A SLIDE RULE FOR ELECTRONIC ENGINEERS

Designed and described by

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An ELECTRONIC ENGINEERS SLIDE RULE. Introduction:-

The Slide Rule is basically a mechanical set of logarithm tables, and works just as logarithms do. To multiply two numbers you add the logarithms, and to divide you subtract one logarithm from another. This is just what one does with a slide rule. To multiply one adds the length equal to the first number, to the length equal to the second number, and the sum of the lengths measured out on the logarithmic scales is the product of the numbers. Likewise to divide, one subtracts one length from the other and the difference is the result of the division. Because one cannot carry around a huge slide rule with many decades on each scale we effectively shrink them to one (C & D Scales), or two (A & B Scales). This reduction is possible since the length of each scale on a logarithmic scale per decade is the same (i.e. the length on the A scale from 1 to 10 is the same as from 10 to 100). The price to be paid for this reduction in overall length to manageable proportions is that one loses the exactness of the decimal point. But more of that later.

If one remembers the above rather oversimplified description, then the following sections on the various scales will I hope be clearer, especially to the beginner. To those who are already well familiar with the usual workings of the slide rule, I apologise for going very much to 'square one', but my reading of a number of slide rule instruction books led me to the conclusion that they took it for granted that one knew how a slide rule worked, and for those new to electronics, and the slide rule, this may well not be so.

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INDEX TO SECTIONS

MULTIPLICATION & DIVISION

C & D Scales:-

Most multiplication and Division calculations are made using the C & D Scales, since these offer greater accuracy then the A & B Scales.

Multiplication:-

To multiply two numbers (A x B) one adds the value of A on the D scale to the value of B on the C scale, and reads this sum on the D scale. To illustrate this -

Example 1. Multiplying by 2

Set the 1 of the C scale against 2 on the D scale The rule has now been set to multiply by 2, and it will be seen that all the values on the C scale areopposite exactly twice their value on the D scale. Likewise if the 1 of the C scale had been set to the 3 of the D scale then all the values on the C scale would have been opposite three times their value on the D scale.

Example 2. Multiply 1.7 by 3.3.

Set the 1 of the C scale against 1.7 on the D scale. Set the line of the cursor to 3.3 on the C scale. The answer now appears under the cursor line on the D scale. (1.7 x 3.3 = 5.61).

Example 3. Multiply 1.7 x 6.3.

In example 2 above the slide is already set to multiply by 1.7, but on trying to move the cursor to 6.3 on the C scale we find that the cursor will not go that far, and that we are off the end of the D scale. Reset the slider so that the 10 of the C scale is opposite 1.7 on the D scale. Set the cursor line to 6.3 on the C scale and the product 1.7 x 6.3 will be found on the D scale. (1.7 x 6.3 = 1.071) Now we know that the answer should be 10.71. This brings us to the important matter of the Decimal Point.

DECIMAL POINT.

As stated in the Introduction the slide rule does not take account of the absolute value of a culculation, and it is therefore necessary to have a knowledge of the magnitude of the answer. In difficult cases it may be necessary to do a quick pencil and paper exercise to determine the position of the decimal point. However, this is not usually a difficult matter, since in many cases in electronics one already knows the magnitude of the answer, and one is only trying to establish the exact numerical value.

Division:-

To divide one number by another $(^{A}/_{B})$, one subtracts the value of B on the C scale from the value of A on the D scale, reading the result on the D scale. To illustrate this:-

Division continued:-

Example 4. Divide 3.4 by 2.12.

Set the cursor to 3.4 on the D scale, Set 2.12 on the C scale under the cursor line. The result is against the 1 of the C scale. (3.4 divided by 2.12 = 1.604).

Example 5. Divide 3.4 by 6.3.

Set the cursor line to 3.4 on the D scale, Set the 6.3 on the C scale to the cursor line. The result will now be found against the 10 of the C scale, and not the 1 as the 1 is off the end of the D scale. As before the decimal point is not retained. (3.4 divided by 6.3 = 0.54, shown as 5.4 on the D scale).

THE A & B SCALES.

The A & B Scales can be used for multiplication and division, and can be slightly quicker to use for the less accurate calculations. In all the above examples Read B for C and A for D where the scales are referred to. The first thing to say is that since there are two decades on each scale one will not normally need to move the scale to use the 10 of the B scale instead of the 1 to read the result, and it is in this respect that the A & B scales save time.

In Example 3 above (Multiplication) Set the 1 of the B scale against 1.7 on the A scale, move the cursor to 6.3 on the B scale, when the answer is on the A scale under the cursor line. (10.71).

SQUARES and SQUARE ROOTS.

To find the square of a number place the cursor line over the number on the D scale, and the square will be found on the A scale.

To find the square root of a number place the cursor line over the number on the A scale, when the square root will be found on the D scale.

It is important to note that the square root of, for instance 4 is 2, whereas square root of 40 is 6.325.

To establish the correct root reduce the number to the form $A \times 10^n$, for example 34300 $= 3.43 \times 10^4$, $7660 = 76.6 \times 10^2$, and $0.0015 = 15.0 \times 10^{-4}$, Note that in all cases A is a number between 1 and 100 and n is an even power of 10. The correct root is the root of the number A, times the power of 10 divided by 2 e.g. Root of 7660 is $\sqrt{76.6} \times 10^{n}/2$.... i.e. $8.75 \times 10^1 = 87.5$. Root of 0.0015 is $\sqrt{15.0} \times 10^{n}/2$ .... i.e. $3.87 \times 10^{-2} = 0.0387$.

LOG-LOG SCALES.

These scales enable powers and roots other than to power 2 to be calculated and certain other values related to 'e' to be calculated as well.

CALCULATION of A^x

Place the cursor line against the number A on the LL2 or LL3 scales as appropriate. Place the 1 of the scale C against the cursor line. Move the cursor to the value of x on the C scale, and read off the value of A^x on the LL2 or LL3 scale as appropriate. Again as in

Multiplication it may be necessary to place the 10 of the C scale against the value of A on the LL2 or LL3 scales in order to get the value of x within the limits of the rule scales. In all cases it is necessary to know the approximate value of A^x in order to know on which scale (LL2 or LL3) to find the answer, but this is not usually a problem.

CALCULATION of $\sqrt[x]{A}$.

This is roughly the reverse of finding A^x above. Place the cursor as before on the value of A on the LL2 or LL3 scales. Now move the slide until the value of x on the C scale is under the cursor line. The cursor should now be moved to either 1 or 10 on the C scale, and the value of $\sqrt[x]{A}$ read off on the LL2 or LL3 scale. As before the approximate value of the answer must be known in order that the correct scale shall be read.

CALCULATION of e^x.

Within the limits of the LL3 scale, any number x on the D scale will be opposite e^x on the LL3 scale.

CALCULATION of A^{-x} .

Use the relationship $A^{-x} = \frac{1}{A} x = (\frac{1}{A})^x$. Here the Reciprocal scale (CI) is useful (see below).

RECIPROCAL SCALE.

Any number on the C scale is opposite its reciprocal on the CI scale.

EXAMPLE $^1/_{2.5} = 0.4$, and it will be seen that the answer on the CI scale is in fact 4.0, so that the decimal point position must be established separately, as in many previous examples.

The CI scale may also be used with the D scale for multiplication and division, and to some extent avoids excessive motion of the slide in successive multiplications, or divisions. It is however recommended that the user gets fully familiar with the use of the normal C & D scales before using this method.

Example. 6. Multiply 3 x 4.

Set the cursor to 3 on the D scale, and place the 4 of the CI scale under the cursor line. Read the answer on the D scale against the 1 of the C scale (For some products the 10 of the C scale will be used where the 1 is off scale.)

Example. 7. Divide 3 by 4.

Set the 1 of the C scale against 3 on the D scale. Place the cursor line at 4 on the CI scale, and read the answer on the D scale under the cursor line.

THE DECIBEL SCALES. (Decibel Ratio of Voltage or Current).

The top scale of the Rule is divided into 40 equal intervals, corresponding to the 1 to 100 of scale A. The Decibel scale is calibrated 0-40 left to right, 0-40 right to left and 20-0-20 about the centre. This eases the reading of the Decibel scales since the answer to a Decibel calculation can be negative or positive depending on whether the ratio being converted is greater or less than unity.

Simple dB conversion.

For the simple conversion of Voltage or Current ratios to Decibels, place the cursor against the voltage or current ratio on the A scale and read the result on the dB scales. For ratios greater than unity read the result on the 0-40 dB scale reading from left to right. For ratios less than unity use the 0-40 dB scale reading from right to left, when the answer will be negative. For such values less than unity take 100 on the A scale as 1, 10 as 0.1 and 1 as 0.01.

The reverse process converts dB's to Voltage or Current Ratios.

CALCULATION of dB's RELATIVE TO A REFERENCE LEVEL.

This is probably the most common 'dB' calculation. One usually needs to convert a list of voltage readings (for say a frequency response graph) to decibels with reference to a point on the curve chosen as the 0 dB level.

Set the reference voltage on the B scale against the 10 of the A scale (0 dB of the 20-0-20 dB scale.)

Each dB value is then read off from the dB scale by moving the cursor to each voltage in turn on the B scale, leaving the slide set with the reference voltage on the B sçale against the 0 dB mark. Each dB value is then read off from the 20-0-20 dB scale. The 0-40 dB scales can be used instead, especially if all the ratios are either greater or less than unity, by setting the reference voltage against the appropriate 0 dB mark.

When the cursor runs off the scale at either end move the cursor left or right as appropriate by one whole decade, and correct the dB ratio obtained by 20 dB. For a move to the left add 20dB, and for a move to the right add -20 dB. Alternatively move the reference voltage by one decade. The equivalent of adding or subtracting 20 dB may be to use one of the other dB scales, and the user will soon find which is easiest in any particular case.

EXAMPLE 8. A typical table of readings.

0.10 v	-22.34 dB	Use 0-40 right to left scale and 1.0 on B scale.
0.24 v	-14.74 dB	Use 0-40 right to left scale and 2.4 on B scale.
0.61 v	- 6.64 dB	Use 0-40 right to left scale and 6.1 on B scale.
0.90 v	- 3.26 dB	Use 0-40 right to left scale and 9.0 on B scale.
1.10 v	- 1.52 dB	
1.15 v	- 1.13 dB	
1.25 v	- 0.41 dB	
1.31 v	0.00 dB	1.31 on B scale set to 10 on A scale.
1.45 v	0.88 dB	
1.90 v	3.23 dB	
2.10 v	4.10 dB	
2.45 vq	5.44 dB	
2.96 v	7.08 dB	
3.40 v	8.28 dB	

4.50 v	10.72 dB	
7.61 v	15.28 dB	
11.20 v	18.64 dB	
15.03 v	21.19 dB	Use 0-40 left to right scale and 1.503 on B scale
111.00 v	38.56 dB	Use 0-40 left to right scale and 1.11 on B scale and add 20.

From the above it will be seen that the first decade shift will be made by changing scales and any further shifts by adding + or - 20 dB.

Again the reverse process may be used to obtain voltage or current ratios from dB's.

THE L/C CALCULATOR.

The reverse side of the rule has an L/C Impedance calculator covering the frequency range from 1 Hz to 100 MHz, and a wide range of Inductance and Capacitance values.

CALCULATION OF INDUCTIVE IMPEDANCE.

Set the frequency at which the Impedance value is required by moving the slide until the frequency scale on the slide is showing the correct frequency against the Reference mark (A triangle at the centre of the Capacitive Impedance Scale). Move the cursor along the centre scale of the slide until it is set to the 'units' value of the inductance. Now read the Impedance on the scale at the top of the rule referring to the value of the units i.e. micrchenries (μH), millihenries (mH), or Henries (H).

Example 9.

Impedance of 30 μH at 20 kHz

Set slide to place 20 kHz against the reference mark. Move the cursor to 30 on the centre 'units' scale, and read off the Impedance on the top impedance scale (μH). Had the Inductance been 30 mH then the Impedance would be read on the middle Inductive Impedance scale (mH).

30 μH at 20 kHz = 3.769 ohms. 30 mH at 20 kHz = 3.769 k.ohms.

Example 10.

Impedance of 400 μH at 5 MHz.

On carrying out this calculation as in Example 9 above, the cursor will be found to have run off the scale, and thus 400μH must be set as 0.400 mH instead.

400 μH 0.400 mH at 5 MHz = 12.57 k.ohms.

CALCULATION OF CAPACITIVE IMPEDANCE.

The calculation of Capacitive Impedance is exactly as for Inductive Impedance, except that one reads on the lower Capacitive Impedance scales.

CALCULATION OF RESONANT VALUES.

Certain calculations relative to resonant values can be made on this calculator, for instance if one has an inductor of 100 mH and wishes to know what capacitance is needed to resonate this at 1 kHz, then one finds the value of the Inductive Impedance and then moves the cursor to an equal Capacitance Impedance value on the Capacitive scales and reads off the Capacitance value with due regard to the capacitive Impedance scale in use. In the case given the value of capacitance needed is one having an Impedance of 628 ohms (The value of the Inductive Impedance obtained). The cursor is now moved to say 628 ohms on the uF scale and the value is read as 0.253 µF.

CARE AND CLEANING OF THE RULE.

It is important to avoid the use of strong solvents to clean the rule. All that is needed is normal soap and water - no more than gently warm.

The cursor may be removed by withdrawing the slide from the rule, and then gently squeezing the sides of the rule towards one another with the cursor at the centre of the rule. The two halves of the cursor may then easily be removed. Note that the two halves of the cursor are identical and mate with one another one way round only.

Do not leave the rule in very hot places such as the parcel shelf of a car in summer or on radiator tops.