DEUTERIUM ARRAY MEMO #046

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY

WESTFORD, MASSACHUSETTS 01886

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Telephone: 978-692-4764
Fax: 781-981-0590

To: Deuterium Array Group

From: Alan E.E. Rogers

Subject: Improving the 5×5 sidelobes by adding a parasitic director element to each active dipole

1] Single active dipole

The sidelobe level at the horizon of a zenith pointed array can be improved by adding parasitic director elements to each dipole element. For a single active dipole on a 0.8×0.8λ ground plane the EZNEC simulations were as follows:

Gain (dBi)	E-width(deg)	H-width (deg)	Horizon sidelobe (dBi)
8.5	60	97	-5.6
11.0	51	65	-23.7 with director

The best parameters for the director were as follows:

Height of dipole above ground plane	0.2λ
Separation of director from dipole	0.36λ
Length of director (3mm diam.)	0.418λ

The good performance is limited to a bandwidth of about 5 MHz owing to the parasitic resonance of the director. The director length is the most critical parameter. The horizon sidelobe reduction predicted by the simulation was tested by transmitting a test signal of -30 dBm from the standard gain antenna placed 10 feet from the edge of the ground plane and horizontally aligned with an active antenna placed in a corner location.

The results were as follows:

Frequency (MHz)	Signal (dBm)	with director	Sidelobe change (dB)
326	-44	-51	-7
320	-43	-55	-12
315	-44	-61	-17
310	-45	-54	-9

The director was 15.4” long and 0.125” diameter which is optimum for 315 MHz.

2] 2×2 array

The full 5×5 simulation cannot be run in a reasonable amount of time with EZNEC-pro and so I started with a 2×2 array which runs in a few seconds and then moved to a 3×3 array which runs in minutes. A full simulation would require running the simulation for every scan azimuth and scan angle as it is not sufficient to consider only the case of applying the same source phase to each dipole which forms at beam normal to the ground plane. A more efficient method of evaluation may be to place a source at each dipole in turn with the other dipoles terminated in the amplifier impedance. Another simplification is to just consider the average horizon sidelobe level for each dipole with others terminated since the beamforming phases become almost random when tracking at large scan angles. At least this method gives an estimate of the worst case.

a) Source on single dipole

Max gain (dBi)	E-wid	H-wid	Sidelobe (dBi)	Conditions
9.2	48	82	-6.3	Dipole#1others terminated no directors
11.3	47	63	-19.6	Dipole #1 with director
10.9	51	65	-11.6	Dipole #1 others terminated and with directors
11.0	50	65	-12.1	Dipole #2 others terminated and with directors

Note: E = E-plane, H=H-plane, E/H = mid plane

b) Source on all dipoles phased to steer beam

Max gain (dBi)	Beam	Sidelobe (dBi)	Conditions
15.0	Zenith	-4.9	No directors
14.2	20º H	-5.8	No directors
13.6	30º H	-3.0	No directors
11.1	20º E	-1.5	No directors
16.1	Zenith	-11.7	with directors at 0.38λ
15.9	20º H	-12.7	with directors at 0.38λ
15.5	30º H	-13.4	with directors at 0.38λ
14.9	30º E	-11.7	with directors at 0.38λ
14.8	30º E/H	-15.2	with directors at 0.38λ
16.1	Zenith	-21.0	with directors at 0.33λ
14.6	30º E	-8.5	with directors at 0.33λ

The simulations with the source on one dipole show that the mutual coupling degrades the improvement in sidelobe reduction but the performance is still quite good. On average the use of directors improve the sidelobes at the horizon by at least 6 dB. While moving the directors closer improves the sidelobe rejection when the beam is steered to the zenith the sidelobe rejection is degraded when the scan angle is increased. When the beam is considered the best separation may be reduced from 0.56λ to 0.55λ.

The improved sidelobe rejection in the beam at small scan angles suggests that consideration should be given to tilting the 5×5 ground plane towards the south so that the observations of the Galactic anticenter can be made at smaller scan angles. The sidelobes remain low for angles more than 75º from the normal to the ground plane so that tilting the ground plane by 15º from the zenith would not significantly enhance the sensitivity to the south.

3] 3×3

a) Source on single dipole

Max gain (dBi)	E-wid	H-wid	Sidelobe (dBi)	Conditions
9.7	40	74	-9.7	Center dipole no directors
10.6	55	69	-10.6	Center dipole with directors
10.9	51	67	-13.5	Corner dipole with directors
10.7	53	69	-11.4	Edge dipole with directors

b) Source on all dipoles

Max gain (dBi)	Beam	Sidelobe (dBi)	Conditions
18.7	Zenith	-5.8	Without directors
15.5	30º E	1.6	Without directors
19.3	Zenith	-11.7	With directors
17.7	30º E	-7.2	With directors
18.5	30º H	-11.6	With directors

These results are similar to those obtained for the 2×2 array so it is expected that the trends in reduced sidelobes will also be seen in larger arrays. In a limited number of simulations the addition of 0.5λ reflector placed 0.03λ gave another 0.5 dB improvement in the sidelobe reduction. The reflector also makes the array less sensitive to imperfections (like poor contact between sections) in the ground screen.

4] Ideas for implementation

The directors could be added to the existing active dipoles by using PVC pipe to hold the directors which could be made of 1/8" brass of ¼" aluminum rod. The PVC pipe could be mounted on top of the upper dipole box using a PVC plate, PVC spacers and #12 self tapping screws. [Parts cost should be under $2 per crossed directors. 24 are needed for each 5×5 array.] The implementation cost should be much less than the cost of additional fences.