HP-67/97 program plots antenna's polar pattern

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Computing the radiation pattern of driven antenna arrays in polar form is easy with this HP-67/97 program. Given the relative spacing, phasing, and orientation of a multielement array having parallel or colinear half-wave elements in the horizontal plane, the routine tabulates the power gain of the array as a function of the incremental compass angle specified by the user.

The program solves the equation derived by Weeks[1]:

$$P(\theta) = \left|1 + \sum_{N=1}^{n} R_n B_n \cos(\theta_n - \theta_t) - A_n\right|$$

where:

$P(\theta)$ = the phasor sum magnitude of the interference pattern produced by n elements

R_n = the ratio of the power applied to the nth element to the power supplied to the user-defined reference element, r

B_n = the relative spacing in electrical degrees between the nth element and r

θ_n = the orientation of the nth element with respect to r (0° if elements are in parallel, 90° if colinear)

θ_t = the bearing, in degrees, at which field strength is measured.

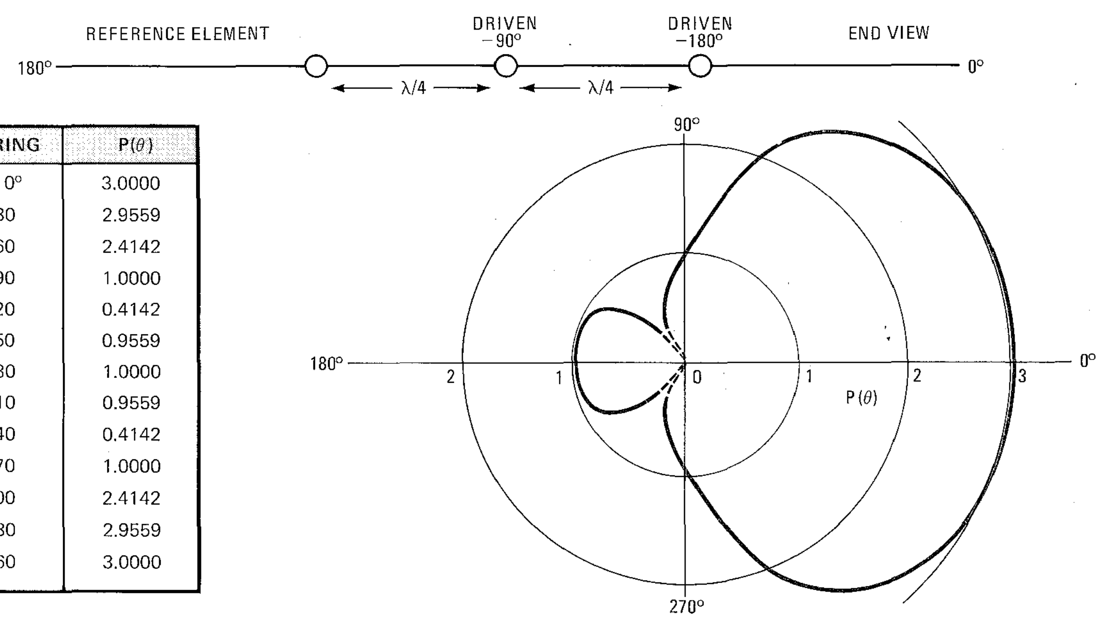
A_n = the relative phase in electrical degrees between element n and r.

Note that the directive (E-plane) pattern as tabulated is not affected by the antenna height above ground, although the user will need a set of ground-reflection factor charts[2] to find the relative gain at a specific take-off angle for a given antenna height and bearing.

An example illustrates the usefulness of the program. A three-element array is arranged as shown in the figure, with each member driven 90° out of phase (lagging) with its preceding element as measured with respect to the reference $P(\theta)$ is required in increments of 30°, starting from 0°.

Thus $\theta_{incr} = 30°$, n = 3, and for the second element, A = -90°, R = 1, θ = 0°, and B = 90°. Keying in these parameters, followed by A = -180°, R = 1, 0 = θ° and

POLAR PLOT: THREE-ELEMENT ARRAY



BEARING	$P(\theta)$
0°	3.0000
30	2.9559
60	2.4142
90	1.0000
120	0.4142
150	0.9559
180	1.0000
210	0.9559
240	0.4142
270	1.0000
300	2.4142
330	2.9559
360	3.0000

B = 180" for the third element, yields the tabulated results as shown, from which the polar plot is constructed.

Note that the analysis of parasitic arrays is possible with this program if the effective power ratios, Rn, and the relative phase factors, An, are known.

Reference.

1. W. L. Weeks, "Antenna Engineering," McGraw-Hiil, 1968
2. J. Kraus, "Antennas," McGraw-HIli, 1950.

HP-67/97 PRINTER LISTING: E-PLANE RADIATION PATTERN FOR DRIVEN ANTENNA ARRAYS

001	*LBLA	032	CHS	063	FRC	094	RCLB
002	CF1	033	X	064	X < 0?	095	DSP0
003	STOD	034	ST + i	065	CHS	096	PSE
004	ISZI	035	P ⇌ S	066	→ R	097	PSE
005	RTN	036	ISZI	067	ST + 0	098	RCLE
006	*LBLB	037	RCLI	068	X ⇌ Y	099	DSP4
007	STOA	038	RCLA	069	P ⇌ S	100	PRTX
008	RTN	039	X = Y?	070	ST + 0	101	RCLB
009	*LBL1	040	GTO0	071	P ⇌ S	102	3
110	RTN	041	GTO1	072	RCLI	103	6
011	*LBLC	042	*LBL0	073	1	104	0
012	STOi	043	RCLB	074	X ⇌ Y	105	X ≤ Y?
013	X < 0?	044	P ⇌ S	075	X ≤ Y?	106	GTO2
014	SF1	045	DSZI	076	GTO3	107	0
015	RTN	046	RCLi	077	GTO0	108	STO0
016	*LBLc	047	INT	078	*LBL3	109	P ⇌ S
017	EEX	048	–	079	RCL0	110	STO0
018	6	049	COS	080	P ⇌ S	111	P ⇌ S
019	CHS	050	RCLi	081	RCL0	112	RCLB
020	F1?	051	FRC	082	X ⇌ Y	113	RCLD
021	CHS	052	1	083	P ⇌ S	114	+
022	ST + i	053	EEX	084	→ P	115	STOB
023	RTN	054	6	085	1	116	RCLA
024	*LBLD	055	X	086	EEX	117	STOI
025	P ⇌ S	056	X	087	6	118	GTO0
026	STOi	057	P ⇌ S	088	X	119	*LBL2
027	RTN	058	RCLi	089	→ R	120	CLRG
028	*LBLd	059	INT	090	1	121	P ⇌ S
029	1	060	CHS	091	+	122	CLRG
030	EEX	061	–	092	→ P	123	CF1
031	6	062	RCLi	093	STOE	124	R/S

Registers								
R_0	R_1	R_2	R_n	S_1	S_2	S_n	A	C
Temporary	$A_1 R_1$	$A_2 R_2$	$A_n R_n$	$\theta_1 B_1$	$\theta_2 B_2$	$\theta_n B_n$	N	θ

Instructions

- Key in program
- Enter angle increment for which tabulated results for $P(\theta)$ are desired and number of elements in array
  (θ_{incr}), A, (N), B.
- Specify phase lag between reference and second driven element, ratio of power applied to second element versus the reference power, and relative position and spacing of elements
  (A), C, (R), f, c, (θ_n), D, (B), f, d.
- Repeat previous step as required for third to nth elements.
  Program is executed automatically upon receipt of all information, displaying angle, then printing the relative power output for that angle.