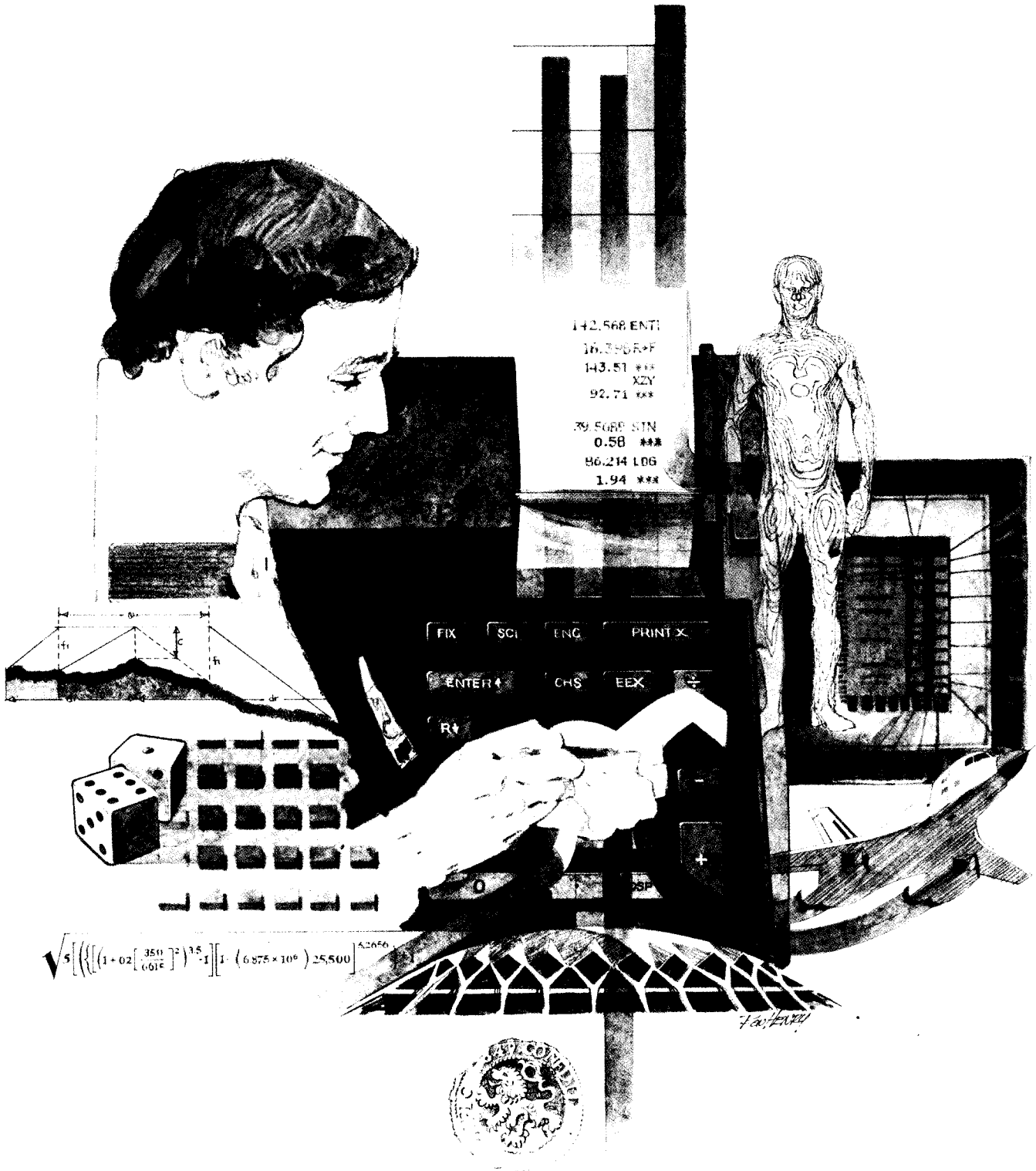


HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Antennas



INTRODUCTION

In an effort to provide continued value to its customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program **solutions** — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Programming Guide**, "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.

REMEMBER! To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

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Converts television channel number to frequency. From frequency, computes ideal length for a cut simple dipole antenna.	

Program Description I

1

Program Title Loaded Vertical Antennas

Contributor's Name HEWLETT-PACKARD

Address 1000 N.E. CIRCLE BLVD.

City CORVALLIS

State OREGON

Zip Code 97330

Program Description, Equations, Variables

Let A = Height above ground in inches

B = Length of lower section in inches

C = Length of upper section in inches

a = Average thickness in inches

F = Frequency in MHz

$$\lambda = V_c/F = 3 \times 10^4 / 2.54F \quad Z_0 = 138 \log [(A + B + C)/a]$$

Electrical length of each section

$$B^\circ = B \cdot 360/\lambda = B \cdot 360 \cdot 2.54F / 3 \times 10^4 = B \cdot F / 32.81 \text{ degrees}$$

$$C^\circ = C \cdot F / 32.81 \text{ degrees}$$

Required Reactance

$$jX_L = jA_0 (\cotan C^\circ - \tan B^\circ)$$

$$\text{Inductance } L = jX_L / 2\pi F = \mu\text{Hy}$$

$$R_{\text{RAD}} = [(C^\circ \cos B^\circ)/2 + B^\circ(1 + \cos B^\circ)/2]^2 / 82.3 = \text{OHMS}$$

Operating Limits and Warnings

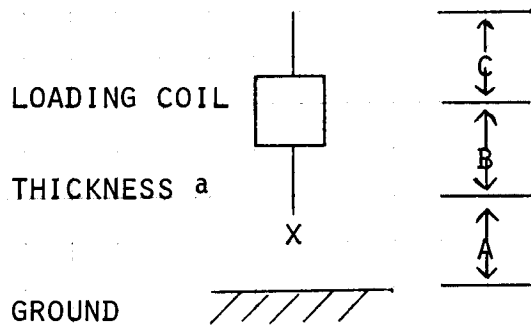
Antenna must be shorter than 90° electrical length.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)



Sample Problem(s)

Given A = 24 inches
 B = 55 inches
 C = 55 inches
 a = .125 inches
 F = 7.2 MHz

Find L and R_{RAD}

Repeat for B = 0 inches
 C = 110 inches

Solution(s)

[RTN] [R/S] 24[A] 55[B] [C] .125 [D] 7.2[E]

[A]

L = 41.24 μ Hy

[R/S]

R_{RAD} = 3.87 OHMS

0 [B] 110[C] [A]

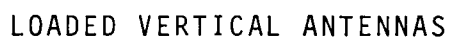
L = 20.62 μ Hy

[R/S]

R_{RAD} = 1.77 OHMS

Reference(s) The Mobile Manual for Radio Amateurs, first edition, Pgs. 239 thru 243, American Radio Relay League, 1955. This program is a translation of the HP-65 User's Library program #1470A submitted by Paul Bunnell.

3

[illegible]

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLα	21 16 11	Initialize	057	=	-24	L in μHy
002	CF1	16 22 01		058	RCL5	36 05	
003	RTN	24		059	=	-24	
004	*LBLA	21 11		060	R/S	51	
005	F1?	16 23 01		061	RCL7	36 07	
006	GT01	22 01		062	COS	42	
007	ST01	35 01		063	ENT↑	-21	
008	SF1	16 21 01		064	ENT↑	-21	
009	RTN	24		065	RCL6	36 06	
010	*LBLB	21 12		066	x	-35	
011	ST02	35 02	B → Reg 2	067	2	02	R in OHMS
012	RTN	24	C → Reg 3	068	=	-24	
013	*LBLC	21 13		069	X*Y	-41	
014	ST03	35 03	a → Reg 4	070	1	01	
015	RTN	24		071	+	-55	
016	*LBLD	21 14	F → Reg 5	072	RCL7	36 07	
017	ST04	35 04		073	x	-35	
018	RTN	24	Z0	074	2	02	
019	*LBL E	21 15		075	=	-24	
020	ST05	35 05		076	+	-55	
021	RTN	24		077	ENT↑	-21	
022	*LBL1	21 01		078	x	-35	
023	RCL1	36 01		079	8	08	
024	RCL2	36 02		080	2	02	
025	RCL3	36 03		081	.	-62	
026	+	-55		082	3	03	
027	+	-55		083	=	-24	
028	RCL4	36 04	C° → Reg 6	084	RTN	24	
029	=	-24					
030	LOG	16 32					
031	1	01					
032	3	03					
033	8	08					
034	x	-35					
035	RCL3	36 03					
036	RCL5	36 05					
037	3	03					
038	2	02	B° → Reg 7				
039	.	-62					
040	8	08					
041	=	-24					
042	ST08	35 08					
043	x	-35					
044	ST06	35 06					
045	TAN	43					
046	1/X	52					
047	RCL2	36 02					
048	RCL8	36 08	XL				
049	x	-35					
050	ST07	35 07					
051	TAN	43					
052	-	-45					
053	x	-35					
054	2	02					
055	=	-24					
056	Pi	16-24					

LABELS				
A Used	B Used	C Used	D Used	E Used
a Used	b	c	d	e
0	1	2	3	4
5	6	7	8	9

FLAGS		SET STATUS		
0	1	ON	OFF	
Used		0 ☐	1 ☒	DEG ☒
		1 ☐	2 ☒	GRAD ☐
		2 ☐	3 ☒	RAD ☐
		3 ☐		
				FIX ☒
				SCI ☐
				ENG ₂ ☐
				n

REGISTERS									
0	1 A	2 B	3 C	4 a	5 F	6 C	7 B	8 Used	9 Used
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

Program Description I

Program Title Loaded Dipole Antennas

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables

The required loading inductance is:

$$L(\mu\text{Hy}) = \frac{10^6}{68\pi^2 f^2} \frac{[\ln(wy) - 1][\frac{y^2}{z^2} - 1]}{y} - \frac{\frac{x^2}{z^2} - 1}{x} [\ln(xw) - 1]$$

where $z = 234/f$

$x = A/2 - B$

$y = Z - B$

$w = 24/DIA$

and $A =$ See sketch pg 2

$B =$ See sketch pg 2

$f =$ Frequency in MHz

$DIA =$ Diameter in inches

Operating Limits and Warnings

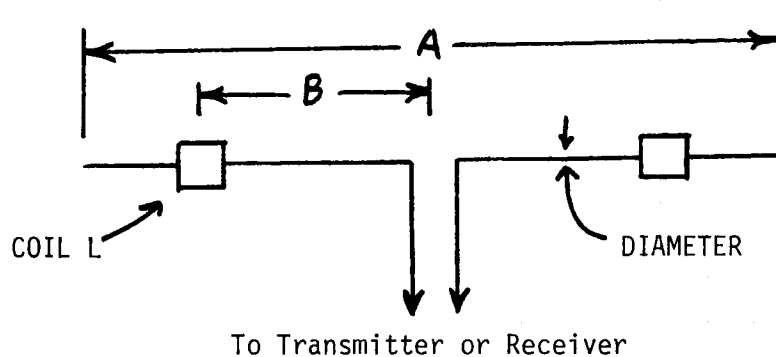
$A < 180^\circ$ Electrical Length.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)



Sample Problem(s)

Given an antenna with the following dimensions:

$A = 130$ feet Frequency = 1.8 MHz

$B = 16.5$ feet DIA = 0.1 Inch

Find the required coil inductance for resonance.

Solution(s)

130 [A] 16.5[B] 1.8[C] .1[D]

[E]

$L = 59.38 \mu\text{Hy}$

Reference(s)

Jerry Hall, Off-Center-Loaded Dipole Antennas, QST, PGs. 28 thru 34, September, 1974.

This program is a translation of the HP-65 Users' Library program # 1619A submitted by Paul Bunnell.

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[illegible]

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Length A	057	1	01	$(\frac{x}{z})^2 - 1$
002	2	02		058	-	-45	
003	=	-24		059	RCL2	36 02	
004	ST07	35 07	A/2→7	060	RCL5	36 05	
005	RTN	24		061	x	-35	
006	*LBLB	21 12	Length B	062	LN	32	
007	ST01	35 01	B →1	063	1	01	$\ln(xw) - 1$
008	RTN	24		064	-	-45	
009	*LBLC	21 13	Frequency	065	x	-35	
010	ST06	35 06	Frequency →6	066	RCL2	36 02	
011	2	02		067	=	-24	
012	3	03		068	-	-45	
013	4	04		069	EEX	-23	
014	RCL6	36 06		070	6	06	
015	=	-24	z→3	071	x	-35	
016	ST03	35 03		072	6	06	
017	RTN	24		073	8	08	
018	*LBLD	21 14	Thickness	074	=	-24	
019	ST09	35 09	D/A 9	075	RCL6	36 06	
020	RTN	24		076	Pi	16-24	
021	*LBLE	21 15		077	x	-35	$\pi^2 f^2$
022	RCL7	36 07		078	ENT↑	-21	
023	RCL1	36 01		079	x	-35	
024	-	-45	x→2	080	=	-24	
025	ST02	35 02		081	RTN	24	
026	RCL3	36 03					
027	RCL1	36 01					
028	-	-45	y→4				
029	ST04	35 04					
030	RCL3	36 03					
031	=	-24					
032	ENT↑	-21					
033	x	-35					
034	1	01		090			
035	-	-45	$\frac{y^2}{z^2} - 1 \rightarrow 8$				
036	ST08	35 08					
037	RCL9	36 09					
038	2	02					
039	4	04					
040	X↔Y	-41					
041	=	-24	w→5				
042	ST05	35 05					
043	RCL4	36 04					
044	x	-35		100			
045	LN	32					
046	1	01	$\ln(wy) - 1$				
047	-	-45					
048	RCL8	36 08					
049	x	-35					
050	RCL4	36 04					
051	=	-24					
052	RCL2	36 02					
053	RCL3	36 03					
054	=	-24		110			
055	ENT↑	-21					
056	x	-35					

SET STATUS		
FLAGS	TRIG	DISP
ON OFF		
0 ☐ ☒	DEG ☒	FIX ☒
1 ☐ ☒	GRAD ☐	SCI ☐
2 ☐ ☒	RAD ☐	ENG ☐
3 ☐ ☒		n <u>2</u>

REGISTERS									
0	1 B	2 x	3 z	4 y	5 w	6 Freq.	7 A/2	8 Used	9 DIA
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

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Program Description II

Sketch(es)

Sample Problem(s)

Antenna characterized by: $H = 20\text{m}$ $L = 114\text{m}$ $\emptyset = 70^\circ$

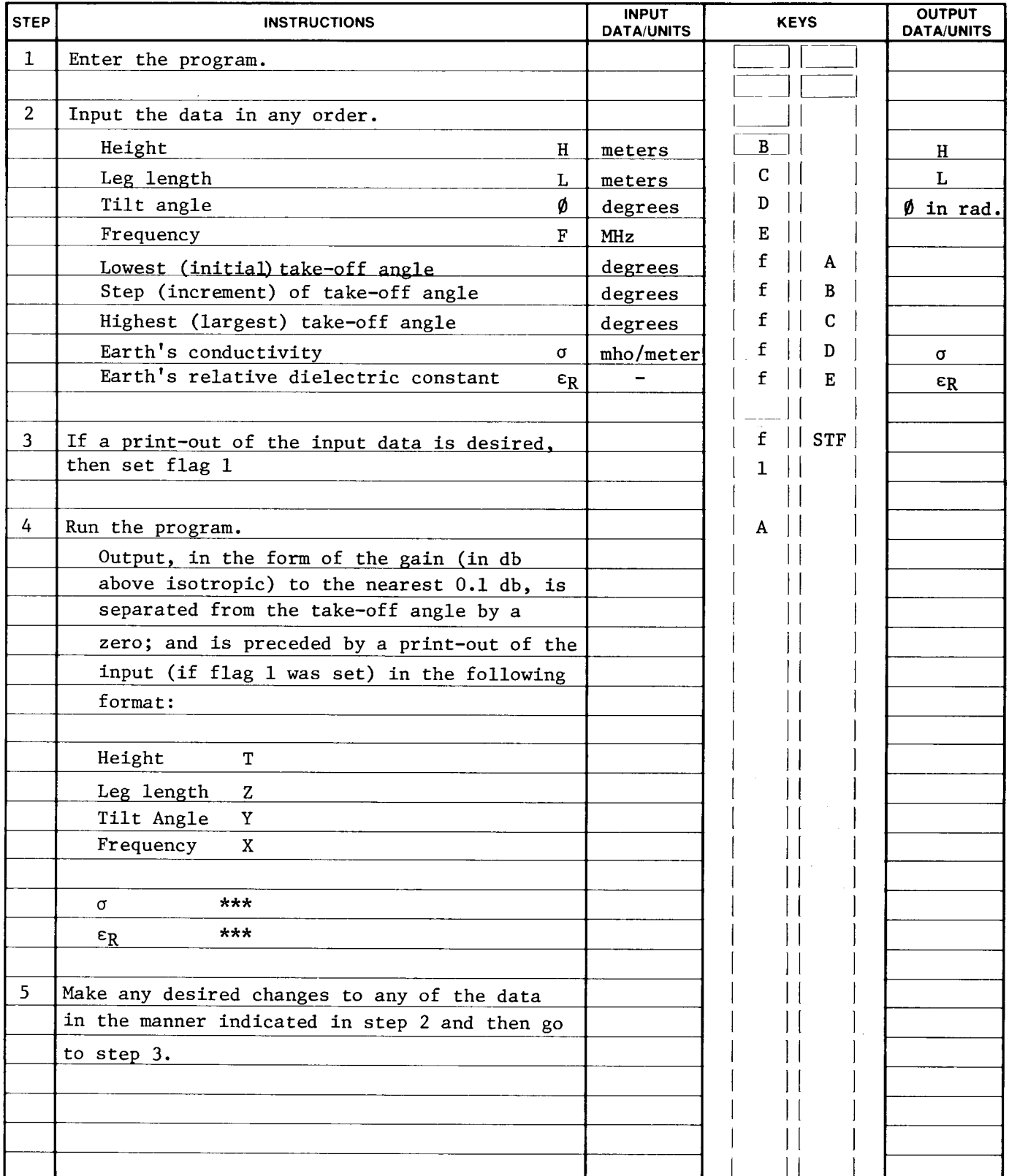
Earth characterized by: $\sigma = 0.001 \text{ mho/m}$ $\epsilon_R = 4$

Wish to evaluate starting at $\text{TOA} = 6^\circ$, in increments of 6° until $\text{TOA} = 24^\circ$ at a frequency of 16 MHz.

Solution(s)	20 [B]	→	20.0000	[A] →	20.0	T	20.8012	***
	114 [C]	→	114.0000		114.0	Z	15.0018	***
	70 [D]	→	1.2217		70.0	Y	-7.2024	***
	.001 [f] [D]	→	0.0010		16.0	X		
	4 [f] [E]	→	4.0000					
	6 [f] [A]	→	6.0000		1.00-03	***		
	6 [f] [B]	→	6.0000		4.00+00	***		
	24 [f] [C]	→	24.0000					
	16 [E]	→	16.0000		18.7006	***		

Reference(s)

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97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL E	21 12		057	+	-55	Increment Δ
002	STOC	35 13	H	058	STO4	35 04	
003	RTN	24		059	RCL3	36 03	
004	*LBL C	21 13		060	-	-45	
005	STOD	35 14	L	061	X>0?	16-44	
006	RTN	24		062	RTN	24	
007	*LBL D	21 14		063	RCL5	36 05	
008	D→R	16 45		064	RCL4	36 04	
009	STOE	35 15	$\emptyset$	065	GT02	22 02	
010	RTN	24		066	*LBL1	21 01	Start of Print
011	*LBL E	21 15		067	FIX	-11	Input Subroutine
012	STO5	35 05	F	068	DSP1	-63 01	
013	RTN	24		069	RCLC	36 13	
014	*LBL a	21 16 11		070	RCLD	36 14	
015	INT	16 34		071	RCL E	36 15	
016	STO1	35 01	Δ lowest	072	R→D	16 46	
017	RTN	24		073	RCL5	36 05	
018	*LBL b	21 16 12		074	PRST	16-14	
019	INT	16 34		075	ENG	-13	
020	STO2	35 02	Δ step	076	DSP2	-63 02	
021	RTN	24		077	RCLA	36 11	
022	*LBL c	21 16 13		078	PRTX	-14	
023	INT	16 34		079	RCLB	36 12	
024	STO3	35 03	Δ largest	080	PRTX	-14	
025	RTN	24		081	SPC	16-11	
026	*LBL d	21 16 14		082	FIX	-11	
027	STOA	35 11	σ	083	DSP3	-63 03	
028	RTN	24		084	RTN	24	
029	*LBL e	21 16 15		085	*LBL0	21 00	Start of Gain
030	STOB	35 12	ϵ_R	086	P→S	16-51	Subroutine; Δ in
031	RTN	24		087	COS	42	X, F in Y.
032	*LBL A	21 11	Start of execution	088	STO1	35 01	
033	F1?	16 23 01	Print input?	089	LSTX	16-63	
034	GSB1	23 01		090	SIN	41	
035	RCL5	36 05		091	STO2	35 02	
036	RCL1	36 01		092	RAD	16-22	
037	STO4	35 04		093	R↓	-31	
038	*LBL2	21 02		094	R↓	-31	
039	GSB0	23 00	Go calculate gain	095	2	02	
040	X<0?	16-45		096	9	09	
041	SF0	16 21 00		097	9	09	
042	DSP1	-63 01		098	.	-62	
043	RND	16 24		099	8	08	
044	RCL4	36 04		100	X→Y	-41	
045	EEX	-23		101	÷	-24	
046	4	04		102	STO3	35 03	
047	CHS	-22		103	P↓	16-24	
048	x	-35		104	X→Y	-41	
049	F0?	16 23 00		105	÷	-24	
050	CHS	-22		106	STO4	35 04	
051	CF0	16 22 00		107	1	01	
052	+	-55		108	RCL1	36 01	
053	DSP4	-63 04	Print gain and Δ	109	RCL E	36 15	
054	PRTX	-14		110	SIN	41	
055	RCL2	36 02		111	x	-35	
056	RCL4	36 04		112	-	-45	

REGISTERS

REGISTERS										
0	1 lowest TOA	2 TOA step	3 largest TOA	4 TOA in use Δ	5 F	6	7	8	9	
S0	S1 $\cos \Delta$	S2 $\sin \Delta$	S3 λ	S4 π/λ	S5 U	S6 $ R_H $	S7 $\angle R_H$	S8	S9	
A σ		B ϵ_R		C H		D L		E $\emptyset$		I

97 Program Listing II

13

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
113	ST05	35 05	Start to calculate reflection coefficient	169	+	-55	Gain is in X
114	RCLA	36 11		170	RCL6	36 06	
115	RCL3	36 03		171	X ²	53	
116	x	-35		172	+	-55	
117	6	06		173	RCL5	36 05	
118	0	00		174	RCL4	36 04	
119	x	-35		175	x	-35	
120	CHS	-22		176	RCLD	36 14	
121	RCLB	36 12		177	x	-35	
122	RCL1	36 01		178	SIN	41	
123	X ²	53		179	X ²	53	
124	-	-45		180	RCL5	36 15	
125	→P	34		181	COS	42	
126	√X	54		182	x	-35	
127	X*Y	-41		183	RCL5	36 05	
128	2	02		184	÷	-24	
129	÷	-24		185	X ²	53	
130	X*Y	-41		186	x	-35	
131	→R	44		187	2	02	
132	ST06	35 06		188	.	-62	
133	R↓	-31		189	1	01	
134	ST07	35 07		190	6	06	
135	CHS	-22		191	x	-35	
136	R↑	16-31		192	LOG	16 32	
137	CHS	-22		193	1	01	
138	RCL2	36 02		194	0	00	
139	+	-55		195	x	-35	
140	→P	34		196	DEG	16-21	
141	X*Y	-41		197	P→S	16-51	
142	RCL6	36 06		198	RTN	24	
143	RCL2	36 02		200			
144	+	-55					
145	RCL7	36 07					
146	X*Y	-41					
147	→P	34					
148	R↓	-31					
149	-	-45					
150	ST07	35 07					
151	X*Y	-41					
152	R↑	16-31					
153	÷	-24		210			
154	ST06	35 06					
155	RCL7	36 07					
156	RCL2	36 02					
157	RCL4	36 04					
158	x	-35					
159	RCLC	36 13					
160	x	-35					
161	4	04					
162	x	-35					
163	-	-45		220			
164	COS	42					
165	x	-35					
166	2	02					
167	x	-35					
168	1	01					

LABELS					FLAGS	SET STATUS			
A start of execution	B H Storage	C L Storage	D Ø storage	E F storage	0 USED	FLAGS		TRIG	DISP
a lowest TOA Storage	b TOA Step Storage	c largest TOA storage	d Ø storage	e E _R storage	1 print input	ON OFF	DEG ☒	FIX ☒	
0 Start of Gain	1 Start of Print	2 part of TOA loop	3	4	2	0 ☐ ☐	GRAD ☐	SCI ☐	
						1 ☒ ☐	RAD ☐	ENG ☐	
5	6	7	8	9	3	2 ☐ ☐		n <u>4</u>	
						3 ☐ ☐			

Program Description I

Program Title Azimuth Pattern of Cylindrical Array of Antennas

Contributor's Name Allan H. Wegner

Address 1312 Toyon Place.

City Davis

State CA

Zip Code 95616

Program Description, Equations, Variables First this program calculates the angle at which the individual radiating element is to be evaluated. With this information the user inputs the magnitude & phase of the individual radiating element at this angle. The program then calculates the phase of the individual's contribution to the total radiated field, with reference to the center of rotation of the structure (point O in sketch). The program then repeats these steps for all of the individual elements, and sums their individual contributions to determine the resultant field at a given observation angle, Θ . The variables are:

α_n = Pattern evaluation angle; R = radius of antenna array; Θ_f = angle between the face normals; γ = skew angle in C.W. direction of the individual radiating element's reference azimuth from face normal.

N = total number of individual radiating elements; n = number of individual element; δ = offset distance of individual element from center of face

ϕ_s = phase of contribution of an individual element due to its location in space; $M(\alpha)$, $p(\alpha)$ = magnitude & phase of individual element evaluated at α ; ψ_n = phase of signal to face n ; A_n = magnitude of signal to face n . The equations are:

$M(\Theta) = \text{abs} \left[\sum_{n=1}^N A_n \cdot m(\alpha_n) \exp(j\Phi(\alpha_n)) \right]$ where $\Phi = \phi_s + p + \psi$; $\alpha_n = \Theta_n - \gamma$; $\phi_s = 360/\lambda (R \cos \Theta_n + \delta \sin \Theta_n)$, and $\Theta_n = \Theta - \Theta_f(n-1)$

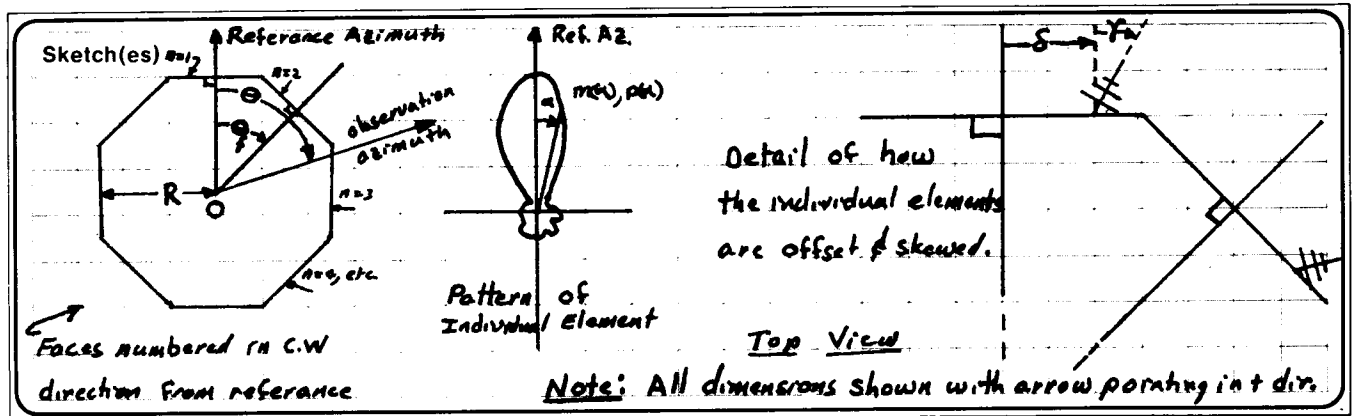
Note: $M(\Theta)$ must be renormalized after computation.

Operating Limits and Warnings

This program has been verified only with respect to the numerical example given in Program Description II. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

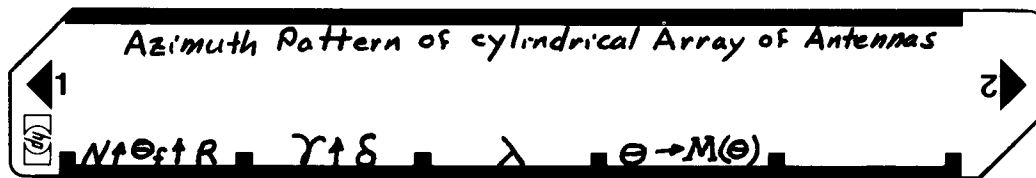


Sample Problem(s) How much less is the radiated field at an azimuth of 140° than at 10° ? The array is a four sided structure with a side of 6 m. The antennas are offset 2 m from the center of the panel towards the right when viewed from the center of the array. Each element is skewed 10° c.w. when viewed from the top. The elements (in order from $n=1$ to $n=4$) are fed as follows: $1.0 \angle 0^\circ$, $0.9 \angle 90^\circ$, $0.9 \angle 180^\circ$, $1.0 \angle 270^\circ$. The pattern of the individual element is as follows (azimuth, magnitude, phase in that order): $0^\circ, 1.0 \angle 0^\circ$; $10^\circ, 0.94 \angle 0^\circ$; $40^\circ, 0.54 \angle 5^\circ$; $90^\circ, 0.05 \angle 10^\circ$; $130^\circ, 0.02 \angle 30^\circ$; $180^\circ, 0.08 \angle -50^\circ$; $220^\circ, 0.02 \angle 30^\circ$; $270^\circ, 0.05 \angle 7^\circ$; $310^\circ, 0.41 \angle 6^\circ$.

Solution(s) keystrokes: 4 [↑] 90 [↑] 3 [A] 10 [↑] 2 [B] 2.2 [C] → 0.00
 10 [D] → 1.00 (n) → 0.00 (α_1); 0 [↑] 0 [R/s] → 540.28; 1 [↑] 1 [R/s] → 2.00 (n)
 → 270.00 (α_2); 7 [↑] 90 [R/s] → -140.06; 0.05 [↑] 0.9 [R/s] → 3.00 (n) → 180.00 (α_3)
 50 [chs] [↑] 180 [R/s] → -410.28, 0.08 [↑] 0.9 [R/s] → 4.00 (n) → 90.00 (α_4);
 10 [↑] 270 [R/s] → 517.06; 0.05 [↑] 1.0 [R/s] → 3.22 (= $M(10^\circ)$)
 140 [D] → 1.00 (n) → 130.00 (α_1); 3 0 [↑] 0 [R/s] → -135.69; 0.02 [↑] 0 [R/s] →
 2.00 (n) → 40.00 (α_2); 5 [↑] 90 [R/s] → 661.26; 0.54 [↑] 0.9 [R/s] → 3.00 (n) → 310.00 (α_3);
 6 [↑] 180 [R/s] → 351.69; 0.41 [↑] 0.9 [R/s] → 4.00 (n) → 220.00 (α_4); 30 [↑] 270
 [R/s] → -226.26; 0.02 [↑] 1 [R/s] → 2.01 (= $M(140^\circ)$); 3.22 [÷] → 0.62 (answer)

Reference(s)

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load Program		↑ ↓	
2	Input Array Geometry: First input number of elements in array, then input angle between faces then input radius of array.	N $\Theta_f, \text{deg.}$ R^*	↑ ↓ A B	
3	Input Skew of elements: First input angular skew, then input lateral skew.	$\gamma, \text{deg.}$ δ^*	↑ ↓ B C	
4	Input wavelength	λ^*	C D	
5	Compute resultant radiated field for each azimuth angle, Θ , desired:		D E	
5a	First input Θ ,	$\Theta, \text{deg.}$	D E	
5b	Then, when the program pauses, read the number of the face that is being evaluated		E F	n
5c	Then, when the program stops, read the individual pattern evaluation angle, α_n		F G	$\alpha_n, \text{deg.}$
5d	Then input the phase of radiated field of individual element at angle α_n .	$p(\alpha_n), \text{deg.}$	↑ ↓	
5e	Then input the phase of the signal to face n .	$\gamma_n, \text{deg.}$	R/S T	
5f	Then input the amplitude of the radiated field of the individual element at angle α_n	$m(\alpha_n), \%$	↑ ↓	
5g	Then input the amplitude of the signal to face n	$A_n, \%$	↑ ↓	
5h	The program repeats Steps 5b through 5h until $n=N$.		↓ E	
6	The program then stops to display the total radiated field of the array in the direction Θ , $M(\Theta)^{**}$		E F	$M(\Theta)^{**}$
7	The phase of the total field may be viewed if desired, $P(\Theta)$.		h xzy	$P(\Theta), \text{deg.}$
8	If another observation angle, Θ , is desired go to Step #5 and repeat.		↓ E	
9	If it is desired to change any of the parameters ($N, \Theta_f, R, \gamma, \delta, \lambda$) go to the proper Step (#2, #3, or #4) then go to Step #5 and continue. The other data does not need to be reentered.		↓ E	
*	Note: R, δ , and λ must ALL be in the same units		↓ E	
**	Note: $M(\Theta)$ must be renormalized when finished		↓ E	

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[illegible]

[illegible]

Program Description I

Program Title COLINEAR ANTENNA GAIN AND PATTERN

Contributor's Name KEN WETZEL

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City RIDGECREST

State CALIF

Zip Code 93555

Program Description, Equations, Variables PROGRAM PERFORMS NUMERICAL

INTEGRATION OF : $G = \int_0^{90} f(\theta)^2 \sin \theta d\theta$ OVER STEPS OF θ_i

$$f(\theta)^2 = f(\theta)_{\text{DIPOLE}}^2 \cdot f(\theta)_{\text{ARRAY}}^2$$

$$f(\theta)_{\text{DIPOLE}} = \frac{\cos(\pi L_{\lambda} \cos \theta) - \cos(\pi L_{\lambda})}{(\sin \theta)(1 - \cos(\pi L_{\lambda}) + 1 \times 10^{-9})}$$

THE TERM $(1 - \cos(\pi L_{\lambda}))$
NORMALIZES $f(\theta)_{\text{DIPOLE}}$

$$f(\theta)_{\text{ARRAY}} = \frac{\sin(N \psi/2)}{N \sin(\psi/2)} \quad \psi = 2\pi(S_{\lambda} + L_{\lambda}) \cos \theta + \psi_0$$

ψ_0 = PROGRESSIVE ELEMENT-TO-ELEMENT PHASE SHIFT IN RADIANS. FOR BROAD-SIDE ARRAY $\psi_0 = 0$. FOR $\psi_0 = 0$ USE BOTH POSITIVE AND NEGATIVE VALUE TO EVALUATE BOTH SIDES OF PATTERN

L_{λ} = TOTAL DIPOLE LENGTH IN WAVELENGTHS

S_{λ} = TIP-TO-TIP DIPOLE SPACING IN WAVELENGTHS

N = TOTAL NUMBER OF ELEMENTS IN ARRAY

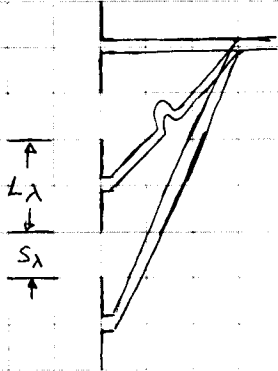
Operating Limits and Warnings VALID ONLY FOR EQUAL AMPLITUDE FEED, AND UNIFORM SPACING & DIPOLE LENGTH. VALID FOR ANY LENGTH CENTER FED DIPOLE, OR END FED DIPOLE OF ONE-HALF WAVELENGTH OR LESS. PROGRAM OPERATES BY ITERATION: ALLOW APPROXIMATELY 10 SECONDS PER ITERATION.

This program has been verified only with respect to the numerical example given in Program Description II. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)



ψ_0 PROGRESSIVE ELEMENT-TO-ELEMENT PHASE SHIFT

N NUMBER OF ELEMENTS (HERE N=3)

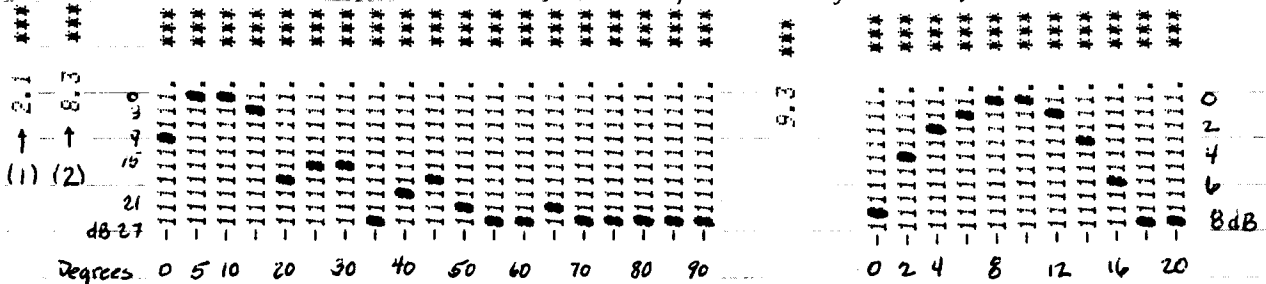
Sample Problem(s)

- (1) CALCULATE GAIN OF $\lambda/2$ DIPOLE
- (2) CALCULATE GAIN OF TWO $1/4 \lambda$ DIPOLES SPACED $1/2 \lambda$ TIP-TO-TIP
- (3) EVALUATE EFFECT OF 0.7 RADIAN PHASE SHIFT ON ARRAY OF SIX $\lambda/2$ DIPOLES SPACED $\lambda/4$ TIP-TIP. PLOT IN 3dB STEPS, $5^\circ/\text{STEP}$; PLOT IN 1dB STEPS, $2^\circ/\text{STEP}$
NOTE: CONTRAST OF PLOT HAS BEEN INCREASED BY MARKING EACH "B" WITH A PENCIL

Solution(s) (1) [A], 0.5 STD 1, 1 STD I, [B] ANS: 2.15 dB

(2) ~~0.5~~ 1.25 STD 1, 0.5 STD 2, 2 STD 3, 0 STD I, [B] ANS: 8.33 dB

(3) 0.7 STD 0, 0.5 STD 1, 0.25 STD 2, 6 STD 3, 5 [C], [E]; 1 STD E, 2 [C], [E] ANS:



Reference(s)

EDWARD A WOLFF, ANTENNA ANALYSIS
PAGES 41 & 248, WILEY 1966

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STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	LOAD SIDES 1 & 2 OF CARD				
2	INITIALIZE		A		3.010
3	INPUT PARAMETERS :				
	PROGRESSIVE PHASE SHIFT, RADIAN	ψ_0	STD	0	
	DIPOLE LENGTH, WAVELENGTHS	$L\lambda$	STD	1	
	DIPOLE SPACING (TIP-TO-TIP), WAVELENGTHS	$S\lambda$	STD	2	
	NUMBER OF DIPOLES IN ARRAY	N	STD	3	
4	CALCULATE ANTENNA GAIN		B		G, dBi
5	CALCULATE RELATIVE GAIN G_r ANGLE :				
	INPUT DEGREES PER STEP *	Θ_i	C		n
	PRINTS G_r , RELATIVE GAIN		D		Θ°, G_{dB}
	ITERATES n TIMES, PRINTS GAIN				G, dBi
6	PLOT ANTENNA PATTERN:				
	INPUT dB/STEP (PROGRAMMED FOR 3dB)	dB/STEP	STD	E	
	INPUT DEGREES PER STEP *	Θ_i	C		
	PLOT		E		SEE NOTE
	NOTE: READ PLOT (3dB/STEP)				
	IIIIIIII181 = +1.5dB to +4.5dB				
	-IIIIIIII18 = 0dB to -1.5dB				
	-IIIIIIII1811 = -4.5dB to -7.5dB etc				
	EACH LINE IS AN INCREMENT OF Θ_i				
	STARTING WITH $\Theta = 0^\circ$; PRINTS GAIN				G, dBi
*	TO START GAIN G_r ANGLE ROUTINES (D AND E) AT AN ADVANCED ANGLE:				
	INPUT START ANGLE AFTER ROUTINE C IS COMPLETE.	Θ_{START}	F	C	-
	CONTINUE WITH APPROPRIATE INSTRUCTIONS: EXAMPLE: PRINT PATTERN WITH 5° STEPS STARTING AT 30° : 5,C,30,5C,D				
7	TO SPEED DIPOLE ONLY OR ARRAY FACTOR ONLY COMPUTATIONS:				
	DIPOLE ONLY	1	STD	I	
	ARRAY FACTOR ONLY +	2	STD	I	
	TO RETURN TO DIPOLE + ARRAY	0	STD	I	
	+ LET $L\lambda = 0$, $S\lambda =$ TOTAL DISTANCE				

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	STORES CONSTANTS	057	x	-35	CALCULATES GAIN
002	ENT↑	-21		058	3	03	
003	1	01		059	+	-55	
004	1	01		060	÷	-24	
005	1	01		061	GSBC	23 13	
006	1	01		062	*LBLb	21 16 12	
007	1	01		063	GSB9	23 09	
008	1	01		064	GSBi	23 45	
009	1	01		065	RCLB	36 12	
010	1	01		066	SIN	41	
011	1	01		067	x	-35	
012	1	01		068	ST+7	35-55 07	
013	STOD	35 14	CALCULATES NUMBER OF STEPS FOR %/STEP; INITIALIZES REGISTERS 5, 6, & 7	069	1	01	PRINTS ANGLE
014	Pi	16-24		070	ST+6	35-55 06	
015	2	02		071	RCL5	36 05	
016	÷	-24		072	RCL6	36 06	
017	STOC	35 13		073	X#Y?	16-32	
018	2	02		074	GTOb	22 16 12	
019	GSB7	23 07		075	RCL7	36 07	
020	STOE	35 15		076	.	-62	
021	RTN	24		077	5	05	
022	*LBLC	21 13		078	-	-45	
023	D+R	16 45		079	RCLA	36 11	
024	STOA	35 11	ADVANCES STARTING ANGLE	080	x	-35	PRINTS RELATIVE GAIN
025	0	00		081	GSB7	23 07	
026	STO6	35 06		082	CHS	-22	
027	STO7	35 07		083	STO4	35 04	
028	RCLC	36 13		084	DSP1	-63 01	
029	RCLA	36 11		085	RND	16 24	
030	÷	-24		086	PRTX	-14	
031	DSP0	-63 00		087	DSP2	-63 02	
032	RND	16 24		088	RCL4	36 04	
033	STO5	35 05		089	RTN	24	
034	DSP2	-63 02		090	*LBLD	21 14	
035	RTN	24	CALCULATES MINIMUM NUMBER OF STEPS (MAX. %/STEP) FOR ACCURATE GAIN COMPUTATION	091	GSB8	23 08	CALCULATES GAIN
036	*LBLc	21 16 13		092	R+D	16 46	
037	D+R	16 45		093	DSP0	-63 00	
038	RCLA	36 11		094	RND	16 24	
039	÷	-24		095	PRTX	-14	
040	DSP0	-63 00		096	GSB9	23 09	
041	RND	16 24		097	GSBi	23 45	
042	STO6	35 06		098	GSB7	23 07	
043	RTN	24		099	DSP1	-63 01	
044	*LBLB	21 12		100	RND	16 24	
045	9	09		101	PRTX	-14	
046	0	00		102	1	01	
047	RCL1	36 01	REGISTERS	103	ST+6	35-55 06	REGISTERS
048	RCL3	36 03		104	RCL5	36 05	
049	x	-35		105	RCL6	36 06	
050	RCL3	36 03		106	X#Y?	16-35	
051	1	01		107	GTOD	22 14	
052	-	-45		108	SPC	16-11	
053	RCL2	36 02		109	GTOb	22 12	
054	x	-35		110	RTN	24	
055	+	-55		111	*LBL E	21 15	
056	RCLC	36 13		112	GSB9	23 09	

0	1	2	3	4	5	6	7	8	9
ψ_0	L_λ	S_λ	N	USED	n	1,2,3,...n	$Z(\theta)^2 \sin \theta$		
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A θ_0 , RADIANS		B θ , RADIANS		C $\pi/2$		D		E dB/STEP	
								I 0, 1, OR 2	

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KEY ENTRY	KEY CODE	COMMENTS	ST	KEY ENTRY	KEY CODE	COMMENTS
113 GSB1	23 45	↓ PLOTS PATTERN		169 *LBL1	21 01	
114 GSB7	23 07			170 RCLB	36 12	CALCULATES
115 X<0?	16-45	CHECK SIGN		171 COS	42	$\xi(0)^2_{\text{DIPOLE}}$
116 SF2	16 21 02			172 Pi	16-24	
117 ABS	16 31			173 x	-35	
118 RCLC	36 15	NORMALIZE		174 RCL1	36 01	
119 =	-24	WITH dB/STEP		175 x	-35	
120 DSP0	-63 00			176 COS	42	
121 RND	16 24			177 RCL1	36 01	
122 9	09			178 Pi	16-24	
123 X<Y?	16-35	} SET LIMITS		179 x	-35	
124 X<Y	-41			180 COS	42	
125 X<Y	-41			181 -	-45	
126 10x	16 33			182 1	01	
127 7	07	} FORMAT		183 LSTX	16-63	
128 x	-35			184 -	-45	
129 RCLD	36 14			185 EEX	-23	PREVENTS
130 +	-55			186 CHS	-22	DIVISION BY
131 F2?	16 23 02	INSERT SIGN		187 9	09	ZERO
132 CHS	-22			188 +	-55	
133 PRTX	-14	PRINT PLOT FORMAT		189 ÷	-24	
134 1	01			190 RCLB	36 12	
135 ST+6	35-55 06			191 SIN	41	
136 RCL5	36 05			192 ÷	-24	
137 RCL6	36 06			193 x ²	53	
138 X<Y?	16-35			194 RTN	24	
139 GT0E	22 15			195 *LBL2	21 02	CALCULATES
140 SPC	16-11			196 RCLB	36 12	$\xi(0)^2_{\text{ARRAY}}$
141 GT0B	22 12	CALCULATE		197 COS	42	
142 RTN	24	GAIN		198 RCL2	36 02	
143 *LBL9	21 09			199 RCL1	36 01	
144 GSB8	23 08			200 +	-55	
145 RCLC	36 13	BRINGS 0°		201 x	-35	
146 +	-55	TO BROADSIDE		202 Pi	16-24	
147 ST0B	35 12			203 x	-35	
148 RTN	24			204 2	02	
149 *LBL8	21 08	CALCULATE		205 x	-35	
150 RCLA	36 11	ANGLE 0		206 RCL0	36 00	
151 RCL6	36 06			207 +	-55	
152 x	-35			208 2	02	
153 RTN	24			209 ÷	-24	
154 *LBL7	21 07			210 ST04	35 04	
155 EEX	-23			211 RCL3	36 03	
156 CHS	-22			212 x	-35	
157 9	09			213 SIN	41	
158 +	-55			214 RCL4	36 04	
159 LOG	16 32			215 SIN	41	
160 1	01			216 ÷	-24	
161 0	00			217 RCL3	36 03	
162 x	-35			218 ÷	-24	
163 RTN	24			219 x ²	53	
164 *LBL0	21 00			220 RTN	24	
165 GSB1	23 01	$\xi(0)^2_D \cdot \xi(0)^2_A$				
166 GSB2	23 02					
167 x	-35					
168 RTN	24					

LABELS					FLAGS	SET STATUS		
A INITIALIZE	B CALCULATE GAIN	C 0/STEP	D LIST PATTERN	E PLOT PATTERN	0	FLAGS	TRIG	DISP
a	b	c ADVANCE (0 START #0)	d	e	1	ON OFF		
$0 \xi(0)^2_D \cdot \xi(0)^2_A$	$1 \xi(0)^2_{\text{DIPOLE}}$	$2 \xi(0)^2_{\text{ARRAY}}$	3	4	2 SIGN OF PLOT	0 ☐ ☒	DEG ☐	FIX ☒
5	6	7 10 Log	8 CALC 0	9 0 + $\pi/2$	3	1 ☐ ☒	GRAD ☐	SCI ☐
						2 ☐ ☒	RAD ☒	ENG ☐
						3 ☐ ☒		n 3

Program Description I

Program Title Beam Pattern for Uniform Array

Contributor's Name Stephen A. Hertz

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City McLean

State Va.

Zip Code 22101

Program Description, Equations, Variables Program computes normalized beam pattern of a uniformly spaced and weighted discrete linear array for arbitrary number of sensors, steering angle and wavelength.

The normalized beam pattern is given by:

$$R(\theta_i) = 10 \log_{10} \left(\frac{\sin \left[\frac{N 180 d}{\lambda} (\sin \theta_i - \sin \theta_s) \right]}{N \sin \left[\frac{180 d}{\lambda} (\sin \theta_i - \sin \theta_s) \right]} \right)^2$$

where

N = total number of sensors

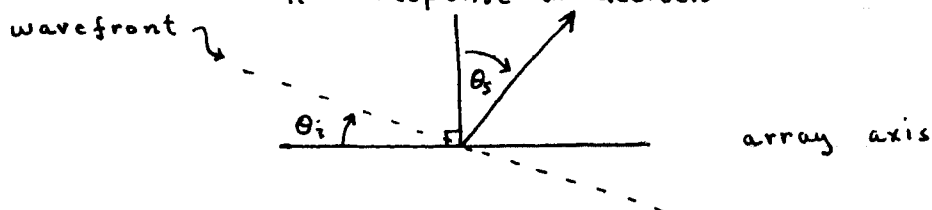
d = inter sensor spacing

λ = wavelength of incident plane wavefront

θ_i = angle of incident wavefront

θ_s = steering angle of array

R = response in decibels



Operating Limits and Warnings All angles are assumed to be measured in degrees. The quantities d and λ must have the same units.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL A	31 25 11	Input Routine		STO + 3	33 61 03	
	SIN	31 62			LBL 2	31 25 02	
	STC D	33 14			RCL 3	34 03	
	RTN	35 22		060	SIN	31 62	
	LBL B	31 25 12			STC D	33 14	
	SIN	31 62	Input Routine		GSB C	31 22 13	
	STC E	33 15			-X-	31 84	
	RTN	35 22			DSZ	31 33	
	LBL C	31 25 13			GTO 1	22 01	
					RTN	35 22	
010	/	01	Computes Beamformer sum for one value of θ_i				
	8	08					
	D	00					
	RCL B	34 12					
	X	71		070			
	RCL C	34 13					
	$\div$	81					
	STC O	33 00					
	RCL D	34 14					
	RCL E	34 15					
020	-	51					
	STO 1	33 01					
	X	71					
	RCL A	34 11					
	X	71		080			
	SIN	31 62					
	RCL 1	34 01					
	RCL O	34 00					
	X	71					
	SIN	31 62					
030	RCL A	34 11	Test for zero divide				
	X	71					
	X = 0	31 51					
	GTO O	22 00					
	$\div$	81					
	ABS	35 64		090			
	LOG	31 53					
	2	02					
	O	00					
	X	71					
040	RTN	35 22	Computes Beamformer sum for several values of θ_i				
	LBL O	31 25 00					
	O	00					
	RTN	35 22					
	LBL D	31 25 14		100			
	STO 2	33 02					
	R $\downarrow$	35 53					
	ABS	35 64					
	INT	31 83					
	ST I	35 33					
050	R $\downarrow$	35 53					
	STO 3	33 03					
	SF 2	35 51 02					
	LBL 1	31 25 01					
	F? 2	35 71 02					
	GTO 2	22 02					
	RCL 2	34 02					

FLAGS		SET STATUS		
		FLAGS	TRIG	DISP
0				
1		ON OFF		
2	used	0 ☐ ☒	DEG ☒	FIX ☒
3		1 ☐ ☒	GRAD ☐	SCI ☐
		2 ☐ ☒	RAD ☐	ENG ☐
		3 ☐ ☒		n <u>2</u>

LABELS				
A θ_i	B θ_s	C $R(\theta_i)$	D R	E
a	b	c	d	e
0 used	1 used	2 used	3	4
5	6	7	8	9

REGISTERS									
0 used	1 used	2 $\Delta \theta_i$	3 θ_i	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A N	B d	C λ	D $\sin \theta_i$	E $\sin \theta_s$	I K				

Program Description I

Program Title Radar Antenna Beamwidth and Gain

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables

Rectangular Antenna

$$\text{Beamwidth}_x = \frac{k\lambda}{L_x}$$

$$\lambda = \frac{299.8}{f}$$

$$\text{Beamwidth}_y = \frac{k\lambda}{L_y}$$

$$G = 10 \text{ LOG } \frac{27000}{\text{BW}_x \cdot \text{BW}_y}$$

Circular Antenna

$$\text{Beamwidth} = \frac{k\lambda}{D}$$

$$G = 10 \text{ LOG } \frac{27000}{\text{BW}}$$

L_x, L_y, D in metres, f in MHz

	<u>Weighting</u>	<u>Rectangular</u>	<u>Circular</u>
k	Uniform	51	58
	Cosin	68	76
	Hamming	74.5	80
	Cos on 10 dB Ped.		
	$\frac{1-R^2}{(1-R^2)^2}$		72.5 84.3

Operating Limits and Warnings on calculated gain.

1. Subtract 1.5 dB for csc^2 beams.
2. Add 1.5 dB for 2 dimensional arrays.
3. Add 0.5 dB for linear array fed parabolic cylinders.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)

Sample Problem(s)

1. Find antenna beamwidths and gain of a uniformly weighted array operating at 500 MHz. $L_x = 50$ m, $L_y = 25$ m.
2. Find antenna beamwidth and gain of a cosin weighted 10 metre circular antenna at 3000 MHz.

Solution(s)

1. [f] [A] 500[A] -----> 0.60 (λ - metres)
 50[+] 25[B] -----> 0.61 (BW_x - deg)
 [R/S] -----> 1.22 (BW_y - deg)
 [R/S] -----> 45.57
 1.5[+] -----> 47.07 (gain dB)
2. [d] [B] 3000[A] -----> 0.10 (λ)
 10[C] -----> 0.76 (BW)
 [R/S] -----> 46.70 (dB)

Reference(s) This program is a translation of the HP-65 Users' Library program #04707A submitted by Robert C. Thor.

User Instructions

```

graph LR
    In1((1)) --> Freq[Freq.]
    Freq --> Radar[Radar Ant. BW and Gain]
    Radar --> Filter[Uniform Cosin Hamming]
    Filter --> Out2((2))
  
```

[illegible]

97 Program Listing I

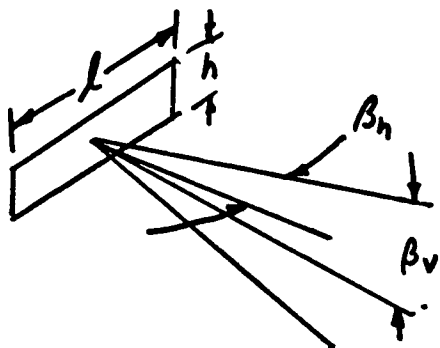
31

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS																				
001	*LBLa	21 16 11		057	F1?	16 23 01	Test for ⊙ ant.																				
002	CF1	16 22 01		058	GT09	22 09																					
003	RTN	24	Rect 1	059	R↓	-31																					
004	*LBLb	21 16 12		060	RCL2	36 02																					
005	SF1	16 21 01		061	X↗Y	-41																					
006	RTN	24	Cir 2	062	÷	-24	BW _x																				
007	*LBLA	21 11		063	RCL3	36 03																					
008	2	02		064	X↗Y	-41																					
009	9	09		065	R/S	51	x BW(deg)																				
010	9	09	c (m/μsec)	066	X↗Y	-41																					
011	.	-62		067	*LBL8	21 08	y or ⊙ BW(deg)																				
012	8	08		068	R/S	51																					
013	X↗Y	-41		069	x	-35																					
014	÷	-24		070	2	02	27000																				
015	ST01	35 01	λ (metres)	071	7	07																					
016	RTN	24		072	EEX	-23																					
017	*LBLB	21 12	Uniform wt.	073	3	03																					
018	F1?	16 23 01		074	X↗Y	-41																					
019	GT01	22 01	Test for ⊙ ant.	075	÷	-24																					
020	5	05		076	LOG	16 32																					
021	1	01	k rect	077	1	01																					
022	GT0E	22 15		078	0	00																					
023	*LBL1	21 01		079	x	-35																					
024	5	05		080	R/S	51	Ant gain (dB)																				
025	8	08	k ⊙	081	*LBL9	21 09																					
026	.	-62		082	ENT↑	-21																					
027	4	04		083	GT08	22 08																					
028	GT0E	22 15		084	R/S	51																					
029	*LBLC	21 13	cosin wt.																								
030	F1?	16 23 01	Test for ⊙ ant.																								
031	GT02	22 02																									
032	6	06																									
033	8	08	k rect.																								
034	GT0E	22 15																									
035	*LBL2	21 02		090																							
036	7	07	k ⊙																								
037	6	06																									
038	GT0E	22 15																									
039	*LBLD	21 14	Hamming wt.																								
040	F1?	16 23 01	Test for ⊙ ant.																								
041	GT03	22 03																									
042	7	07																									
043	4	04	k rect.																								
044	.	-62																									
045	5	05		100																							
046	GT0E	22 15																									
047	*LBL3	21 03																									
048	8	08	k ⊙																								
049	0	00																									
050	*LBLE	21 15																									
051	RCL1	36 01																									
052	x	-35	kλ																								
053	ST02	35 02																									
054	X↗Y	-41																									
055	÷	-24		110																							
056	ST03	35 03	BWy or BW⊙																								
SET STATUS <table><tr><th colspan="2">FLAGS</th><th>TRIG</th><th>DISP</th></tr><tr><td>0</td><td>☐ ON ☒ OFF</td><td>DEG ☒</td><td>FIX ☒</td></tr><tr><td>1</td><td>☐ ON ☒ OFF</td><td>GRAD ☐</td><td>SCI ☐</td></tr><tr><td>2</td><td>☐ ON ☒ OFF</td><td>RAD ☐</td><td>ENG ☐</td></tr><tr><td>3</td><td>☐ ON ☒ OFF</td><td></td><td>n <u>2</u></td></tr></table>								FLAGS		TRIG	DISP	0	☐ ON ☒ OFF	DEG ☒	FIX ☒	1	☐ ON ☒ OFF	GRAD ☐	SCI ☐	2	☐ ON ☒ OFF	RAD ☐	ENG ☐	3	☐ ON ☒ OFF		n <u>2</u>
FLAGS		TRIG	DISP																								
0	☐ ON ☒ OFF	DEG ☒	FIX ☒																								
1	☐ ON ☒ OFF	GRAD ☐	SCI ☐																								
2	☐ ON ☒ OFF	RAD ☐	ENG ☐																								
3	☐ ON ☒ OFF		n <u>2</u>																								
REGISTERS																											
0	1 λ metres	2 kλ	3 BWy or BW⊙	4	5	6	7	8	9 Used																		
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9																		
A	B	C	D	E	I																						

Program Description II

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Sketch(es)



Sample Problem(s)

1. A plate antenna array operating at 620 MHz ($\lambda=0.16$ ft) is 8.5 ft wide and 1.9 ft high, assuming a taper factor of 1.4, what are the associated horizontal and vertical beamwidths?
2. If vertical and horizontal beamwidths of 6.5 and 2.5 degrees were desired, what antenna dimensions would be required for antenna in (1)?
3. A dish antenna operating at 8500 MHz ($\lambda= .12$ ft) has a measured gain of 28 dB. What is its equivalent area?
4. An antenna operating at 6500 MHz ($\lambda= 0.15$ ft) has an area of 16.5 sq. ft. What is its expected gain?

Solution(s)

Solutions continued on next page →

1. [f][A] Initialize 8.5[+] ----->Enter l -----> 8.50
 1.9[A] ----->Enter h -----> 8.50
 .16[+] ----->Enter λ -----> 0.16
 [C][B] ----->Compute β_h -----> 1.51 deg
 [R/S] ----->Compute β_v -----> 6.75 deg
2. 2.5[+] ----->Enter β_h -----> 2.50
 6.5[B] ----->Enter β_v -----> 2.50
 .16 + ----->Enter λ -----> 0.16

Reference(s)

This program is a translation of the HP-65 Users' Library program #02928A submitted by Carroll F. Lam.

Program Description II

Sketch(es)

Sample Problem(s)

Solution(s)

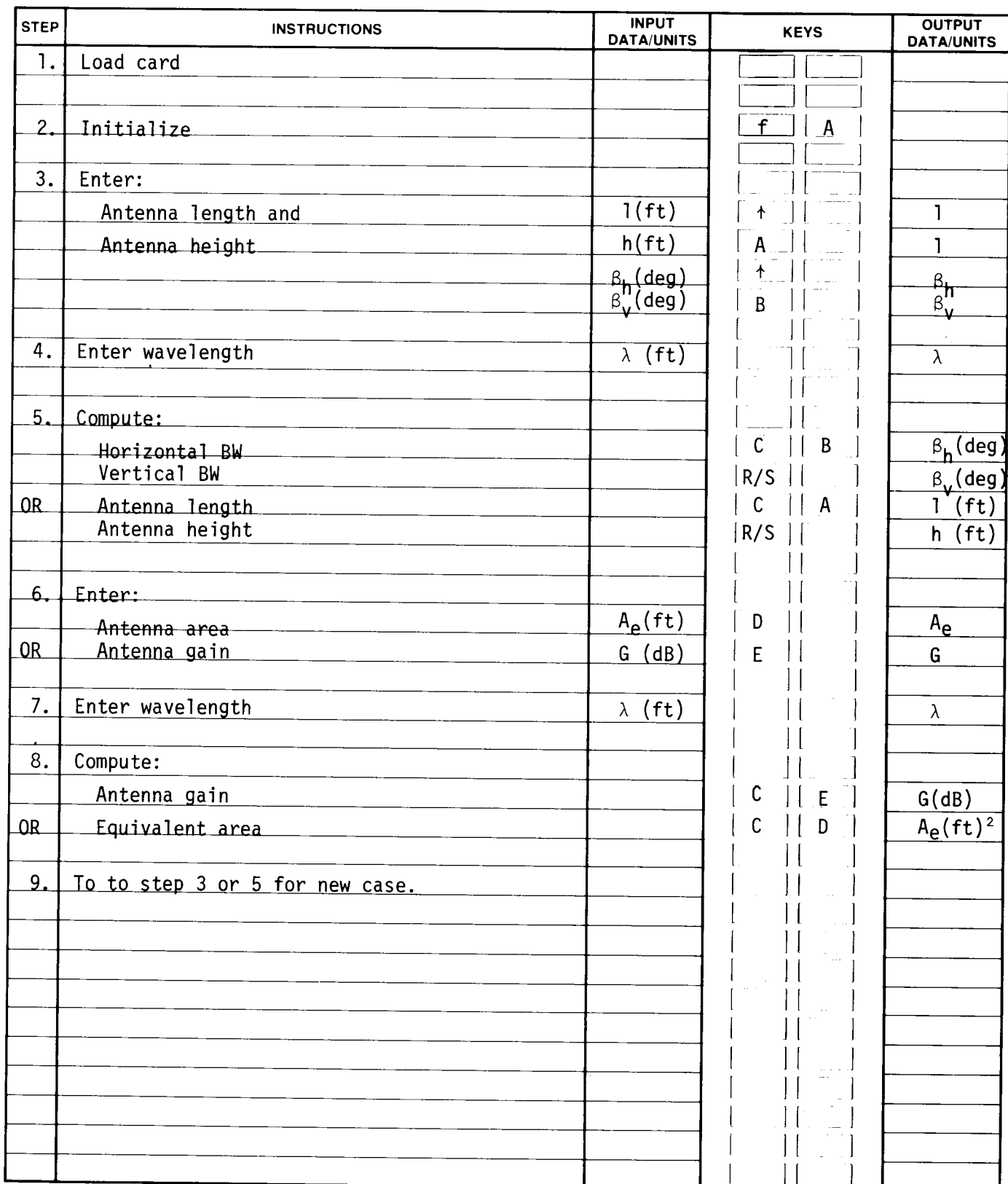
```

[C] [A] -----> Compute l -----> 5.13 ft
[R/S]-----> Compute h -----> 1.97 ft
3.  28[E] -----> Enter G ----->28.00
    .12[+] -----> Enter λ -----> 0.12
    [C][D] -----> Compute Ae-----> 0.72 ft2
4.  16.5[D] -----> Enter Ac----->16.50
    .15[+] -----> Enter λ -----> 0.15
    [C][E] -----> Compute G ----->39.65 dB

```

Reference(s)

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97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS		
001	GSB _a	23 16 11	Initialize	057	STOI	35 46	If c pressed then calculate		
002	1	01		058	R↓	-31			
003	8	08		059	RTN	24			
004	0	00		060	*LBLD	21 14			
005	Pi	16-24		061	DSZI	16 25 46			
006	÷	-24		062	GT06	22 06			
007	1	01		063	ENT↑	-21			
008	.	-62		064	x	-35			
009	4	04		065	RCL7	36 07			
010	x	-35		066	1	01			
011	STOI	35 01	If c pressed then calculate	067	0	00	Else store		
012	0	00		068	÷	-24			
013	STOI	35 46		069	10 ^x	16 33			
014	RTN	24		070	x	-35			
015	*LBLA	21 11		071	4	04			
016	DSZI	16 25 46		072	÷	-24			
017	GT00	22 00		073	Pi	16-24			
018	ST08	35 08		074	÷	-24			
019	RCL5	36 05		075	RTN	24			
020	÷	-24		076	*LBL6	21 06		If c pressed then calculate	
021	RCL1	36 01	077	ST06	35 06	Else store			
022	x	-35	078	RTN	24				
023	R/S	51	079	*LBL E	21 15				
024	RCL1	36 01	080	DSZI	16 25 46				
025	RCL4	36 04	081	GT07	22 07				
026	÷	-24	082	ENT↑	-21				
027	RCL8	36 08	083	x	-35				
028	x	-35	084	RCL6	36 06				
029	RTN	24	085	4	04		If c pressed then calculate		
030	*LBL0	21 00	086	x	-35			Else store	
031	ST02	35 02	087	Pi	16-24				
032	R↓	-31	088	x	-35				
033	ST03	35 03	089	÷	-24				
034	R/S	51	090	1/X	52				
035	*LBLB	21 12	091	LOG	16 32				
036	DSZI	16 25 46	092	1	01				
037	GT01	22 01	093	0	00				
038	ST08	35 08	094	x	-35				
039	RCL3	36 03	095	RTN	24	Else store			
040	÷	-24	096	*LBL7	21 07				
041	RCL1	36 01	097	ST07	35 07				
042	x	-35	098	RTN	24				
043	R/S	51							
044	RCL1	36 01	100						
045	RCL2	36 02							
046	÷	-24							
047	RCL8	36 08							
048	x	-35							
049	RTN	24							
050	*LBL1	21 01	Else store						
051	ST04	35 04							
052	R↓	-31							
053	ST05	35 05							
054	RTN	24							
055	*LBLC	21 13		110					
056	1	01							
REGISTERS									
0	1 $k(\frac{180}{\pi})$	2 h	3 1	4 β_v	5 β_h	6 Used	7 Used	8 Used	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I Used				

Program Description I

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Program Title	Parabolic Antenna Calculations		
Contributor's Name	Hewlett-Packard		
Address	1000 N.E. Circle Blvd.		
City	Corvallis	State	Oregon
		Zip Code	97330

Program Description, Equations, Variables

$$G = 20 \log_{10} D F + 10 \log_{10} 10.2E$$

$$D = \log_{10}^{-1} \frac{G - 20 \log_{10} f - 10 \log_{10} 10.2E}{20}$$

$$\theta_{3dB} = \frac{66.4}{fD}$$

$$\theta_{NdB} = \left[\frac{\theta_{3dB}^2 \downarrow NdB}{3} \right]^{1/2}$$

$$\downarrow NdB = \frac{12\alpha^2}{\theta_{3dB}^2}$$

D = Antenna Dia., ft.

f = Frequency, GHz

E = Efficiency, decimal

α = Off-Axis Angle, deg.

G = Gain over isotropic, dB

θ_{3dB} = 3dB beamwidth, deg.

θ_{NdB} = NdB beamwidth, deg.

θ_{NdB} = Off-axis dB down

Operating Limits and Warnings

All calculations are based on the main beam only. Side lobes are not considered.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)**Sample Problem(s)**

- A. Perform the following calculations for a 10 ft. parabolic antenna at 6.175 GHz:
1. Gain (55% efficiency)
 2. 3dB beamwidth
 3. 15dB beamwidth
 4. dB down at 1 deg. off-axis
- B. Calculate the required antenna size required for 45 dB gain at 11.2 GHz assume 65% efficiency.

Solution(s)

- A. 1. 43.3 dB
2. 1.1 deg.
3. 2.4 deg.
4. 10.4 dB down
- B. 6.2 ft dia.

Reference(s)

This program is a translation of the HP-65 Users' Library program #01380A submitted by Ronald J. Finger.

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[illegible]

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL0	21 16 11		057	RTN	24	
002	ST02	35 02	Freq.	058	*LBL8	21 08	
003	LOG	16 32		059	RCL4	36 04	Conv. ft. to meters
004	2	02		060	=	-24	
005	0	00		061	RTN	24	
006	ST06	35 06		062	*LBL9	21 09	
007	X	-35	20 log freq.	063	RCL4	36 04	Conv. meters to ft.
008	ST03	35 03		064	X	-35	
009	3	03		065	RTN	24	
010	.	-62		066	*LBLC	21 13	
011	2	02		067	F1?	16 23 01	
012	8	08		068	GSB9	23 09	
013	ST04	35 04	Meters to ft. mul	069	RCL2	36 02	
014	5	05		070	X	-35	
015	5	05	55% is norm eff.	071	6	06	
016	RTN	24		072	6	06	
017	*LBL6	21 16 12		073	.	-62	
018	ENT↑	-21		074	4	04	
019	.	-62		075	X*Y	-41	
020	1	01		076	=	-24	3dB BW
021	0	00		077	ST01	35 01	
022	2	02		078	RTN	24	
023	X	-35		079	*LBLD	21 14	
024	LOG	16 32		080	RCL1	36 01	
025	1	01		081	X²	53	
026	0	00		082	X	-35	
027	X	-35	Eff. constant K _E	083	3	03	n pB BW
028	ST+3	35-55 03	20 log f + K _f	084	=	-24	
029	RTN	24		085	JX	54	
030	*LBL0	21 16 13		086	RTN	24	
031	F1?	16 23 01		087	*LBLE	21 15	
032	GT01	22 01		088	X²	53	
033	SF1	16 21 01	m or ft. toggle	089	1	01	
034	1	01	1 = m 0 = ft.	090	2	02	
035	RTN	24		091	X	-35	
036	*LBL1	21 01		092	RCL1	36 01	pB down
037	CF1	16 22 01		093	X²	53	
038	0	00		094	=	-24	
039	RTN	24		095	RTN	24	
040	*LBLA	21 11					
041	F1?	16 23 01					
042	GSB9	23 09					
043	LOG	16 32					
044	RCL6	36 06	20 log D	100			
045	X	-35					
046	RCL3	36 03					
047	+	-55	20 log Df+k _E =gain				
048	RTN	24					
049	*LBLB	21 12					
050	RCL3	36 03					
051	-	-45					
052	RCL6	36 06					
053	=	-24					
054	10*	16 33					
055	F1?	16 23 01					
056	GSB8	23 08					

REGISTERS									
0	1 3dB BW	2 FreqGHz	3 20log f	4 m/ft conv	5	6 20	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	F	G	H	I	J

SET STATUS			
FLAGS		TRIG	DISP
ON	OFF		
0	☐	DEG ☒	FIX ☒
1	☐	GRAD ☐	SCI ☐
2	☐	RAD ☐	ENG ☐
3	☐		n

Program Description I

Program Title RF PATH LOSS , DB

Contributor's Name ROBERT E. STONE

Address 19645 NORTHAMPTON DR

City SARATOGA

State CA

Zip Code 95070

Program Description, Equations, Variables USING THE FOLLOWING EQUATIONS:

$$L_1 = 20 \log (41.87 f D)$$

$$L_2 = 66.2 + 1070 \left(\frac{H}{D}\right) - 7500 \left(\frac{H}{D}\right)^2 + 0.00268 f + 28.34 \log f + 0.879 D - 0.00378 D^2$$

$$L_3 = -10 \log \left\{ \frac{1.033 \times 10^{-3}}{(fD)^4} \left[1 + 31.1 (fh_1)^2 \right] \left[1 + 31.1 (fh_2)^2 \right] \right\}$$

THE RF PATH LOSS IN DB IS CALCULATED. L_1 IS THE FREE SPACE PATH LOSS AND IS ALWAYS OUTPUTTED. L_3 IS THE SMOOTH EARTH PATH LOSS AND IS PRINTED NEXT UNLESS L_2 IS GREATER. L_2 IS THE PATH LOSS DUE TO AN OBSTACLE IN THE TERRAIN IN THE PATH. IN THIS CASE L_2 IS PRINTED INPLACE OF L_3 .

Operating Limits and Warnings OUTPUT DATA VALID ONLY FOR VHF; IE,
 $20 \text{ MHz} < f < 500 \text{ MHz}$

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)

Sample Problem(s) WHAT IS THE FREE SPACE RF PATH LOSS AND THE RF PATH LOSS DUE TO A TERRAIN OBSTACLE FOR THE FOLLOWING CONDITIONS:

RF FREQUENCY	20 MHE	(f)
DISTANCE BETWEEN ANTENNAS	5 KM	(D)
HEIGHT OF ANTENNA 1	0.1 KM	(h ₁)
HEIGHT OF ANTENNA 2	0.01 KM	(h ₂)
HEIGHT OF OBSTACLE ABOVE LINE-OF-SIGHT BETWEEN THE ANTENNAS	0.01 KM	(H)

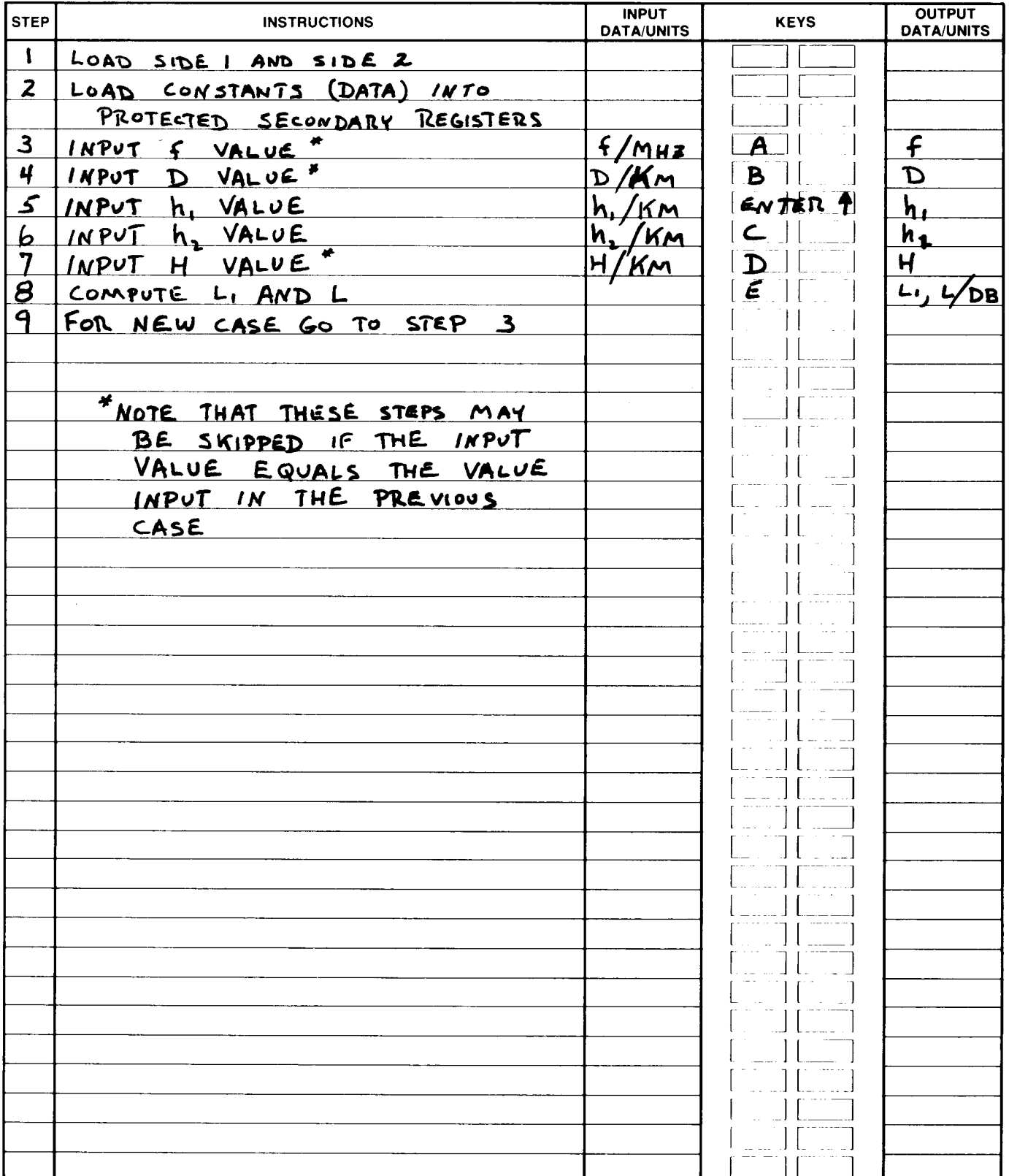
Solution(s)

KEYSTROKES

20 [A]	→	20.00	
5 [B]	→	5.00	
0.1 [↑] 0.01 [C]	→	0.10	
0.01 [D]	→	0.01	
[E]	→	72.44 ***	(L ₁) DB
	→	109.54 ***	(L) DB

Reference(s) FOLLIS, L.E. & ROOD, R.D.; "JAMMING CALCULATIONS FOR FM VOICE COMMUNICATIONS", EW MAGAZINE, PAGES 33-40, NOVEMBER/DECEMBER 1976

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97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11		057	X	-35	
002	ST05	35 05		058	LOG	16 32	
003	RTN	24		059	RCLA	36 11	
004	*LBLB	21 12		060	2	02	
005	ST06	35 06		061	÷	-24	
006	RTN	24		062	X	-35	
007	*LBLC	21 13		063	CHS	-22	
008	ST03	35 03		064	STOD	35 14	
009	R↓	-31		065	ISZI	16 26 46	
010	ST02	35 02		066	RCLi	36 45	
011	RTN	24		067	ISZI	16 26 46	
012	*LBLD	21 14		068	RCLi	36 45	
013	ST04	35 04		069	RCL4	36 04	
014	RTN	24		070	RCL6	36 06	
015	*LBLE	21 15		071	÷	-24	
016	2	02		072	X	-35	
017	0	00		073	+	-55	
018	ST0A	35 11		074	ISZI	16 26 46	
019	1	01		075	RCLi	36 45	
020	0	00		076	RCL4	36 04	
021	ST0I	35 46		077	RCL6	36 06	
022	RCLi	36 45		078	÷	-24	
023	RCL5	36 05		079	X ²	53	
024	RCL6	36 06		080	X	-35	
025	X	-35		081	-	-45	
026	X	-35		082	ISZI	16 26 46	
027	LOG	16 32		083	RCLi	36 45	
028	RCLA	36 11		084	RCL5	36 05	
029	X	-35		085	X	-35	
030	ST0B	35 12		086	+	-55	
031	ISZI	16 26 46		087	ISZI	16 26 46	
032	RCLi	36 45		088	RCLi	36 45	
033	RCL5	36 05		089	RCL5	36 05	
034	RCL6	36 06		090	LOG	16 32	
035	X	-35		091	X	-35	
036	X ²	53		092	+	-55	
037	X ²	53		093	ISZI	16 26 46	
038	÷	-24		094	RCLi	36 45	
039	ISZI	16 26 46		095	RCL6	36 06	
040	RCLi	36 45		096	X	-35	
041	RCL5	36 05		097	+	-55	
042	RCL2	36 02		098	ISZI	16 26 46	
043	X	-35		099	RCLi	36 45	
044	X ²	53		100	RCL6	36 06	
045	X	-35		101	X ²	53	
046	1	01		102	X	-35	
047	+	-55		103	-	-45	
048	X	-35		104	STOC	35 13	
049	RCLi	36 45		105	RCLB	36 12	
050	RCL5	36 05		106	PRTX	-14	
051	RCL3	36 03		107	RCLC	36 13	
052	X	-35		108	RCLD	36 14	
053	X ²	53		109	X>Y?	16-34	
054	X	-35		110	GT00	22 00	
055	1	01		111	*LBL2	21 02	
056	+	-55		112	R↓	-31	

REGISTERS									
0	1	2	3	4	5	6	7	8	9
		h_1	h_2	H	f	D			
S0	41.87	S1	1.03×10^{-3}	S2	31.10	S3	66.20	S4	1070
S5	7500	S6	2.68×10^{-3}	S7	28.34	S8	0.88	S9	3.78×10^{-3}
A	USED	B	L_1	C	L_2	D	L_3	E	USED

45

[illegible]

Program Description I

Program Title	Antenna Gain or Power of A Remote Transmitter		
Contributor's Name	Hewlett-Packard		
Address	1000 N.E. Circle Blvd.		
City	Corvallis	State	Oregon
		Zip Code	97330

Program Description, Equations, Variables

Program computes T' using the formula:

$$T' = \frac{(4\pi)^2 f^2 R^2 P_R}{T G_R C^2}$$

Where f = Frequency of RF carrier (MHz)

R = Range from xmitter or rcvr (Km)

P_R = Strength of received signal(watts)

G_R = Gain of rcvr antenna (dB)

T = Gain of smit. antenna (or xmit power) (dB)

T' = Xmit power (or gain or xmit antenna) (watts)

and C = Speed of light (see constants below)

Program will convert nautical miles or statute miles to kilometers for input to program, using constants below.

Operating Limits and Warnings T = 0; G_R = 0. Limits are limits of the HP-65.

Constants: C = 0.29979250 kilometers/μsec.

1 = Naut mile = 1.85325 kilometers

1 = Statute mile = 1.609347219 kilometers

Values are ideal; user should apply any known system losses to avoid error in computation. (propagation, etc.)

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)

Sample Problem(s) (1) Given receiving system with antenna gain of 150 dB; a transmitter 45 naut. miles away operating at 9050 MHz; strength of received signal .02 watts; and transmitted power of 50,000 watts, compute xmit antenna gain.

(2) Given rcvr antenna gain of 15 dB; transmitter located 750 statute miles away; freq. of 120 MHz; 15×10^{-6} watts received signal; and known transmit antenna gain of 300 dB, compute transmitted power.

Solution(s)

(1) [f] [A] 150[A] 45[D] 9050[B] 0.02[+] 50,000[C] ----- 2668929.71
 Answer to #1 is in dB very hypothetical case, demo only.

(2) [f] [A] 15[A] 750[E] 120[B] 15[EEX] [CHS] [6] [+] 300[C] - 122868.76
 Answer to #2 is in watts.

Reference(s)

This program is a translation of the HP-65 Users' Library program #03214A submitted by William A. Sholar.

User Instructions

1 INT Antenna Gain or Power For Transmitter 2

G_R R f P_R T Nm Km Sm Km

[illegible]

97 Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11		057	X	-35	
002	Pi	16-24		058	RTN	24	
003	4	04					
004	X	-35		060			
005	ENT↑	-21	Initialize				
006	X	-35					
007	.	-62					
008	2	02					
009	9	09					
010	9	09					
011	7	07					
012	9	09					
013	2	02	C (km/μsec)	070			
014	5	05					
015	ENT↑	-21					
016	X	-35					
017	÷	-24					
018	ST08	35 08					
019	CLX	-51					
020	RTN	24	Input G _R				
021	*LBLA	21 11					
022	ST÷8	35-24 08	$R8 = (4\pi)^2 c^2 G_R$				
023	RTN	24	Input R; f	080			
024	*LBLB	21 12					
025	X	-35	$\frac{R^2 f^2 (4\pi)^2}{c^2 G_R}$				
026	ENT↑	-21	R8 =				
027	X	-35					
028	ST×8	35-35 08					
029	RTN	24	Input Pr; T				
030	*LBLC	21 13					
031	÷	-24					
032	RCL8	36 08					
033	X	-35		090			
034	RTN	24					
035	*LBLD	21 14					
036	1	01	Convert nautical				
037	.	-62	miles to kilometers				
038	8	08					
039	5	05					
040	3	03					
041	2	02					
042	5	05					
043	X	-35		100			
044	RTN	24					
045	*LBLE	21 15					
046	1	01					
047	.	-62					
048	6	06	Converts statute				
049	0	00	miles to kilometers				
050	9	09					
051	3	03					
052	4	04					
053	7	07					
054	2	02		110			
055	1	01					
056	9	09					

REGISTERS									
0	1	2	3	4	5	6	7	8 Sto be- tween labels	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

SET STATUS									
FLAGS				TRIG		DISP			
	ON	OFF							
0	☐	☒		DEG	☒	FIX	☒		
1	☐	☒		GRAD	☐	SCI	☐		
2	☐	☒		RAD	☐	ENG	☐		
3	☐	☒				n	2		

Program Description I

Program Title Planar Phased Array Radar Beam Positions

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables Coordinate conversion between boresight plane and any other rotated plane by:

- 1) Converting spherical coordinates ($\sin\alpha$, $\sin\beta$, R -unity) to rectangular coordinates where $x = \sin\theta \cos\phi$; $y = \sin\theta \sin\phi$, $z = \cos\theta$.
- 2) Rotating the boresight plane to the new plane and computing new rectangular coordinates using the "directed angle cosines".
- 3) Converting the new rectangular coordinates to spherical coordinates in the new plane where $\theta = \sin^{-1}z$, $\phi = \tan^{-1}x/y$.

The inverse of the above procedure using angle inputs and obtaining $\sin\alpha$, $\sin\beta$ outputs is also used. The above steps are accomplished using the following formulas:

A. Conversion of $\sin\alpha$, $\sin\beta$ to α' , β
where BS = Boresight angle

B. Conversion of α , β to $\sin\alpha'$, $\sin\beta'$
where BS = Boresight angle.

$$\alpha' = \tan^{-1} \left[\frac{\sin\alpha \cos\beta}{\cos BS \cos\alpha \cos\beta - \sin BS \sin\beta} \right] \quad \sin\alpha' = \sin \left(\tan^{-1} \left(\frac{\sin\alpha \cos\beta}{\cos BS \cos\alpha \cos\beta - \sin BS \sin\beta} \right) \right)$$

$$\beta' = \sin^{-1} [\sin BS \cos\alpha \cos\beta + \cos BS \sin\beta] \quad \sin\beta' = (\cos BS \sin\beta - \sin BS \cos\alpha \cos\beta)$$

Operating Limits and Warnings

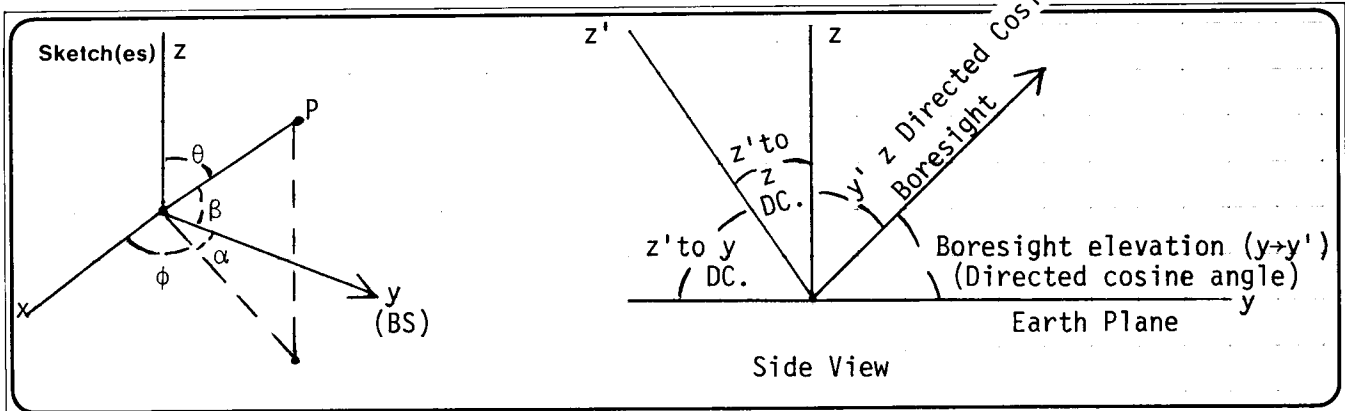
Radar boresight (BS) elevation planes can be used within the following limits $0^\circ \leq BS \leq 90^\circ$. For sign convention, elevation sines below boresight should be entered with a negative sign. Azimuth sines to the left of Boresight (viewers eyes looking out of boresight) should be entered as negatives. All other sines should be entered as positive.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

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Sample Problem(s)

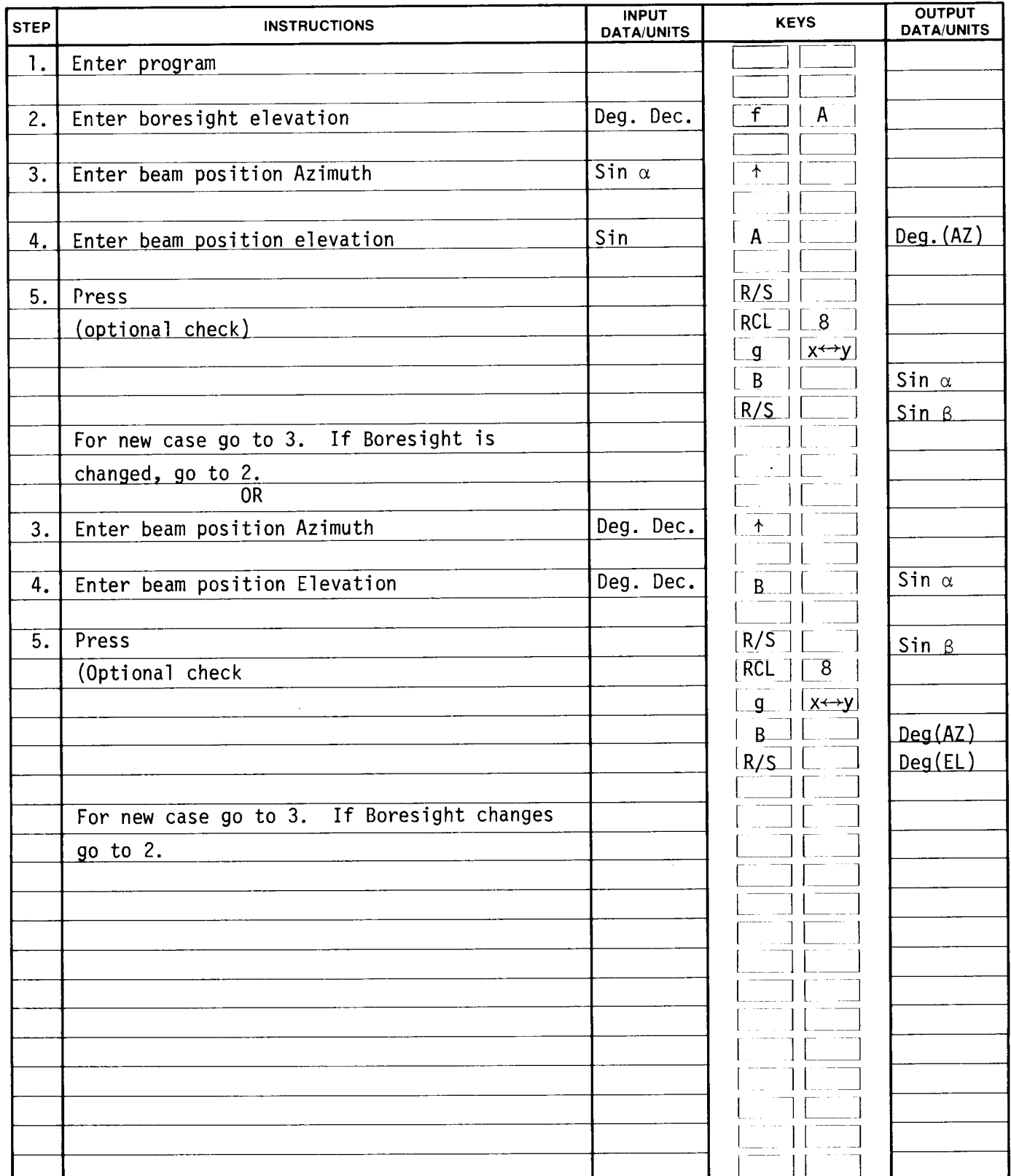
- Using a boresight angle of 45° with the earth plane, convert the following $\sin \alpha$ & $\sin \beta$ beam positions to spherical coordinates (deg. dec.)(azimuth and elevation) in the tangent earth plane: a. $\sin \alpha = -.7071$, $\sin \beta = .3$; b. $\sin \alpha = .707$, $\sin \beta = .3$; c. $\sin \alpha = .32$, $\sin \beta = .6$; d. $\sin \alpha = -.35$, $\sin \beta = -.5$.
- Using a boresight angle of 30° with the earth plane, convert the following beam positions (deg. dec.) in earth plane reference to $\sin \alpha$ and $\sin \beta$ beam positions in the boresight plane: a. 50°az , 50°EL ; b. -20°az , 10°EL ; c. -45°az , 60°EL ; d. 60°az , 25°EL .

Solution(s)

- 45[f] [A]
 - .7071 [CHS] [↑] .3[CHS][A]-----> -44.39° [R/S] ----> 15.36°
 - .707[↑] .3[A] -----> 68.56° [R/S] ----> 43.56°
 - .32 [↑] .6[A] -----> 66.43° [R/S] ----> 73.78°
 - .35 [CHS] [↑] .5[CHS][A]-----> -18.1° [R/S] ----> 12.71°
- 30[f] [A]
 - 50[↑] 50[B] -----> .55 [R/S] ----> .46
 - 20[CHS] [↑] 10[B] -----> -.35 [R/S] ----> -.31
 - 45[CHS] [↑] 60[B] -----> -.43 [R/S] ----> .57
 - 60[↑] 25[B] -----> .79 [R/S] ----> .14

Reference(s) CRC Standard Math Tables, 18th Edition, 1970, pp 364-369.

This program is a translation of the HP-65 Users' Library program #03690A submitted by George E. Wilkins.



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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLα	21 16 11	Initialize	057	*LBLC	21 13	Common subroutine
002	ST07	35 07		058	RCL7	36 07	
003	RTN	24		059	COS	42	
004	*LBLA	21 11		060	ST05	35 05	
005	ST01	35 01		061	RCL7	36 07	
006	SIN ⁻¹	16 41		062	SIN	41	
007	COS	42		063	ST06	35 06	
008	ST02	35 02		064	R↓	-31	
009	X↔Y	-41		065	x	-35	
010	ST03	35 03		066	RTN	24	
011	SIN ⁻¹	16 41	Lb1 A Housekeeping	067	*LBLD	21 14	Common subroutine
012	COS	42		068	RCL2	36 02	
013	ST04	35 04		069	RCL3	36 03	
014	GSBC	23 13		070	x	-35	
015	x	-35		071	X↔Y	-41	
016	X↔Y	-41		072	=	-24	
017	RCL1	36 01		073	TAN ⁻¹	16 43	
018	x	-35		074	RTN	24	
019	-	-45		075	*LBLE	21 15	
020	GSBD	23 14		076	RCL5	36 05	
021	ST08	35 08	077	RCL1	36 01		
022	R/S	51	078	x	-35		
023	GSBE	23 15	079	RCL6	36 06		
024	+	-55	080	RCL4	36 04		
025	SIN ⁻¹	16 41	081	RCL2	36 02		
026	RTN	24	082	x	-35		
027	*LBLB	21 12	083	x	-35		
028	ENT↑	-21	084	RTN	24		
029	ENT↑	-21					
030	1	01					
031	x	-35					
032	SIN	41					
033	ST01	35 01	Lb1 B Housekeeping	090			
034	R↓	-31					
035	COS	42					
036	ST02	35 02					
037	R↓	-31					
038	SIN	41					
039	ST03	35 03					
040	R↓	-31					
041	COS	42					
042	ST04	35 04					
043	GSBC	23 13					
044	RCL2	36 02	100				
045	x	-35					
046	R↑	16-31					
047	RCL1	36 01					
048	x	-35					
049	+	-55					
050	GSBD	23 14					
051	SIN	41					
052	ST08	35 08					
053	R/S	51					
054	GSBE	23 15					
055	-	-45					
056	RTN	24					

Calculated display
deg(AZ)

Calculate &
display deg(EL)

Calculate &
display sin α

Calculate &
display sin β

SET STATUS		
FLAGS	TRIG	DISP
0 ☐ ON ☒ OFF	DEG ☒	FIX ☒
1 ☐ ☒	GRAD ☐	SCI ☐
2 ☐ ☒	RAD ☐	ENG ₂ ☐
3 ☐ ☒		n _____

REGISTERS

0	1 Sin β	2 Cos β	3 Sin α	4 Cos α	5 Cos BS	6 Sin BS	7 BS (deg)	8 Deg (AZ)	9 Used
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A B C D E I

Program Description I

Program Title Radar Parameter Unit Conversions

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables Conversion relationships are:

- 1) Radians - $(\pi/180)$ degrees
- 2) Milradians = $(\pi/0.18)$ degrees
- 3) Kilometers = 1.852 nautical miles
- 4) Meters = 0.3048 feet
- 5) Nautical miles = 1645×10^{-7} feet
- 6) Wavelength(m) = $299.79/\text{frequency (MHz)}$
- 7) PRI (μsec) = $10^6/\text{PRF}$
- 8) Distance light travels(m) - $299.79 \times \text{time (sec.)}$
- 9) Radar range (nm) = $0.08089 \times \text{time (sec.)}$
- 10) Nautical miles = 0.8686 statute miles

Operating Limits and Warnings

Accuracies to 4 and 5 places as indicated by constants used.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

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Sketch(es)

Sample Problem(s)

- 1) Convert 90° to radians
- 2) Convert 1 radian to degrees
- 3) Convert 100 ft. to meters
- 4) Convert 100 meters to ft.
- 5) Convert 5 statute miles to kilometers
- 6) Find radar range for PRF of 50

Solution(s)

- 1) 90[A] -----> 1.57
- 2) 1[R/S][A] -----> 57.30
- 3) 100[D] -----> 30.48
- 4) 100 [R/S] [D] -----> 328.08
- 5) 5 [f] [E] [C] -----> 8.04
- 6) 50 [f] [B] [f] [D] -----> 1617.80

Reference(s)

This program is a translation of the HP-65 Users' Library program #04706A submitted by Robert C. Thor.

97 Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLG	21 00	Conversion Operation	057	.	-62	
002	F2?	16 23 02	Test for Reverse	058	7	07	
003	1/X	52		059	9	09	
004	x	-35	End of Conversion	060	GT00	22 00	
005	RTN	24		061	*LBLb	21 16 12	
006	SF2	16 21 02	Set for Reverse	062	CF2	16 22 02	PRF ↔ PRI
007	R/S	51		063	1/X	52	
008	*LBLA	21 11		064	EEX	-23	
009	Pi	16-24		065	6	06	
010	1	01		066	GT00	22 00	
011	0	08	Deg ↔ Rad.	067	*LBLd	21 16 14	
012	0	00		068	.	-62	
013	=	-24		069	0	00	Time ↔ Radar Range
014	GT00	22 00		070	8	08	
015	*LBLB	21 12		071	0	00	
016	F2?	16 23 02		072	8	08	
017	SF1	16 21 01		073	9	09	
018	F1?	16 23 01		074	GT00	22 00	
019	SF2	16 21 02	Deg ↔ Mil Rad	075	*LBLc	21 16 15	
020	EEX	-23		076	.	-62	Sm ↔ Nm
021	3	03		077	8	08	
022	F1?	16 23 01		078	6	06	
023	1/X	52		079	8	08	
024	x	-35		080	6	06	
025	CF1	16 22 01		081	GT00	22 00	
026	GT0A	22 11		082	R/S	51	
027	*LBLC	21 13					
028	1	01	Nm ↔ Km				
029	.	-62					
030	8	08					
031	5	05					
032	2	02					
033	GT00	22 00					
034	*LBLD	21 14		090			
035	.	-62					
036	3	03	Ft ↔ Meters				
037	0	00					
038	4	04					
039	8	08					
040	GT00	22 00					
041	*LBLE	21 15					
042	1	01					
043	6	06	Ft ↔ Nm				
044	4	04		100			
045	5	05					
046	EEX	-23					
047	CHS	-22					
048	7	07					
049	GT00	22 00					
050	*LBLa	21 16 11	Freq ↔ Wavelength				
051	CF2	16 22 02					
052	1/X	52					
053	*LBLc	21 16 13					
054	2	02		110			
055	9	09	Time ↔ Dis. LT. Trav				
056	9	09					

LABELS					FLAGS	SET STATUS		
A	B	C	D	E	0	FLAGS	TRIG	DISP
a Used	b Used	c Used	d Used	e Used	1 Used	ON OFF	DEG ☒	FIX ☒
0	1	2	3	4	2 Reverse	0 ☐ ☒	GRAD ☐	SCI ☐
5	6	7	8	9	3	1 ☐ ☒	RAD ☐	ENG ☐
						2 ☐ ☒		n <u>2</u>
						3 ☐ ☒		

Program Description I

Program Title Television Antenna Length and Channel Frequency

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis

State Oregon

Zip Code 97330

Program Description, Equations, Variables

Computes TV Channel frequency using the following:

$$(2 \leq N \leq 4) \quad f = 6N + 45$$

$$(5 \leq N \leq 6) \quad f = 6(N - 5) + 79$$

$$(7 \leq N \leq 13) \quad f = 6(N - 7) + 177$$

$$(14 \leq N \leq 83) \quad f = 6(N - 14) + 473$$

(frequency f may be entered without use of above formulae)

Program then computes antenna length length (wave length) using:

$w = c/f$ 2nd, 3rd, ...nth best lengths determined by successively halving previous length, to produce $\frac{1}{2}$ wave, $\frac{1}{4}$ wave, $1/8$ wave, etc.

Converts back and forth between inches and meters using constant 0.0254

N = TV Channel Number (2 thru 83)

w = wavelength

c = 299.8 meters per microsecond

f = frequency in cycles per microsecond - frequency in megahertz

Operating Limits and Warnings TV Channel frequency computed is approximate mid-channel.

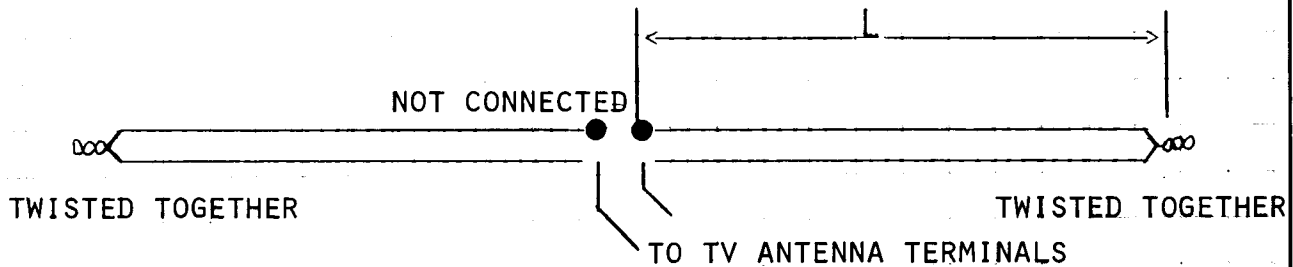
For other uses where lower edge of band is desired, subtract 3 MHz from the frequency produced; for programming, subtract 3 from the added constants in the TV Channel frequency formulae above.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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Program Description II

Sketch(es)



Use ordinary lead-in (flat) wire. Twist wire together as indicated above after cutting as shown. Connect to TV set antenna terminals. Adjust direction of the antenna for the best picture. Leave gap at the top, as shown. Tape bare wires.

Sample Problem(s)

- (1) Find the antenna length in meters for TV Channel 27.
- (2) Find the antenna length in inches for a frequency of 30 MHz.
- (3) Find the TV Channel Frequency for channel 56.
- (4) Find the best antenna length under 1.2 meters for 37.5 MHz.

Solution(s)

- (1) 27 [A] → 0.54 (meters)
- (2) 30 [E] [B] → 393.44 (inches)
- (3) 56 [A] [D] → 725.00 (MHz)
- (4) 37.5 [E] → 7.99, [R/S] → 4.00, [R/S] → 2.00, [R/S] → 1.00 (meters)

Reference(s) This program is a translation of the HP-65 User's Library program #3213A submitted by William A. Sholar.

User Instructions

The diagram shows a horizontal cable with a black outer jacket and a white inner core. The cable is connected to a meter on the right. The meter has a scale from 0 to 100. The cable is labeled "TV ANTENNA LENGTH" and "TV #". The meter is labeled "M → IN" and "IN → M". The frequency is labeled "FREQ" and "MHz".

TV ANTENNA LENGTH

TV # M → IN IN → M FREQ MHz

[illegible]

97 Program Listing I

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STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11		057	.	-62	
002	ST05	35 05	Input TV Channel	058	0	00	
003	1	01	# → R ₅	059	X	-35	Freq. → R ₆
004	3	03		060	RTN	24	
005	X=V	-41		061	*LBL3	21 03	Converts freq.
006	X=V?	16-35		062	2	02	to wave length
007	GT01	22 01	CH # - 13?	063	÷	-24	using $w = \frac{c}{f}$
008	1	01	Yes then go to 1	064	R/S	51	
009	4	04		065	GT03	22 03	
010	-	-45		066	*LBLB	21 12	
011	6	06		067	.	-62	
012	X	-35	Calculates freq.	068	0	00	1/2 wave length
013	4	04	of channel 14-83	069	2	02	repeating
014	7	07		070	5	05	
015	3	03	using 6(N-14)+473	071	4	04	
016	+	-55		072	÷	-24	
017	GT0E	22 15		073	RTN	24	Converts from
018	*LBL1	21 01		074	*LBLC	21 13	meters → inches
019	6	06		075	.	-62	
020	RCL5	36 05	Compute Length	076	0	00	
021	X=V?	16-35		077	2	02	
022	GT00	22 00	CH # ≤ 6?	078	5	05	
023	7	07	Yes, then go to 0	079	4	04	
024	-	-45		080	X	-35	
025	6	06		081	RTN	24	Converts from
026	X	-35		082	*LBLD	21 14	inches → meters
027	1	01	Calculates freq.	083	RCL6	36 06	
028	7	07	of channel 7-13	084	RTN	24	
029	7	07					
030	+	-55	using 6(N-7)+177				
031	GT0E	22 15					
032	*LBL0	21 00					
033	4	04					
034	RCL5	36 05	Is channel # 7 4				
035	X=V?	16-34	If so go to 2				
036	GT02	22 02					
037	6	06					
038	X	-35					
039	4	04					
040	5	05	Calculates freq.				
041	+	-55	of channel 2-4				
042	GT0E	22 15	using 6N+45				
043	*LBL2	21 02					
044	5	05					
045	-	-45	Calculates freq.				
046	6	06	of CH 5-6 Using				
047	X	-35	6(N-5) + 79				
048	7	07					
049	9	09					
050	+	-55					
051	*LBL E	21 15					
052	ST06	35 06					
053	1/X	52					
054	2	02					
055	9	09					
056	9	09					

REGISTERS									
0	1	2	3	4	5	6	7	8	9
					TV Chan.#	Freq.(MHz)			Used
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

FLAGS				SET STATUS			
0	1	2	3	ON	OFF	TRIG	DISP
0	☐	☒	☐	DEG	☒	FIX	☒
1	☐	☒	☐	GRAD	☐	SCI	☐
2	☐	☒	☐	RAD	☐	ENG	☐
3	☐	☒	☐			n	2

NOTES

Hewlett-Packard Software

In terms of power and flexibility, the problem-solving potential of the Hewlett-Packard line of fully programmable calculators is nearly limitless. And in order to see the practical side of this potential, we have several different types of software to help save you time and programming effort. Every one of our software solutions has been carefully selected to effectively increase your problem-solving potential. Chances are, we already have the solutions you're looking for.

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Home Construction Estimating
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Small Business
Antennas
Butterworth and Chebyshev Filters
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Aeronautical Engineering
Control Systems
Beams and Columns
High-Level Math
Test Statistics
Geometry
Reliability/QA

Medical Practitioner
Anesthesia
Cardiac
Pulmonary
Chemistry
Optics
Physics
Earth Sciences
Energy Conservation
Space Science
Biology
Games
Games of Chance
Aircraft Operation
Aviation
Calendars
Photo Dark Room
COGO-Surveying
Astrology
Forestry

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LOADED DIPOLE ANTENNAS

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AZIMUTH

AZIMUTH PATTERN OF CYLINDRICAL ARRAY OF ANTENNAS

COLINEAR ANTENNA GAIN AND PATTERN

BEAM PATTERN FOR UNIFORM ARRAY

RADAR ANTENNA BEAMWIDTH AND GAIN

ANTENNAS

PARABOLIC ANTENNA CALCULATIONS

RF PATH LOSS, dB

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