HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Antennas

INTRODUCTION

In an effort to provide continued value to it's 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.

TABLE OF CONTENTS

Program Description I

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

$\lambda = V_c/F = 3\times10^4/2.54F$ $\qquad Z_0 = 138 \text{ LOG } [(A + B + C)/a]$

Electrical length of each section

$B° = B\cdot360/\lambda = B\cdot360\cdot254F/3\times10^4 = B\cdot F/32.81$ degrees

$C° = C\cdot F/32.81$ degrees

Required Reactance

$jX_L = jA_0$ (Cotan C° - Tan B°)

Inductance $L = jX_L/2\Pi F$ = µHy

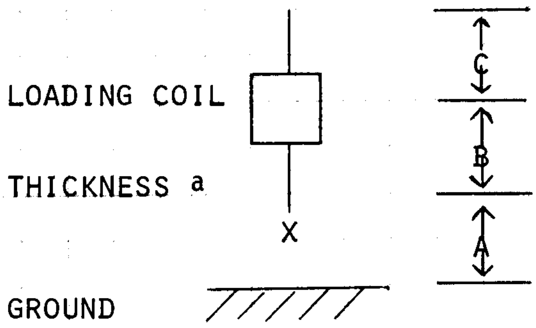
$R_{RAD} = [(C°\text{COS}B°)/2 + B°(1 + \text{COS}B°)/2]^2/82.3$ = OHMS

Operating Limits and Warnings

Antenna must be shorter than 90°electrical length.

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 μHy
[R/S]	R_{RAD} = 3.87 OHMS
0 [B] 110[C] [A]	L = 20.62 μHy
[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.

User Instructions

LOADED VERTICAL ANTENNAS

1 | A | B | C | a | Freq. | 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	
3.	Inputs				
	Dimension A	Inches	A		
	Dimension B	Inches	B		
	Dimension C	Inches	C		
	Thickness a	Inches	D		
	Frequency	MHz	E		
4.	Outputs				
	Inductance		A		L µHy
	Radiation resistance		R/S		R_{RAD} OHMS

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	CF1	16 22 01	Initialize
003	RTN	24	
004	*LBLA	21 11	
005	F1?	16 23 01	
006	GTO1	22 01	
007	STO1	35 01	A → Reg 1
008	SF1	16 21 01	
009	RTN	24	
010	*LBLB	21 12	
011	STO2	35 02	B → Reg 2
012	RTN	24	
013	*LBLC	21 13	
014	STO3	35 03	C → Reg 3
015	RTN	24	
016	*LBLD	21 14	
017	STO4	35 04	a → Reg 4
018	RTN	24	
019	*LBLE	21 15	
020	STO5	35 05	F → Reg 5
021	RTN	24	
022	*LBL1	21 01	
023	RCL1	36 01	
024	RCL2	36 02	
025	RCL3	36 03	
026	+	-55	
027	+	-55	
028	RCL4	36 04	
029	÷	-24	
030	LOG	16 32	
031	1	01	
032	3	03	
033	8	08	
034	x	-35	Z0
035	RCL3	36 03	
036	RCL5	36 05	
037	3	03	
038	2	02	
039	.	-62	
040	8	08	
041	÷	-24	
042	STO8	35 08	
043	x	-35	
044	STO6	35 06	C° → Reg 6
045	TAN	43	
046	1/X	52	
047	RCL2	36 02	
048	RCL8	36 08	
049	x	-35	
050	STO7	35 07	B° → Reg 7
051	TAN	43	
052	-	-45	
053	x	-35	XL
054	2	02	
055	÷	-24	
056	Pi	16-24	
057	÷	-24	
058	RCL5	36 05	
059	÷	-24	L in μHy
060	R/S	51	
061	RCL7	36 07	
062	COS	42	
063	ENT↑	-21	
064	ENT↑	-21	
065	RCL6	36 06	
066	x	-35	
067	2	02	
068	÷	-24	
069	X⇄Y	-41	
070	1	01	
071	+	-55	
072	RCL7	36 07	
073	x	-35	
074	2	02	
075	÷	-24	
076	+	-55	
077	ENT↑	-21	
078	x	-35	
079	8	08	
080	2	02	
081	.	-62	
082	3	03	
083	÷	-24	R in OHMS
084	RTN	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

0	
1	Used
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG	☐
n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	A	B	C	a	F	C	B	Used	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:

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

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

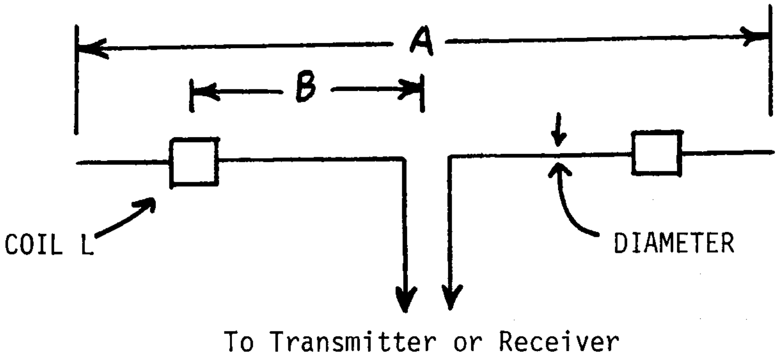
DIA = Diameter in inches

Operating Limits and Warnings

A < 180° Electrical Length.

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[C2 .1[D]

[E]   L = 59.38 μHy

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.

User Instructions

1 Loaded Dipole Antennas 2

A | B | Freq. | D/A | Calc

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Enter program			
2.	Inputs			
	Dimension A	Feet	A	
	Dimension B	Feet	B	
	Frequency	MHz	C	
	Diameter	inches	D	
3.	Outputs - Inductance		E	L,µHy

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Length A
002	2	02	
003	÷	-24	
004	STO7	35 07	A/2→7
005	RTN	24	
006	*LBLB	21 12	Length B
007	STO1	35 01	B →1
008	RTN	24	
009	*LBLC	21 13	Frequency
010	STO6	35 06	Frequency →6
011	2	02	
012	3	03	
013	4	04	
014	RCL6	36 06	
015	÷	-24	z→3
016	STO3	35 03	
017	RTN	24	
018	*LBLD	21 14	Thickness
019	STO9	35 09	D/A 9
020	RTN	24	
021	*LBLE	21 15	
022	RCL7	36 07	
023	RCL1	36 01	
024	-	-45	
025	STO2	35 02	x→2
026	RCL3	36 03	
027	RCL1	36 01	
028	-	-45	
029	STO4	35 04	y→4
030	RCL3	36 03	
031	÷	-24	
032	ENT↑	-21	
033	x	-35	
034	1	01	
035	-	-45	
036	STO8	35 08	$\frac{y^2}{z^2} - 1 \rightarrow 8$
037	RCL9	36 09	
038	2	02	
039	4	04	
040	X⇄Y	-41	
041	÷	-24	
042	STO5	35 05	w→5
043	RCL4	36 04	
044	x	-35	
045	LN	32	
046	1	01	
047	-	-45	ln(wy) - 1
048	RCL8	36 08	
049	x	-35	
050	RCL4	36 04	
051	÷	-24	
052	RCL2	36 02	
053	RCL3	36 03	
054	÷	-24	
055	ENT↑	-21	
056	x	-35	
057	1	01	$(\frac{x}{z})^2 - 1$
058	-	-45	
059	RCL2	36 02	
060	RCL5	36 05	
061	x	-35	
062	LN	32	
063	1	01	
064	-	-45	ln (xw) - 1
065	x	-35	
066	RCL2	36 02	
067	÷	-24	
068	-	-45	
069	EEX	-23	
070	6	06	
071	x	-35	
072	6	06	
073	8	08	
074	÷	-24	
075	RCL6	36 06	
076	Pi	16-24	
077	x	-35	
078	ENT↑	-21	$\pi^2 f^2$
079	x	-35	
080	÷	-24	
081	RTN	24	

090

100

110

SET STATUS

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

REGISTERS

0	1	2	3	4	5	6	7	8	9
	B	x	z	y	w	Freq.	A/2	Used	DIA

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Gain of a Horizontal Rhombic Antenna at Zero Azimuth

Contributor's Name James C. McLaughlin, P.E.

Address General Motors Institute, 1700 W. Third Avenue

City Flint **State** MI **Zip Code** 48502

Program Description, Equations, Variables

The program estimates the on axis gain of a horizontal rhombic antenna, placed above real earth, for specified take-off angles (TOA).

Inputs are: The antenna's height in meters (H); the leg length in meters (L); the tilt angle in degrees (Ø); the frequency of operation in MHz (F); the lowest (initial) TOA, the step (increment) of TOA, and the highest (largest) TOA to be used, all in integer degrees; the earth's conductivity in Mho/meter (σ); and the earth's relative dielectric constant (ε_R).

Output consists of a print-out of input parameters (if Flag One is set) and a list of gains paired with the TOA at which they are estimated.

The program uses the formulation of ESSA Technical Report ERL110-ITS78.

Operating Limits and Warnings The program contains no testing for invalid inputs.

Only integer values of the take-off angle are used.

One data point takes approximately 16s to calculate and print.

Program Description II

Sketch(es)

Sample Problem(s)

Antenna characterized by: H = 20m L = 114m Ø = 70°

Earth characterized by: σ = 0.001 mho/m ε_R = 4

Wish to evaluate starting at TOA = 6°, in increments of 6° until TOA = 24° 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)

User Instructions

GAIN OF A HORIZONTAL RHOMBIC ANTENNA AT ZERO AZIMUTH

1 | 2

RUN	HEIGHT	LEG LENGTH	TILT ANGLE	FREQUENCY
init. TOA	TOA step	larg. TOA	σ	ε_R

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter the program.				
2	Input the data in any order.				
	Height H	meters	B		H
	Leg length L	meters	C		L
	Tilt angle Ø	degrees	D		Ø in rad.
	Frequency F	MHz	E		
	Lowest (initial) take-off angle	degrees	f	A	
	Step (increment) of take-off angle	degrees	f	B	
	Highest (largest) take-off angle	degrees	f	C	
	Earth's conductivity σ	mho/meter	f	D	σ
	Earth's relative dielectric constant ε_R	-	f	E	ε_R
3	If a print-out of the input data is desired, then set flag 1		f 1	STF	
4	Run the program.		A		
	Output, in the form of the gain (in db above isotropic) to the nearest 0.1 db, is separated from the take-off angle by a zero; and is preceded by a print-out of the input (if flag 1 was set) in the following format:				
	Height T				
	Leg length Z				
	Tilt Angle Y				
	Frequency X				
	σ ***				
	ε_R ***				
5	Make any desired changes to any of the data in the manner indicated in step 2 and then go to step 3.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLB	21 12	
002	STOC	35 13	H
003	RTN	24	
004	*LBLC	21 13	
005	STOD	35 14	L
006	RTN	24	
007	*LBLD	21 14	
008	D→R	16 45	
009	STOE	35 15	Ø
010	RTN	24	
011	*LBLE	21 15	
012	STO5	35 05	F
013	RTN	24	
014	*LBLa	21 16 11	
015	INT	16 34	
016	STO1	35 01	Δ lowest
017	RTN	24	
018	*LBLb	21 16 12	
019	INT	16 34	
020	STO2	35 02	Δ step
021	RTN	24	
022	*LBLc	21 16 13	
023	INT	16 34	
024	STO3	35 03	Δ largest
025	RTN	24	
026	*LBLd	21 16 14	
027	STOA	35 11	σ
028	RTN	24	
029	*LBLe	21 16 15	
030	STOB	35 12	ε_R
031	RTN	24	
032	*LBLA	21 11	Start of execution
033	F1?	16 23 01	Print input?
034	GSB1	23 01	
035	RCL5	36 05	
036	RCL1	36 01	
037	STO4	35 04	
038	*LBL2	21 02	
039	GSB0	23 00	Go calculate gain
040	X<0?	16-45	
041	SF0	16 21 00	
042	DSP1	-63 01	
043	RND	16 24	
044	RCL4	36 04	
045	EEX	-23	
046	4	04	
047	CHS	-22	
048	×	-35	
049	F0?	16 23 00	
050	CHS	-22	
051	CF0	16 22 00	
052	+	-55	
053	DSP4	-63 04	Print gain and Δ
054	PRTX	-14	
055	RCL2	36 02	
056	RCL4	36 04	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	+	-55	Increment Δ
058	STO4	35 04	
059	RCL3	36 03	
060	-	-45	
061	X>0?	16-44	
062	RTN	24	
063	RCL5	36 05	
064	RCL4	36 04	
065	GTO2	22 02	
066	*LBL1	21 01	Start of Print
067	FIX	-11	Input Subroutine
068	DSP1	-63 01	
069	RCLC	36 13	
070	RCLD	36 14	
071	RCLE	36 15	
072	R→D	16 46	
073	RCL5	36 05	
074	PRST	16-14	
075	ENG	-13	
076	DSP2	-63 02	
077	RCLA	36 11	
078	PRTX	-14	
079	RCLB	36 12	
080	PRTX	-14	
081	SPC	16-11	
082	FIX	-11	
083	DSP3	-63 03	
084	RTN	24	
085	*LBL0	21 00	Start of Gain
086	P⇄S	16-51	Subroutine; Δ in
087	COS	42	X, F in Y.
088	STO1	35 01	
089	LSTX	16-63	
090	SIN	41	
091	STO2	35 02	
092	RAD	16-22	
093	R↓	-31	
094	R↓	-31	
095	2	02	
096	9	09	
097	9	09	
098	.	-62	
099	8	08	
100	X⇄Y	-41	
101	÷	-24	
102	STO3	35 03	
103	Pi	16-24	
104	X⇄Y	-41	
105	÷	-24	
106	STO4	35 04	
107	1	01	
108	RCL1	36 01	
109	RCLE	36 15	
110	SIN	41	
111	×	-35	
112	-	-45	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	lowest TOA	TOA step	largest TOA	TOA in use Δ	F				

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
	cos Δ	sin Δ	λ	π/λ	U	$\lvert R_H \rvert$	$\angle R_H$		

A	B	C	D	E	I
σ	ε_R	H	L	Ø	

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	STO5	35 05	Start to calculate reflection coefficient
114	RCLA	36 11	
115	RCL3	36 03	
116	×	-35	
117	6	06	
118	0	00	
119	×	-35	
120	CHS	-22	
121	RCLB	36 12	
122	RCL1	36 01	
123	X^2	53	
124	-	-45	
125	→P	34	
126	√X	54	
127	X⇄Y	-41	
128	2	02	
129	÷	-24	
130	X⇄Y	-41	
131	→R	44	
132	STO6	35 06	
133	R↓	-31	
134	STO7	35 07	
135	CHS	-22	
136	R↑	16-31	
137	CHS	-22	
138	RCL2	36 02	
139	+	-55	
140	→P	34	
141	X⇄Y	-41	
142	RCL6	36 06	
143	RCL2	36 02	
144	+	-55	
145	RCL7	36 07	
146	X⇄Y	-41	
147	→P	34	
148	R↓	-31	
149	-	-45	
150	STO7	35 07	
151	X⇄Y	-41	
152	R↑	16-31	
153	÷	-24	
154	STO6	35 06	
155	RCL7	36 07	
156	RCL2	36 02	
157	RCL4	36 04	
158	×	-35	
159	RCLC	36 13	
160	×	-35	
161	4	04	
162	×	-35	
163	-	-45	
164	COS	42	
165	×	-35	
166	2	02	
167	×	-35	
168	1	01	

STEP	KEY ENTRY	KEY CODE	COMMENTS
169	+	-55	
170	RCL6	36 06	
171	X^2	53	
172	+	-55	
173	RCL5	36 05	
174	RCL4	36 04	
175	×	-35	
176	RCLD	36 14	
177	×	-35	
178	SIN	41	
179	X^2	53	
180	RCLE	36 15	
181	COS	42	
182	×	-35	
183	RCL5	36 05	
184	÷	-24	
185	X^2	53	
186	×	-35	
187	2	02	
188	.	-62	
189	1	01	
190	6	06	
191	×	-35	
192	LOG	16 32	
193	1	01	
194	0	00	
195	×	-35	
196	DEG	16-21	
197	P⇄S	16-51	Gain is in X
198	RTN	24	
200			
210			
220			

LABELS					FLAGS
A Start of execution	B H Storage	C L Storage	D Ø storage	E F storage	0 USED
a lowest TOA storage	b TOA step storage	c largest TOA storage	d σ storage	e ϵ_R storage	1 print input
0 Start of Gain	1 Start of Print	2 Part of TOA loop	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☐	DEG	☒	FIX	☒
1	☒	☐	GRAD	☐	SCI	☐
2	☐	☐	RAD	☐	ENG	☐
3	☐	☐			n	4

Program Description I

Program Title Azimuth Pattern of Cylindrical Array of Antennas

Contributor's Name Allan H. Wegner
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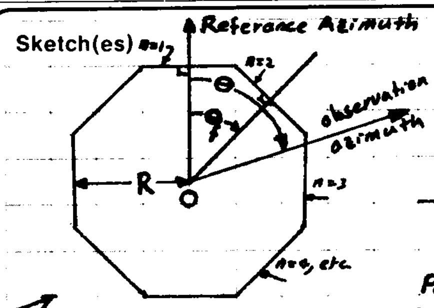
Program Description, Equations, Variables First this program calculates the angle at which the individual radiating element is to be evaluated. With this information the user inputs the magnitude & phase of the individual radiating element at this angle. The program then calculates the phase of the individual's contribution to the total radiated field, with referance 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; Υ = skew angle in C.W. direction of the individual radiating element's referance 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 $\Phi = \phi_s + p + \Psi$; $\alpha_n = \Theta_n - \Upsilon$; $\phi_s = 360/\lambda\,(R\cos\Theta_n + \delta\sin\Theta_n)$, and $\Theta_n = \Theta - \Theta_f(n-1)$

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

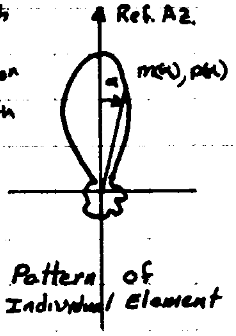
Operating Limits and Warnings

Program Description II

Sketch(es)

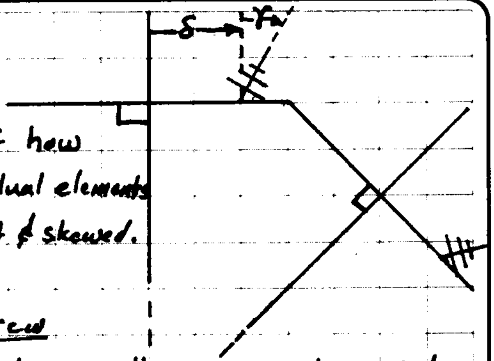


Faces numbered in C.W direction from referance



Pattern of Individual Element

Detail of how the individual elements are offset & skewed.



Top View

Note: All dimensions shown with arrow pointing in + dir.

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 ∠ 0°, 0.9 ∠ 90°, 0.9 ∠ 180°, 1.0 ∠ 270°. The pattern of the individual element is as follows (azimuth, magnitude, phase in that order): 0°, 1.0 ∠ 0°; 10°, 0.94 ∠ 0°; 40°, 0.54 ∠ 5°; 90°, 0.05 ∠ 10°; 130°, 0.02 ∠ 30°; 180°, 0.08 ∠ -50°; 220°, 0.02 ∠ 30°; 270°, 0.05 ∠ 7°; 310°, 0.41 ∠ 6°.

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°))
140 [D] → 1.00 (n) → 130.00 (α_1); 30 [↑] 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°)); 3.22 [÷] → 0.62 (answer)

Reference(s)

User Instructions

Azimuth Pattern of cylindrical Array of Antennas

1 ◀ ▶ 2

$N\uparrow\Theta_f\uparrow R$ | $\Upsilon\uparrow\delta$ | λ | $\Theta\rightarrow M(\Theta)$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load Program				
2	Input Array Geometry:				
	First input number of elements in array,	N	↑		
	then input angle between faces	Θ_f, deg.	↑		
	then input radius of array.	R*	A		
3	Input Skew of elements:				
	First input angular skew,	Υ, deg.	↑		
	then input lateral skew.	δ*	B		
4	Input wavelength	λ*	C		
5	Compute resultant radiated field for				
	each azimuth angle, Θ, desired:				
5a	First input Θ,	Θ, deg.	D		
5b	Then, when the program pauses, read the				
	number of the face that is being evaluated				n
5c	Then, when the program stops, read the				
	individual pattern evaluation angle, α_n				α_n, deg.
5d	Then input the phase of radiated field of				
	individual element at angle α_n.	$p(\alpha_n)$, deg.	↑		
5e	Then input the phase of the signal to face n.	Ψ_n, deg	R/S		
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 $n=N$.				
6	The program then stops to display the total radiated				
	field of the array in the direction Θ, $M(\Theta)$**				$M(\Theta)$**
7	The phase of the total field may be				
	viewed if desired, $P(\Theta)$.		h	x⇄y	$P(\Theta)$, deg
8	If another observation angle, Θ, is				
	desired go to Step #5 and repeat.				
9	If it is desired to change any of the				
	parameters ($N, \Theta_f, R, \Upsilon, \delta, \lambda$) 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.				
*	Note: R, δ, and λ must ALL be in the same units				
**	Note: $M(\Theta)$ must be renormalized when finished				

67 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	Enter N, θ_f & R
	STO A	33 11	
	h R↓	35 53	
	STO B	33 12	
	h R↓	35 53	
	STO C	33 13	
	f GSB 1	31 22 01	
	h RTN	35 22	
	f LBL B	31 25 12	Enter γ & δ
010	STO D	33 14	
	h R↓	35 53	
	STO E	33 15	
	f GSB 1	31 22 01	
	h RTN	35 22	
	f LBL C	31 25 13	Enter λ
	STO 9	33 09	
	f GSB 1	31 22 01	
	h RTN	35 22	
	f LBL 1	31 25 01	
020	CLX	44	
	3	03	
	6	06	
	0	00	
	↑	41	
	↑	41	
	RCL A	34 11	
	×	71	
	RCL 9	34 09	
	f x=0	31 51	calculate freq. sensitive constants
030	h RTN	35 22	
	÷	81	
	STO 8	33 08	
	h x⇄y	35 52	
	RCL D	34 14	
	×	71	
	RCL 9	34 09	
	÷	81	
	STO 7	33 07	
	CLX	44	
040	h RTN	35 22	
	f LBL D	31 25 14	Pattern calculation
	STO 5	33 05	
	1	01	
	STO 6	33 06	
	3	03	
	5	05	
	CHS	42	Initialize
	h STI	35 33	
	CLX	44	
050	STO 4	33 04	
	STO 3	33 03	
	RCL 5	34 05	
	f COS	31 63	
	RCL 8	34 08	
	×	71	
	RCL 5	34 05	

STEP	KEY ENTRY	KEY CODE	COMMENTS
	f SIN	31 62	
	RCL 7	34 07	
	×	71	
060	+	61	
	RCL 5	34 05	
	RCL E	34 15	
	−	51	
	f x<0	31 71	
	f GSB 3	31 22 03	
	RCL 6	34 06	
	h PAUSE	35 72	
	h R↓	35 53	
	R/S	84	
070	+	61	
	h R↑	35 54	
	+	61	
	R/S	84	
	+	61	
	f →R	31 72	
	STO + 3	33 61 03	
	h x⇄y	35 52	
	STO + 4	33 61 04	
	RCL C	34 13	
080	RCL 6	34 06	
	g x=y	32 51	
	GTO 2	22 02	
	1	01	
	STO + 6	33 61 06	
	RCL B	34 12	
	STO − 5	33 51 05	
	GTO (i)	22 24	End of Pattern Calc.
	f LBL 2	31 25 02	
	RCL 4	34 04	Rectangular to Polar conversion & display result
090	RCL 3	34 03	
	g →P	32 72	
	h RTN	35 22	
	f LBL 3	31 25 03	
	3	03	change neg. α's to positive angles.
	6	06	
	0	00	
	+	61	
	f x<0	31 71	
	GTO 3	22 03	
100	h RTN	35 22	
110			

REGISTERS

0	1	2	3	4	5	6	7	8	9
			Re Σ Field	Im Σ Field	θ_n	n	360δ/λ	360R/λ	λ

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
R	θ_f	N	δ	γ	used

67 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
120			
130			
140			
150			
160			

STEP	KEY ENTRY	KEY CODE	COMMENTS
170			
180			
190			
200			
210			
220			

LABELS

A Enter N, Θ_F & R	B Enter γ & δ	C Enter λ	D Calculate $\mathcal{M}(\Theta)$	E
a	b	c	d	e
0	1 Constant calculations	2 Rect → Polar	3 Change − angles to +	4
5	6	7	8	9

FLAGS

0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

Program Description I

Program Title COLINEAR ANTENNA GAIN AND PATTERN

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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

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

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

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

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

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

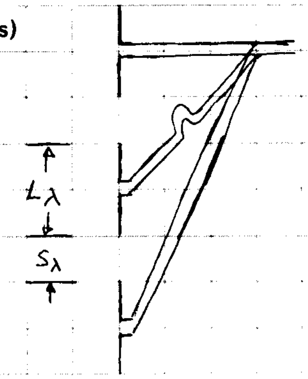
S_λ = TIP-TO-TIP DIPOLE SPACING IN WAVELENGTHS

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.

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 λ/2 DIPOLE

(2) CALCULATE GAIN OF TWO 1¼λ DIPOLES SPACED ½λ TIP-TO-TIP

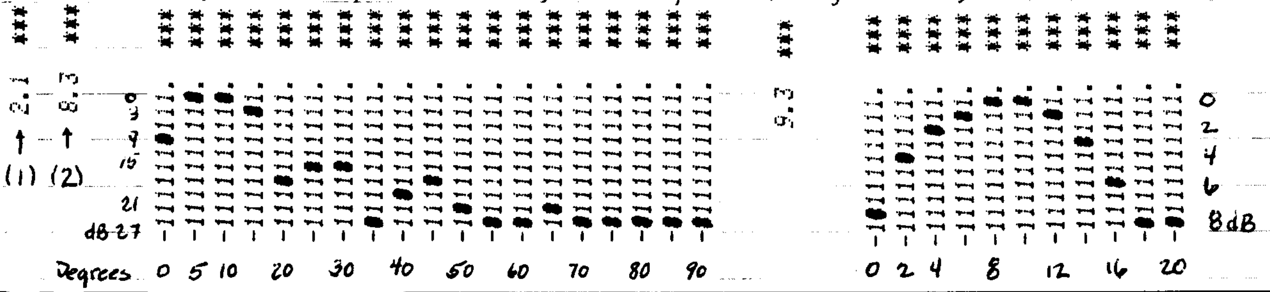
(3) EVALUATE EFFECT OF 0.7 RADIAN PHASE SHIFT ON ARRAY OF SIX λ/2 DIPOLES SPACED λ/4 TIP-TIP. PLOT IN 3dB STEPS, 5°/STEP; PLOT IN 1dB STEPS, 2°/STEP

NOTE: CONTRAST OF PLOT HAS BEEN INCREASED BY MARKING EACH "8" WITH A PENCIL

Solution(s) (1) [A], 0.5 STO 1, 1 STO I, [B] ANS: 2.15 dBi

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

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



Reference(s)

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

User Instructions

COLINEAR ANTENNA GAIN, PATTERN

1 INITIAL | GAIN | °/STEP ADVANCE | PATTERN | PLOT 2

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, RADIANS	ψ_o	STO	0	
	DIPOLE LENGTH, WAVELENGTHS	L_λ	STO	1	
	DIPOLE SPACING (TIP-TO-TIP), WAVELENGTHS	S_λ	STO	2	
	NUMBER OF DIPOLES IN ARRAY	N	STO	3	
4	CALCULATE ANTENNA GAIN		B		G, dBi
5	CALCULATE RELATIVE GAIN vs ANGLE:				
	INPUT DEGREES PER STEP *	θ_i	C		n
	PRINTS θ, RELATIVE GAIN		D		θ°, GdB
	ITERATES n TIMES, PRINTS GAIN				G, dBi
6	PLOT ANTENNA PATTERN:				
	INPUT dB/STEP (PROGRAMMED FOR 3dB)	dB/STEP	STO	E	
	INPUT DEGREES PER STEP *	θ_i	C		
	PLOT		E		SEE NOTE
	NOTE: READ PLOT (3dB/STEP)				
	111111181 = +1.5dB to +4.5dB				
	-111111118 = 0dB to -1.5dB				
	-111111811 = -4.5dB to -7.5dB etc				
	EACH LINE IS AN INCREMENT OF θ_i				
	STARTING WITH θ = 0°; PRINTS GAIN				G, dBi
*	TO START GAIN vs 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, fC, D				
7	TO SPEED DIPOLE ONLY OR ARRAY				
	FACTOR ONLY COMPUTATIONS:				
	DIPOLE ONLY	1	STO	I	
	ARRAY FACTOR ONLY +	2	STO	I	
	TO RETURN TO DIPOLE + ARRAY	0	STO	I	
	+ LET L_λ = 0, S_λ = TOTAL DISTANCE				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	ENT↑	-21	
003	1	01	
004	1	01	
005	1	01	
006	1	01	
007	1	01	
008	1	01	STORES CONSTANTS
009	1	01	
010	1	01	
011	1	01	
012	1	01	
013	STOD	35 14	
014	Pi	16-24	
015	2	02	
016	÷	-24	
017	STOC	35 13	
018	2	02	
019	GSB7	23 07	
020	STOE	35 15	
021	RTN	24	
022	*LBLC	21 13	
023	D→R	16 45	
024	STOA	35 11	CALCULATES NUMBER OF STEPS FOR °/STEP; INITIALIZES REGISTERS 5, 6, & 7
025	0	00	
026	STO6	35 06	
027	STO7	35 07	
028	RCLC	36 13	
029	RCLA	36 11	
030	÷	-24	
031	DSP0	-63 00	
032	RND	16 24	
033	STO5	35 05	
034	DSP2	-63 02	
035	RTN	24	
036	*LBLc	21 16 13	
037	D→R	16 45	
038	RCLA	36 11	ADVANCES STARTING ANGLE
039	÷	-24	
040	DSP0	-63 00	
041	RND	16 24	
042	STO6	35 06	
043	RTN	24	
044	*LBLB	21 12	
045	9	09	
046	0	00	CALCULATES MINIMUM NUMBER OF STEPS (MAX. °/STEP) FOR ACCURATE GAIN COMPUTATION
047	RCL1	36 01	
048	RCL3	36 03	
049	×	-35	
050	RCL3	36 03	
051	1	01	
052	-	-45	
053	RCL2	36 02	
054	×	-35	
055	+	-55	
056	RCLC	36 13	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	×	-35	
058	3	03	
059	+	-55	
060	÷	-24	
061	GSBC	23 13	
062	*LBLb	21 16 12	
063	GSB9	23 09	
064	GSBi	23 45	
065	RCLB	36 12	CALCULATES GAIN
066	SIN	41	
067	×	-35	
068	ST+7	35-55 07	
069	1	01	
070	ST+6	35-55 06	
071	RCL5	36 05	
072	RCL6	36 06	
073	X≠Y?	16-32	
074	GTOb	22 16 12	
075	RCL7	36 07	
076	.	-62	
077	5	05	
078	-	-45	
079	RCLA	36 11	
080	×	-35	
081	GSB7	23 07	
082	CHS	-22	
083	STO4	35 04	
084	DSP1	-63 01	
085	RND	16 24	
086	PRTX	-14	
087	DSP2	-63 02	
088	RCL4	36 04	
089	RTN	24	
090	*LBLD	21 14	
091	GSB8	23 08	
092	R→D	16 46	
093	DSP0	-63 00	
094	RND	16 24	PRINTS ANGLE
095	PRTX	-14	
096	GSB9	23 09	
097	GSBi	23 45	
098	GSB7	23 07	
099	DSP1	-63 01	PRINTS RELATIVE GAIN
100	RND	16 24	
101	PRTX	-14	
102	1	01	
103	ST+6	35-55 06	
104	RCL5	36 05	
105	RCL6	36 06	
106	X≤Y?	16-35	CALCULATES GAIN
107	GTOD	22 14	
108	SPC	16-11	
109	GTOB	22 12	
110	RTN	24	
111	*LBLE	21 15	
112	GSB9	23 09	

REGISTERS

0	1	2	3	4	5	6	7	8	9
ψ_o	L_λ	S_λ	N	USED	n	1, 2, 3, ... n	$\Sigma S(\theta)^2 \sin\theta$		

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
θ_i, RADIANS	θ, RADIANS	$\pi/2$	1111111111	dB/STEP	0, 1, OR 2

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	GSBi	23 45	↓ PLOTS PATTERN
114	GSB7	23 07	
115	X<0?	16-45	CHECK SIGN
116	SF2	16 21 02	
117	ABS	16 31	
118	RCLE	36 15	NORMALIZE
119	÷	-24	WITH dB/STEP
120	DSP0	-63 00	
121	RND	16 24	
122	9	09	} SET LIMITS
123	X≤Y?	16-35	
124	X⇄Y	-41	
125	X⇄Y	-41	
126	10ˣ	16 33	} FORMAT
127	7	07	
128	x	-35	
129	RCLD	36 14	
130	+	-55	
131	F2?	16 23 02	INSERT SIGN
132	CHS	-22	
133	PRTX	-14	PRINT PLOT FORMAT
134	1	01	
135	ST+6	35-55 06	
136	RCL5	36 05	
137	RCL6	36 06	
138	X≤Y?	16-35	
139	GTOE	22 15	
140	SPC	16-11	
141	GTOB	22 12	CALCULATE
142	RTN	24	GAIN
143	*LBL9	21 09	
144	GSB8	23 08	
145	RCLC	36 13	BRINGS 0°
146	+	-55	TO BROADSIDE
147	STOB	35 12	
148	RTN	24	
149	*LBL8	21 08	CALCULATE
150	RCLA	36 11	ANGLE Θ
151	RCL6	36 06	
152	x	-35	
153	RTN	24	
154	*LBL7	21 07	
155	EEX	-23	
156	CHS	-22	
157	9	09	
158	+	-55	
159	LOG	16 32	
160	1	01	
161	0	00	
162	x	-35	
163	RTN	24	
164	*LBL0	21 00	
165	GSB1	23 01	$f(\Theta)^2_D \cdot f(\Theta)^2_A$
166	GSB2	23 02	
167	x	-35	
168	RTN	24	

STEP	KEY ENTRY	KEY CODE	COMMENTS
169	*LBL1	21 01	
170	RCLB	36 12	CALCULATES
171	COS	42	$f(\Theta)^2_{DIPOLE}$
172	Pi	16-24	
173	x	-35	
174	RCL1	36 01	
175	x	-35	
176	COS	42	
177	RCL1	36 01	
178	Pi	16-24	
179	x	-35	
180	COS	42	
181	-	-45	
182	1	01	
183	LSTX	16-63	
184	-	-45	
185	EEX	-23	PREVENTS
186	CHS	-22	DIVISION BY
187	9	09	ZERO
188	+	-55	
189	÷	-24	
190	RCLB	36 12	
191	SIN	41	
192	÷	-24	
193	X²	53	
194	RTN	24	
195	*LBL2	21 02	CALCULATES
196	RCLB	36 12	$f(\Theta)^2_{ARRAY}$
197	COS	42	
198	RCL2	36 02	
199	RCL1	36 01	
200	+	-55	
201	x	-35	
202	Pi	16-24	
203	x	-35	
204	2	02	
205	x	-35	
206	RCL0	36 00	
207	+	-55	
208	2	02	
209	÷	-24	
210	STO4	35 04	
211	RCL3	36 03	
212	x	-35	
213	SIN	41	
214	RCL4	36 04	
215	SIN	41	
216	÷	-24	
217	RCL3	36 03	
218	÷	-24	
219	X²	53	
220	RTN	24	

LABELS

A INITIALIZE	B CALCULATE GAIN	C %/STEP	D LIST PATTERN	E PLOT PATTERN
a	b	c ADVANCE (Θ START ≠ 0)	d	e
0 $f(\Theta)^2_D \cdot f(\Theta)^2_A$	1 $f(\Theta)^2_{DIPOLE}$	2 $f(\Theta)^2_{ARRAY}$	3	4
5	6	7 10 log	8 CALC Θ	9 Θ + π/2

FLAGS

0	
1	
2	SIGN OF PLOT
3	

SET STATUS

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

Program Description I

Program Title Beam Pattern for Uniform Array

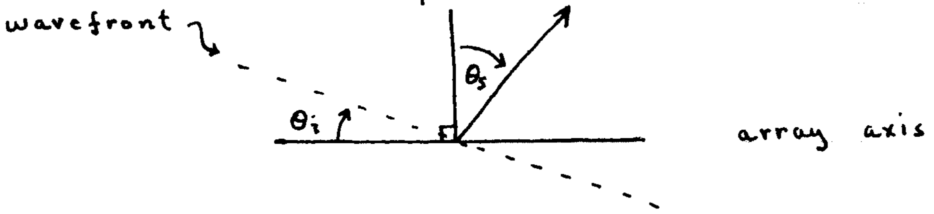
Contributor's Name Stephen A. Hertz
Address TRW Systems Group , 7600 Colshire Dr.
City McLean State Va. Zip Code 22101

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.

Program Description II

Sketch(es)

Sample Problem(s) Given a 5 sensor array with an inter sensor spacing of 50 ft. and steered to broadside ($\theta_s = 0$), calculate the normalized response for a plane wave of wavelength 100 ft. incident at 0 degrees and 20 degrees. Then calculate the response for $\theta_i = 5°, 10°$, and 15°.

Solution(s) Keystrokes 5 [STO A] 50 [STO B] 100 [STO C] 0 [B] 0 [A]
[C] → 0 db
20 [A] [C] → -15.30 db

5 [ENTER↑] 3 [ENTER↑] 5 [D] → -0.66 ***
-2.77 ***
-6.88 ***

Reference(s) "Principles of Aperture + Array System Design"
Steinberg
John Wiley + Sons 1976

User Instructions

BEAM PATTERN

1 θ_i | θ_s | $R(\theta_i)$ | R 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Load side 1				
2	If this is the first case, steps 2a thru 2d must be performed. Otherwise, input only those quantities that need be changed.				
	2a) Input number of sensors	N	STO	A	N
	2b) Input intersensor spacing	d	STO	B	d
	2c) Input wavelength	λ	STO	C	λ
	2d) Input steering angle	θ_s	B		$\sin \theta_s$
	Go to 3 or 5*				
3	Input angle of incident wavefront	θ_i	A		$\sin \theta_i$
4	Calculate $R(\theta_i)$		C		$R(\theta_i)$
	For new θ_i only, go to 3 or 5. Otherwise, go to 2.				
5	Input starting angle θ_i	θ_i	ENTER↑		θ_i
6	Input number of points to calculate	K	ENTER↑		K
7	Input incremental angle $\Delta\theta_i$	$\Delta\theta_i$	D		$R(\theta_i)$
					⋮
					$R(\theta_i + (K-1)\Delta\theta_i)$
	* Steps 3 + 4 are used to calculate the beam pattern at one value of θ_i. Steps 5 thru 7 are used to calculate the beam pattern at K values of θ_i ranging from $R(\theta_i)$ to $R[\theta_i + (K-1)\Delta\theta_i]$				

67 Program Listing I

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

FLAGS	
0	
1	
2	used
3	

SET STATUS

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

LABELS

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

REGISTERS

0	1	2	3	4	5	6	7	8	9
used	used	$\Delta\theta_i$	θ_i						
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
N	d	λ	$\sin\theta_i$	$\sin\theta_s$	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

$$\text{Beamwidth}_x = \frac{k\lambda}{L_x} \qquad \lambda = \frac{299.8}{f}$$

$$\text{Beamwidth}_y = \frac{k\lambda}{L_y} \qquad G = 10 \text{ LOG } \frac{27000}{BW_x \cdot BW_y}$$

Circular Antenna

$$\text{Beamwidth} = \frac{k\lambda}{D} \qquad G = 10 \text{ LOG } \frac{27000}{BW}$$

L_x, L_y, D in metres, f in MHz

	Weighting	Rectangular	Circular
	Uniform	51	58
k	Cosin	68	76
	Hamming	74.5	80
	Cos on 10 dB Ped.		
	$1-R^2$		72.5
	$(1-R^2)^2$		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.

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.

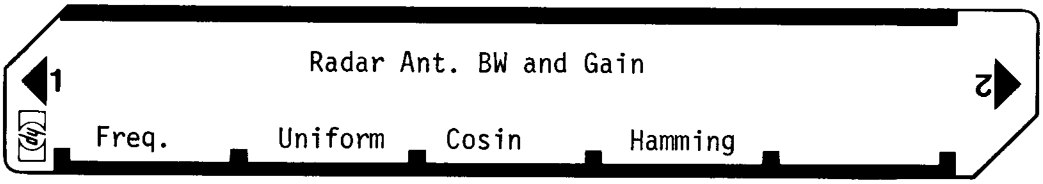
2. Find antenna beamwidth and gain of a cosin weighted 10 metre circular antenna at 3000 MHz.

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



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Enter frequency	MHz	A		λ (metres)
3.	Set Ant. type				
	Rect. Ant.		f	A	
	Cir. Ant.		f	B	
4.	Enter Ant. Dim. x or d	m	↑		
	Enter Ant. Dim y if Req.	m			
5.	uniform Wt.		B		x or
	cosin wt.		C		cir
	Hamming wt.		D		BW(deg)
5a.	y BW if required		R/S		yBW(deg)
6.	Antenna gain		R/S		dB
	For other values of k do steps 1 thru 4		↑		
5.	Enter k		E		x or cir BW
5a.	y BW if required		R/S		y BW
6.	Antenna gain		R/S		dB

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	CF1	16 22 01	Rect 1
003	RTN	24	
004	*LBLb	21 16 12	
005	SF1	16 21 01	Cir 2
006	RTN	24	
007	*LBLA	21 11	
008	2	02	
009	9	09	
010	9	09	c (m/µsec)
011	.	-62	
012	8	08	
013	X⇄Y	-41	
014	÷	-24	
015	STO1	35 01	λ (metres)
016	RTN	24	
017	*LBLB	21 12	Uniform wt.
018	F1?	16 23 01	
019	GTO1	22 01	Test for ⊙ ant.
020	5	05	
021	1	01	k rect
022	GTOE	22 15	
023	*LBL1	21 01	
024	5	05	
025	8	08	k ⊙
026	.	-62	
027	4	04	
028	GTOE	22 15	
029	*LBLC	21 13	cosin wt.
030	F1?	16 23 01	Test for ⊙ ant.
031	GTO2	22 02	
032	6	06	
033	8	08	k rect.
034	GTOE	22 15	
035	*LBL2	21 02	
036	7	07	k⊙
037	6	06	
038	GTOE	22 15	
039	*LBLD	21 14	Hamming wt.
040	F1?	16 23 01	Test for ⊙ ant.
041	GTO3	22 03	
042	7	07	
043	4	04	k rect.
044	.	-62	
045	5	05	
046	GTOE	22 15	
047	*LBL3	21 03	
048	8	08	k⊙
049	0	00	
050	*LBLE	21 15	
051	RCL1	36 01	
052	×	-35	kλ
053	STO2	35 02	
054	X⇄Y	-41	
055	÷	-24	
056	STO3	35 03	BWy or BW⊙
057	F1?	16 23 01	Test for ⊙ ant.
058	GTO9	22 09	
059	R↓	-31	
060	RCL2	36 02	
061	X⇄Y	-41	
062	÷	-24	BW_x
063	RCL3	36 03	
064	X⇄Y	-41	
065	R/S	51	x BW(deg)
066	X⇄Y	-41	
067	*LBL8	21 08	y or ⊙ BW(deg)
068	R/S	51	
069	×	-35	
070	2	02	27000
071	7	07	
072	EEX	-23	
073	3	03	
074	X⇄Y	-41	
075	÷	-24	
076	LOG	16 32	
077	1	01	
078	0	00	
079	×	-35	
080	R/S	51	Ant gain (dB)
081	*LBL9	21 09	
082	ENT↑	-21	
083	GTO8	22 08	
084	R/S	51	
090			
100			
110			

SET STATUS

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

REGISTERS

0	1	2	3	4	5	6	7	8	9
	λ metres	kλ	BWy or BW⊙						Used

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Antennas

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables Given the height, h, and width, l, of an antenna, this program will compute the -3dB vertical and horizontal beamwidths, β_v and β_h respectively, equations for these quantities are:

$$\beta_v \approx k\left(\frac{\lambda}{h}\right)$$

$$\beta_h \approx k\left(\frac{\lambda}{l}\right)$$

where: k = antenna taper factor (k = 1.4 is used in this program)

λ = wavelength

Given the gain of antenna, G, this program will also compute the equivalent antenna area:

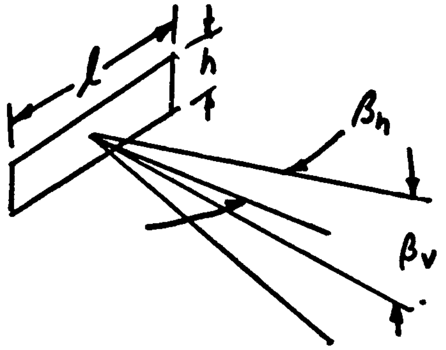
$$A_e = \frac{G\lambda^2}{4\pi}$$

The program will also compute the inverse of these quantities.

Operating Limits and Warnings λ should be small compared to antenna dimensions.

Program Description II

Sketch(es)



Sample Problem(s)

1. A plate antenna array operating at 620 MHz (λ=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 (λ= .12 ft) has a measured gain of 28 dB. What is its equivalent area?

4. An antenna operating at 6500 MHz (λ= 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_n---------> 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 A_e--------------->	0.72 ft^2
4.	16.5[D] --------------->	Enter A_c----------------->	16.50
	.15[↑] --------------->	Enter λ ------------------>	0.15
	[C][E] --------------->	Compute G ---------------->	39.65 dB

Reference(s)

User Instructions

	Antennas		Initialize A	
l,h	β_h,β_v	λ,calc	A_e	G

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load card				
2.	Initialize		f	A	
3.	Enter:				
	Antenna length and	l(ft)	↑		l
	Antenna height	h(ft)	A		1
		β_h(deg)	↑		β_h
		β_v(deg)	B		β_v
4.	Enter wavelength	λ (ft)			λ
5.	Compute:				
	Horizontal BW		C	B	β_h(deg)
	Vertical BW		R/S		β_v(deg)
OR	Antenna length		C	A	l (ft)
	Antenna height		R/S		h (ft)
6.	Enter:				
	Antenna area	A_e(ft)	D		A_e
OR	Antenna gain	G (dB)	E		G
7.	Enter wavelength	λ (ft)			λ
8.	Compute:				
	Antenna gain		C	E	G(dB)
OR	Equivalent area		C	D	$A_e(ft)^2$
9.	To to step 3 or 5 for new case.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	GSBa	23 16 11	
002	1	01	
003	8	08	
004	0	00	Initialize
005	Pi	16-24	
006	÷	-24	
007	1	01	
008	.	-62	
009	4	04	
010	x	-35	
011	STO1	35 01	
012	0	00	
013	STOI	35 46	
014	RTN	24	
015	*LBLA	21 11	
016	DSZI	16 25 46	
017	GTO0	22 00	If c pressed
018	STO8	35 08	then calculate
019	RCL5	36 05	
020	÷	-24	
021	RCL1	36 01	
022	x	-35	
023	R/S	51	
024	RCL1	36 01	
025	RCL4	36 04	
026	÷	-24	
027	RCL8	36 08	
028	x	-35	
029	RTN	24	
030	*LBL0	21 00	
031	STO2	35 02	Else store
032	R↓	-31	
033	STO3	35 03	
034	R/S	51	
035	*LBLB	21 12	
036	DSZI	16 25 46	
037	GTO1	22 01	If c pressed
038	STO8	35 08	then calculate
039	RCL3	36 03	
040	÷	-24	
041	RCL1	36 01	
042	x	-35	
043	R/S	51	
044	RCL1	36 01	
045	RCL2	36 02	
046	÷	-24	
047	RCL8	36 08	
048	x	-35	
049	RTN	24	
050	*LBL1	21 01	
051	STO4	35 04	Else store
052	R↓	-31	
053	STO5	35 05	
054	RTN	24	
055	*LBLC	21 13	
056	1	01	calculate "flag"
057	STOI	35 46	
058	R↓	-31	
059	RTN	24	
060	*LBLD	21 14	
061	DSZI	16 25 46	If c pressed
062	GTO6	22 06	then calculate
063	ENT↑	-21	
064	x	-35	
065	RCL7	36 07	
066	1	01	
067	0	00	
068	÷	-24	
069	10^x	16 33	
070	x	-35	
071	4	04	
072	÷	-24	
073	Pi	16-24	
074	÷	-24	
075	RTN	24	
076	*LBL6	21 06	
077	STO6	35 06	Else store
078	RTN	24	
079	*LBLE	21 15	
080	DSZI	16 25 46	If c pressed
081	GTO7	22 07	
082	ENT↑	-21	then calculate
083	x	-35	
084	RCL6	36 06	
085	4	04	
086	x	-35	
087	Pi	16-24	
088	x	-35	
089	÷	-24	
090	1/X	52	
091	LOG	16 32	
092	1	01	
093	0	00	
094	x	-35	
095	RTN	24	Else store
096	*LBL7	21 07	
097	STO7	35 07	
098	RTN	24	
100			
110			

REGISTERS

0	1	2	3	4	5	6	7	8	9
	$k(\frac{180}{\pi})$	h	l	β_v	β_h	Used	Used	Used	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					Used

Program Description I

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.

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 1
   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.

User Instructions

Parabolic Antenna

1				2
GHz	%	m or ft		
■ Dia→Gain	■ Gain→Dia	■ Dia → 3dB	■ dB → width	■ Deg → dB

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load program				
2.	Enter frequency	GHz	f	A	55
	NOTE: If efficiency = 55%, skip step 3				
3.	Enter efficiency	%			
4.	Run			B	
5.	Select meter length unit (repeat if necessary)		f	C	1 = m 0 = ft.
6.	Enter antenna diameter	ft. or m.			
	Compute gain		A		dB1
7.	Enter antenna gain required	dB1			
	Compute antenna diameter		B		ft. or m.
8.	Enter antenna diameter	ft. or m.			
	Compute 3dB beamwidth		C		deg.
	NOTE: Computed 3dB BW is in reg. 1				
9.	Enter 3dB BW (If not computed above)	deg.	STO	1	
10.	Enter n dB (below max.)	dB			
	Compute n dB beamwidth		D		deg.
11.	Enter off-axis angle	deg.			
	Compute dB below max.		E		dB

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	STO2	35 02	Freq.
003	LOG	16 32	
004	2	02	
005	0	00	
006	STO6	35 06	
007	x	-35	
008	STO3	35 03	20 log freq.
009	3	03	
010	.	-62	
011	2	02	
012	8	08	
013	STO4	35 04	Meters to ft. mul
014	5	05	
015	5	05	55% is norm eff.
016	RTN	24	
017	*LBLb	21 16 12	
018	ENT↑	-21	
019	.	-62	
020	1	01	
021	0	00	
022	2	02	
023	x	-35	
024	LOG	16 32	
025	1	01	
026	0	00	
027	x	-35	Eff. constant K_E
028	ST+3	35-55 03	20 log f + K_f
029	RTN	24	
030	*LBLc	21 16 13	
031	F1?	16 23 01	
032	GTO1	22 01	
033	SF1	16 21 01	m or ft. toggle
034	1	01	1 = m 0 = ft.
035	RTN	24	
036	*LBL1	21 01	
037	CF1	16 22 01	
038	0	00	
039	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
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^x	16 33	
055	F1?	16 23 01	
056	GSB8	23 08	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	RTN	24	
058	*LBL8	21 08	
059	RCL4	36 04	Conv. ft. to meters
060	÷	-24	
061	RTN	24	
062	*LBL9	21 09	
063	RCL4	36 04	Conv. meters to ft.
064	x	-35	
065	RTN	24	
066	*LBLC	21 13	
067	F1?	16 23 01	
068	GSB9	23 09	
069	RCL2	36 02	
070	x	-35	
071	6	06	
072	6	06	
073	.	-62	
074	4	04	
075	X⇄Y	-41	
076	÷	-24	3dB BW
077	STO1	35 01	
078	RTN	24	
079	*LBLD	21 14	
080	RCL1	36 01	
081	X^2	53	
082	x	-35	
083	3	03	
084	÷	-24	n pB BW
085	√X	54	
086	RTN	24	
087	*LBLE	21 15	
088	X^2	53	
089	1	01	
090	2	02	
091	x	-35	
092	RCL1	36 01	
093	X^2	53	pB down
094	÷	-24	
095	RTN	24	
100			
110			

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	3dB BW	FreqGHz	20log f	m/ft conv		20			

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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:

$$L_1 = 20 \text{ LOG}(41.87\, f\, D)$$

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

$$L_3 = -10 \text{ LOG}\left\{\frac{1.033\times10^{-3}}{(fD)^4}\left[1 + 31.1\,(f h_1)^2\right]\left[1 + 31.1\,(f h_2)^2\right]\right\}$$

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 MHZ < f < 500 MHZ

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 MHZ	(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

User Instructions

RF PATH LOSS , DB

1 | 2

f | D | $h_1 \uparrow h_2$ | H | $\rightarrow L_1, L$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	LOAD SIDE 1 AND SIDE 2			
2	LOAD CONSTANTS (DATA) INTO			
	PROTECTED SECONDARY REGISTERS			
3	INPUT f VALUE *	f/MHZ	A	f
4	INPUT D VALUE *	D/KM	B	D
5	INPUT h_1 VALUE	h_1/KM	ENTER↑	h_1
6	INPUT h_2 VALUE	h_2/KM	C	h_2
7	INPUT H VALUE *	H/KM	D	H
8	COMPUTE L_1 AND L		E	L_1, L/DB
9	FOR NEW CASE GO TO STEP 3			
	*NOTE THAT THESE STEPS MAY			
	BE SKIPPED IF THE INPUT			
	VALUE EQUALS THE VALUE			
	INPUT IN THE PREVIOUS			
	CASE			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	STO5	35 05	
003	RTN	24	
004	*LBLB	21 12	
005	STO6	35 06	
006	RTN	24	
007	*LBLC	21 13	
008	STO3	35 03	
009	R↓	-31	
010	STO2	35 02	
011	RTN	24	
012	*LBLD	21 14	
013	STO4	35 04	
014	RTN	24	
015	*LBLE	21 15	
016	2	02	
017	0	00	
018	STOA	35 11	
019	1	01	
020	0	00	
021	STOI	35 46	
022	RCLi	36 45	
023	RCL5	36 05	
024	RCL6	36 06	
025	x	-35	
026	x	-35	
027	LOG	16 32	
028	RCLA	36 11	
029	x	-35	
030	STOB	35 12	
031	ISZI	16 26 46	
032	RCLi	36 45	
033	RCL5	36 05	
034	RCL6	36 06	
035	x	-35	
036	X^2	53	
037	X^2	53	
038	÷	-24	
039	ISZI	16 26 46	
040	RCLi	36 45	
041	RCL5	36 05	
042	RCL2	36 02	
043	x	-35	
044	X^2	53	
045	x	-35	
046	1	01	
047	+	-55	
048	x	-35	
049	RCLi	36 45	
050	RCL5	36 05	
051	RCL3	36 03	
052	x	-35	
053	X^2	53	
054	x	-35	
055	1	01	
056	+	-55	
057	x	-35	
058	LOG	16 32	
059	RCLA	36 11	
060	2	02	
061	÷	-24	
062	x	-35	
063	CHS	-22	
064	STOD	35 14	
065	ISZI	16 26 46	
066	RCLi	36 45	
067	ISZI	16 26 46	
068	RCLi	36 45	
069	RCL4	36 04	
070	RCL6	36 06	
071	÷	-24	
072	x	-35	
073	+	-55	
074	ISZI	16 26 46	
075	RCLi	36 45	
076	RCL4	36 04	
077	RCL6	36 06	
078	÷	-24	
079	X^2	53	
080	x	-35	
081	-	-45	
082	ISZI	16 26 46	
083	RCLi	36 45	
084	RCL5	36 05	
085	x	-35	
086	+	-55	
087	ISZI	16 26 46	
088	RCLi	36 45	
089	RCL5	36 05	
090	LOG	16 32	
091	x	-35	
092	+	-55	
093	ISZI	16 26 46	
094	RCLi	36 45	
095	RCL6	36 06	
096	x	-35	
097	+	-55	
098	ISZI	16 26 46	
099	RCLi	36 45	
100	RCL6	36 06	
101	X^2	53	
102	x	-35	
103	-	-45	
104	STOC	35 13	
105	RCLB	36 12	
106	PRTX	-14	
107	RCLC	36 13	
108	RCLD	36 14	
109	X>Y?	16-34	
110	GTO0	22 00	
111	*LBL2	21 02	
112	R↓	-31	

REGISTERS

0	1	2	3	4	5	6	7	8	9
		h_1	h_2	H	f	D			

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
41.87	1.03×10^{-3}	31.10	66.20	1070	7500	2.68×10^{-3}	28.34	0.88	3.78×10^{-3}

A	B	C	D	E	I
USED	L_1	L_2	L_3		USED

97 Program Listing II

STEP	KEY ENTRY	KEY CODE	COMMENTS
113	X>Y?	16-34	
114	GTO1	22 01	
115	R↓	-31	
116	*LBL1	21 01	
117	PRTX	-14	
118	SPC	16-11	
119	SPC	16-11	
120	RTN	24	
121	*LBL0	21 00	
122	X⇄Y	-41	
123	GTO2	22 02	
124	R/S	51	

LABELS

A	B	C	D	E
A f	B D	C $h_1 \uparrow h_2$	D H	E → L_1, L
a	b	c	d	e

REGISTERS

0 USED	1 USED	2 USED	3	4
5	6	7	8	9

FLAGS: 0, 1, 2, 3

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

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.)

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 x 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

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	0.00
3.	Input rcvr ant gain	G_R(dB)	A		G_R
4.	Input range in				
	either kilometers	Km	↑		Km
	or in nat miles	Nm	D		Km
	or in stat miles	Sm	E		Km
5.	Input frequency	MHz	B		
6.	Input received power	watts	↑		watts
7.	Input transmitted power and compute ant. gain	watts	C		dB
	OR				
	Input ant gain (xmit) and compute xmit power	dB	C		watts
	For a new case, go to step 2 (initialize)				
	If there is no change in prior input parameters, a new case may be begun with step 6.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	Pi	16-24	
003	4	04	
004	x	-35	
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	
014	5	05	C (km/μsec)
015	ENT↑	-21	
016	x	-35	
017	÷	-24	
018	STO8	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	
024	*LBLB	21 12	Input R; f
025	x	-35	
026	ENT↑	-21	$R8 = \frac{R^2 f^2 (4\pi)^2}{c^2 G_R}$
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	
034	RTN	24	
035	*LBLD	21 14	
036	1	01	
037	.	-62	Convert nautical
038	8	08	miles to kilometers
039	5	05	
040	3	03	
041	2	02	
042	5	05	
043	x	-35	
044	RTN	24	
045	*LBLE	21 15	
046	1	01	
047	.	-62	
048	6	06	Converts statute
049	0	00	
050	9	09	miles to kilometers
051	3	03	
052	4	04	
053	7	07	
054	2	02	
055	1	01	
056	9	09	
057	x	-35	
058	RTN	24	

SET STATUS

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

REGISTERS

0	1	2	3	4	5	6	7	8	9
								Sto between labels	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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 (sinα, sinβ-,R-unity) to rectangular coordinates where $\chi = \sin\theta, \cos\phi$; $y=\sin\theta\sin\phi$, $z=\cos\theta$.
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 α, sin β outputs is also used. The above stops are accomplished using the following formulas:

A. Conversion of sin α, sin β to α', β where BS = Boresight angle

$$\alpha' = \text{Tan}^{-1}\left[\frac{\sin\alpha\cos\beta}{\cos BS\cos\alpha\cos\beta - \sin BS\sin\beta}\right]$$

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

B. Conversion of α, β to sinα', sinβ' where BS=Boresight angle.

$$\sin\alpha' = \sin\left(\text{Tan}^{-1}\left(\frac{\sin\alpha\cos\beta}{\cos BS\cos\alpha\cos\beta + \sin BS\sin\beta}\right)\right)$$

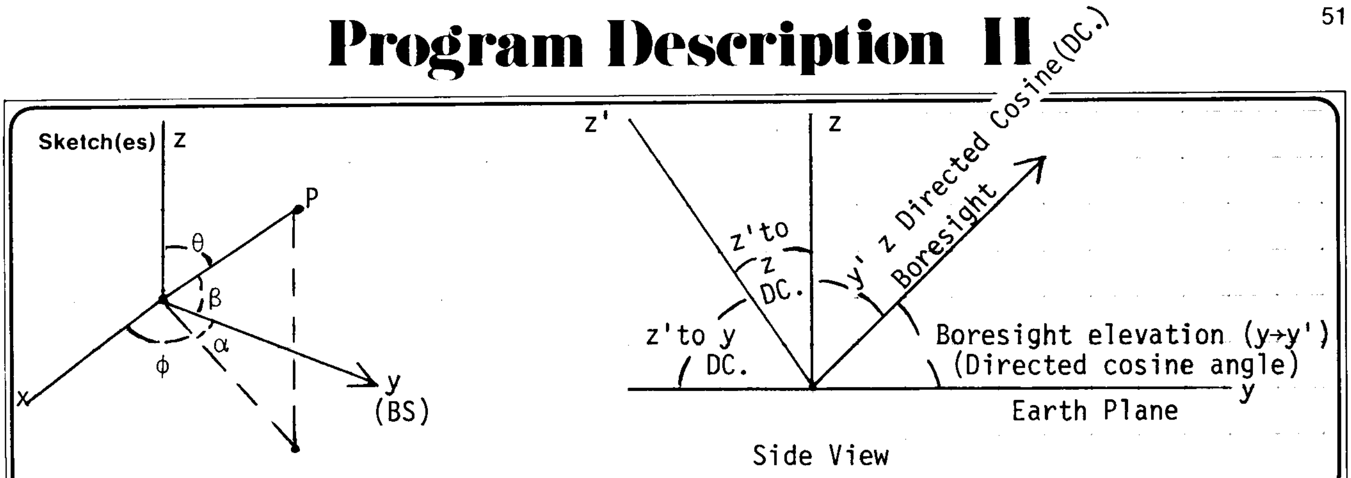
$$\sin\beta' = (\cos BS\sin\beta - \sin BS\cos\alpha\cos\beta)$$

Operating Limits and Warnings

Radar boresight (BS) elevation planes can be used within the following limits $0° \le BS° \le 90°$. 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.

Program Description II

Sketch(es)



Sample Problem(s)

1. Using a boresight angle of 45° with the earth plane, convert the following sin α & sin β beam positions to spherical coordinates (deg. dec.)(azimuth and elevation) in the tangent earth plane: a. sinα=-.7071, sinβ-.3; b. sinα=.707, sinβ=.3; c. sinα=.32, sinβ=.6; d. sinα=-.35, sinβ=-.5.

2. Using a boresight angle of 30° with the earth plane, convert the following beam positions (deg. dec.) in earth plane reference to sin α and sin β 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)

```
1.  45[f] [A]
    a.  .7071 [CHS] [↑] .3[CHS][A]---------------->-44.39° [R/S] ---->  15.36°
    b.  .707[↑]         .3[A]  -------------------> 68.56° [R/S] ---->  43.56°
    c.  .32 [↑]         .6[A]  -------------------> 66.43° [R/S] ---->  73.78°
    d.  .35   [CHS] [↑] .5[CHS][A]---------------->-18.1°  [R/S] ---->  12.71°
2.  30[f] [A]
    a.  50[↑] 50[B] ------------------------------>   .55  [R/S] ---->    .46
    b.  20[CHS] [↑] 10[B] ------------------------>  -.35  [R/S] ---->   -.31
    c.  45[CHS] [↑] 60[B] ------------------------>  -.43  [R/S] ---->    .57
    d.  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.

User Instructions

Planar Phased Array Radar Beam Positions

1 → Deg → Sin 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Enter boresight elevation	Deg. Dec.	f	A	
3.	Enter beam position Azimuth	Sin α	↑		
4.	Enter beam position elevation	Sin	A		Deg.(AZ)
5.	Press		R/S		
	(optional check)		RCL	8	
			g	x↔y	
			B		Sin α
			R/S		Sin β
	For new case go to 3. If Boresight is				
	changed, go to 2.				
	OR				
3.	Enter beam position Azimuth	Deg. Dec.	↑		
4.	Enter beam position Elevation	Deg. Dec.	B		Sin α
5.	Press		R/S		Sin β
	(Optional check		RCL	8	
			g	x↔y	
			B		Deg(AZ)
			R/S		Deg(EL)
	For new case go to 3. If Boresight changes				
	go to 2.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	Initialize
002	STO7	35 07	
003	RTN	24	
004	*LBLA	21 11	
005	STO1	35 01	
006	SIN^{-1}	16 41	
007	COS	42	
008	STO2	35 02	Lbl A
009	X⇄Y	-41	Housekeeping
010	STO3	35 03	
011	SIN^{-1}	16 41	
012	COS	42	
013	STO4	35 04	
014	GSBC	23 13	
015	x	-35	
016	X⇄Y	-41	
017	RCL1	36 01	Calculated display
018	x	-35	deg(AZ)
019	-	-45	
020	GSBD	23 14	
021	STO8	35 08	
022	R/S	51	
023	GSBE	23 15	Calculate &
024	+	-55	display deg(EL)
025	SIN^{-1}	16 41	
026	RTN	24	
027	*LBLB	21 12	
028	ENT↑	-21	
029	ENT↑	-21	
030	1	01	
031	x	-35	
032	SIN	41	
033	STO1	35 01	Lbl B
034	R↓	-31	Housekeeping
035	COS	42	
036	STO2	35 02	
037	R↓	-31	
038	SIN	41	
039	STO3	35 03	
040	R↓	-31	
041	COS	42	
042	STO4	35 04	
043	GSBC	23 13	
044	RCL2	36 02	
045	x	-35	
046	R↑	16-31	
047	RCL1	36 01	Calculate &
048	x	-35	display sin α
049	+	-55	
050	GSBD	23 14	
051	SIN	41	
052	STO8	35 08	
053	R/S	51	
054	GSBE	23 15	Calculate &
055	-	-45	display sin β
056	RTN	24	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	*LBLC	21 13	
058	RCL7	36 07	Common subroutine
059	COS	42	
060	STO5	35 05	
061	RCL7	36 07	
062	SIN	41	
063	STO6	35 06	
064	R↓	-31	
065	x	-35	
066	RTN	24	
067	*LBLD	21 14	
068	RCL2	36 02	Common subroutine
069	RCL3	36 03	
070	x	-35	
071	X⇄Y	-41	
072	÷	-24	
073	TAN^{-1}	16 43	
074	RTN	24	
075	*LBLE	21 15	
076	RCL5	36 05	
077	RCL1	36 01	Common subroutine
078	x	-35	
079	RCL6	36 06	
080	RCL4	36 04	
081	RCL2	36 02	
082	x	-35	
083	x	-35	
084	RTN	24	
090			
100			
110			

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG_2	☐
3	☐	☑			n ____	

REGISTERS

0	1	2	3	4	5	6	7	8	9
	Sin β	Cos β	Sin α	Cos α	Cos BS	Sin BS	BS (deg)	Deg (AZ)	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 - (π/180) degrees
2) Milradians = (π/0.18) degrees
3) Kilometers = 1.852 nautical miles
4) Meters = 0.3048 feet
5) Nautical miles = 1645 x 10^{-7} feet
6) Wavelength(m) = 299.79/frequency (MHz)
7) PRI (μsec) = 10^6/PRF
8) Distance light travels(m) - 299.79 x time (sec.)
9) Radar range (nm) = 0.08089 x time (sec.)
10) Nautical miles = 0.8686 statute miles

Operating Limits and Warnings

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

Program Description II

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.

User Instructions

◀1	F↔λ	PRF↔PRI	Light T/m	Radar T/Nm	Sm/Nm	2▶
	Deg/Rad	Deg/Milr	Nm/Km	Ft/m	Ft/Nm	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		E		
	Deg. to radians	Deg.	A		Radians
	Radians to deg.	Radians	R/S	A	Deg.
	Deg. to mil rad.	Deg	B		Mil Rad
	Mil rad to deg	Mil Rad	R/S	B	Deg.
	Nm to Km	Nm	C		Km
	Km to Nm	Km	R/S	C	Nm
	Ft to meters	Ft	D		M.
	Meters to Ft.	M	R/S	D	Ft.
	Ft. to Nm	Ft	E		Nm
	Nm to Ft.	Nm	R/S	E	Ft.
	Freq. to Wavelength	MHz	f	A	Meters
	Wavelength to Frequency	Meters	R/S	f	
			A		MHz
	PRF to PRI	PPS	f	B	µsec.
	PRI to PRF	µsec.	R/S	f	
			B		PPS
	Time to dis. LT. Trav.	µsec.	RTN	C	Meters
	Dis. LT. Trav. to Time	Meters	R/S	RTN	
			C		µsec.
	Time to Radar Range	µsec.	RTN	D	Nm
	Radar Range to Time	Nm	R/S	RTN	
			D		µsec.
	Statute M. to Nm	Sm	RTN	E	Nm
	Nm to statute M.	Nm	R/S	RTN	
			E		Sm
	NOTE: Once initialized conversions may be performed in any sequence desired.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBL0	21 00	Conversion Operation
002	F2?	16 23 02	Test for Reverse
003	1/X	52	
004	x	-35	
005	RTN	24	End of Conversion
006	SF2	16 21 02	Set for Reverse
007	R/S	51	
008	*LBLA	21 11	
009	Pi	16-24	
010	1	01	
011	8	08	Deg↔Rad.
012	0	00	
013	÷	-24	
014	GTO0	22 00	
015	*LBLB	21 12	
016	F2?	16 23 02	
017	SF1	16 21 01	
018	F1?	16 23 01	
019	SF2	16 21 02	Deg ↔ Mil Rad
020	EEX	-23	
021	3	03	
022	F1?	16 23 01	
023	1/X	52	
024	x	-35	
025	CF1	16 22 01	
026	GTOA	22 11	
027	*LBLC	21 13	
028	1	01	Nm ↔ Km
029	.	-62	
030	8	08	
031	5	05	
032	2	02	
033	GTO0	22 00	
034	*LBLD	21 14	
035	.	-62	
036	3	03	Ft ↔ Meters
037	0	00	
038	4	04	
039	8	08	
040	GTO0	22 00	
041	*LBLE	21 15	
042	1	01	
043	6	06	Ft ↔ Nm
044	4	04	
045	5	05	
046	EEX	-23	
047	CHS	-22	
048	7	07	
049	GTO0	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	
055	9	09	Time ↔ Dis. LT. Trav
056	9	09	
057	.	-62	
058	7	07	
059	9	09	
060	GTO0	22 00	
061	*LBLb	21 16 12	
062	CF2	16 22 02	PRF ↔ PRI
063	1/X	52	
064	EEX	-23	
065	6	06	
066	GTO0	22 00	
067	*LBLd	21 16 14	
068	.	-62	
069	0	00	Time ↔ Radar Range
070	8	08	
071	0	00	
072	8	08	
073	9	09	
074	GTO0	22 00	
075	*LBLe	21 16 15	
076	.	-62	Sm ↔ Nm
077	8	08	
078	6	06	
079	8	08	
080	6	06	
081	GTO0	22 00	
082	R/S	51	
090			
100			
110			

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

SET STATUS

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

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:

($2 \le N \le 4$) f= 6N + 45 ($5 \le N \le 6$) f= 6(N - 5) + 79

($7 \le N \le 13$) f= 6(N - 7) +177 ($14 \le N \le 83$) 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 ½ wave, ¼ 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

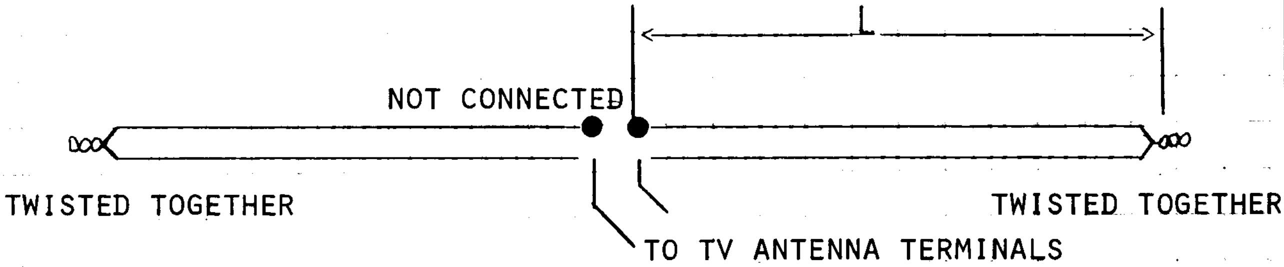
c = 299.8 meters per microsecond

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.

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

TV ANTENNA LENGTH

TV #	M→IN	IN → M	FREQ	MHz

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Input TV Channel	(2-83)	A		Meters
	or				
2a.	Input Frequency	MHz	E		Meters
3.	(Optional) If indicated length is too long for room, etc., determine next best length By: (Repeat 3 as necessary)		R/S		Meters
4.	(Optional) Convert (Meters) to inches		B		Inches
5.	(Optional) Convert (Inches) to meters		C		Meters
6.	(Optional) Recall Calculated TV Frequency (or input frequency)		D		MHz
	For new case go to step 2.				

LABELS

A CH#→MHz	B M→in	C in→M	D Freq.	E MHz→ANT
a	b	c	d	e
0 2-6	1 2-13	2 5-6	3 1/2	4
5	6	7	8	9

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	Input TV Channel
002	STO5	35 05	# → R_5
003	1	01	
004	3	03	
005	X⇄Y	-41	
006	X≤Y?	16-35	CH # – 13?
007	GTO1	22 01	Yes then go to 1
008	1	01	
009	4	04	
010	-	-45	
011	6	06	Calculates freq.
012	×	-35	of channel 14-83
013	4	04	using 6(N-14)+473
014	7	07	
015	3	03	
016	+	-55	
017	GTOE	22 15	
018	*LBL1	21 01	
019	6	06	Compute Length
020	RCL5	36 05	
021	X≤Y?	16-35	CH # ≤ 6?
022	GTO0	22 00	Yes, then go to 0
023	7	07	
024	-	-45	
025	6	06	Calculates freq.
026	×	-35	of channel 7-13
027	1	01	using 6(N-7)+177
028	7	07	
029	7	07	
030	+	-55	
031	GTOE	22 15	
032	*LBL0	21 00	
033	4	04	Is channel # 7 4
034	RCL5	36 05	If so go to 2
035	X>Y?	16-34	
036	GTO2	22 02	
037	6	06	
038	×	-35	Calculates freq.
039	4	04	of channel 2-4
040	5	05	using 6N+45
041	+	-55	
042	GTOE	22 15	
043	*LBL2	21 02	
044	5	05	Calculates freq.
045	-	-45	of CH 5-6 Using
046	6	06	6(N-5) + 79
047	×	-35	
048	7	07	
049	9	09	
050	+	-55	
051	*LBLE	21 15	
052	STO6	35 06	
053	1/X	52	
054	2	02	
055	9	09	
056	9	09	
057	.	-62	Freq. → R_6
058	8	08	Converts freq.
059	×	-35	to wave length
060	RTN	24	using $w = \frac{c}{f}$
061	*LBL3	21 03	
062	2	02	
063	÷	-24	
064	R/S	51	
065	GTO3	22 03	
066	*LBLB	21 12	1/2 wave length
067	.	-62	repeating
068	0	00	
069	2	02	
070	5	05	
071	4	04	
072	÷	-24	Converts from
073	RTN	24	meters → inches
074	*LBLC	21 13	
075	.	-62	
076	0	00	
077	2	02	
078	5	05	
079	4	04	
080	×	-35	Converts from
081	RTN	24	inches → meters
082	*LBLD	21 14	
083	RCL6	36 06	
084	RTN	24	Freq. in wave length calculation

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☑
1	☐	☑
2	☐	☑
3	☐	☑

TRIG	
DEG	☑
GRAD	☐
RAD	☐

DISP	
FIX	☑
SCI	☐
ENG	☐
n	2

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

NOTES

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