Beam Steering on 160 Meters

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Contest Forum

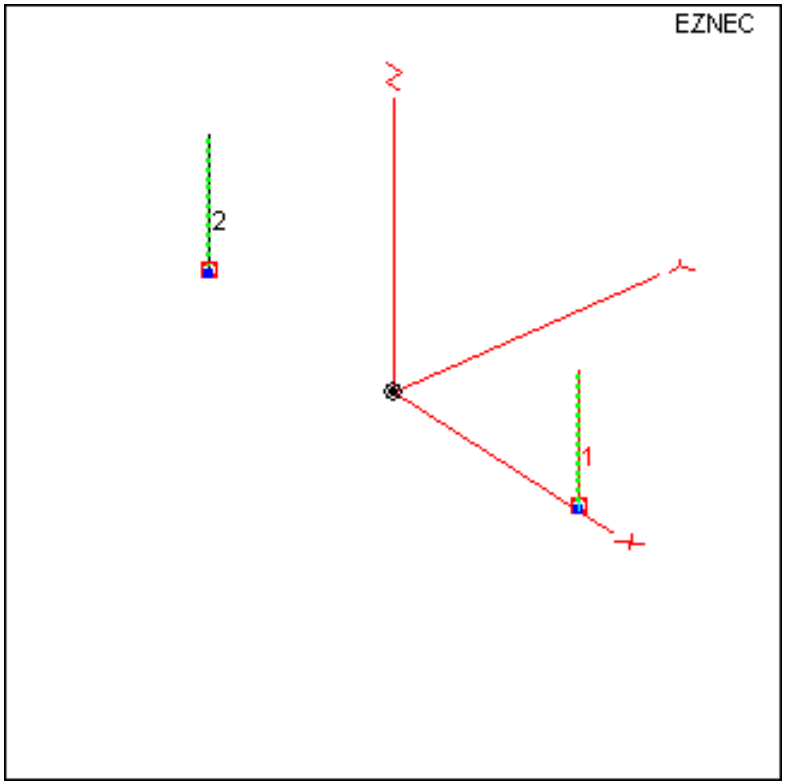
Dayton Hamvention

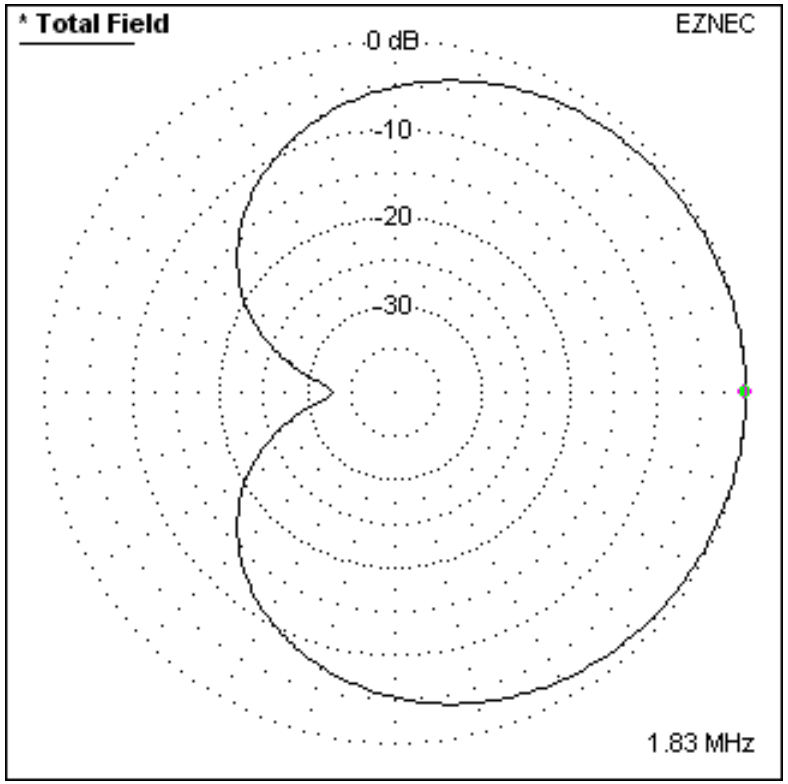
May 17,2008

K1LT QTH

2 Element End-Fire Array

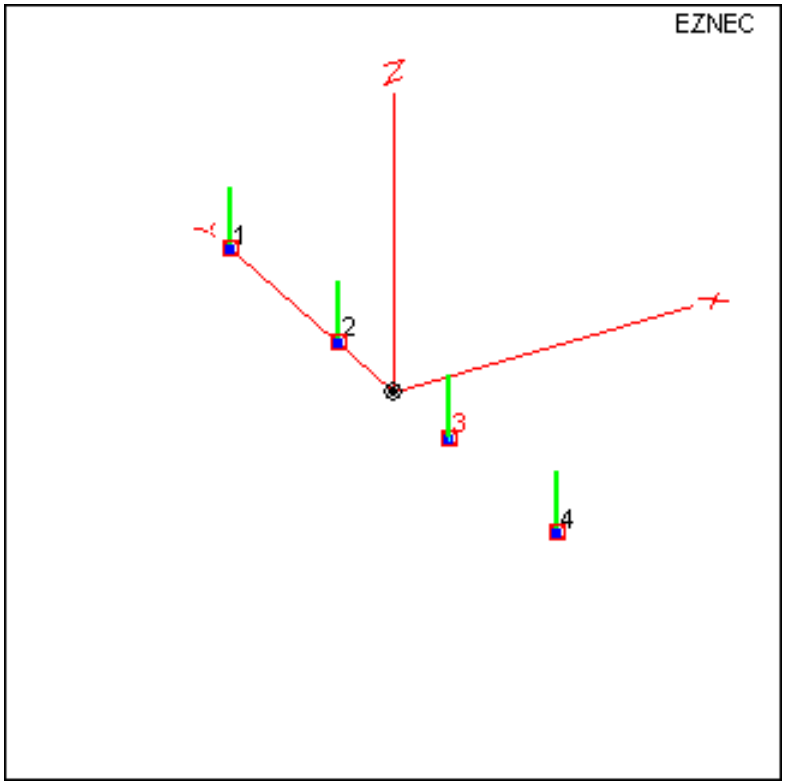
- Classic cardioid pattern
- Null aimed up about 20 degrees

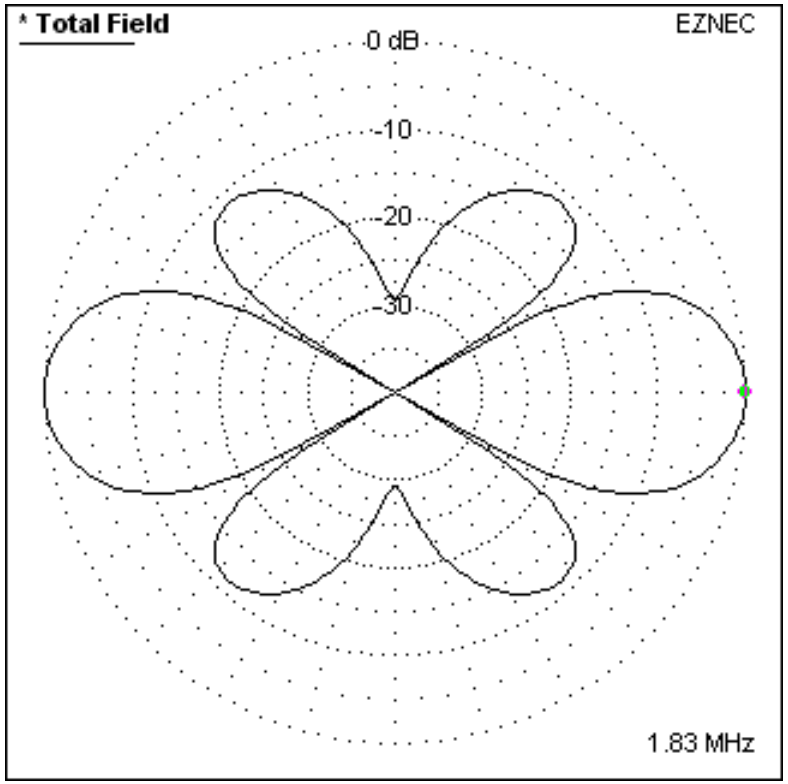




4 Element Broadside Array

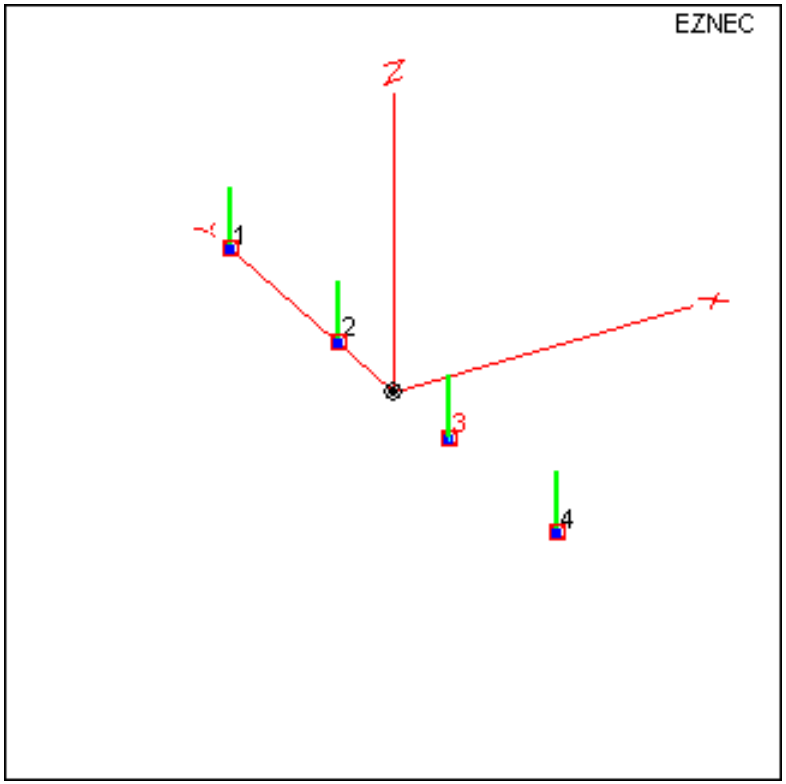
- Bidirectional pattern
- 1:1:1:1 amplitude assignment for max directivity

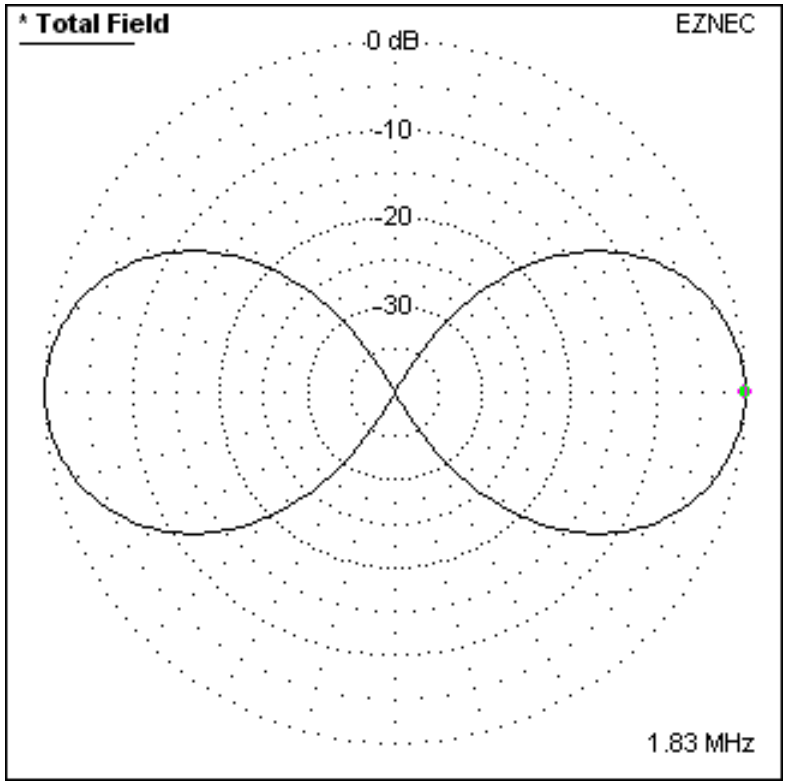




4 Element Broadside Array

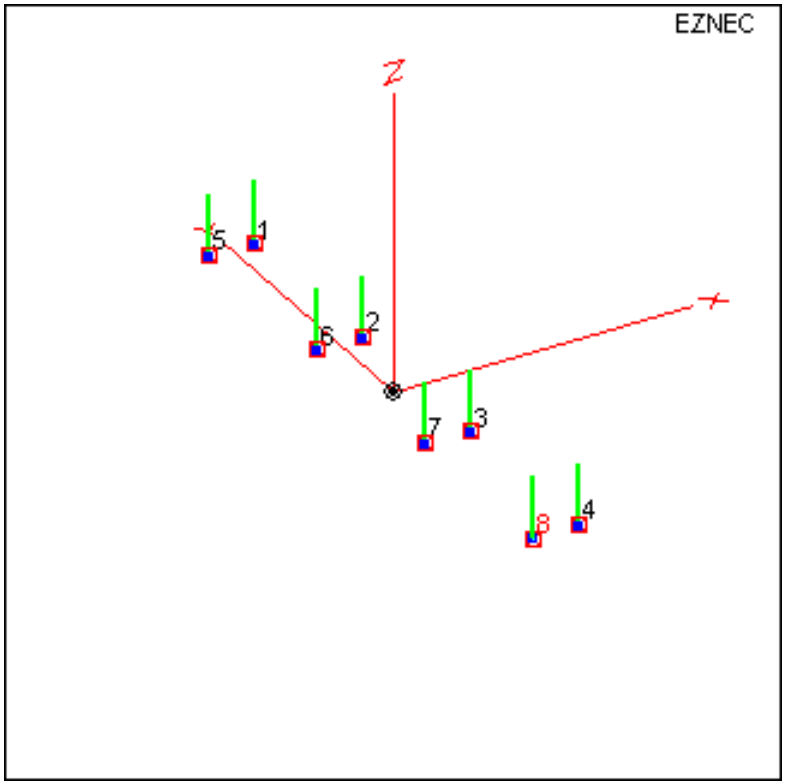
- Bidirectional pattern
- 1:3:3:1 amplitude assignment for no sidelobes

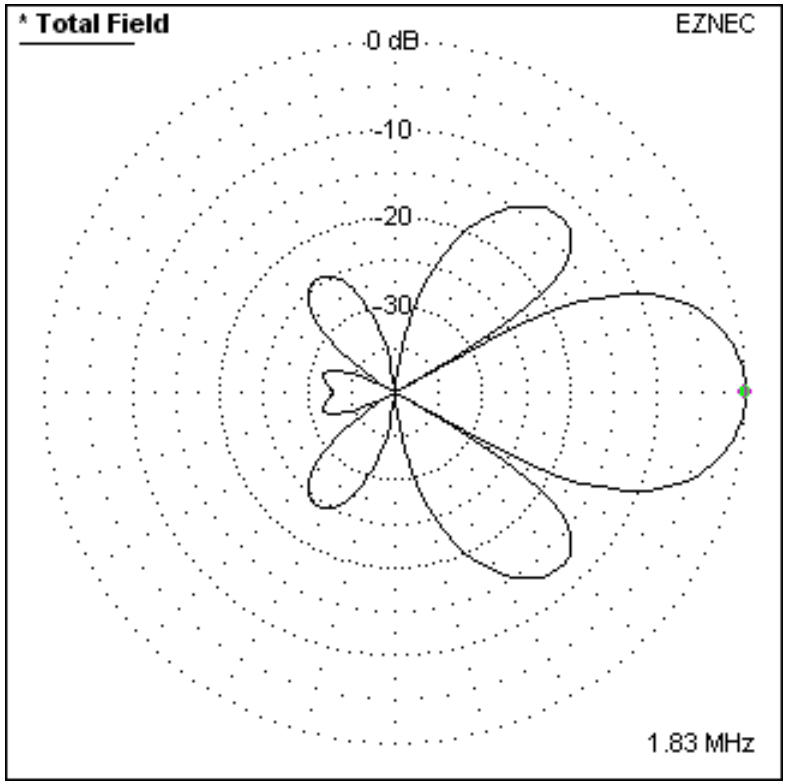




8 Element Broadside/End-Fire Array

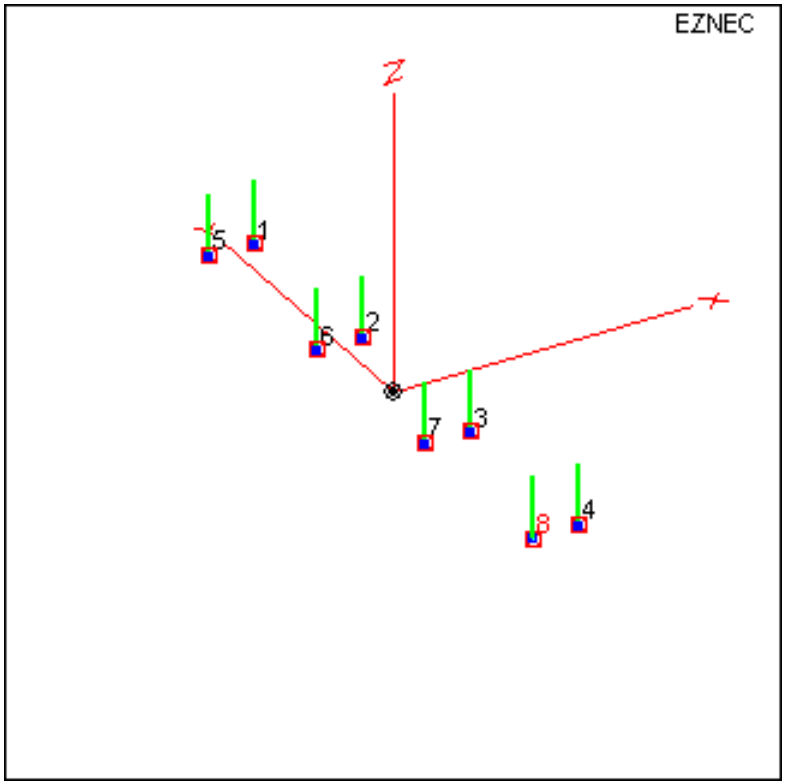
- Product of end-fire and 1-1-1-1 broadside patterns
- End-Fire null not as wide as broadside main lobe
- Many back and side lobes – yet max directivity

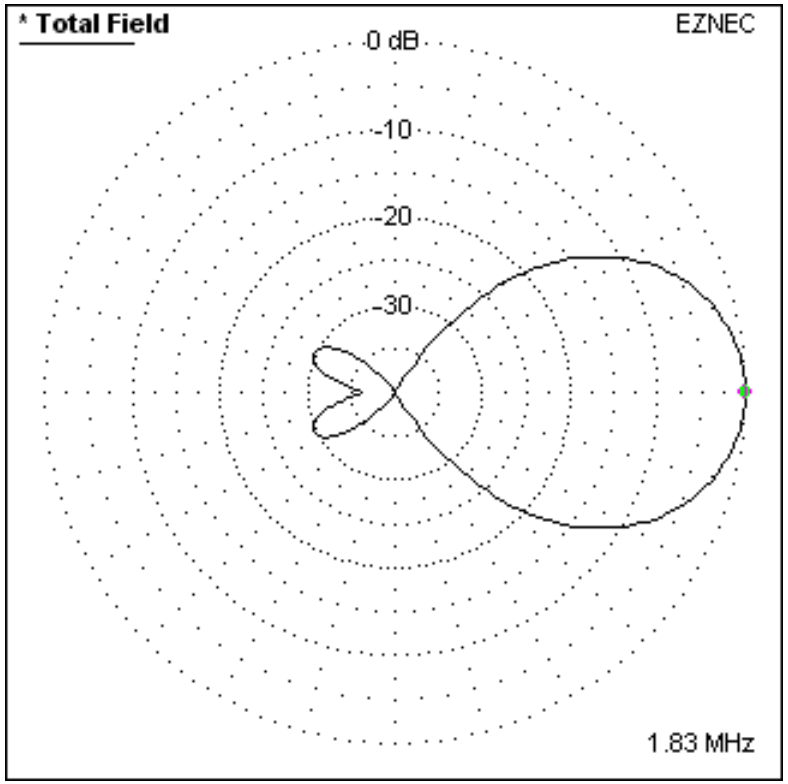




8 Element Broadside/End-Fire Array

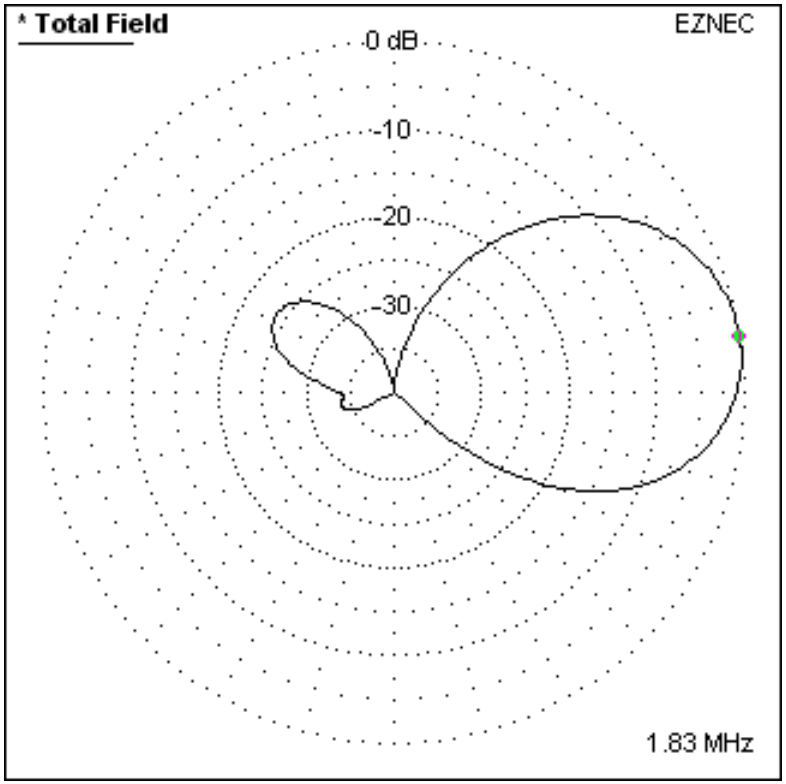
- Product of end-fire and 1-3-3-1 broadside patterns
- End-Fire null not as wide as broadside main lobe
- Leaves two little back lobes

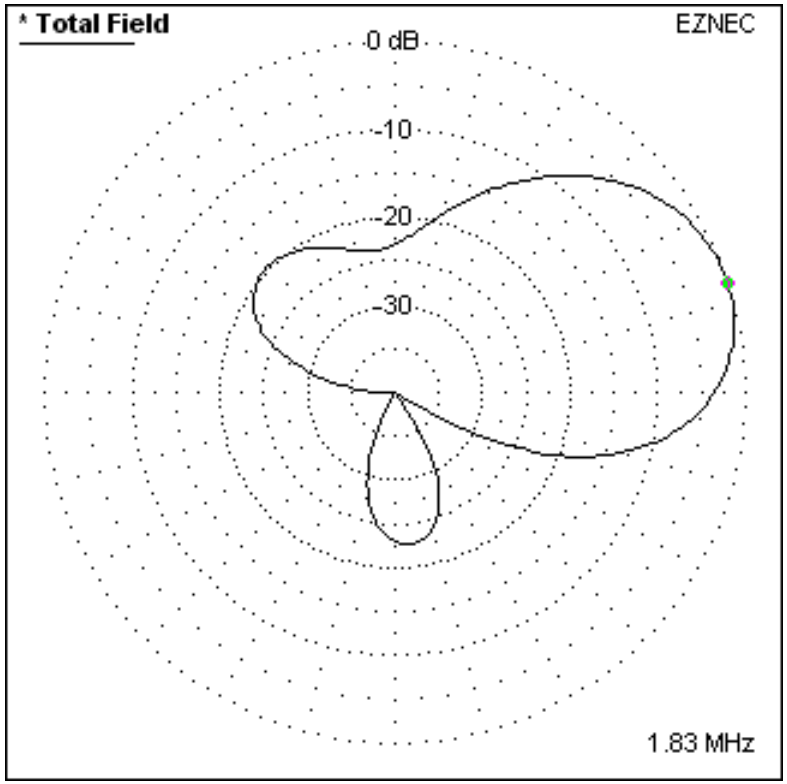




8 Element BS/EF Array Steered

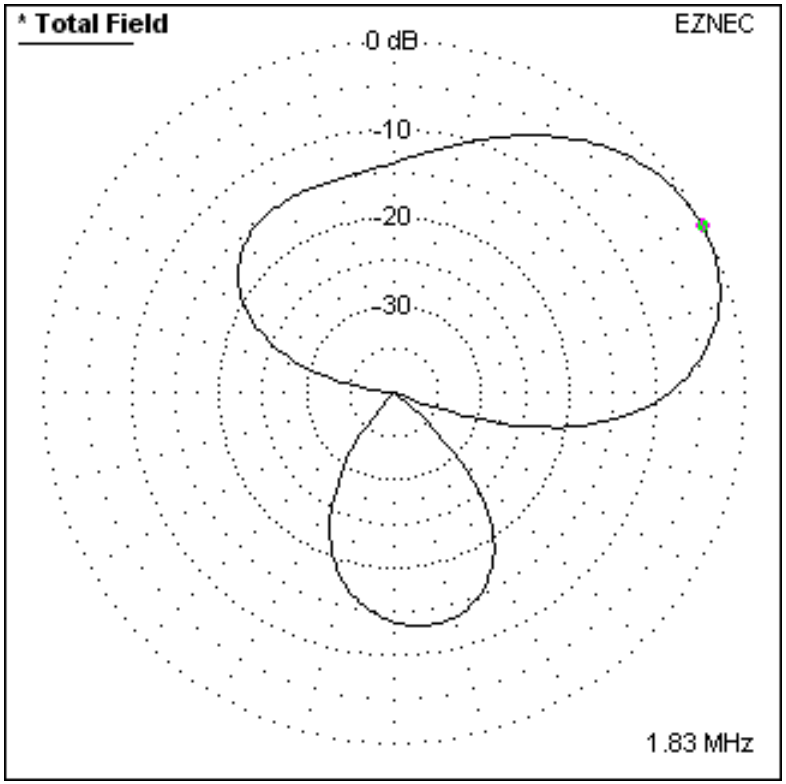
- Pattern broadens as steered away from normal
- Using no-sidelobe 1-3-3-1 feed pattern
- Steered 10 degrees, 20 degrees

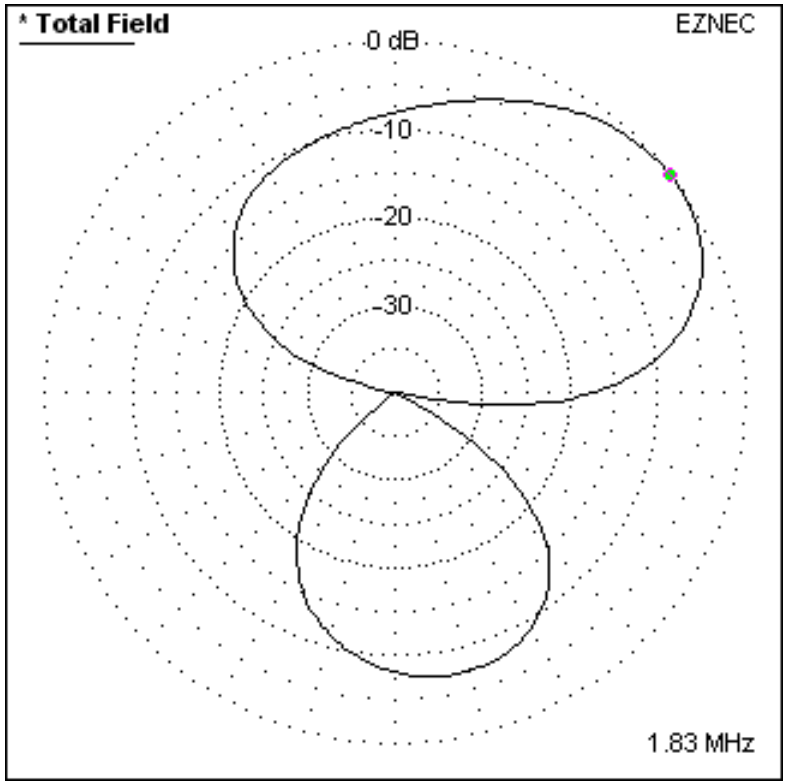




8 Element BS/EF Array Steered II

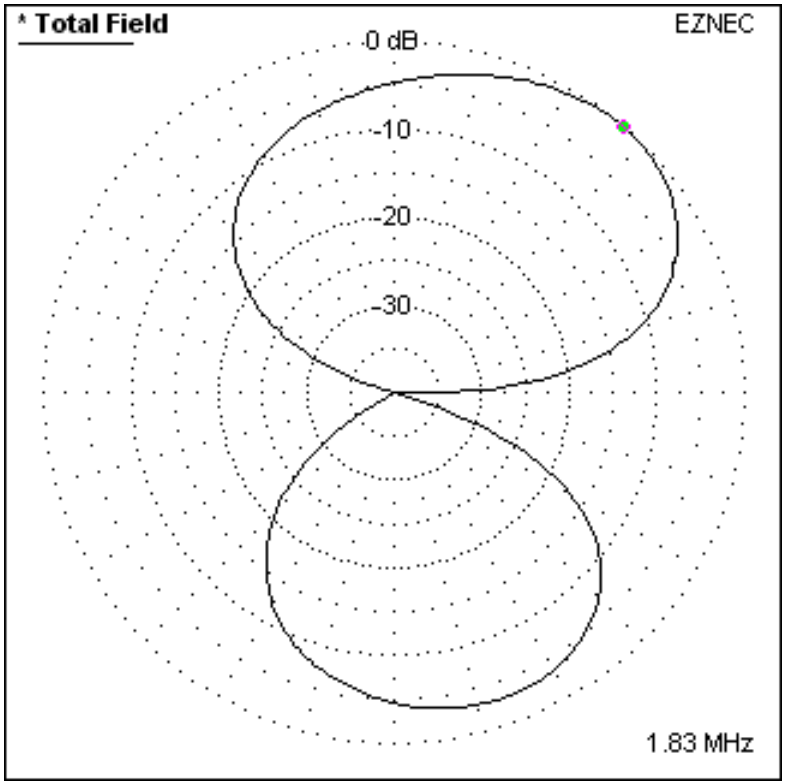
- Pattern broadens as steered away from normal
- Pattern degenerates to bidirectional
- Steered 30 degrees, 40 degrees

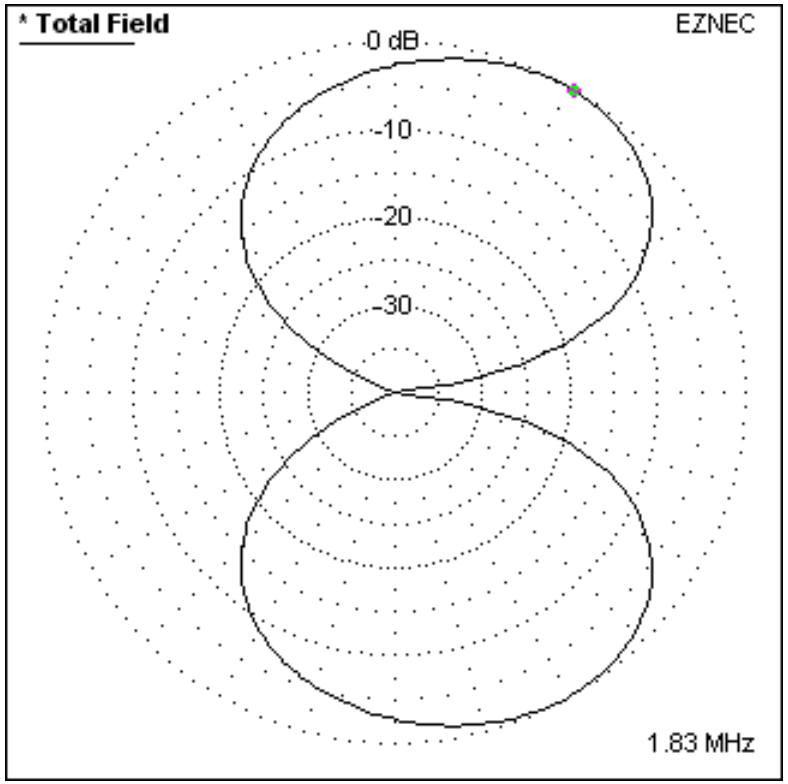




8 Element BS/EF Array Steered III

- Pattern broadens as steered away from normal
- After 60 degrees, secondary lobe becomes biggest
- Steered 50 degrees, 60 degrees





8 Element BS/EF Array Numbers

Maximum directivity				
Steered Angle degrees	**RDF db**	**RDF change from best db**	**Direction of Maximum RDF**	**Beam Width degrees**
0	15.43	0.00	0	26.0
10	15.27	-0.16	11	26.5
20	14.97	-0.46	21	27.9
30	14.53	-0.90	31	30.2
40	13.84	-1.59	41	34.3
50	12.96	-2.47	50	40.0
60	12.06	-3.37	58	46.1
70	11.33	-4.10	64	wider than secondary lobe
80	10.73	-4.70	68	
87	10.51	-4.92	69	

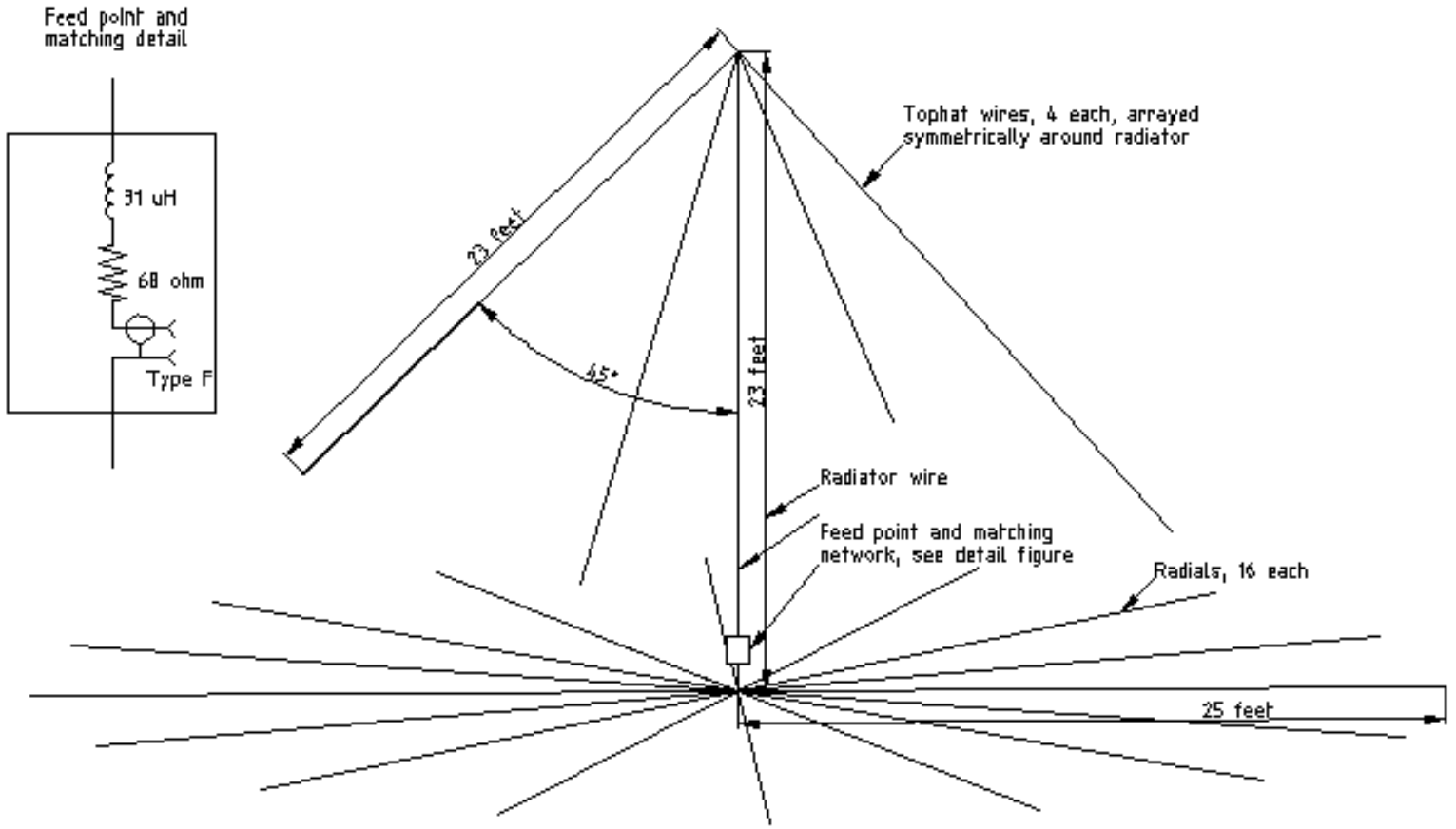
8 Element BS/EF Array Numbers

Minimum sidelobes				
Steered Angle degrees	**RDF db**	**RDF change from best db**	**Direction of Maximum RDF**	**Beam Width degrees**
0	14.46	0.00	0	34.2
10	14.34	-0.12	10	34.8
20	14.02	-0.44	20	36.2
30	13.50	-0.96	30	39.2
40	12.83	-1.63	40	43.6
50	12.08	-2.38	48	48.7
60	11.35	-3.11	55	52.6
70	10.92	-3.54	60	wider than secondary lobe
80	10.27	-4.19	63	
87	10.11	-4.35	64	

RDF Compared to Other Antennas

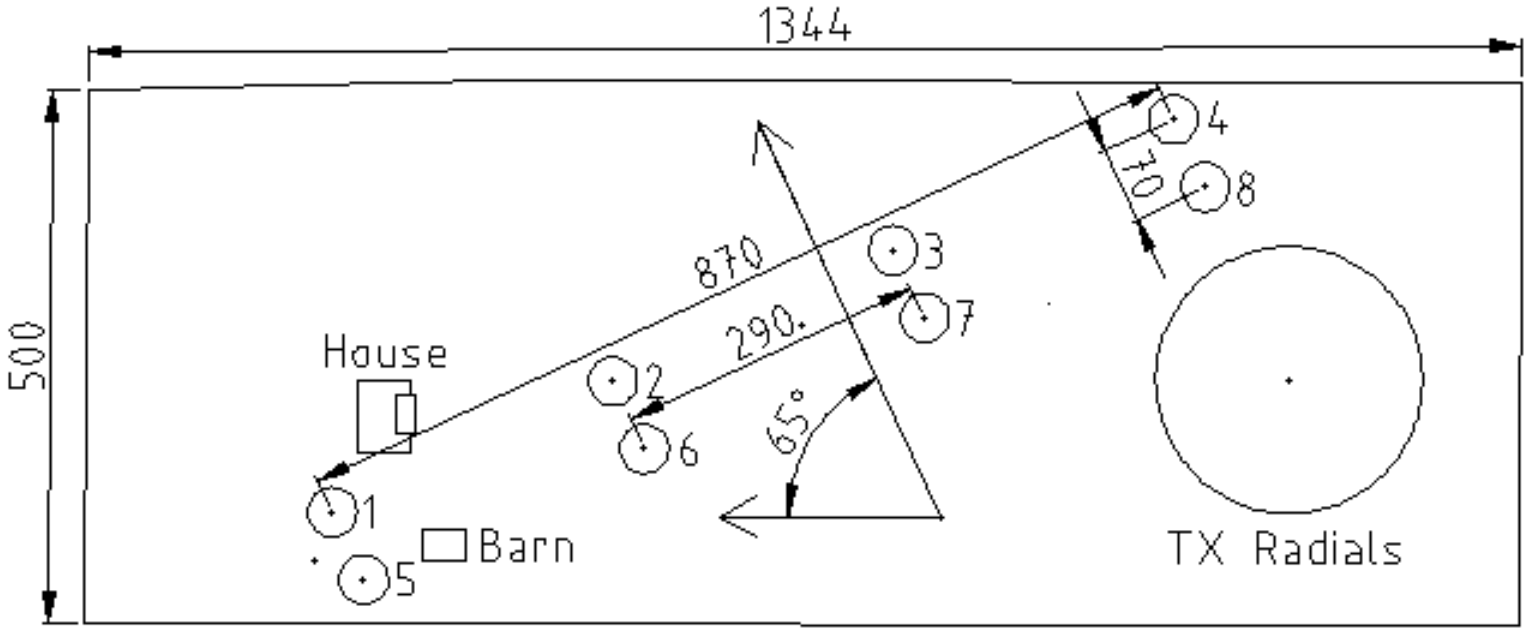
160 Meter Antenna Array Comparison							
Description of Array	**Avg. Gain dB**	**Max Gain dB**	**RDF dB**	**Beam Width degrees**	**Length feet**	**Width feet**	**Area sq. feet**
750' Beverage	-17.58	-5.78	11.8	74.4	750	10	7500
2 Element End-Fire 750' Beverage Array, 100 foot stagger	-17.68	-5.12	12.56	65.9	850	10	8500
3 Element Yagi in free space	-0.01	9.68	9.69	54.6	248	215	53320
4 Element Broadside/End-Fire 750' Beverage Array, 100 foot stagger, 330 foot separation	-16.23	-2.06	14.17	43.4	850	340	289000
8 Element BS/EF Vertical Array, 70 foot stagger, 290 foot separation, no sidelobes, 1:3:3:1 feed	-28.98	-14.52	14.46	34.2	920	120	110400
8 Element BS/EF Vertical Array, 70 foot stagger, 290 foot separation, max directivity 1:1:1:1 feed	-28.98	-13.55	15.43	26	920	120	110400

Short Vertical Design



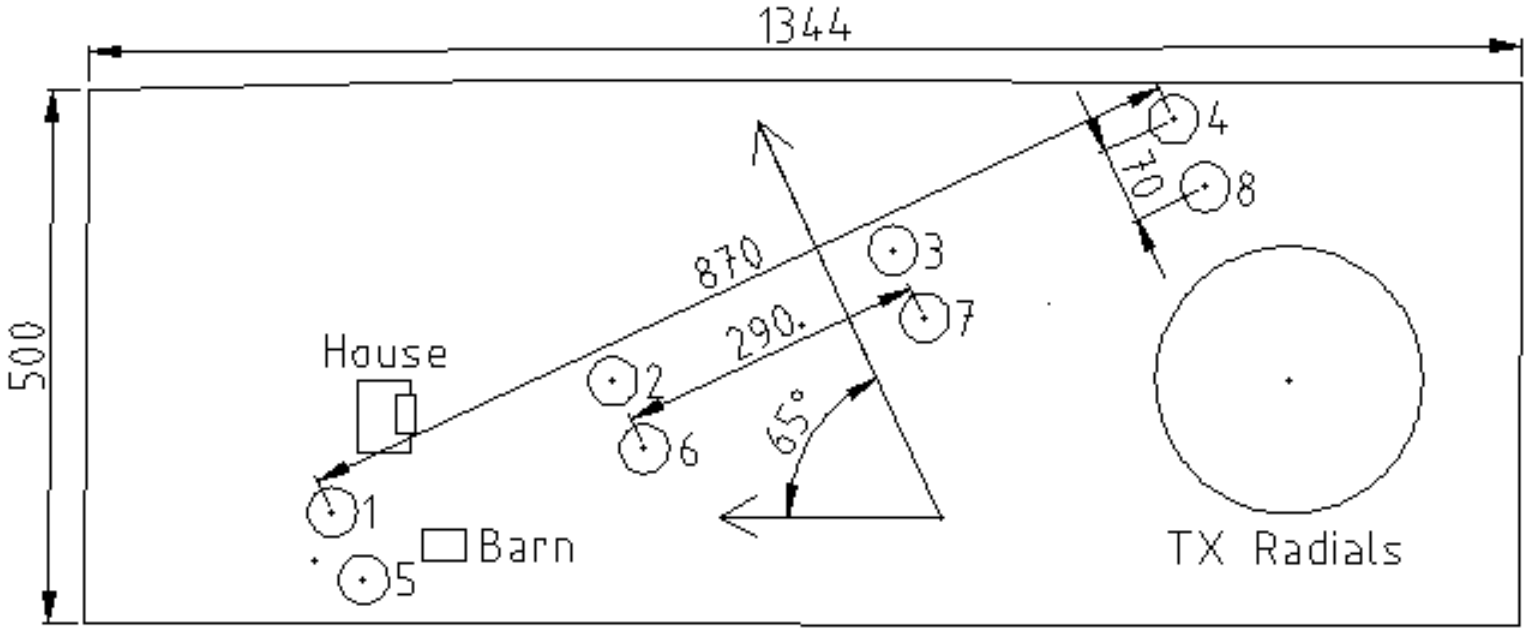
- Slightly scaled W8JI short vertical design
- More numerous but shorter radials

Array Layout



- North to the left, Africa is up
- Needs more real estate than a Beverage

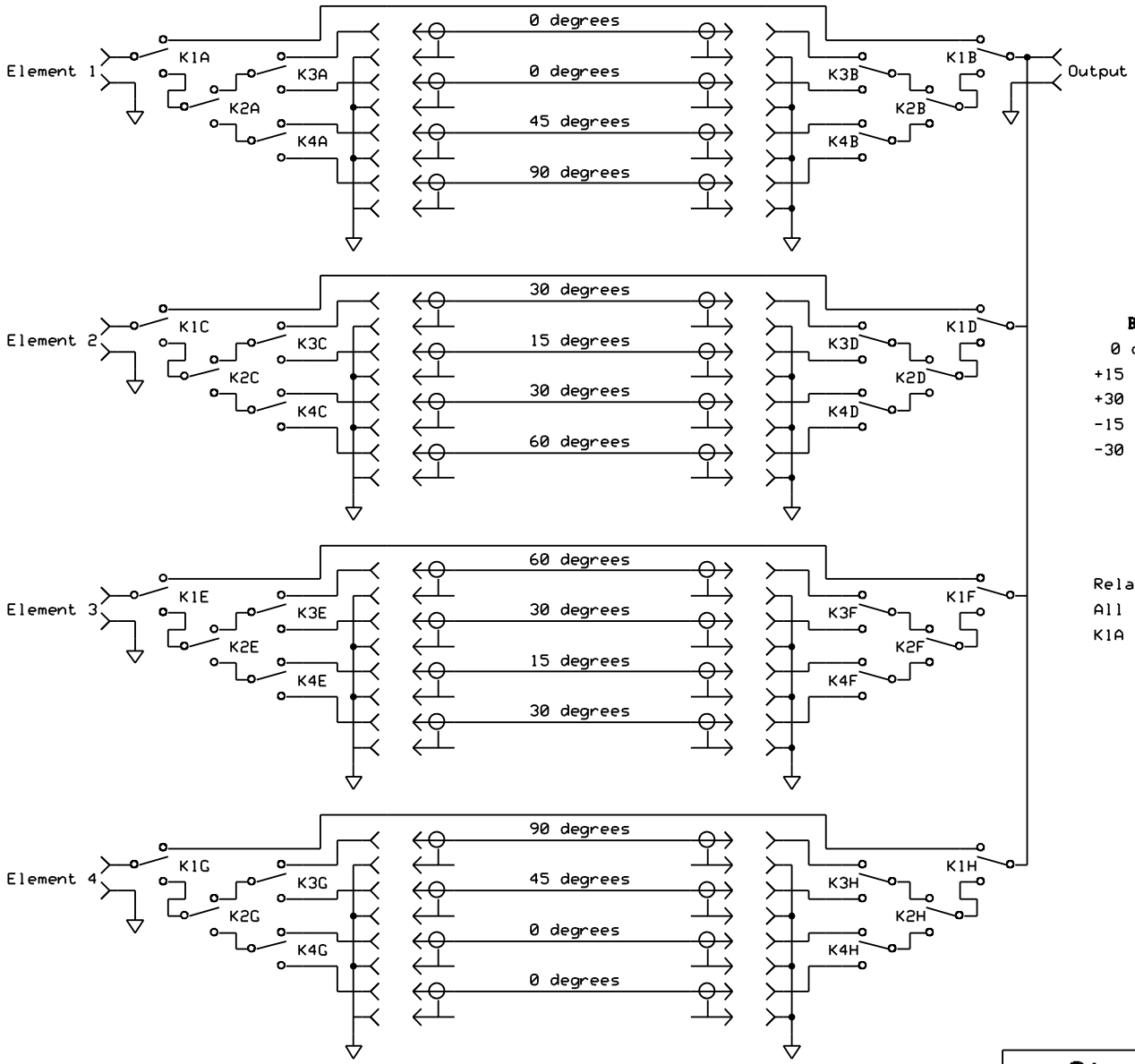
Array of Arrays



- Each pair (1 & 5, 2 & 6, etc.) is an end-fire array
- There are 4 end-fire arrays in phase

End-Fire Reversing Switch

- Decouples relay power from feedline
- First transformer inverts signal from east vertical
- Second transformer converts 37Ω to 75Ω
- Phasing specs from ON4UN's book



Bearing	K1	K2	K3	K4
0 degrees	idle	idle	idle	idle
+15 degrees	active	idle	idle	idle
+30 degrees	active	idle	active	active
-15 degrees	active	active	idle	idle
-30 degrees	active	active	active	active

Relay Coils omitted for clarity
All same numbered relays switched together:
K1A through K1H all activated simultaneously

Steerable Phased Array

Electro-mechanical Phasing

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Electro-Mechanical Steering Issues

Advantages:

- Easy to place in the middle of the array
- Just an antenna, not a receiver

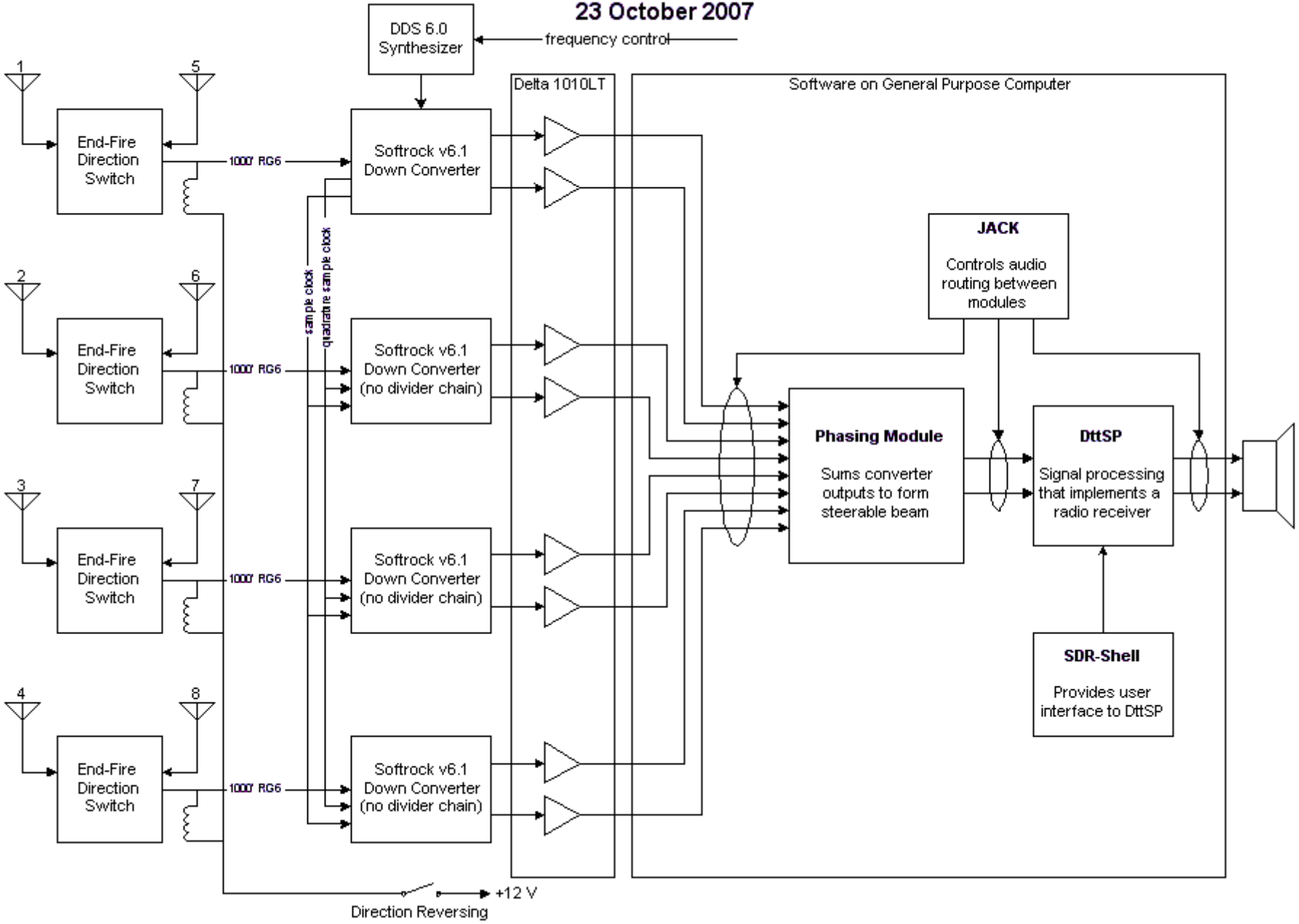
Disadvantages:

- Many relays, connectors, and phasing lines
- Limited number of directions
- New array layout requires new phasing box

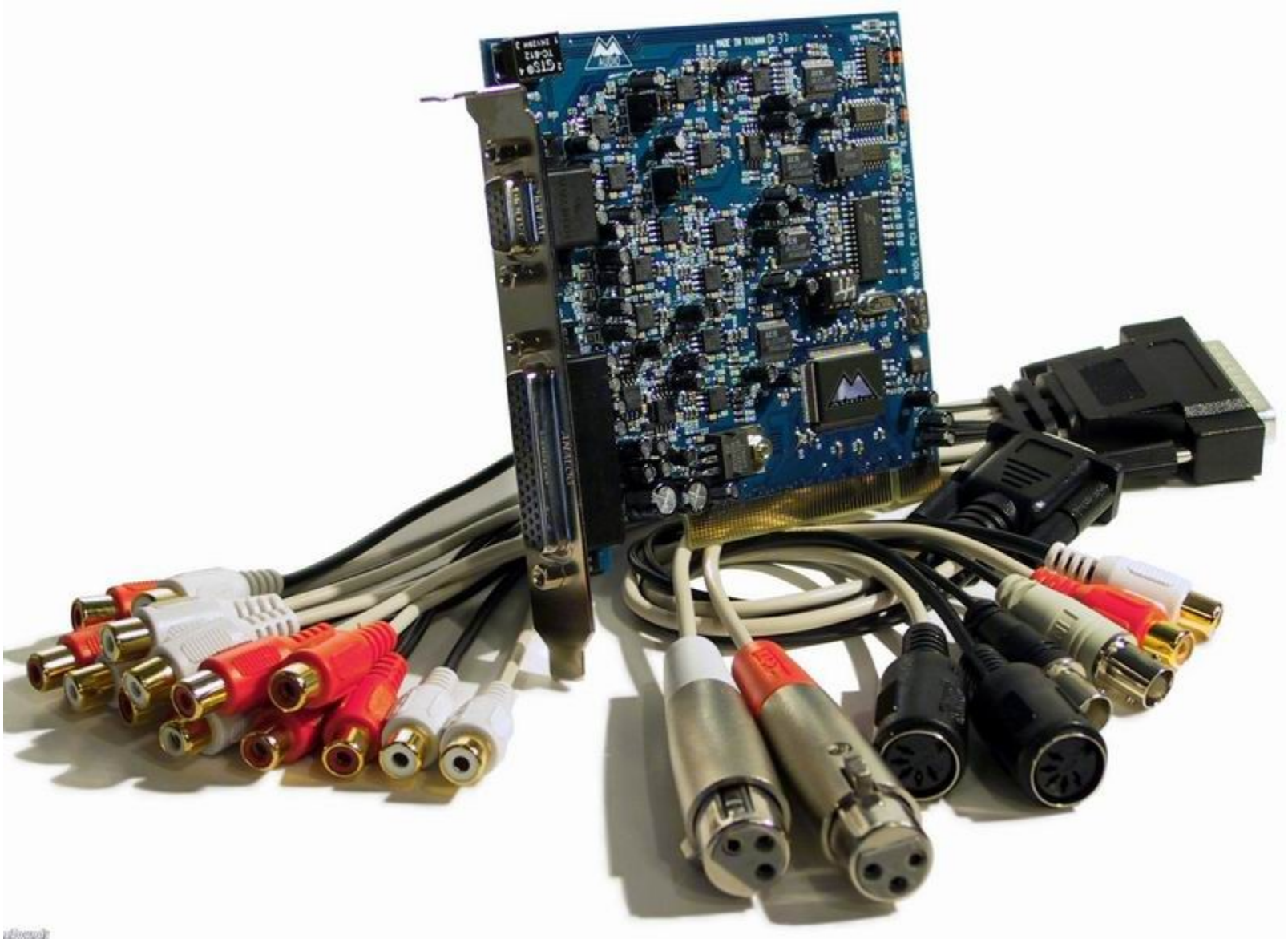
8 Element Electronic Beam Steering Phased Array Antenna

K1LT

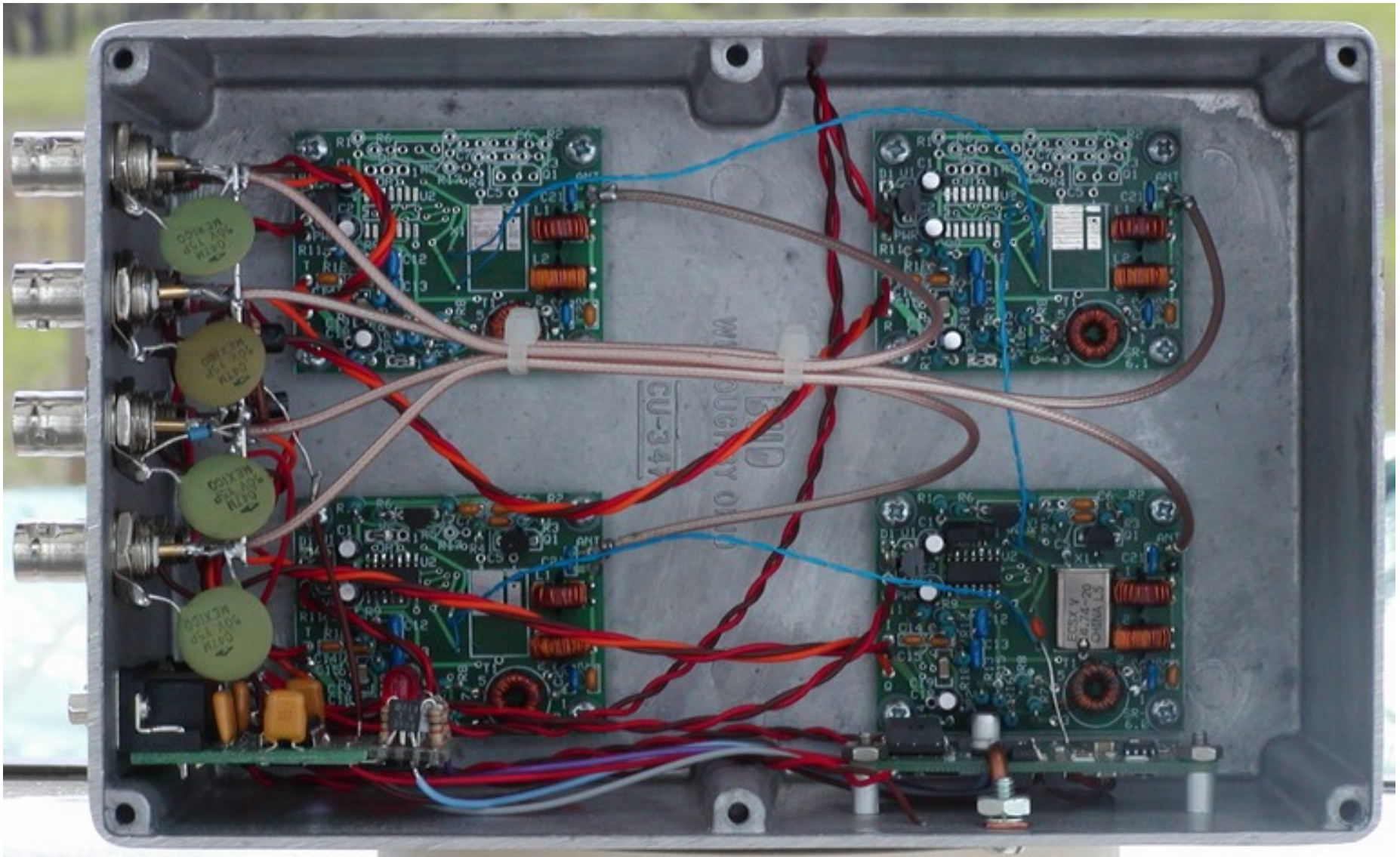
23 October 2007



M-Audio Delta 1010LT



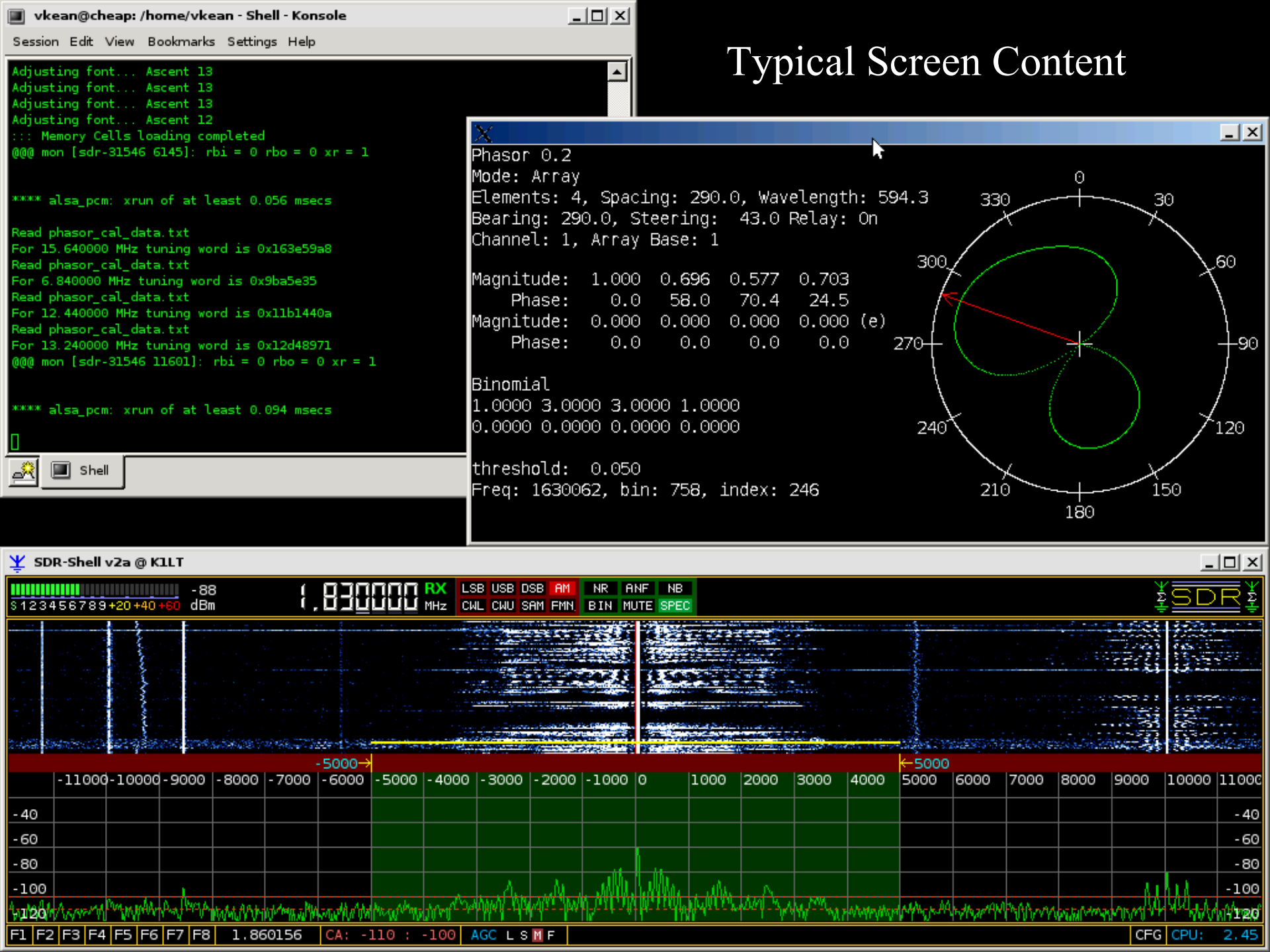
Softrock v6 Receivers & DDS 6.0 VFO



Calibration is Annoying

- Softrock input filter very inconsistent
- Antennas vary despite careful tuning
- Calibration accommodates inconsistency
- Use of off-site signal best calibration strategy
- In-shack calibration source seems almost good enough

Typical Screen Content



CW0TOP works HG3DX

- From CQ 160, about 2347Z Jan 26
- This clip with array pointed South

HG3DX works CW0TOP

- Same QSO with array pointed at Europe

Computer Requirements

- Just a guess based on my computer
- Faster than 1.5 GHz
- Probably 512 megabytes RAM
- PCI slot for the Delta 1010LT
- Serial or USB to control frequency
- Huge hard drive if you want to make recordings

Software Requirements

- Linux 2.6.18 or later
- Real Time patches
- Jack Audio Connection Kit (JACK)
- DttSP (see dttsp.org for other requirements)
- SDR_Shell (ewpereira.org/sdr-shell)
- My phasing software
- Numerous other packages
- Eventually I will document installation

Advantages

- Continuously steerable
- Optimal – best RDF for the real estate
- Flexible – broadside, end-fire, circle, etc.
- Panoramic display is built-in
- Multiple outputs simultaneously

Disadvantages

- SDR versus traditional radio tradeoffs:
  - Latency versus selectivity
  - Wide front end versus narrow front end
- Integration: not just an antenna, it's a radio
- Requires much coax – or put the computer in the middle of the array
- Lack of knobs

Future Work

- Active elements – facilitates experimentation
- 9 Element circle array
- 5 Element end-fire array
- Integrate receiving system with transmitter
- Transmit beam steering