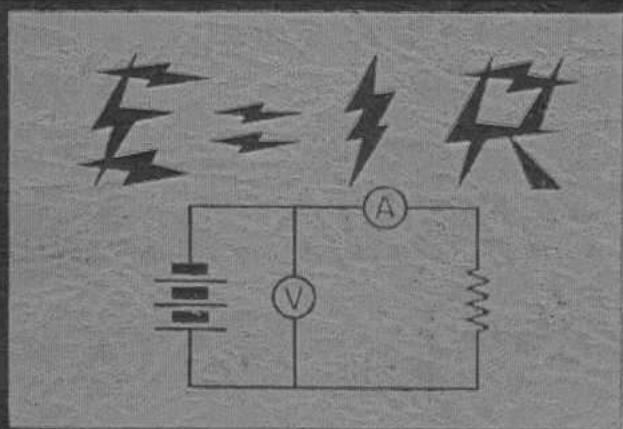


ALLIED'S ELECTRONICS DATA HANDBOOK

George V. Hahn



ALLIED RADIO CORPORATION
CHICAGO

ALLIED'S ELECTRONICS DATA HANDBOOK

Formerly Allied's Radio Data Handbook

A Compilation of Formulas and Data Most Commonly Used in the Field of Radio and Electronics

*Written and Compiled by the
Publications Division*
ALLIED RADIO CORPORATION
Under the Direction of
EUGENE CARRINGTON

Edited by
NELSON M. COOKE,
Lieutenant Commander, United States Navy (Ret.)
Senior Member, Institute of Radio Engineers Author, "Mathematics for Electricians and Radiomen".

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FOREWORD

Allied Radio Corporation has long recognized the need for a comprehensive and condensed handbook of formulas and data most commonly used in the field of radio and electronics. It was felt also that such a book should serve entirely as a convenient source of information and reference and that all attempts to teach or explain the basic principles involved should be left to classroom instruction and to the many already existing publications written for this distinct purpose.

The *Electronics Data Handbook*, therefore, consists of formulas, tables, charts and data. Every effort has been made to present this information clearly and to arrange it in a convenient manner for instant reference. All material was carefully selected and prepared by *Allied's* technical staff to serve the requirements of many specific groups in the radio and electronics field. It is hoped that our objectives have been successfully attained and that this *Handbook* will serve as: (1) A valuable adjunct to classroom study and laboratory work for the student and instructor; (2) A dependable source of information for the beginner, experimenter and set builder; (3) A reliable guide for the service engineer and maintenance man in his everyday work; (4) A time-saving and practical reference for the radio amateur, technician and engineer, both in the laboratory and in the field of operations.

The publishers are indebted to the McGraw-Hill Book Company, Inc., for their permission to use material selected from "*Mathematics for Electricians and Radiomen*" by Nelson M. Cooke. *Allied* also takes this opportunity to thank those manufacturers who so generously permitted our use of current data prepared by their engineering personnel. Special recognition and our sincere appreciation are extended to Commander Cooke for his helpful suggestions and generous contribution of his time and specialized knowledge in editing the material contained in this book.

ALLIED RADIO CORPORATION

TABLE OF CONTENTS

Fundamental Mathematical Data	4-5
Mathematical Constants	4
Mathematical Symbols	4
Decimal Parts of an Inch	4
Fundamental Algebraic Formulas	5
Decibel Tables, Attenuators and Matching Pads	5-10
Decibels, Fundamental Formulas	5
dB Expressed in Watts and Volts	5
Decibel-Voltage, Current and Power Ratio Table	6
Table of Values for Attenuator Network Formulas	7-8
Attenuator Network Formulas	8-9
Minimum Loss Pads	10
Most Used Radio and Electronic Formulas	11-25
70-Volt Loud-Speaker Matching Formulas	11
Resistance	12
Capacitance	12
Inductance	12-13
Reactance	13
Resonance	13
Frequency and Wavelength	13
"Q" Factor	14
Impedance	14-16
Conductance	17
Susceptance	17
Admittance	17
Transient <i>I</i> and <i>E</i> in <i>LCR</i> Circuits	18-19
Steady State Current Flow	19
Transmission Line Formulas	20
Capacity of a Vertical Antenna	20
Vacuum Tube Formulas and Symbols	21
R.M.S., Peak and Average Volts and Current	21
D-C Meter Formulas	22-23
Ohm's Law for A-C and D-C Circuits	24-25
Engineering and Servicing Data	26-55
R-F Coil Winding Formulas	26
Wire Table	27
R-F Coil Winding Data Chart	28
Inductance, Capacitance, Reactance Charts	29-32
How to Use Logarithms	33-35
Trigonometric Relationships	36
Metric Relationships	37
Pilot Lamp Data	38
Directly Interchangeable Tubes	39-42
Directly Interchangeable TV Picture Tubes	43-44
Interchangeable Batteries	45-46
RETMA and Military Color Codes for Resistors and Capacitors	47-50
RETMA Color Codes for Chassis Wiring	51-53
Schematic Symbols used in Radio Diagrams	54
Abbreviations and Letter Symbols	55
Log and Trig Tables	56-63
Four-Place Common Log Tables	56-57
Table of Natural Sines, Cosines and Tangents	58-63
Index	64

Mathematical Symbols

- × or · Multiplied by
- ÷ or : Divided by
- + Positive, Plus, Add
- Negative, Minus, Subtract
- ± Positive or negative, Plus or minus
- ±± Negative or positive, Minus or plus
- = or :: Equals
- ≡ Identity
- ≈ Is approximately equal to
- ≠ Does not equal
- > Is greater than
- ≫ Is much greater than
- < Is less than
- ≪ Is much less than
- ≥ Greater than or equal to
- ≤ Less than or equal to
- ∴ Therefore
- ∠ Angle
- Δ Increment or Decrement
- ⊥ Perpendicular to
- ∥ Parallel to
- |n| Absolute value of n

Decimal Inches

- Inches × 2.540 = Centimeters
- Inches × 1.578 × 10⁵ = Miles
- Inches × 10³ = Mils

Inches		Decimal Equivalent	Millimeter Equivalent
1/64		.0156	0.397
	1/32	.0313	0.794
3/64		.0469	1.191
		.0625	1.588
5/64		.0781	1.985
	3/32	.0938	2.381
7/64		.1094	2.778
		.1250	3.175
9/64		.1406	3.572
	5/32	.1563	3.969
11/64		.1719	4.366
		.1875	4.762
13/64		.2031	5.159
	7/32	.2188	5.556
15/64		.2344	5.953
		.2500	6.350
17/64		.2656	6.747
	9/32	.2813	7.144
19/64		.2969	7.541
		.3125	7.937
21/64		.3281	8.334
	11/32	.3438	8.731
23/64		.3594	9.128
		.3750	9.525
25/64		.3906	9.922
	13/32	.4063	10.319
27/64		.4219	10.716
		.4375	11.112
29/64		.4531	11.509
	15/32	.4688	11.906
31/64		.4844	12.303
		.5000	12.700
33/64		.5156	13.097
	17/32	.5313	13.494
35/64		.5469	13.891
		.5625	14.287
37/64		.5781	14.684
	19/32	.5938	15.081
39/64		.6094	15.478
		.6250	15.875
41/64		.6406	16.272
	21/32	.6563	16.669
43/64		.6719	17.067
		.6875	17.463
45/64		.7031	17.860
	23/32	.7188	18.258
47/64		.7344	18.655
		.7500	19.049
49/64		.7656	19.446
	25/32	.7813	19.842
51/64		.7969	20.239
		.8125	20.636
53/64		.8281	21.033
	27/32	.8438	21.430
55/64		.8594	21.827
		.8750	22.224
57/64		.8906	22.621
	29/32	.9063	23.018
59/64		.9219	23.415
		.9375	23.812
61/64		.9531	24.209
	31/32	.9688	24.606
63/64		.9844	25.004
		1.0000	25.400

Mathematical Constants

- π = 3.14
- 2π = 6.28
- (2π)² = 39.5
- 4π = 12.6
- π² = 9.87
- π/2 = 1.57
- 1/π = 0.318
- 1/2π = 0.159
- 1/π² = 0.101
- 1/√π = 0.564
- √π = 1.77
- √(π/2) = 1.25
- √2 = 1.41
- √3 = 1.73
- 1/√2 = 0.707
- 1/√3 = 0.577
- log π = 0.497
- log π/2 = 0.196
- log π² = 0.994
- log √π = 0.248

Algebra

Exponents and Radicals

$$a^x \times a^y = a^{(x+y)}, \quad \frac{a^x}{a^y} = a^{(x-y)},$$

$$(ab)^x = a^x b^x, \quad \left(\frac{a}{b}\right)^x = \frac{a^x}{b^x},$$

$$\sqrt[x]{\frac{a}{b}} = \frac{\sqrt[x]{a}}{\sqrt[x]{b}}, \quad a^{-x} = \frac{1}{a^x}$$

$$(a^x)^y = a^{xy}, \quad \sqrt[x]{\sqrt[y]{a}} = \sqrt[xy]{a},$$

$$\sqrt[x]{ab} = \sqrt[x]{a} \sqrt[x]{b}, \quad a^{\frac{1}{b}} = \sqrt[b]{a^1},$$

$$a^x = \sqrt[x]{a^x}, \quad a^0 = 1.$$

Solution of a Quadratic

Quadratic equations in the form

$$ax^2 + bx + c = 0$$

may be solved by the following:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Transposition of Terms

If $A = \frac{B}{C}$, then $B = AC$, $C = \frac{B}{A}$.

If $\frac{A}{B} = \frac{C}{D}$, then $A = \frac{BC}{D}$,

$$B = \frac{AD}{C}, \quad C = \frac{AD}{B}, \quad D = \frac{BC}{A}$$

If $A = \frac{1}{D\sqrt{BC}}$, then $A^2 = \frac{1}{D^2BC}$,

$$B = \frac{1}{D^2A^2C}, \quad C = \frac{1}{D^2A^2B}, \quad D = \frac{1}{A\sqrt{BC}}$$

If $A = \sqrt{B^2 + C^2}$, then $A^2 = B^2 + C^2$,

$$B = \sqrt{A^2 - C^2}, \quad C = \sqrt{A^2 - B^2}.$$

Decibels

The number of db by which two power outputs P_1 and P_2 (in watts) may differ, is expressed by

$$10 \log \frac{P_1}{P_2};$$

or in terms of volts,

$$20 \log \frac{E_1}{E_2};$$

or in current,

$$20 \log \frac{I_1}{I_2}.$$

While power ratios are independent of source and load impedance values, voltage and current ratios in these formulas hold true only when the source and load impedances Z_1 and Z_2 are equal. In circuits where these impedances differ, voltage and current ratios are expressed by,

$$db = 20 \log \frac{E_1 \sqrt{Z_2}}{E_2 \sqrt{Z_1}} \quad \text{or,} \quad 20 \log \frac{I_1 \sqrt{Z_1}}{I_2 \sqrt{Z_2}}$$

DB Expressed in Watts & Volts

DB	Above Zero Level		Below Zero Level	
	Watts	Volts	Watts	Volts
0	0.00500	1.73	6.00x10 ⁻³	1.73
1	0.00755	1.94	4.77x10 ⁻³	1.54
2	0.00951	2.18	3.78x10 ⁻³	1.38
3	0.0120	2.45	3.01x10 ⁻³	1.23
4	0.0151	2.74	2.39x10 ⁻³	1.09
5	0.0190	3.08	1.90x10 ⁻³	0.974
6	0.0239	3.46	1.51x10 ⁻³	0.868
7	0.0301	3.88	1.20x10 ⁻³	0.774
8	0.0378	4.35	9.51x10 ⁻⁴	0.690
9	0.0477	4.88	7.55x10 ⁻⁴	0.614
10	0.0600	5.48	6.00x10 ⁻⁴	0.548
11	0.0755	6.14	4.77x10 ⁻⁴	0.488
12	0.0951	6.90	3.78x10 ⁻⁴	0.435
13	0.120	7.74	3.01x10 ⁻⁴	0.388
14	0.151	8.68	2.39x10 ⁻⁴	0.346
15	0.190	9.74	1.90x10 ⁻⁴	0.308
16	0.239	10.93	1.51x10 ⁻⁴	0.275
17	0.301	12.26	1.20x10 ⁻⁴	0.245
18	0.378	13.76	9.51x10 ⁻⁵	0.218
19	0.477	15.44	7.55x10 ⁻⁵	0.191
20	0.600	17.32	6.00x10 ⁻⁵	0.173
25	1.90	30.8	1.90x10 ⁻⁶	0.0974
30	6.00	54.8	6.00x10 ⁻⁷	0.0548
35	19.0	97.4	1.90x10 ⁻⁸	0.0308
40	60.0	173	6.00x10 ⁻⁹	0.0173
45	190	308	1.90x10 ⁻¹⁰	0.00974
50	600	548	6.00x10 ⁻¹¹	0.00548
60	6,000	1,730	6.00x10 ⁻¹³	0.00173
70	60,000	5,480	6.00x10 ⁻¹⁵	0.000548
80	600,000	17,300	6.00x10 ⁻¹⁷	0.000173

*Zero db = 6 milliwatts into a 500 ohm load. Power ratios hold for any impedance, but voltages must be referred to an impedance load of 500 ohms.

Decibel—Voltage, Current and Power Ratio Table

-		DB	+		-		DB	+	
Voltage or Current Ratio	Power Ratio		Voltage or Current Ratio	Power Ratio	Voltage or Current Ratio	Power Ratio		Voltage or Current Ratio	Power Ratio
1.0000	1.0000	0	1.000	1.000	.4898	.2399	6.2	2.042	4.169
.9886	.9772	.1	1.012	1.023	.4842	.2344	6.3	2.065	4.266
.9772	.9550	.2	1.023	1.047	.4786	.2291	6.4	2.089	4.365
.9661	.9333	.3	1.035	1.072	.4732	.2239	6.5	2.113	4.467
.9550	.9120	.4	1.047	1.096	.4677	.2188	6.6	2.138	4.571
.9441	.8913	.5	1.059	1.122	.4624	.2138	6.7	2.163	4.677
.9333	.8710	.6	1.072	1.148	.4571	.2089	6.8	2.188	4.786
.9226	.8511	.7	1.084	1.175	.4519	.2042	6.9	2.213	4.898
.9120	.8318	.8	1.096	1.202	.4467	.1995	7.0	2.239	5.012
.9016	.8128	.9	1.109	1.230	.4416	.1950	7.1	2.265	5.129
.8913	.7943	1.0	1.122	1.259	.4365	.1905	7.2	2.291	5.248
.8810	.7762	1.1	1.135	1.288	.4315	.1862	7.3	2.317	5.370
.8710	.7586	1.2	1.148	1.318	.4266	.1820	7.4	2.344	5.495
.8610	.7413	1.3	1.161	1.349	.4217	.1778	7.5	2.371	5.623
.8511	.7244	1.4	1.175	1.380	.4169	.1738	7.6	2.399	5.754
.8414	.7079	1.5	1.189	1.413	.4121	.1698	7.7	2.427	5.888
.8318	.6918	1.6	1.202	1.445	.4074	.1660	7.8	2.455	6.026
.8222	.6761	1.7	1.216	1.479	.4027	.1622	7.9	2.483	6.166
.8128	.6607	1.8	1.230	1.514	.3981	.1585	8.0	2.512	6.310
.8035	.6457	1.9	1.245	1.549	.3936	.1549	8.1	2.541	6.457
.7943	.6310	2.0	1.259	1.585	.3890	.1514	8.2	2.570	6.607
.7852	.6166	2.1	1.274	1.622	.3846	.1479	8.3	2.600	6.761
.7762	.6026	2.2	1.288	1.660	.3802	.1445	8.4	2.630	6.918
.7674	.5888	2.3	1.303	1.698	.3758	.1413	8.5	2.661	7.079
.7586	.5754	2.4	1.318	1.738	.3715	.1380	8.6	2.692	7.244
.7499	.5623	2.5	1.334	1.778	.3673	.1349	8.7	2.723	7.413
.7413	.5495	2.6	1.349	1.820	.3631	.1318	8.8	2.754	7.586
.7328	.5370	2.7	1.365	1.862	.3589	.1288	8.9	2.786	7.762
.7244	.5248	2.8	1.380	1.905	.3548	.1259	9.0	2.818	7.943
.7161	.5129	2.9	1.396	1.950	.3508	.1230	9.1	2.851	8.128
.7079	.5012	3.0	1.413	1.995	.3467	.1202	9.2	2.884	8.318
.6998	.4898	3.1	1.429	2.042	.3428	.1175	9.3	2.917	8.511
.6918	.4786	3.2	1.445	2.089	.3388	.1148	9.4	2.951	8.710
.6839	.4677	3.3	1.462	2.138	.3350	.1122	9.5	2.985	8.913
.6761	.4571	3.4	1.479	2.188	.3311	.1096	9.6	3.020	9.120
.6683	.4467	3.5	1.496	2.239	.3273	.1072	9.7	3.055	9.333
.6607	.4365	3.6	1.514	2.291	.3236	.1047	9.8	3.090	9.550
.6531	.4266	3.7	1.531	2.344	.3199	.1023	9.9	3.126	9.772
.6457	.4169	3.8	1.549	2.399	.3162	.1000	10.0	3.162	10.000
.6383	.4074	3.9	1.567	2.455	.2985	.08913	10.5	3.350	11.22
.6310	.3981	4.0	1.585	2.512	.2818	.07943	11.0	3.548	12.59
.6237	.3890	4.1	1.603	2.570	.2661	.07079	11.5	3.758	14.13
.6166	.3802	4.2	1.622	2.630	.2512	.06310	12.0	3.981	15.85
.6095	.3715	4.3	1.641	2.692	.2371	.05623	12.5	4.217	17.78
.6026	.3631	4.4	1.660	2.754	.2239	.05012	13.0	4.467	19.95
.5957	.3548	4.5	1.679	2.818	.2113	.04467	13.5	4.732	22.39
.5888	.3467	4.6	1.698	2.884	.1995	.03981	14.0	5.012	25.12
.5821	.3388	4.7	1.718	2.951	.1884	.03548	14.5	5.309	28.18
.5754	.3311	4.8	1.738	3.020	.1778	.03162	15.0	5.623	31.62
.5689	.3236	4.9	1.758	3.090	.1585	.02512	16.0	6.310	39.81
.5623	.3162	5.0	1.778	3.162	.1413	.01995	17.0	7.079	50.12
.5559	.3090	5.1	1.799	3.236	.1259	.01585	18.0	7.943	63.10
.5495	.3020	5.2	1.820	3.311	.1122	.01259	19.0	8.913	79.43
.5433	.2951	5.3	1.841	3.388	.1000	.01000	20.0	10.000	100.00
.5370	.2884	5.4	1.862	3.467	.03162	.00100	30.0	31.620	1,000.00
.5309	.2818	5.5	1.884	3.548	.01	.00010	40.0	100.00	10,000.00
.5248	.2754	5.6	1.905	3.631	.003162	.00001	50.0	316.20	10 ⁵
.5188	.2692	5.7	1.928	3.715	.001	10 ⁻⁴	60.0	1,000.00	10 ⁶
.5129	.2630	5.8	1.950	3.802	.0003162	10 ⁻⁷	70.0	3,162.00	10 ⁷
.5070	.2570	5.9	1.972	3.890	.0001	10 ⁻¹	80.0	10,000.00	10 ⁸
.5012	.2512	6.0	1.995	3.931	.00003162	10 ⁻⁹	90.0	31,620.00	10 ⁹
.4955	.2455	6.1	2.018	4.074	10 ⁻⁵	10 ⁻¹⁰	100.0	10 ²	10 ¹⁰

Table of Values for Attenuator Network Formulas

db	A	B	C	D	E	db	A	B	C	D	E
-1	98855	011447	86.360	.005756	86.857	27.0	.044668	.95533	.046757	.91448	.089515
-2	97724	022763	42.931	.011512	43.426	27.5	.042170	.95783	.044026	.91907	.084490
.25	97163	028372	34.247	.014390	34.739	28.0	.039811	.96019	.041461	.92343	.079748
.3	96605	.034046	28.456	.017268	28.947	30.0	.031623	.96838	.032655	.93869	.063309
.4	95499	.045008	21.219	.023022	21.707	32.0	.025119	.97488	.025766	.95069	.050269
.5	94406	.055939	16.876	.028774	17.362	32.5	.023114	.97629	.024290	.94754	.047454
.6	93325	.066745	13.982	.034525	14.428	33.0	.022287	.97761	.022900	.94521	.044797
.7	92257	.077429	11.915	.040274	12.395	34.0	.019953	.98005	.020359	.94088	.039921
.75	91728	.082724	11.088	.043147	11.567	35.0	.017783	.98222	.018105	.93506	.035577
.8	91201	.087989	10.365	.046019	10.842	36.0	.015949	.98415	.016104	.92880	.031706
.9	90157	.094829	9.1596	.051762	9.6337	37.5	.013335	.98666	.013515	.92368	.026675
1.0	89125	0.10875	8.1955	.057501	8.6667	38.0	.012589	.98741	.012750	.91833	.025183
1.5	84140	0.15860	5.3050	.086133	5.7619	39.0	.011220	.98878	.011348	.91243	.022443
2.0	79433	0.20567	3.8621	.11462	4.3048	40.0	.010000	.99000	.010101	.90620	.020002
2.5	74989	.25011	2.9863	.14293	3.4268	42.0	.0079433	.99206	.0080069	.89824	.015888
3.0	70795	.29205	2.4240	.17100	2.8385	42.5	.0074989	.99250	.0075556	.89511	.014999
3.5	66834	.33166	2.0152	.19879	2.4158	44.0	.0063096	.99369	.0063496	.88746	.012620
4.0	63096	.36904	1.7097	.22627	2.0966	45.0	.0056234	.99438	.0056552	.88282	.011247
4.5	59566	.40434	1.4732	.25340	1.8465	45.5	.0042170	.99578	.0042348	.87841	.0084341
5.0	56234	.43766	1.2849	.28013	1.6448	48.0	.0039811	.99602	.0039970	.87073	.0079623
6.0	50119	.49881	1.0048	.33228	1.3386	50.0	.0031623	.99684	.0031723	.863246	.0065246
7.0	44668	.55332	.80728	.38247	1.1160	51.0	.0028184	.99718	.0028264	.85438	.0056368
7.5	42170	.57830	.72920	.40677	1.0258	52.0	.0025119	.99749	.0025182	.84999	.0050238
8.0	39811	.60189	.66143	.43051	.94617	54.0	.0019953	.99800	.0019993	.84502	.0039905
9.0	35481	.64519	.54994	.46183	.81183	55.0	.0017893	.99822	.0017815	.84045	.0035566
10.0	31623	.68377	.46248	.51949	.70273	56.0	.0015849	.99842	.0015874	.83584	.0031698
11.0	28184	.71816	.39244	.56026	.61231	57.0	.0014125	.99859	.0014145	.83118	.0028291
12.0	25119	.74891	.33545	.59848	.53521	60.0	.0010000	.99900	.00100100	.82200	.0020000
12.5	23174	.76286	31085	.61664	.50253	64.0	.00063096	.99937	.00063136	.81619	.0012619
13.0	22387	.77613	28845	.63416	.47137	65.0	.00056234	.99944	.00056266	.81127	.0011247
14.0	19953	.80047	24926	.66732	.41560	66.0	.00050119	.99950	.00050144	.80624	.0010024
15.0	17783	.82217	.21629	.69804	.36727	68.0	.00039811	.99960	.00039827	.80120	.0007962
16.0	15849	.84131	.18834	.72639	.32515	70.0	.00031623	.99968	.00031633	.79625	.0006325
17.0	14125	.85875	.16449	.75246	.28826	72.0	.00025119	.99975	.00025125	.79129	.0005024
17.5	13335	.86665	.15387	.76468	.27153	75.0	.00017783	.99982	.00017786	.78633	.0003557
18.0	12589	.87411	.14402	.77637	.25584	76.0	.00015849	.99984	.00015851	.78137	.0003170
19.0	11220	.88780	.12638	.79823	.22726	78.0	.00012589	.99987	.00012591	.77641	.0002518
20.0	100000	.90000	.111111	.81818	.20202	80.0	.00010000	.99990	.00010000	.77145	.0002000
21.0	089125	.91087	.097846	.83634	.17968	84.0	.00006310	.99994	.00006310	.76649	.0001262
22.0	079439	.92057	.086287	.85282	.15987	85.0	.00005623	.99994	.00005624	.76154	.0001125
22.5	074989	.92501	.081069	.86048	.15083	90.0	.00003162	.99997	.00003162	.75659	.00006325
24.0	063096	.93690	.067345	.88130	.12670	95.0	.00001778	.99998	.00001778	.75164	.00003557
25.0	056234	.94377	.059585	.89352	.11283	96.0	.00001585	.99998	.00001585	.74669	.00003170
26.0	050119	.94988	.052763	.90455	.10049	100.0	.00001000	.99999	.00001000	.74174	.00002000

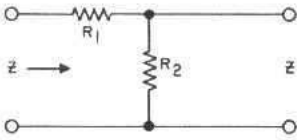
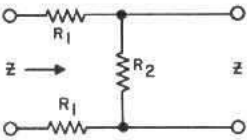
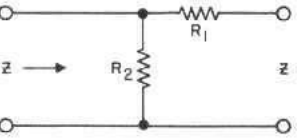
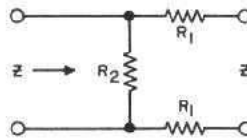
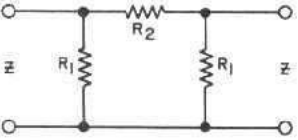
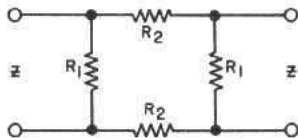
Attenuator Networks

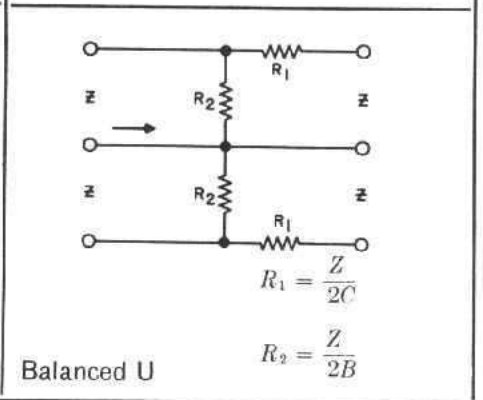
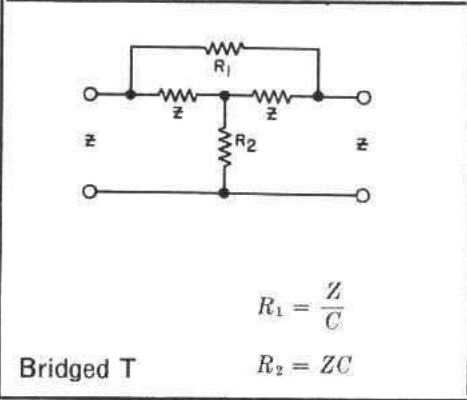
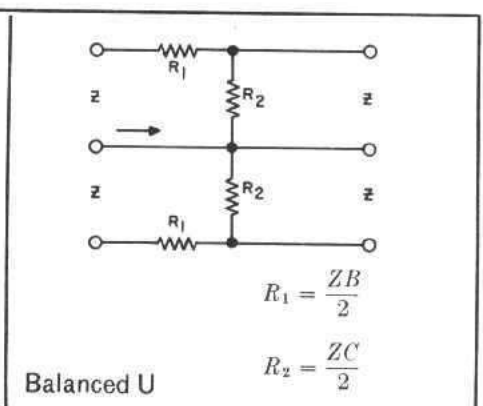
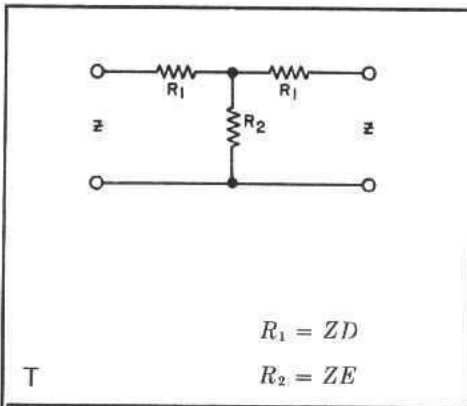
For Insertion Between Equal Impedances

For data covering networks between unequal impedances, see Minimum Loss Pads on page 10. See also Decibel—Voltage Current and Power Ratio Table on page 6.

See table on page 7 for values of A, B, C, D, E used in the following attenuator network formulas.

In the case of L and U networks where only the input or output can be matched, as required, the matched side is indicated by an arrow pointing toward the pad. On all other networks, both the input and output circuits are matched.

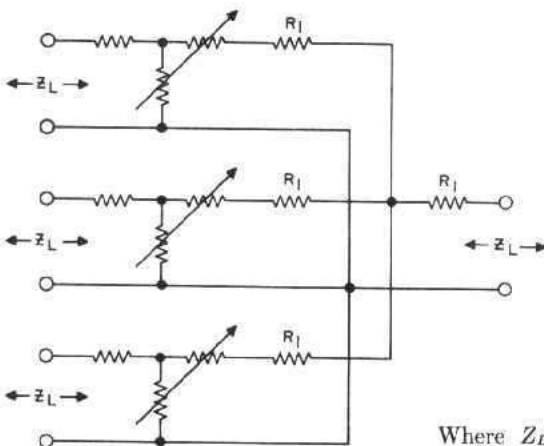
 <p style="text-align: center;">$R_1 = ZB$ $R_2 = ZC$</p> <p>L</p>	 <p style="text-align: center;">$R_1 = \frac{ZB}{2}$ $R_2 = ZC$</p> <p>U</p>
 <p style="text-align: center;">$R_1 = \frac{Z}{C}$ $R_2 = \frac{Z}{B}$</p> <p>L</p>	 <p style="text-align: center;">$R_1 = \frac{Z}{2C}$ $R_2 = \frac{Z}{B}$</p> <p>U</p>
 <p style="text-align: center;">$R_1 = \frac{Z}{D}$ $R_2 = \frac{Z}{E}$</p> <p>π</p>	 <p style="text-align: center;">$R_1 = \frac{Z}{D}$ $R_2 = \frac{Z}{2E}$</p> <p>O</p>



Constant Impedance Attenuators in Parallel

Table of R_1 Values in Ohms

Z	Number of Channels				
	2	3	4	5	6
30	10	15	18	20	21.5
50	16.6	25	30	33.3	35.7
150	50	75	90	100	107
200	66.6	100	120	133	143
250	83.3	125	150	166	179
500	166	250	300	333	357
600	200	300	360	400	428
Network db Loss	6	9.5	12	14	15.5



$$R_1 = Z_L \left(\frac{N-1}{N+1} \right) \quad \left| \quad \begin{array}{l} \text{Insertion loss} \\ \text{in db} = 20 \log_{10} N \end{array} \right.$$

Where Z_L = identical line and load impedances;
and N = number of channels in parallel.