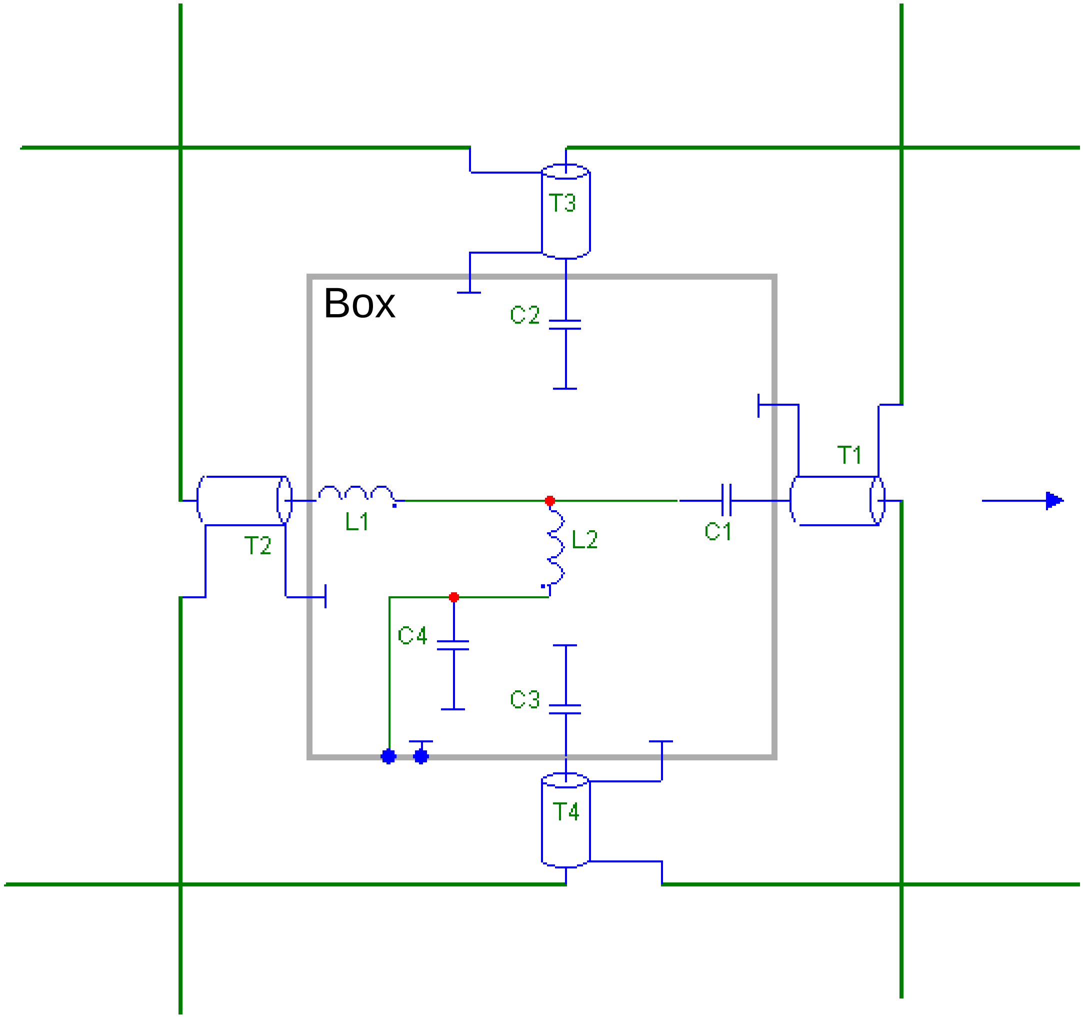
- Instant direction switching in 90 deg steps
  - Advantage in contest use on low bands
- Can be stacked 2 over 2
- 20dB F/B, 6dBi gain + ground reflection = abt 11dBi
- Angle of radiation as in yagi's, depends on height
- All element equal length
- Band can be divided into multiple segments if desired
- No need for tower rotation or separate continent specific antennas
  - Free standing towers can be used.

Concept



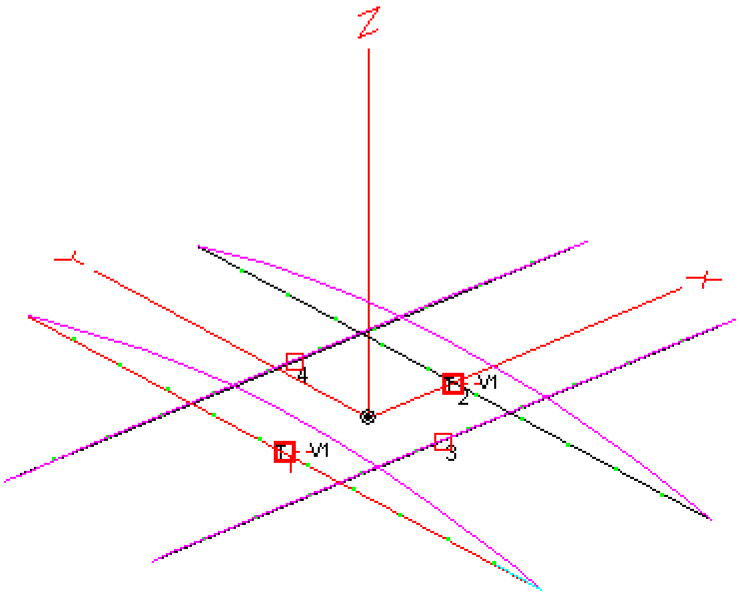
- 2x2 equal elements in 90 deg angle
- Vertical spacing 50cm on 7MHz band
- Opposite voltage feed of two elements, reactive loading of sideways elements
- 0.5 λ cables from all element to a phasing box
- All tuning and matching components are in the box
- Separate patterns for RX and TX possible
  - Receiving mode with better F/B but lower gain
  - Transmitting mode with high gain

How to do it



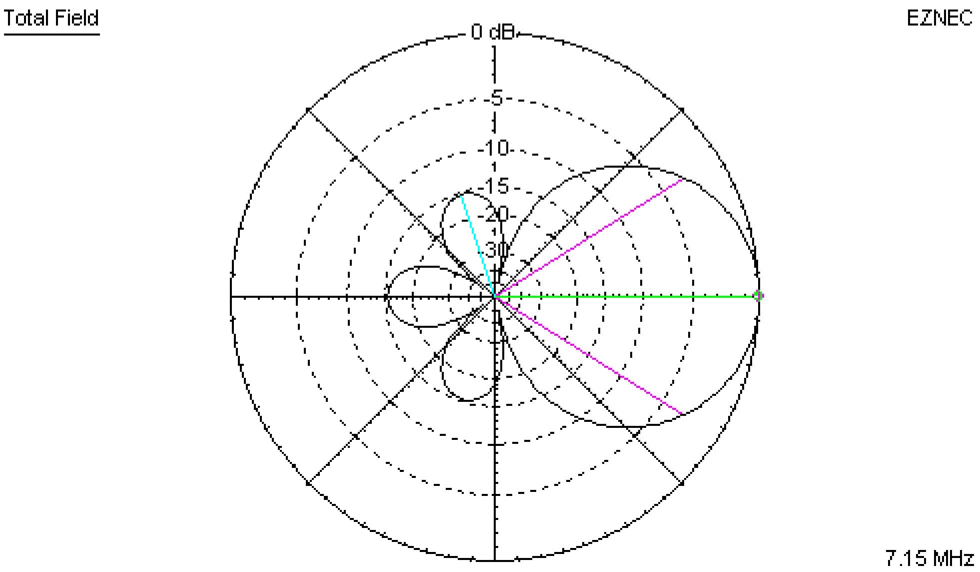
- All elements equal
- T1=T2=T3=T4 = λ/2 cable
- C1, L1 phasing components
- C2, C3 = coupling reactances
  - capacitor or coil
- L2, C4 = L-match for 50 ohm
- Rotation relays not shown here

Example 40m band



- All elements 20.8m long dia 36mm
  - Free space resonance 6910kHz
    - Can be higher and then leads to different component values
- Horizontal spacing 600cm
- Vertical spacing 50cm
- All 4 cables 21.2m electrical length 3dB/100m @ 100MHz
- Current baluns in each cable
- Note: Antenna booms are assumed to be non-conductive

..Example, 2uH



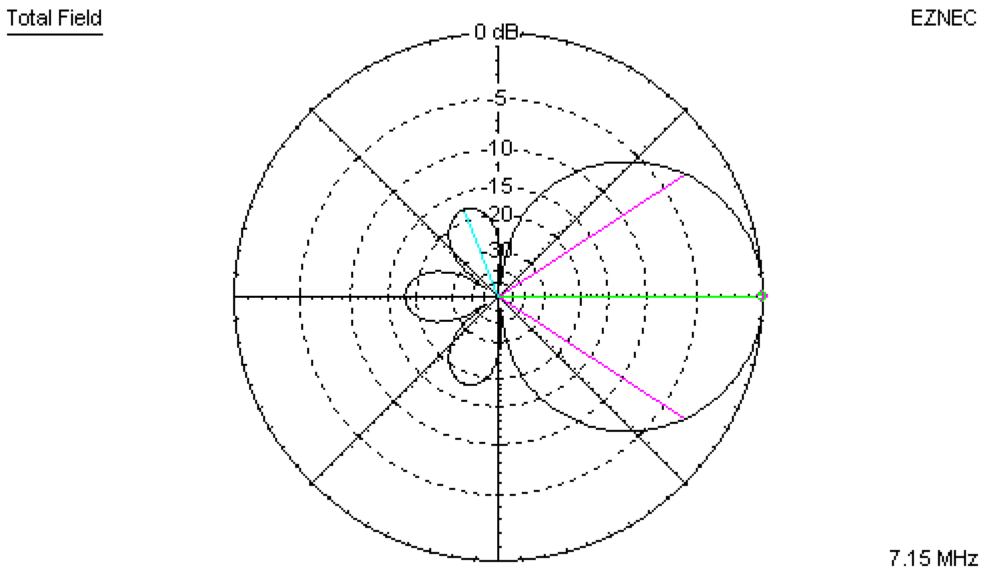
Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	6.44 dBi
Outer Ring	6.44 dBi		0.0 dBmax

Slice Max Gain	6.44 dBi @ Az Angle = 0.0 deg.
Front/Back	15.52 dB
Beamwidth	64.5 deg.; -3dB @ 327.7, 32.2 deg.
Sidelobe Gain	-9.01 dBi @ Az Angle = 108.0 deg.
Front/Sidelobe	15.45 dB

- C2 = C3 = 2uH (coil)
- L1 = 0.5uH, C1 = 265pF
- Includes cable loss abt 0.15dB

- F/B = 15.5dB
- Gain = 6.44dB

..Example, 6uH



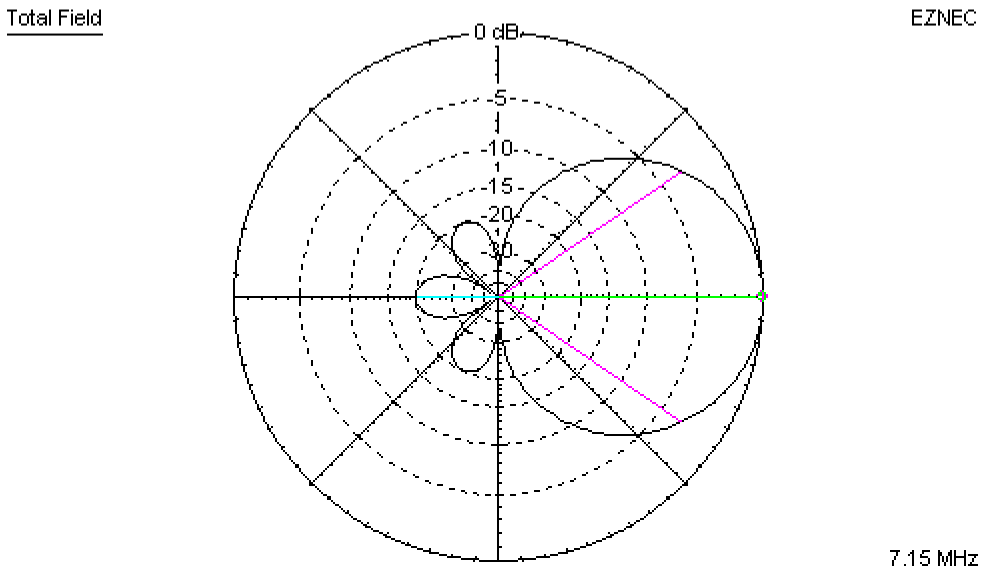
Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	6.27 dBi
Outer Ring	6.27 dBi		0.0 dBmax

Slice Max Gain	6.27 dBi @ Az Angle = 0.0 deg.
Front/Back	17.91 dB
Beamwidth	66.8 deg.; -3dB @ 326.6, 33.4 deg.
Sidelobe Gain	-11.61 dBi @ Az Angle = 112.0 deg.
Front/Sidelobe	17.88 dB

- C2 = C3 = 6uH (coil)
- L1 = 0.55uH, C1 = 245pF
- Includes cable loss abt 0.15dB

- F/B = 17.9dB
- Gain = 6.27dB

..Example, 10pF

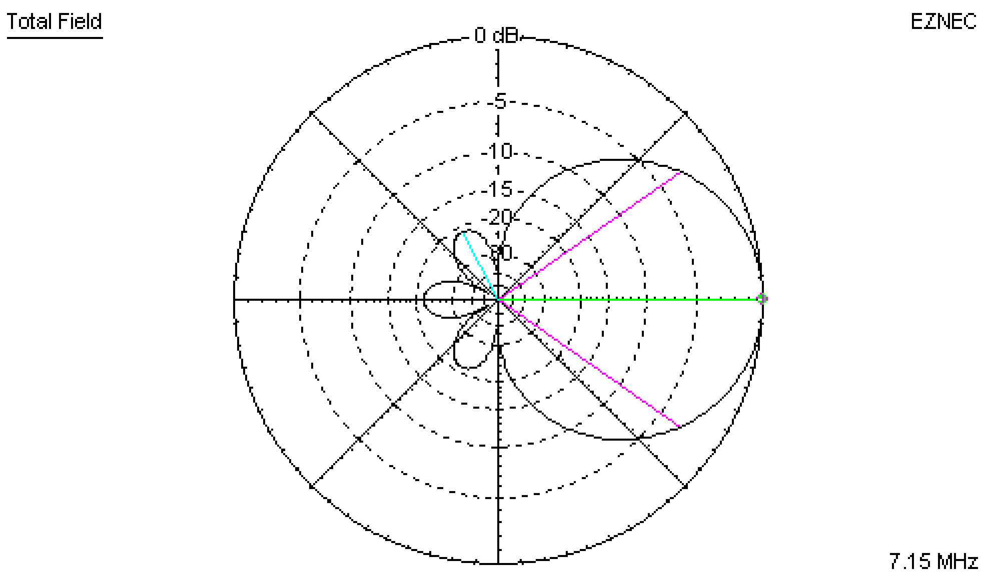


Azimuth Plot	
Elevation Angle	0.0 deg.
Outer Ring	6.11 dBi
Slice Max Gain	6.11 dBi @ Az Angle = 0.0 deg.
Front/Back	20.09 dB
Beamwidth	68.8 deg.; -3dB @ 325.6, 34.4 deg.
Sidelobe Gain	-13.98 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe	20.09 dB

- C2 = C3 = 10pF
- L1 = 0.6uH, C1 = 235pF
- Includes cable loss abt 0.15dB

- F/B = 19.9dB
- Gain = 6.12dB

..Example, 47pF



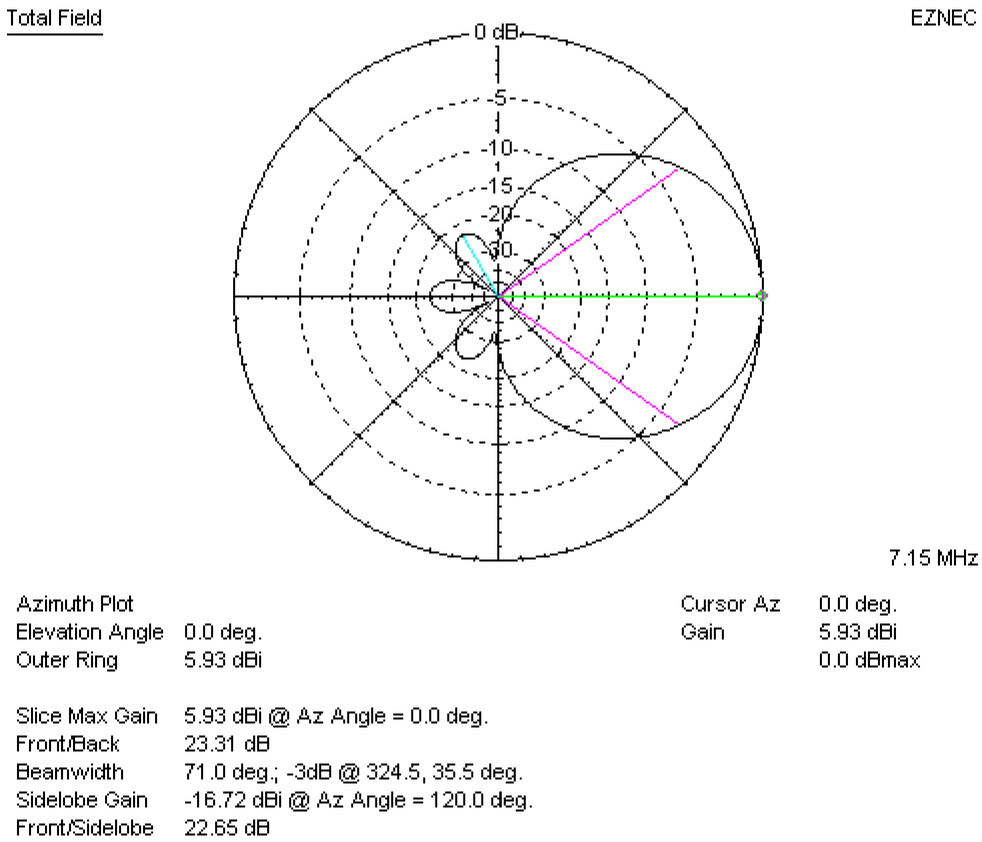
Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	6.02 dBi
Outer Ring	6.02 dBi		0.0 dBmax

Slice Max Gain	6.02 dBi @ Az Angle = 0.0 deg.
Front/Back	21.78 dB
Beamwidth	69.8 deg.; -3dB @ 325.1, 34.9 deg.
Sidelobe Gain	-15.28 dBi @ Az Angle = 118.0 deg.
Front/Sidelobe	21.3 dB

- C2 = C3 = 47pF
- L1 = 0.7uH, C1 = 235pF
- Includes cable loss abt 0.15dB

- F/B = 21.8dB
- Gain 6.02dB

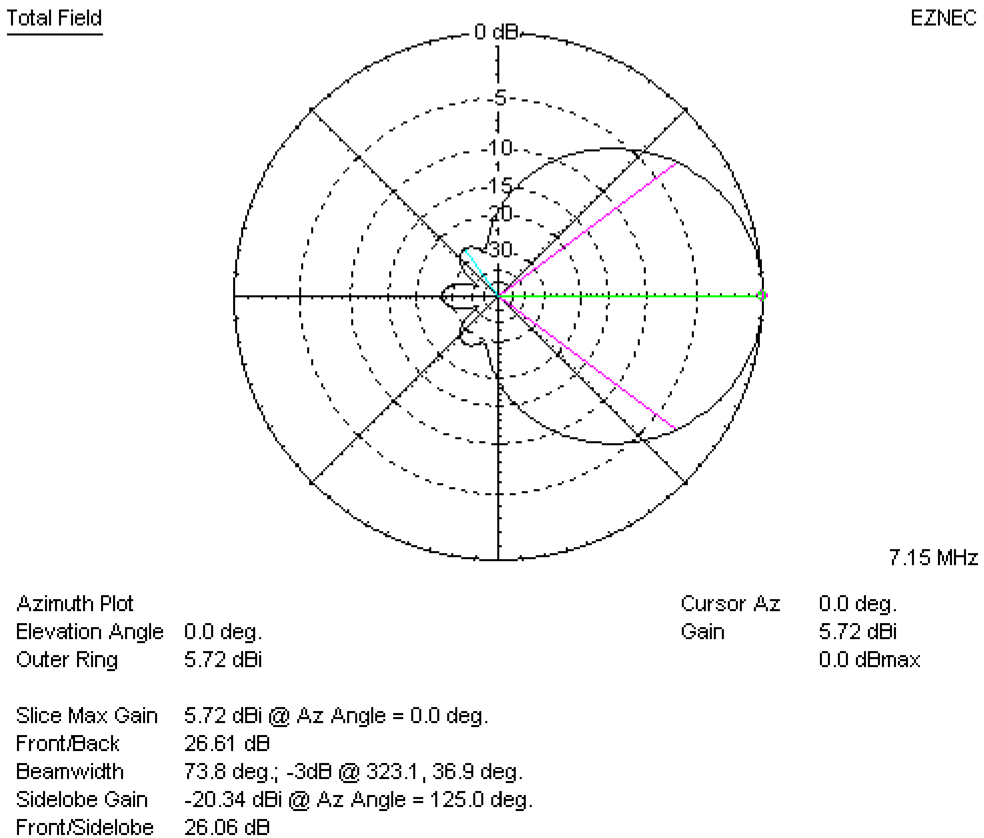
..Example, 82pF



- C2 = C3 = 82pF
- L1 = 0.77uH, C1 = 235pF
- Includes cable loss abt 0.15dB

- F/B = 23.3dB
- Gain 5.93dB

..Example, 150pF

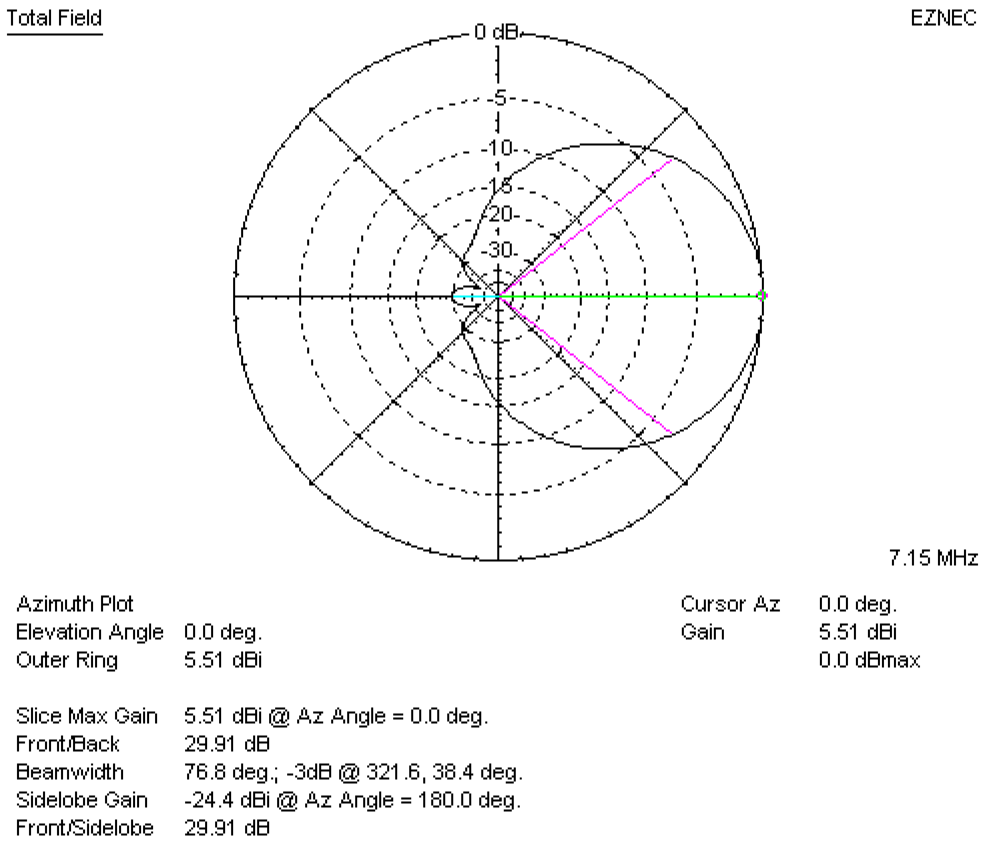


- C2 = C3 = 150pF
- L1 = 0.9uH, C1 = 235pF
- Includes cable loss abt 0.15dB

- F/B = 26.6dB
- Gain 5.72dB

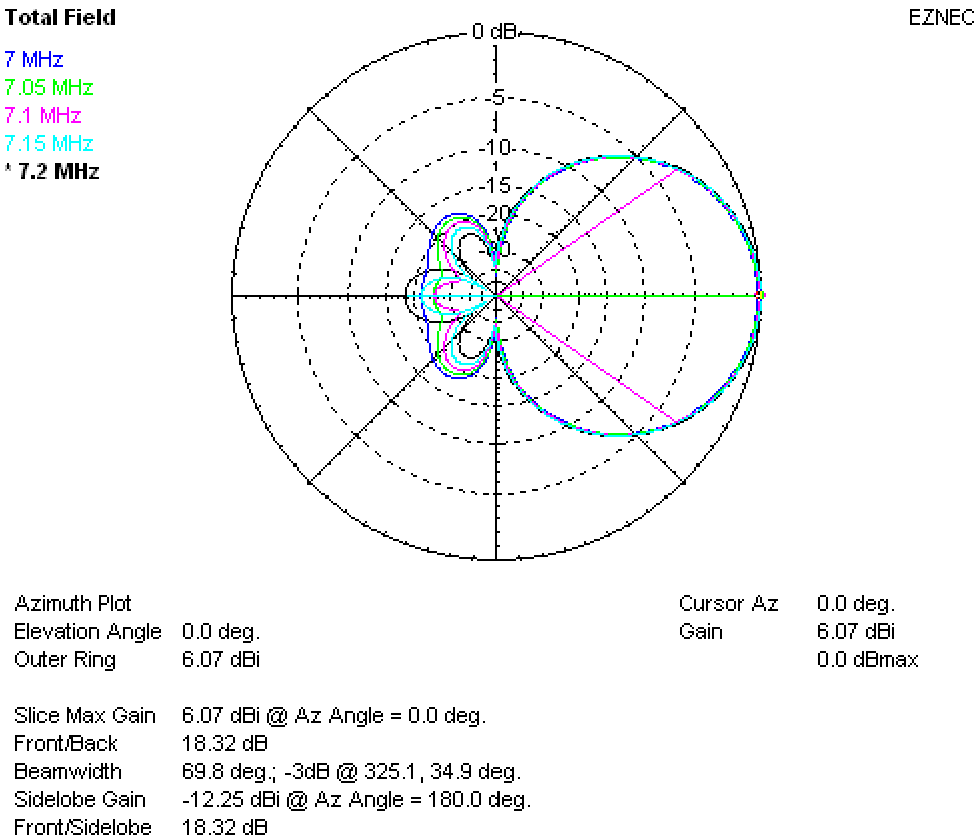
- >> Corresponds Moxon performance

..Example, 200pF



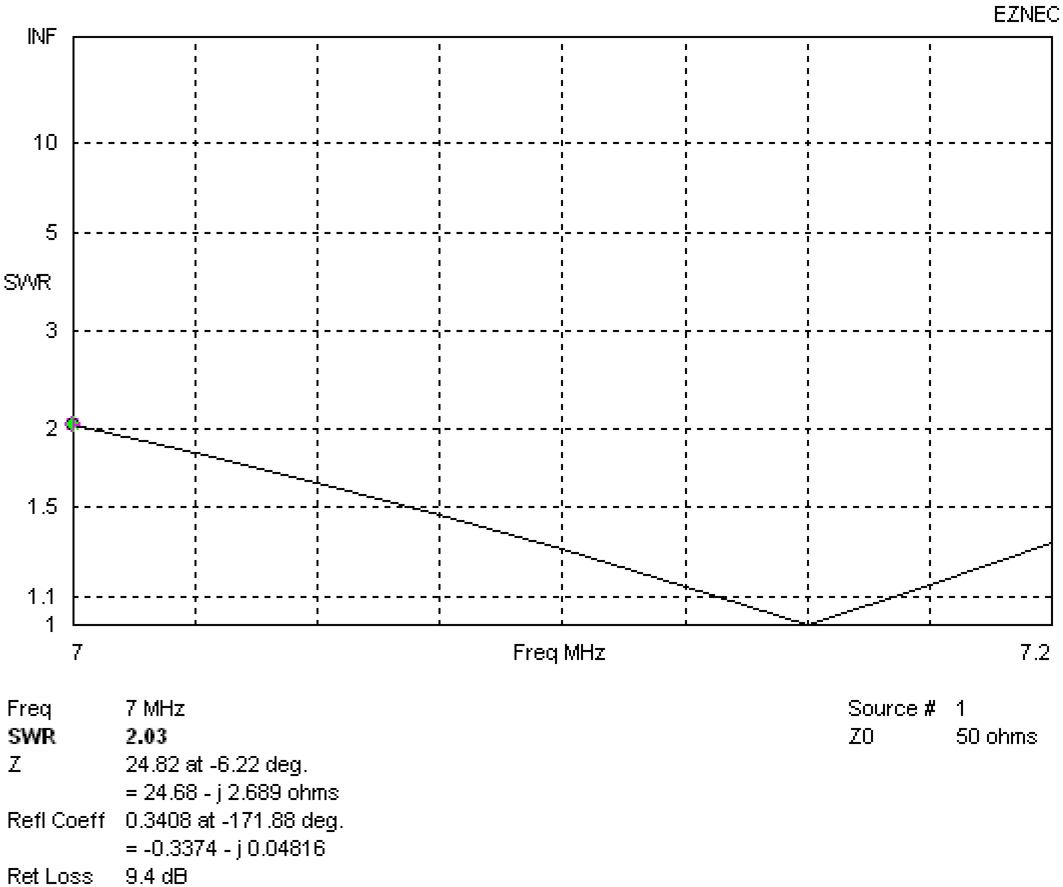
- C2 = C3 = 200pF
- L1 = 0.95u, C1 = 230pF
- Includes cable loss abt 0.15dB
- F/B = 29.9dB
- Gain 5.5dB
- >> Corresponds Moxon performance

Bandwidth, 47pF



- Center frequency 7150kHz
- F/B better than 18dB @ 7000-7200kHz
- Gain variation is small
- Band segments can be added if better performance needed, for example 7050 and 7150kHz center frequencies

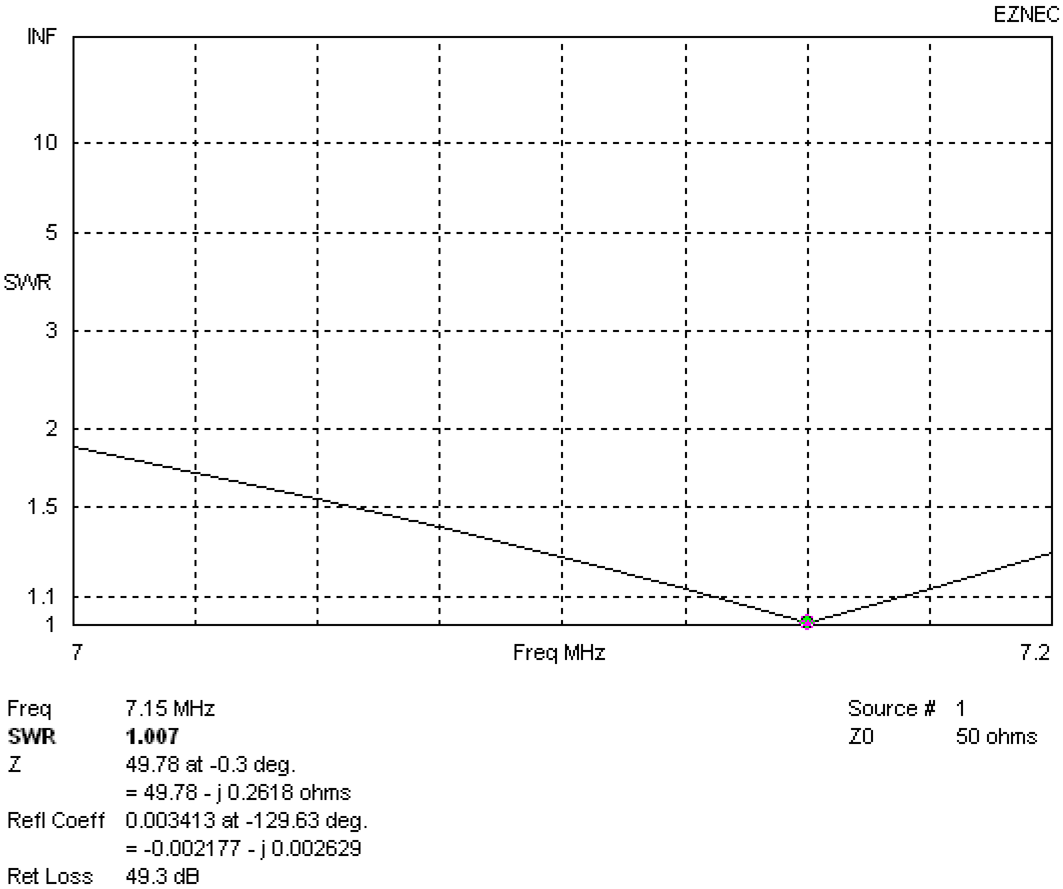
SWR bandwidth, 10pF loading



- Center frequency 7150kHz
- Satisfactory SWR if center frequency is 7100kHz

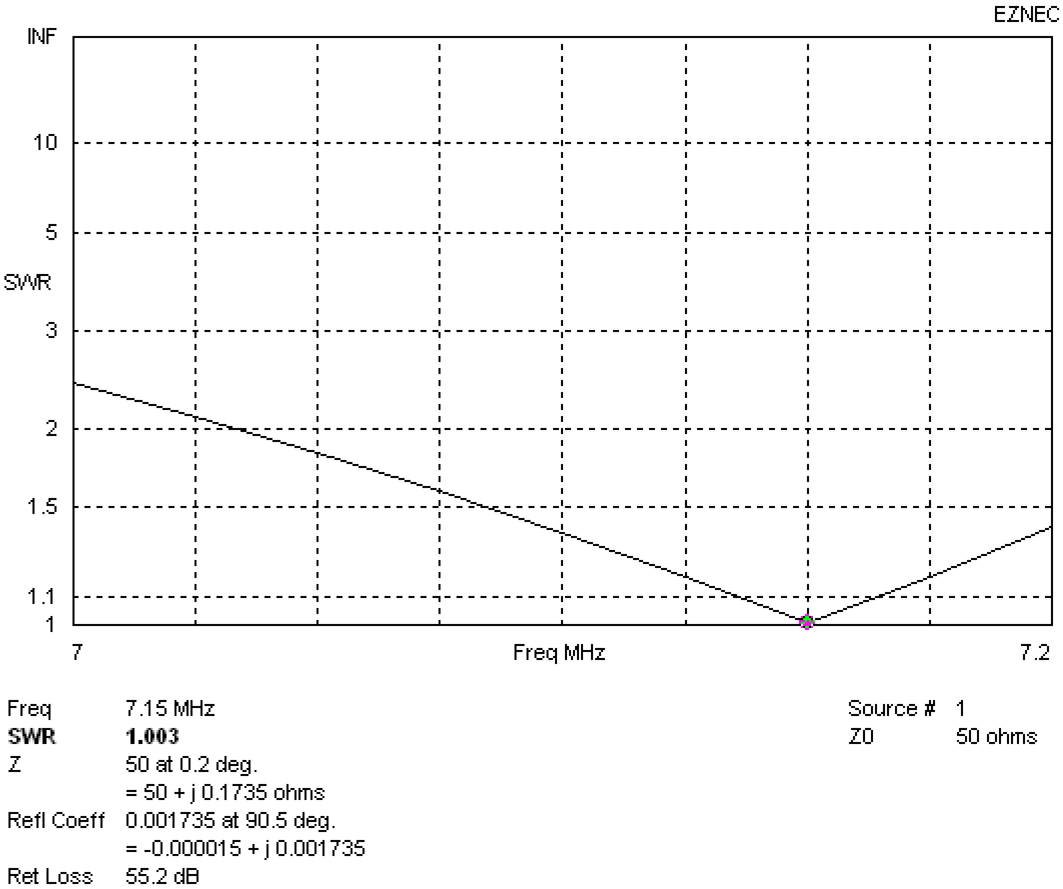
- Band segments can be added if better performance needed, for example 7050 and 7150kHz center frequencies

SWR bandwidth, 150pF loading



- Center frequency 7150kHz
- Satisfactory SWR if center frequency is 7100kHz
- SWR bandwidth I getting wider when F/B is improved by capacitive loading of the side elements

SWR bandwidth, 2uH loading



- Center frequency 7150kHz
- SWR bandwidth I getting more narrow when gain is added by inductive loading of the side elements
- Band segments can be added if better performance needed, for example 7050 and 7150kHz center frequencies

Conclusions

- It is feasible to build 2-element switchable array and achieve four directions with equal performance
- Performance is equal or better than with parasitic Yagi as current in reflector is increased with phased feed
  - equal current amplitudes in front and rear, better F/B
  - but losses in side-element cables lower antenna gain about 0.1dB
- It is possible to achieve radiation pattern like in Moxon antenna, more than 25dB F/B, if some 0.5 dB gain can be sacrificed
  - This feature can be used for receiving
- Currents in the side-elements can be controlled with reactive loading in the box
  - Inductive loading increases gain but reduces F/B and SWR bandwidth
  - Capacitive loading improves F/B and SWR bandwidth but lowers forward gain

Choices to be made

- The builder of # -antenna has to decide:
  - What are those 4 main headings in 90 deg steps
  - If stack of 2 antennas is chosen, dimensioning must be done for the whole package. Combining just two antennas doesn't lead to best performance
  - 1,2 or 3 frequency segments
    - More segments means more relays but a bit better performance
    - If maximal gain for transmitting is sought, multiple band segments are needed
  - Separate TX and RX positions or just one common