ALLIED'S RADIO-FORMULA AND DATA BOOK

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

ALLIED RADIO CORPORATION
CHICAGO

FOREWORD

ALLIED RADIO CORPORATION offers this publication to fill a long standing need for a convenient collection of radio formulas and data in handy, pocket-size form. Students of radio and electronics and engineers and technicians actively engaged in the field will find this booklet extremely helpful in their everyday work.

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 extends sincere appreciation to Lieutenant Nelson M. Cooke, U. S. Navy, for generous contribution of his time and specialized knowledge in editing the material contained in this booklet as well as for his many helpful suggestions.

★ *Any opinions or assertions contained herein are those of the publisher and are not to be construed as official or reflecting the view of the Navy Department or the naval service at large.*

CONTENTS

ALLIED'S RADIO FORMULAS AND DATA BOOK

A Condensed Compilation of Essential Mathematical Formulas, Tables, Data, and Standards Commonly Used in the Field of Radio and Electronics.

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Compiled under the direction of the Technical Staff of ALLIED RADIO CORPORATION.

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Edited by NELSON M. COOKE
Lieutenant, U. S. N., Naval Reasearch Laboratory, Washington, D. C.
Member, Institute of Radio Engineers.
Author, "Mathematics for Electricians and Radiomen."

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FUNDAMENTAL ALGEBRAIC FORMULAS

Exponents and Radicals

$a^x \times a^y = a^{(x+y)}$. $\frac{a^x}{a^y} = a^{(x-y)}$. $(a^x)^y = a^{xy}$. $\sqrt[x]{\sqrt[y]{a}} = \sqrt[xy]{a}$.

$(ab)^x = a^x b^x$. $\left(\frac{a}{b}\right)^x = \frac{a^x}{b^x}$. $\sqrt[x]{ab} = \sqrt[x]{a}\sqrt[x]{b}$.

$\sqrt[x]{\frac{a}{b}} = \frac{\sqrt[x]{a}}{\sqrt[x]{b}}$. $a^0 = 1$. $a^{-x} = \frac{1}{a^x}$. $a^{\frac{1}{x}} = \sqrt[x]{a}$. $a^{\frac{x}{y}} = \sqrt[y]{a^x}$.

Solution of a Quadratic Equation

Quadratic equations in the form $ax^2 + bx + c = 0$ may be solved by use of the following formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

MISCELLANEOUS FORMULAS

The capacity of a vertical antenna, shorter than one-quarter wave length at its operating frequency, may be computed by the equation

$$C_a = \frac{17l}{\left[\left(\log_\epsilon \frac{24l}{d}\right) - 1\right]\left[1 - \left(\frac{fl}{246}\right)^2\right]}$$

where C_a = capacity of antenna in micromicrofarads,
l = height of antenna in feet,
d = diameter of antenna conductor in inches,
f = operating frequency in megacycles.

In a capacitive circuit, the equation for the current is $i = \frac{E}{R}\,\epsilon^{-\frac{t}{RC}}$

where i = current in amperes t seconds after the voltage is impressed,
E = impressed voltage in volts,
C = capacity of the circuit in farads,
R = resistance of the circuit in ohms,
ϵ = base of the natural system of logarithms (2.718).

Miscellaneous Formulas—continued

In an inductive circuit, the equation for the growth of current is given by

$$i = \frac{E}{R}\left(1 - \epsilon^{-\frac{Rt}{L}}\right)$$

where i = current in amperes t seconds after the voltage is impressed,

E = impressed voltage in volts,

L = inductance of the circuit in henrys,

R = resistance of the circuit in ohms,

ϵ = base of the natural system of logarithms (2.718).

The inductance of a single-layer-wound air-core coil is given by the equation

$$L = \frac{(rN)^2}{9r + 10l}$$

where N = number of turns,

r = radius of coil form in inches,

l = length of winding in inches,

L = inductance in microhenrys.

Miscellaneous Formulas (continued)

Ohms Law for AC Circuits

$$I = \frac{E}{Z}, \quad Z = \frac{E}{I}, \quad E = ZI, \quad W = IE \cos \theta.$$

where I = current in amperes,
Z = impedance in ohms,
E = r.m.s. volts.
W = power in watts,
θ = phase angle.

Resistances in Series

$$R_X = R_1 + R_2 + R_3 \ldots \text{etc.}$$

where R_X = total value of resistances in series.

Resistance in Parallel

$$R_X = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots \text{etc.}},$$

or where only two resistors are used, $= \dfrac{R_1 \times R_2}{R_1 + R_2}$

where R_X = effective value of resistances in parallel.

Capacities in Series

$$C_X = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots \text{etc.}}$$

where C_X = effective value of capacities in series.

Miscellaneous Formulas (continued)

Condensers in Parallel

$$C_X = C_1 + C_2 + C_3 \ . \ . \ . \ \text{etc.}$$

where C_X = total value of capacities in parallel.

Capacitive Reactance (In Ohms)

$$X_C = \frac{1}{2\pi f C}$$

where $2\pi = 6.28$,

f = frequency in cycles per second,

C = capacity in farads.

Inductive Reactance (In Ohms)

$$X_L = 2\pi f L$$

where $2\pi = 6.28$,

f = frequency in cycles per second,

L = inductance in henries.

Impedance (In Ohms)

(Of a Resistance and Reactance in Series)

$$Z = \sqrt{R^2 + X^2}$$

(Of a Resistance and Reactance in Parallel)

$$Z = \frac{RX}{\sqrt{R^2 + X^2}}$$

Miscellaneous Formulas (continued)

(Of an Inductance, Resistance and Capacity in Series)

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

(Of an Inductance, Resistance and Capacity in Parallel)

$$Z = \frac{RX_L X_C}{\sqrt{(RX_L - RX_C)^2 + (X_L X_C)^2}}$$

where R = resistance in ohms,
X = reactance in ohms,
X_C = reactance of capacity in ohms,
X_L = reactance of inductance in ohms.

Frequency (In Megacycles)

$$f_r = \frac{159}{\sqrt{LC}}$$

L = inductance in microhenries,
C = capacity in micromicrofarads.

Wavelength from Frequency

$$\lambda = \frac{3 \times 10^5}{f} \text{ (meters)}$$

where f = frequency in kilocycles.

$$\lambda = \frac{3 \times 10^4}{f} \text{ (centimeters)}$$

where f = frequency in megacycles.

FORMULAS FOR CONCENTRIC TRANSMISSION LINES

The characteristic impedance in ohms, of a concentric transmission line is

$$Z_o = 138 \log \frac{d_1}{d_2}$$

where d_1 is the inside diameter of the outer conductor, and d_2 is the outside diameter of the inner conductor. d_1 and d_2 must be expressed *in the same units.*

The radio frequency resistance r, in ohms per foot, of a copper concentric transmission line is

$$r = \sqrt{f}\left(\frac{1}{d_1} + \frac{1}{d_2}\right) \times 10^{-3}$$

where f is the frequency in megacycles.

The attenuation in decibels per foot of *line*, for a concentric transmission line is

$$\alpha = \frac{4.6\sqrt{f}\,(d_1 + d_2)}{d_1 d_2 \log \frac{d_1}{d_2}} \times 10^{-6}$$

where d_1 and d_2 are in inches, and f is the frequency in megacycles.

FORMULAS FOR TWO-WIRE OPEN-AIR TRANSMISSION LINES

The characteristic impedance of a two-wire open-air transmission line is given by

$$Z_o = 276 \log \frac{2D}{d} \text{ ohms}$$

where D is the spacing between wire centers, and d is the dia. of the conductors *in the same units as D.*

The inductance L, in microhenrys per foot, of a two-wire open-air transmission line is

$$L = 0.281 \log \frac{2D}{d}$$

The capacity C, in micromicrofarads per foot, of a two-wire open-air transmission line is

$$C = \frac{3.68}{\log \frac{2D}{d}}$$

The attenuation in decibels per foot of *wire* for a two-wire open-air transmission line is

$$\text{db} = \frac{0.0157\ R_f}{\log \frac{2D}{d}}$$

where R_f is the r.f. resistance per loop-foot of *wire.*

VACUUM TUBE CONSTANTS

$$\text{Amplification factor } (Mu \text{ or } \mu) = \frac{\text{Change in plate voltage } (E_p)}{\text{Change in grid voltage } (E_c)}$$

$$\text{Dynamic plate resistance in ohms } (r_p) = \frac{\text{Change in plate voltage } (E_p)}{\text{Change in plate current } (I_p)}$$

$$\text{Mutual conductance in mhos } (gm) = \frac{\text{Change in plate current } (I_p)}{\text{Change in grid voltage } (E_c)}$$

VACUUM TUBE SYMBOLS

Mu or μ = Amplification factor
r_p = Dynamic plate resistance
g_m = Mutual conductance
E_p = Plate voltage
E_c = Grid voltage
I_p = Plate current
R_l = Plate load resistance
I_k = Total cathode current
E_s = Signal voltage

VACUUM TUBE FORMULAS

Gain per stage $= \mu\left(\frac{R_l}{R_l + r_p}\right)$

Voltage output $= \mu\left(\frac{E_s R_l}{r_p + R_l}\right)$

Power output $= R_l\left(\frac{\mu E_s}{r_p + R_l}\right)^2$

Maximum power output $= \frac{(\mu E_s)^2}{4 r_p}$

Maximum undistorted power output $= \frac{2(\mu E_s)^2}{9 r_p}$

Required cathode resistor value in ohms, for a single tube $= \frac{E_g}{I_k}$

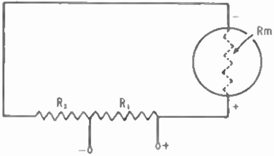
DC-METER FORMULAS

Ohms Per Volt

$$\Omega/V = \frac{1}{I_{fs}}$$

Ω/V = Ohms per volt.
I_{fs} = Current in amps. required for full scale reading.

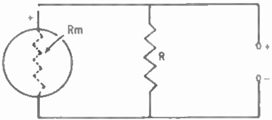
Universal Current Shunt



$$R_1 = \frac{(R_1 + R_2) + Rm}{K}$$

$R_1 + R_2$ = Total resistance required for the lowest shunted current range wanted.
Rm = Meter resistance.
K = Multiplying factor.

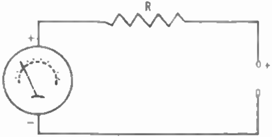
Fixed Current Shunt*



$$R = \frac{Rm}{K-1}$$

Rm = Meter resistance.
K = Multiplying factor (full scale).
R = Shunt resistance.

Voltage Multiplier*

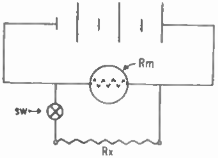


$$R = \frac{E_{fs}}{I_{fs}}$$

E_{fs} = Full scale volts desired.
I_{fs} = Full scale current of meter in amps.
R = Multiplier resistance.

*See table of shunt and multiplier values on page 15.

Formula for Measuring Unknown Resistance with Milliammeter and Battery.*

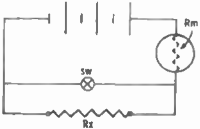


$$Rx = Rm \left(\frac{I_2}{I_1 - I_2} \right)$$

Rx = Unknown resistance.
Rm = Meter resistance.
I_1 = Current reading with switch open.
I_2 = Current reading with switch closed.
sw = SPST switch.

*A current limiting resistor (not shown) should be connected in series with battery.

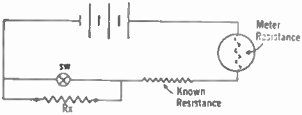
Formula for Measuring Unknown Resistance with Voltmeter and Battery.



$$Rx = Rm \left(\frac{E_1}{E_2} - 1 \right)$$

Rx = Unknown resistance.
Rm = Meter resistance.
E_1 = Voltmeter reading with switch closed.
E_2 = Voltmeter reading with switch open.
sw = SPST switch.

Formula for Measuring Unknown Resistor with Milliammeter, Battery and Known Resistor.



$$Rx = Ry\left(\frac{I_1 - I_2}{I_2}\right)$$

Rx = Unknown resistance.

Ry = Known resistance plus meter resistance.

I_1 = Current reading with switch closed.

I_2 = Current reading with switch open.

sw = SPST switch.

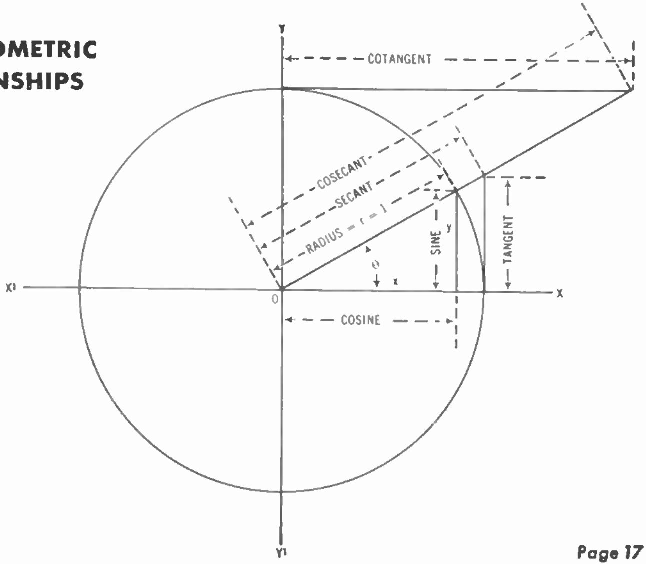
Shunt and Multiplier Values for 27 ohm (0-1) Milliammeter

Current Scale	Shunt Resistance	Voltage Scale	Multiplier Resistance
0-10 Mills	3.0 Ohms	0-10 Volts	10,000 Ohms
0-50 Mills	0.551 Ohms	0 50 Volts	50,000 Ohms
0-100 Mills	0.272 Ohms	0-100 Volts	100,000 Ohms
0-500 Mills	0.0541 Ohms	0-250 Volts	250,000 Ohms
		0-500 Volts	500,000 Ohms
		0-1,000 Volts	1,000,000 Ohms

BARE COPPER WIRE TABLE

B & S Gauge No.	Diam. in Mils	Area Circular Mils	Ohms per 1,000 Ft. 25°C, 77°F.	Approx. Pounds per 1,000 Ft.
1	289.3	83,690.0	0.1264	253
2	257.6	66,370.0	0.1593	201
3	229.4	52,640.0	0.2009	159
4	204.3	41,740.0	0.2533	126
5	181.9	33,100.0	0.3195	100
6	162.0	26,250.0	0.4028	79
7	144.3	20,820.0	0.5080	63
8	128.5	16,510.0	0.6405	50
9	114.4	13,090.0	0.8077	40
10	101.9	10,380.0	1.018	31
11	90.74	8,234.0	1.284	25
12	80.81	6,530.0	1.619	20
13	71.96	5,178.0	2.042	15.7
14	64.08	4,107.0	2.575	12.4
15	57.07	3,257.0	3.247	9.8
16	50.82	2,583.0	4.094	7.8
17	45.26	2,048.0	5.163	6.2
18	40.30	1,624.0	6.510	4.9
19	35.89	1,288.0	8.210	3.9
20	31.96	1,022.0	10.35	3.1
21	28.46	810.1	13.05	2.5
22	25.35	642.4	16.46	1.9
23	22.57	509.5	20.76	1.5
24	20.10	404.0	26.17	1.2
25	17.90	320.4	33.00	0.97
26	15.94	254.1	41.62	0.77
27	14.20	201.5	52.48	0.61
28	12.64	159.8	66.17	0.48
29	11.26	126.7	83.44	0.38
30	10.03	100.5	105.2	0.30
31	8.93	79.70	132.7	0.24
32	7.95	63.21	167.3	0.19
33	7.08	50.13	211.0	0.15
34	6.31	39.75	266.0	0.12
35	5.62	31.52	335.5	0.095
36	5.00	25.00	423.0	0.076
37	4.45	19.83	533.4	0.060
38	3.96	15.72	672.6	0.048
39	3.53	12.47	848.1	0.038
40	3.14	9.89	1,069.0	0.030
41	2.80	7.84	1,323.0	0.0229
42	2.50	6.22	1,667.0	0.0189
43	2.22	4.93	2,105.0	0.0153
44	1.98	3.91	2,655.0	0.0121

TRIGONOMETRIC RELATIONSHIPS



TRIGONOMETRIC FUNCTIONS

$$\text{Sine of } \theta = \sin\theta = \frac{\text{Side opposite } \theta}{\text{Hypotenuse}} = \frac{y}{r}$$

$$\text{Cosine of } \theta = \cos\theta = \frac{\text{Side adjacent } \theta}{\text{Hypotenuse}} = \frac{x}{r}$$

$$\text{Tangent of } \theta = \tan\theta = \frac{\text{Side opposite } \theta}{\text{Side adjacent } \theta} = \frac{y}{x}$$

$$\text{Cotangent of } \theta = \cot\theta = \frac{\text{Side adjacent } \theta}{\text{Side opposite } \theta} = \frac{x}{y}$$

$$\text{Secant of } \theta = \sec\theta = \frac{\text{Hypotenuse}}{\text{Side adjacent } \theta} = \frac{r}{x}$$

$$\text{Cosecant of } \theta = \csc\theta = \frac{\text{Hypotenuse}}{\text{Side opposite } \theta} = \frac{r}{y}$$

FORMULAS FOR THE TRIGONOMETRIC SOLUTION OF A RIGHT TRIANGLE

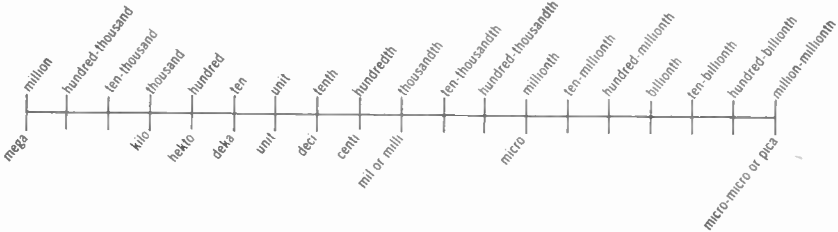
See diagram of Trigonometric Relationships on page 17.

Length of side opposite θ =
- Hypotenuse $\times$ sine $\theta = r \cdot \sin \theta$
- Side adjacent θ $\times$ tangent $\theta = x \cdot \tan \theta$

Length of side adjacent θ =
- Hypotenuse $\times$ cosine $\theta = r \cdot \cos \theta$
- Side opposite θ $\div$ tangent $\theta = \dfrac{y}{\tan \theta}$

Length of hypotenuse =
- Side opposite θ $\div$ sine $\theta = \dfrac{y}{\sin \theta}$
- Side adjacent θ $\div$ cosine $\theta = \dfrac{x}{\cos \theta}$

METRIC RELATIONSHIPS



The chart above shows the relationship between our American system of numbering and the most used metric equivalents. The number of steps to the left or right, between two metric prefixes being compared, is the same as the number of places and direction the decimal point would be moved, in converting a figure from the terms of one, to the terms of the other. See Metric Conversion Chart on page 21.

METRIC CONVERSION CHART

From ↓ To →	Mega	Kilo	Units	Deci	Centi	Milli	Micro	Micromicro
Mega		3 →	6 →	7 →	8 →	9 →	12 →	18 →
Kilo	← 3		3 →	4 →	5 →	6 →	9 →	15 →
Units	← 6	← 3		1 →	2 →	3 →	6 →	12 →
Deci	← 7	← 4	← 1		1 →	2 →	5 →	11 →
Centi	← 8	← 5	← 2	← 1		1 →	4 →	10 →
Milli	← 9	← 6	← 3	← 2	← 1		3 →	9 →
Micro	← 12	← 9	← 6	← 5	← 4	← 3		6 →
Micromicro	← 18	← 15	← 12	← 11	← 10	← 9	← 6	

The figures and arrows indicate the number of places and the direction in which the decimal point moves. The boxes marked *Units* represent fundamental terms of measure such as amperes, volts, watts, cycles, etc. The chart reads only one way; from left to right as indicated in the upper left hand corner.

Example: Convert 0.15 amperes to milliamperes. First find *Units* box in the left-hand column. Then follow this line across until you come to the box directly under the word *Milli*. Read 3 →, which indicates decimal is to be moved three places to the right. 0.15 amperes therefore is the equivalent of 150 milliamperes.

Example: To convert kilocycles to megacycles, read on the line level with *Kilo*, and under *Mega*, the figure ←3. 50,000 kilocycles therefore would become 50 megacycles. Conversely, in converting from megacycles to kilocycles, read on a level with *Mega*, and under *Kilo*, the figure 3→. 0.05 megacycles therefore would become 50 kilocycles.

RADIO COLOR CODES

The color codes which follow are used by most radio and instrument manufacturers in the wiring of their products, and by parts manufacturers for identifying lead placement or resistor and condenser values, ratings, and tolerances. These have been included for whatever help they may provide in identifying parts and leads when shooting trouble. Since all manufacturers do not use these codes however, due caution must be used to determine whether or not the set, instrument, or part under examination, does or does not follow the code colors given here. A quick check with a voltmeter, ohmmeter or continuity meter is usually all that is needed to establish this fact.

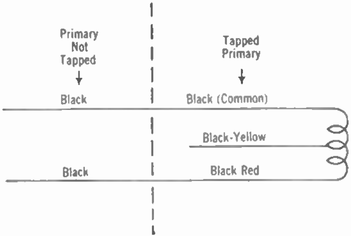
RESISTOR COLOR CODES *(Values in Ohms)*

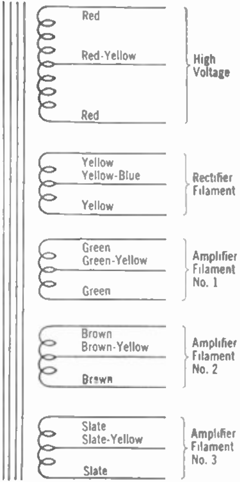
Body		Heavy Woven Thread		Light Woven Thread		← Flexible type resistors. *All others below are carbon*	
Body		End		Dot or Band		End	
1st Band or Dot		2nd Band or Dot		3rd Band or Dot		End Band	
Color	Value	Color	Value	Color	Value	Color	Tolerance
Black	0	Black	0	Black	None	Gold	± 5%
Brown	1	Brown	1	Brown	0	Silver	±10%
Red	2	Red	2	Red	00	None	±20%
Orange	3	Orange	3	Orange	000		
Yellow	4	Yellow	4	Yellow	0000		
Green	5	Green	5	Green	00000		
Blue	6	Blue	6	Blue	000000		
Violet	7	Violet	7				
Grey	8	Grey	8				
White	9	White	9				

CONDENSER COLOR CODES *(Values in Micromicrofarads)*

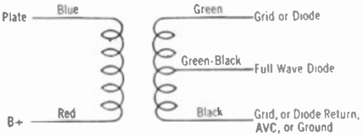
1st Dot		2nd Dot		3rd Dot		4th Dot		Used on paper condensers only	
Color	Value	Color	Value	Color	Value	Color	% Tolerance	Color	DC Working Volts
Black	0	Black	0	Black	None	White	±2.5	Brown	100
Brown	1	Brown	1	Brown	0	Green	± 5	Red	200
Red	2	Red	2	Red	00	Blue	±10	Orange	300
Orange	3	Orange	3	Orange	000	Yellow	±15	Yellow	400
Yellow	4	Yellow	4	Yellow	0000	Red	±20	Green	500
Green	5	Green	5	Green	00000	None	Over 20	Blue	600
Blue	6	Blue	6	Blue	000000			Violet	700
Violet	7	Violet	7	Violet	0000000			Gray	800
Grey	8	Grey	8					White	900
White	9	White	9					Gold	1,000
								Copper	1,600
								Silver	2,000

POWER TRANSFORMER LEADS

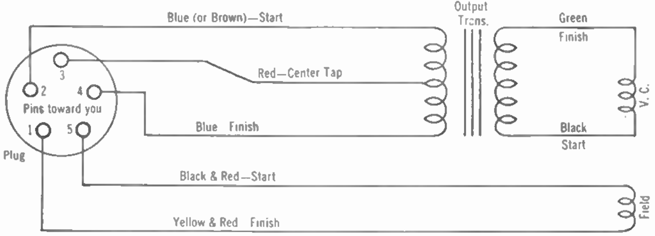


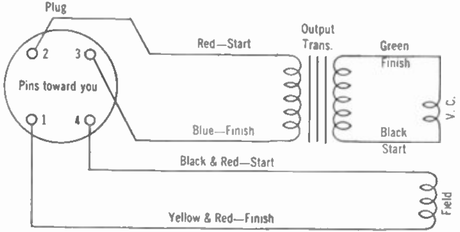


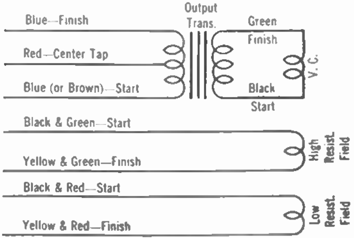
I F TRANSFORMER LEADS



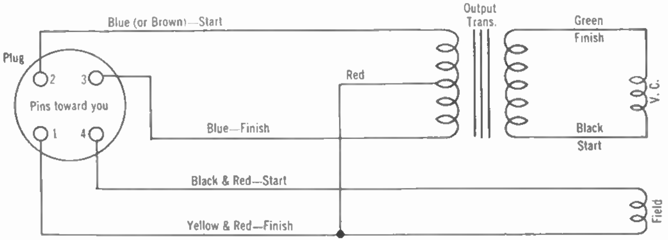
SPEAKER LEADS AND PLUG CONNECTIONS

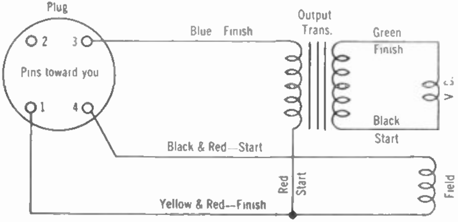


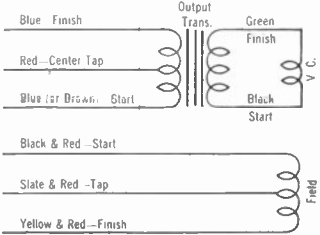




Speaker Leads and Plug Connections—continued

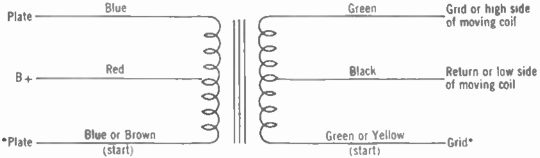






AUDIO TRANSFORMER LEADS

(Input, Interstage, Output)



*Found only on push-pull primary or secondary windings.

BATTERY CABLE LEADS

Red	A+	White	B+Intermediate
Black	A−	Brown	C+
Blue	B+	Orange	C−Intermediate
Yellow	B−	Green	C−

MANTISSAS OF COMMON LOGARITHMS

No.	Log	No.	Log	No.	Log	No.	Log
1	000	26	415	51	708	76	881
2	301	27	431	52	716	77	886
3	477	28	447	53	724	78	892
4	602	29	462	54	732	79	898
5	699	30	477	55	740	80	903
6	778	31	491	56	748	81	908
7	845	32	505	57	756	82	914
8	903	33	518	58	763	83	919
9	954	34	532	59	771	84	924
10	000	35	544	60	778	85	929
11	041	36	556	61	785	86	934
12	079	37	568	62	792	87	940
13	114	38	580	63	799	88	944
14	146	39	591	64	806	89	949
15	176	40	602	65	813	90	954
16	204	41	613	66	820	91	959
17	230	42	623	67	826	92	964
18	255	43	634	68	832	93	968
19	279	44	644	69	839	94	973
20	301	45	653	70	845	95	978
21	322	46	663	71	851	96	982
22	342	47	672	72	857	97	987
23	362	48	681	73	863	98	991
24	380	49	690	74	869	99	996
25	398	50	699	75	875	100	000

NATURAL SINES, COSINES, TANGENTS AND RADIANS*

Angle	Radians	Sine	Cosine	Tangent	Angle	Radians	Sine	Cosine	Tangent
0	0.0000	0.0000	1.000	0.0000	21	0.3665	0.3584	0.9336	0.3839
1	0.0175	0.0175	0.9998	0.0175	22	0.3840	0.3746	0.9272	0.4040
2	0.0349	0.0349	0.9994	0.0349	23	0.4014	0.3907	0.9205	0.4245
3	0.0524	0.0523	0.9986	0.0524	24	0.4189	0.4067	0.9135	0.4452
4	0.0698	0.0698	0.9976	0.0699	25	0.4363	0.4226	0.9063	0.4663
5	0.0873	0.0872	0.9962	0.0875	26	0.4538	0.4384	0.8988	0.4877
6	0.1047	0.1045	0.9945	0.1051	27	0.4712	0.4540	0.8910	0.5095
7	0.1222	0.1219	0.9925	0.1228	28	0.4887	0.4695	0.8829	0.5317
8	0.1396	0.1392	0.9903	0.1405	29	0.5061	0.4848	0.8746	0.5543
9	0.1571	0.1564	0.9877	0.1584	30	0.5236	0.5000	0.8660	0.5774
10	0.1745	0.1736	0.9848	0.1763	31	0.5411	0.5150	0.8572	0.6009
11	0.1920	0.1908	0.9816	0.1944	32	0.5585	0.5299	0.8480	0.6249
12	0.2094	0.2079	0.9781	0.2126	33	0.5760	0.5446	0.8387	0.6494
13	0.2269	0.2250	0.9744	0.2309	34	0.5934	0.5592	0.8290	0.6745
14	0.2443	0.2419	0.9703	0.2493	35	0.6109	0.5736	0.8192	0.7002
15	0.2618	0.2588	0.9659	0.2679	36	0.6283	0.5878	0.8090	0.7265
16	0.2793	0.2756	0.9613	0.2867	37	0.6458	0.6018	0.7986	0.7536
17	0.2967	0.2924	0.9563	0.3057	38	0.6632	0.6157	0.7880	0.7813
18	0.3142	0.3090	0.9511	0.3249	39	0.6807	0.6293	0.7771	0.8098
19	0.3316	0.3256	0.9455	0.3443	40	0.6981	0.6428	0.7660	0.8391
20	0.3491	0.3420	0.9397	0.3640	41	0.7156	0.6561	0.7547	0.8693

*1 Radian = 57.3°

Angle	Radians	Sine	Cosine	Tangent	Angle	Radians	Sine	Cosine	Tangent
42	0.7330	0.6691	0.7431	0.9004	66	1.1519	0.9135	0.4067	2.2460
43	0.7505	0.6820	0.7314	0.9325	67	1.1694	0.9205	0.3907	2.3559
44	0.7679	0.6947	0.7193	0.9657	68	1.1868	0.9272	0.3746	2.4751
45	0.7854	0.7071	0.7071	1.0000	69	1.2043	0.9336	0.3584	2.6051
46	0.8029	0.7193	0.6947	1.0355	70	1.2217	0.9397	0.3420	2.7475
47	0.8203	0.7314	0.6820	1.0724	71	1.2392	0.9455	0.3256	2.9042
48	0.8378	0.7431	0.6691	1.1106	72	1.2566	0.9511	0.3090	3.0777
49	0.8552	0.7547	0.6561	1.1504	73	1.2741	0.9563	0.2924	3.2709
50	0.8727	0.7660	0.6428	1.1918	74	1.2915	0.9613	0.2756	3.4874
51	0.8901	0.7771	0.6293	1.2349	75	1.3090	0.9659	0.2588	3.7321
52	0.9076	0.7880	0.6157	1.2799	76	1.3265	0.9703	0.2419	4.0108
53	0.9250	0.7986	0.6018	1.3270	77	1.3439	0.9744	0.2250	4.3315
54	0.9425	0.8090	0.5878	1.3764	78	1.3614	0.9781	0.2079	4.7046
55	0.9599	0.8192	0.5736	1.4281	79	1.3788	0.9816	0.1908	5.1446
56	0.9774	0.8290	0.5592	1.4826	80	1.3963	0.9848	0.1736	5.6713
57	0.9948	0.8387	0.5446	1.5399	81	1.4137	0.9877	0.1564	6.3138
58	1.0123	0.8480	0.5299	1.6003	82	1.4312	0.9903	0.1392	7.1154
59	1.0297	0.8572	0.5150	1.6643	83	1.4486	0.9925	0.1219	8.1443
60	1.0472	0.8660	0.5000	1.7321	84	1.4661	0.9945	0.1045	9.5144
61	1.0647	0.8746	0.4848	1.8040	85	1.4835	0.9962	0.0872	11.43
62	1.0821	0.8829	0.4695	1.8807	86	1.5010	0.9976	0.0698	14.30
63	1.0996	0.8910	0.4540	1.9626	87	1.5184	0.9986	0.0523	19.08
64	1.1170	0.8988	0.4384	2.0503	88	1.5359	0.9994	0.0349	28.64
65	1.1345	0.9063	0.4226	2.1445	89	1.5533	0.9998	0.0175	57.29

DB EXPRESSED IN WATTS AND VOLTS

*DB	Above Zero Level		Below Zero Level	
	Watts	Volts	Watts	Volts
0	0.00600	1.73	6.00×10^{-3}	1.73
1	0.00755	1.94	4.77×10^{-3}	1.54
2	0.00951	2.18	3.78×10^{-3}	1.38
3	0.0120	2.45	3.01×10^{-3}	1.23
4	0.0151	2.74	2.39×10^{-3}	1.09
5	0.0190	3.08	1.90×10^{-3}	0.974
6	0.0239	3.46	1.51×10^{-3}	0.868
7	0.0301	3.88	1.20×10^{-3}	0.774
8	0.0378	4.35	9.51×10^{-4}	0.690
9	0.0477	4.88	7.55×10^{-4}	0.614
10	0.0600	5.48	6.00×10^{-4}	0.548
11	0.0755	6.14	4.77×10^{-4}	0.488
12	0.0951	6.90	3.78×10^{-4}	0.435
13	0.120	7.74	3.01×10^{-4}	0.388
14	0.151	8.68	2.39×10^{-4}	0.346
15	0.190	9.74	1.90×10^{-4}	0.308
16	0.239	10.93	1.51×10^{-4}	0.275
17	0.301	12.26	1.20×10^{-4}	0.245
18	0.378	13.76	9.51×10^{-5}	0.218
19	0.477	15.44	7.55×10^{-5}	0.194
20	0.600	17.32	6.00×10^{-5}	0.173
25	1.90	30.8	1.90×10^{-5}	0.0974
30	6.00	54.8	6.00×10^{-6}	0.0548
35	19.0	97.4	1.90×10^{-6}	0.0308
40	60.0	173	6.00×10^{-7}	0.0173
45	190	308	1.90×10^{-7}	0.00974
50	600	548	6.00×10^{-8}	0.00548
60	6,000	1,730	6.00×10^{-9}	0.00173
70	60,000	5,480	6.00×10^{-10}	0.000548
80	600,000	17,300	6.00×10^{-11}	0.000173

DB in Watts and Volts—continued

*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.

The number of db by which two power outputs P_1 and P_2 (expressed in watts) may differ = 10 $\log(P_1/P_2)$; or expressed in terms of volts, 20 log (E_1/E_2); or current, 20 $\log(I_1/I_2)$. 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 are equal. In circuits where these impedances differ, voltage and current ratios are calculated as follows:

$$DB = 20 \log \frac{E_1\sqrt{R_2}}{E_2\sqrt{R_1}} \text{ or } 20 \log \frac{I_1\sqrt{R_1}}{I_2\sqrt{R_2}}$$

where R_1 and R_2 = the source and load impedances; $E_1\sqrt{R_2}$ and $I_1\sqrt{R_1}$ always being higher in value than $E_2\sqrt{R_1}$ and $I_2\sqrt{R_2}$.

OHMS LAW FORMULAS FOR DC CIRCUITS

$$I = \frac{E}{R} = \frac{W}{E} = \sqrt{\frac{W}{R}}$$

$$R = \frac{E}{I} = \frac{W}{I^2} = \frac{E^2}{W}$$

$$E = IR = \frac{W}{I} = \sqrt{WR}$$

$$W = EI = I^2R = \frac{E^2}{R}$$

GREEK ALPHABET

Name	Capital	Lower Case	Commonly used to designate
Alpha	A	α	Angles. Area. Coefficients
Beta	B	β	Angles. Flux density. Coefficients
Gamma	Γ	γ	Conductivity. Specific gravity
Delta	Δ	δ	Variation. Density
Epsilon	E	ϵ	Base of natural logarithms
Zeta	Z	ζ	Impedance. Coefficients. Coordinates
Eta	H	η	Hysteresis coefficient. Efficiency
Theta	Θ	θ	Temperature. Phase angle
Iota	I	ι	
Kappa	K	κ	Dielectric constant. Susceptibility
Lambda	Λ	λ	Wave length
Mu	M	μ	Micro. Amplification factor. Permeability
Nu	N	ν	Reluctivity
Xi	Ξ	ξ	

Greek Alphabet—Continued

Name	Capital	Lower Case	Commonly used to designate
Omicron	Ο	ο	
Pi	Π	π	Ratio of circumference to diameter = 3.1416
Rho	Ρ	ρ	Resistivity
Sigma	Σ	σ	Sign of summation
Tau	Τ	τ	Time constant. Time phase displacement
Upsilon	Υ	υ	
Phi	Φ	φ	Magnetic flux. Angles
Chi	Χ	χ	
Psi	Ψ	ψ	Dielectric flux. Phase difference
Omega	Ω	ω	Capital, ohms. Lower case, angular velocity

ABBREVIATIONS AND LETTER SYMBOLS

Many of the abbreviations given are in lower-case letters. Obviously, however, there will be occasions such as when the abbreviations are used in titles of columns, where the original word would have been capitalized. In these cases, the abbreviation should be similarly capitalized.

A two-word adjective expression should contain a hyphen.

Term	*Abbreviation*
Alternating-current (adjective)	a-c
Alternating current (noun)	a.c.
Ampere	a
Antenna	ant.
Audio-frequency (adjective)	a-f
Audio frequency (noun)	a.f.
Centimeter	cm
Continuous wave	cw
Cycle per second	~
Decibel	db
Direct-current (adjective)	d-c
Direct current (noun)	d.c.

Term	*Abbreviation*
Electric field intensity	ϵ
Electromotive force	e.m.f.
Frequency	f
Ground	gnd
Henry	h
High-frequency (adjective)	h-f
Intermediate-frequency (adjective)	i-f
Intermediate frequency (noun)	i.f.
Interrupted continuous waves	icw
Kilocycle (per second)	kc

Abbreviations and Letter Symbols—continued

Term	*Abbreviation*	*Term*	*Abbreviation*
Kilowatt	kw	Millivolt	mv
Low-frequency (adjective)	l-f	Millivolt per meter	mv/m
Magnetic field intensity	H	Milliwatt	mw
Megacycle	Mc	Modulated continuous waves	m.c.w.
Megohm	M Ω	Ohm	Ω
Meter	m	Power	P
Microfarad (mfd)	μf	Power factor	p.f.
Microhenry	μh	Radio-frequency (adjective)	r-f
Micromicrofarad (mmfd)	μμf	Radio frequency (noun)	r.f.
Microvolt	μv	Revolutions per minute	r.p.m.
Microvolt per meter	μv/m	Root mean square	r.m.s.
Microwatt	μw	Ultra high frequency	u.h.f.
Milliampere	ma	Volt	v
Millihenry	mh	Watt	w

*Reprinted from "Report of the Standards Committee of The Institute of Radio Engineers."

FRACTIONAL INCHES TO DECIMAL AND MILLIMETER EQUIVALENTS

$$\text{Inches} \times 2.540 = \text{Centimeters}$$
$$\text{Inches} \times 8.33 \times 10^{-2} = \text{Feet}$$
$$\text{Inches} \times 1.578 \times 10^{-5} = \text{Miles}$$
$$\text{Inches} \times 10^{3} = \text{Mils}$$
$$\text{Inches} \times 2.778 \times 10^{-2} = \text{Yards}$$

Inches			Decimal Equivalent	Millimeter Equivalent
1/64			.0156	0.397
	1/32		.0313	0.794
3/64			.0469	1.191
		1/16	.0625	1.588
5/64			.0781	1.985
	3/32		.0938	2.381
7/64			.1094	2.778
		1/8	.1250	3.175
9/64			.1406	3.572
	5/32		.1563	3.969
11/64			.1719	4.366
		3/16	.1875	4.762
13/64			.2031	5.159
	7/32		.2188	5.556
15/64			.2344	5.953
		1/4	.2500	6.350
17/64			.2656	6.747
	9/32		.2813	7.144
19/64			.2969	7.541
		5/16	.3125	7.937
21/64			.3281	8.334
	11/32		.3438	8.731
23/64			.3594	9.128
		3/8	.3750	9.525
25/64			.3906	9.922
	13/32		.4063	10.319

Inches			Decimal Equivalent	Millimeter Equivalent
27/64			.4219	10.716
		7/16	.4375	11.112
29/64			.4531	11.509
	15/32		.4688	11.906
31/64			.4844	12.303
		1/2	.5000	12.700
33/64			.5156	13.097
	17/32		.5313	13.494
35/64			.5469	13.891
		9/16	.5625	14.287
37/64			.5781	14.684
	19/32		.5938	15.081
39/64			.6094	15.478
		5/8	.6250	15.875
41/64			.6406	16.272
	21/32		.6563	16.669
43/64			.6719	17.067
		11/16	.6875	17.463
45/64			.7031	17.860
	23/32		.7188	18.238
47/64			.7344	18.635
		3/4	.7500	19.049
49/64			.7656	19.446
	25/32		.7813	19.842
51/64			.7969	20.239
		13/16	.8125	20.636
53/64			.8281	21.033
	27/32		.8438	21.430
55/64			.8594	21.827
		7/8	.8750	22.224
57/64			.8906	22.621
	29/32		.9063	23.018
59/64			.9219	23.415
		15/16	.9375	23.812
61/64			.9531	24.209
	31/32		.9688	24.606
63/64			.9844	25.004
		1.0	1.0000	25.400

MATHEMATICAL SYMBOLS

$\times$ or $\cdot$	Multiplied by
$\div$ or $:$	Divided by
$+$	Positive. Plus. Add
$-$	Negative. Minus. Subtract
$\pm$	Positive or **negative.** Plus or minus
$\mp$	Negative or positive. Minus or plus
$=$ or $::$	Equals
$\equiv$	Identity
$\cong$	Is approximately equal to
$\neq$	Does not equal
$>$	Is greater than
$\gg$	Is much greater than
$<$	Is less than
$\ll$	Is much less than
$\geqq$	Greater than or equal to
$\leqq$	Less than or equal to
$\therefore$	Therefore
$\angle$	Angle
$\perp$	Perpendicular to
$\parallel$	Parallel to
$\|n\|$	Absolute value of n

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