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CONCISE

CONVERSION TABLES AND CIRCULAR SLIDE RULE

MODEL EE-112

designed, imported and distributed by
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INTRODUCTION

The Concise Conversion Tables and Circular Slide Rule, Model EE-112, was designed and constructed to facilitate calculations encountered daily by engineers, scientists and students. The conversion tables provide a very handy reference to many frequently used conversion factors and physical data, and the slide rule is sufficiently accurate for most purposes. In addition, the reactance nomograph permits rapid calculations of the relationships among capacitance or inductance, frequency, and reactance.

The circular slide rule has the following characteristics:

1. The outer scales have a circumference of approximately 7½ inches, and as many subdivisions as a 10 inch slide rule.

2. Problems invloving multiplication, division, logarithms, roots, powers, and trigonometric functions, can be easily solved.

3. All scales and tables are engraved, thus insuring a lifetime of accurate readability.

4. As with all circular slide rules, the answer can never be off the scale.

USE OF REACTANCE NOMOGRAPH

Four scales are provided on the Reactance Nomograph side of the slide rule representing inductance (L), reactance (X_L or X_c), capacitance (C), and frequency. The scales are color coded to permit rapid identification of corresponding units. The nomograph is used by aligning any two known quantities, and reading the two remaining quantities from the other two scales.

Example 1:

Find the reactance of a 0.1 μf capacitor at a frequency of 60 cycles per second.

Procedure:

Since frequency in cycles appears in black, capacitance should be located on the C scale in the black column. Withdraw the conversion table insert and use it as a straightedge to intersect 0.1 μf on the black

C scale and 60 cycles on the frequency scale. A pencil line may be drawn directly on the nomograph if a temporary record is desired. The reactance on the X scale which lies on this straight line is approximately 27KΩ. (By actual computation: $X_c = \frac{1}{2\pi fC} = 26.5K\Omega$)

The pencil line, if drawn, may now be erased with your thumb.

Example 2:

Find a capacitor which will resonate with a 2 mh inductor at 8 kilocycles per second.

Procedure:

Frequency in kc indicates that the red scale should be used. Line up 8 kc on the frequency scale with 2 mh on the L scale using the edge of the conversion table insert.

The answer read on the red C scale is approximately 0.2 μf. (By actual computation:

$$X_L = X_c,\ 2\pi fL = \frac{1}{2\pi fC},\ C = \frac{1}{4\pi^2 f^2 L} = 0.198\ \mu f)$$

USE OF CONVERSION TABLES

Tables of conversion factors of length, area, volume, weight, energy, power, and velocity are found on the insert for the user's quick reference. In addition, conversions among mks, cgs, esu, and emu units are accomplished by using the unit conversions table. Also included for ready reference are tables showing orders of magnitude, the Greek alphabet, standard (1%, 5%, 10%, and 20%) component values, standard EIA(RETMA) color code, copper wire information, h parameter equations, and a list of useful constants and data.

The tables are constructed in such a way that a number in units of i is converted to units of j by multiplying it by the number found in row i and column j of the conversion tables. (see figure 1)

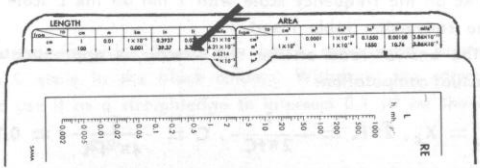


Figure 1:

Example:

Convert 3 meters into feet. (see figure 1)

Procedure:

Pull the sliding insert out to the right. On the back of this insert the LENGTH Table can be found. Pull the insert out to the m row in the "from" column. Locate the ft column in the "to" row. The number found in the m row and the ft column is 3.281. When 3 is multiplied by 3.281, the answer 9.843 is the number of feet in 3 meters.

For convenience in writing and manipulation, numbers are often expressed in the tables as factors of the appropriate power of 10, for instance: 1.23×10^{6} denotes 1,230,000

1.23×10^{-6} denotes 0.00000123

Squares and cubes are expressed by exponents of 2 and 3.

Note that there is a star on the face of the instrument and on the sliding table near the orders of magnitude table. By keeping the two stars in the same relative position the user's speed will be enhanced as he becomes familiar with the location of the various tables of the instrument.

The UNIT CONVERSIONS table allows rapid conversion to rationalized MKS units from any of the following systems: Non-rationalized MKS, CGS, ESU, or EMU.

The numbers in the STANDARD COMPONENT VALUES table represent the "preferred values" for many resistors and small capacitors. In this system, the numbers represent only the significant figures and must be multiplied by the appropriate power of ten to obtain the actual value.

Example:

162 in the 1% tolerance table could represent 1.62, 16.2, 162, 1620, 16200, etc., $\pm 1\%$.

This table allows rapid selection of resistors, capacitors and inductors for particular circuit applications.

For example, if calculations called for a 420 Ω resistor, the table shows the following possibilities:

$470 \pm 20\%$
$390 \pm 10\%$
$430 \pm 5\%$
$422 \pm 1\%$

The particular resistor could then be chosen to conform to the other design considerations.

The COPPER WIRE TABLE lists important constants for commonly used sizes of copper wire. The current capacity limits, figured at 700 circular mils of cross sectional area per ampere, are conservative ratings, often used in the design of inductors or transformers. When single wires are to be run in free air, or a group of wires are to be run in a cable or conduit, more liberal figures may apply. For example, the following table (from MIL-W-5088B(ASG)) is often used.

Wire Size	Continuous-duty current (Amperes)	
	Single wire in free air	Wires and cables in conduit or bundles*
8	73	46
10	55	33
12	41	23
14	32	17
16	22	13
18	16	10
20	11	7.5
22	—	5

*Based upon bundles of 15 or more wires carrying no more than 20% of the total carrying capacity of the bundle.

The COLOR CODE table may be used to identify resistors or capacitors. For example, the resistor shown in figure 2 is identified as follows:

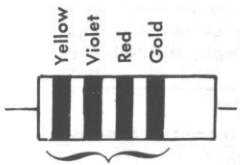


Figure 2

1. Start with the colored band nearest to the end of the resistor.
2. The first and second bands indicate figures as listed in the color code table (4 and 7 in this example)
3. The third band indicates a multiplier for the first two figures (10^2 in this example). This colored band can also be interpreted as specifying the number of zeros following the first two figures.
4. The last band indicates the resistor tolerance as tabulated in the color code table (5% in this example).

ABBREVIATIONS

Å = Angstrom
amp = ampere
atm = atmosphere
AWG = American Wire Gauge
B & S = Brown and Sharp
Br. = British
Btu = British thermal unit
c = speed of light
cal = calorie
cap = capacity
cgs = centimeter, gram, second unit
cir = circular
cm = centimeter
cos θ = power factor
coul = coulomb
db = decibels
deg = degree
°C = degree Celcius
°F = degree Fahrenheit
°K = degree Kelvin
°R = degree Rankine
e = electric
E = potential in volts
emf = electromotive force
emu = electromagnetic unit
equiv = equivalent
esu = electrostatic unit
fl = fluid
ft = foot
g = gram
g_0 = gravitational constant
gal = gallon
hp = horsepower
h parameters = hybrid parameters

hr = hour
I = current in amperes
in = inch
Kg = kilogram
Km = kilometer
Kw = kilowatt
lb = pound
lg ton = long ton
Ln = Logarithm base e
Log = Logarithm base 10
m = meter
M = magnetic
mks = meter, kilogram, second unit
(nr) = non rationalized
(r) = rationalized
mmf = magneto-motive force
mph = miles per hour
m ton = metric ton
mult = multiplier
oz = ounce
P = power
π = ratio of circumference of a circle to its diameter
pt = pint
qt = quart
sec = second
sh ton = short ton
tol = tolerance
W = weber

USE OF CIRCULAR SLIDE RULE

The slide rule has D, C, CI, L, S, T_1, T_2, and ST Scales. The C, D, and CI scales are used for multiplication and division. Logarithms are obtained with the L and C scales and may be conveniently used to obtain roots and powers. The remaining scales S, T_1, T_2, and ST are used in conjunction with the D, C, and CI scales to obtain and manipulate trigonometric functions. They may also be used to easily convert complex numbers from rectangular to polar form.

In order to simplify explanation of the use of the circular slide rule, the following symbols are used in this booklet:

↗ ..... setting of the C scale

↑ ..... setting of the indicator

* ..... answer

MULTIPLICATION

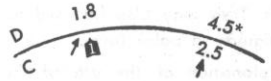
Example:

$1.8 \times 2.5 = 4.5$ (figure 3)

Procedure:

Locate 1.8 on the D scale, and line up ▮ on the C scale with it. Set the indicator to 2.5 on the C scale. The indicator shows the answer 4.5 on the D scale.

Figure 3:



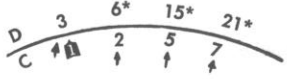
Example:

$3 \times 2 = 6$, $3 \times 5 = 15$, $3 \times 7 = 21$ (figure 4)

Procedure:

Locate 3 on the D scale, and line up ▮ on the C scale with it. Set the indicator to the values 2, 5 and 7 on the C scale, and read the answers 6, 15, 21 on the D scale.

Figure 4:



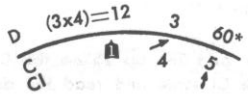
Example:

$3 \times 4 \times 5 = 60$ (figure 5)

Procedure:

Locate 3 on the D scale, and line up 4 on the CI scale with it. Move the indicator to 5 on the C scale which gives the answer 60 on the D scale.

Figure 5:



DIVISION

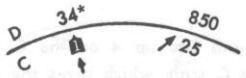
Example:

$850 \div 25 = 34$ (figure 6)

Procedure:

Locate 850 on the D scale, and line up 25 on the C scale with it. The marking ▮ on the C scale points to the answer 34 on the D scale.

Figure 6:



Example:

$850 \div 25 \div 8 = 4.25$ (figure 7)

Procedure:

Locate 850 on the D scale, and line up 25 on the C scale with it. Move the indicator to 8 on the CI scale and read the answer 4.25 on the D scale.

Figure 7:

MULTIPLICATION AND DIVISION

Example:

$$\frac{3 \times 6}{5} = 3.6$$ (figure 8)

Procedure:

Locate 3 on the D scale, and line up 5 on the C scale with it. Set the indicator to 6 on the C scale. The answer 3.6 is read on the D scale.

Figure 8:

LOGARITHMS

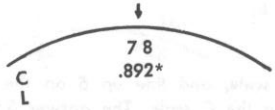
Example:

Log 78 = 1.892 (figure 9)

Procedure:

Set the indicator to 78 on the C scale. The mantissa 0.892 is read on the L scale. Since the characteristic number is 1, the logarithm of 78 is 1.892.

Figure 9:



ROOTS

Example:

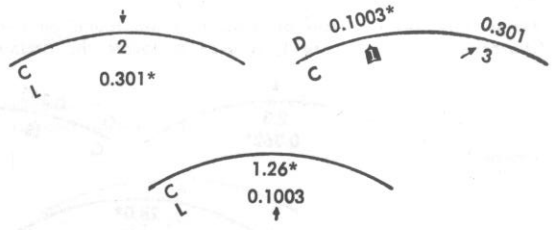
$\sqrt[3]{2} = 1.26$ (figure 10)

Procedure:

Set the indicator to 2 on the C scale. Read log 2 = 0.301 on the L scale. Locate 0.301 on the D scale, and line up 3 on the C scale

with it. The marking ▲ on the C scale points to 0.1003 on the D scale. This is the log of the answer. Therefore set the indicator to 0.1003 on the L scale. The answer 1.26 is read on the C scale.

Figure 10:



POWERS

Example:

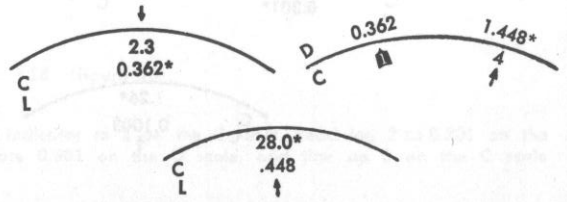
$(2.3)^4 = 28.0$ (figure 11)

Procedure:

Set the indicator to 2.3 on the C scale. Read log $2.3 = 0.362$ on the L scale. Line up the marking on the C scale with 0.362 on the D scale. Move the indicator to 4 on the C scale and read 4 log $2.3 = 1.448$ on the D scale. This is the log of the answer since log $(2.3)^4 = 4$ log 2.3. Therefore set the indicator to 0.448 on the L scale. The answer $= 28.0$ is read on the C scale.

Note: Only the mantissas of logarithms are found on the L scale. The characteristic, in this case 1, is used to locate the decimal.

Figure 11:



SINES & COSINES

The S & ST scales are used to determine sines of angles. Since the cosine of an angle is equal to the sine of its compliment, i.e. $\cos \theta = \sin (90 - \theta)$, these same scales can be used to find cosines of angles. The S scale is used for the sine of angles between 6 and 90 degrees and the ST scale is used for the sine of angles between 40 minutes and 6 degrees. For convenience when working with cosines, the compliments of the angles are shown in red on the S scale.

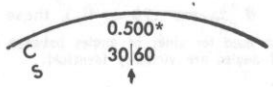
Example:

$\sin 30° = 0.500$ (figure 12)

Procedure:

Set the indicator to the black 30° marking on the S scale. The answer 0.500 is read on the C scale.

Figure 12:



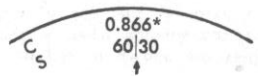
Example:

cos 30° = 0.866 (figure 13)

Procedure:

Set the indicator to the red 30° marking on the S scale. The answer 0.866 is read on the C scale.

Figure 13:



TANGENTS & COTANGENTS

The tangent scale is divided into 3 sections, T_1, T_2, & ST. The T_1 scale is used for tangents of angles between 6 and 45 degrees. The T_2 scale is used for tangents of angles between 45 and 84 degrees, and the ST scale* is used for tangents of angles between 40 minutes and 6 degrees. Since the cotangent of an angle is equal to the tangent of its compliment, i.e. cot θ = tan (90 − θ), these same scales can

*Note that the ST scale is also used for sines of angles between 40′ and 6°. In this range the sines and tangents of angles are virtually identical.

be used to find cotangents of angles. For convenience when working with cotangents, the compliments of the angles are shown in red on the T_1 and T_2 scales.

Example:

tan 42° = 0.900 (figure 14)

Procedure:

Set the indicator to the black 42° marking on the T_1 scale. The answer 0.900 is read on the C scale.

Figure 14:

Example:

cot 30°=1.732 (figure 15)

Procedure:

Set the indicator to the red 30° on the T_2 scale. The answer 1.732 is read on the C scale.

Figure 15:

COORDINATE CONVERSIONS

Perhaps the most useful conversion on this slide rule is between the rectangular and polar coordinate forms of complex numbers.

Example:

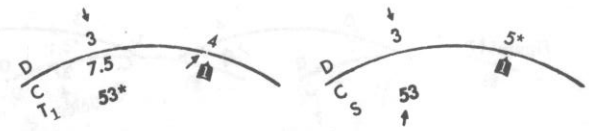
$3 + j4 = 5 \angle 53° *$ (figure 16)

*Note: $5 \angle 53°$ represents a vector of magnitude 5 at an angle of 53° with the plus x axis.

Procedure:

Line up the marking on the C scale with the larger rectangular component (4 in this example) on the D scale. Set the indicator to the other component on the D scale (3 in the example). Determine mentally whether the angle will be larger or smaller than 45°. If larger, read the angle (53°) using the red numerals on the T_1 scale. If smaller, read the black numerals on the T_1 scale. Next, without moving the indicator, rotate the S scale until the angle just determined falls under the hairline on the S scale. The magnitude of this number, 5, can now be read on the D scale opposite the marking on the C scale.

Figure 16:



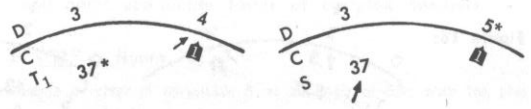
Example:

$4 + j3 = 5 \angle 37°$ (figure 17)

Procedure:

Line up the marking ▲ on the C scale with 4 on the D scale. Set the indicator to 3 on the D scale. Since the angle is less than 45°, read the black numerals on the T_1 scale, 37°. Next, without moving the indicator, rotate the S scale until the angle just determined (black 37°) falls under the hairline on the S scale. The magnitude of the number 5, can now be read on the D scale opposite the ▲ marking on the C scale.

Figure 17:



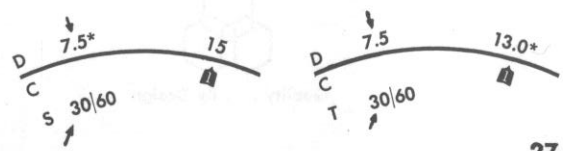
Example:

$15 \angle 30° = 13.0 + j7.5$ (figure 18)

Procedure:

Line up the marking ▲ on the C scale with 15 on the D scale. Set the indicator to the angle designated on the S scale (30°). Use black numerals if the angle is smaller than 45°, red if the angle is larger than 45°. The smaller rectangular component ($j7.5$) now lies under the hairline on the D scale. Next, without moving the indicator, rotate the T_1 scale until the angle on the T_1 scale (same number and color as just read) falls under the hairline. The larger component 13.0 now is on the D scale opposite the marking ▲ on the C scale.

Figure 18:



OTHER FEATURES

The size of the instrument is such that it will fit easily into a shirt pocket, but yet will not fall out easily when the user bends over.

For the measurement of small lengths, an inch scale and a centimeter scale are provided on the face of the instrument.

The instrument is made of plastic and can be safely washed with lukewarm water and mild soap.

Quality . . . By Design

Concise Conversion Tables and Circular Slide Rules

MODEL CTCS-552 . . . Recommended for chemical & mechanical engineers, and chemists

MODEL EE-112 . . . Recommended for electrical & electronic engineers, and physicists