INSTRUCTIONS

PROFESSIONAL SLIDE RULE

MODEL NO. 1580

SCIENTIFIC INSTRUMENTS CO.
BERKELEY CALIF.

CONTENTS

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FOR THE USE OF ELECTRIC SLIDE RULE

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1. GENERAL DESCRIPTION

This slide rule has been designed for the expert electrical engineers to simplify in use in calculating problems involving the various electrical phenomena, namely not only the computation of multiplication and division can be done with the A, BI, CI, C and D scales, but also the LL_1, LL_2 and LL_3 scales make it possible to obtain the result of a^n, e^x and $\log_e N$, moreover, the P_1, P_2 and Q scales are essential for vector computation, the Sh_1, Sh_2 and Th scales for hyperbolic functions, the X_1, X_2, Y, $|\underline{X}$, $|\underline{Y}$, $|\underline{\theta_1}$ and $|\underline{\theta_2}$ scales for hyperbolic functions of complex quantities.

2. SCALE ARRANGEMENT AND USAGE

(Front Face) Sh_2, Sh_1, Th, A, BI, S, T, CI, C, D, LL_3, LL_2, LL_1

(Back Face) X_2, X_1, P_2, P_1, Q, Y, L, $|\underline{X}$, I, I, $|\underline{\theta_1}$, $|\underline{\theta_2}$, $|\underline{Y}$

(a) Sh_1 and Sh_2

These scales make it possible to compute the sine hyperbolic function, which is frequently necessary in alternating current theory.

(b) A

It is used to find the square root.

(c) **BI**

This is an inverted A scale.

(d) **S**

This scale gives the sine and cosine of an angle.

(e) **T**

This scale gives the tangent of an angle.

(f) **CI**

This is an inverted C scale and is used with the C scale in reading directly the reciprocal of a number. And it is let us do multiplication of three factors with just one setting of the slide.

(g) **C and D**

These are exactly alike and the fundamental scales of the slide rule. And they are used for general fundamental calculations.

(h) **LL_1, LL_2 and LL_3**

These are used to find the values of the type forms of a^n, e^x and give the national logarithms of a number.

(i) **X_1 and X_2**

These are unlogarithmic hyperbolic sine scales referred to the P_1 and P_2 scales respectively.

(j) **P_1 and P_2**

These are unlogarithmic square scales. The computation of the vector can be conveniently done by the P_1, P_2 and Q scales as ordinary multiplication and division done by the C and D scales.

(k) **Q**

This is an inverted P_1 scale.

(l) **Y**

This is unlogarithmic sine scale referred to the Q scale and is used witn the X_1, X_2, P_1 and P_2 scales for hyperbolic functions of complex quantities. This scale is divided to represent radians and decimals of a radian.

(m) **L**

This scale is used with the C or D scale in finding directly the mantissa of the common logarithms of a number.

(n) **$\underline{|X}$**

This is a scale of hyperbolic tangent referred to the A scale and is used with the $\underline{|Y}$, $\underline{|\theta_1}$ and $\underline{|\theta_2}$ scales for hyperbolic functions of complex quantities.

(o) **I**

This is a reciprocal scale and is used to find sum of the reciprocals.

(p) **$\underline{|\theta_1}$ and $\underline{|\theta_2}$**

These are tangent scales referred to the A scale and are used with the $\underline{|X}$, $\underline{|Y}$, A and BI scales. They are divided to represent degrees and decimals of a degree.

(q) **$\underline{|Y}$**

This is a tangent scale referred to the A scale. Angles are graduated at radian.

3. DECIBEL CALCULATIONS

In the electric communication circuit, let voltage and current at the input side be V_1 and I_1, and those at the output side be V_2 and I_2, the decibel for voltage ratio $db_{(V)}$ and the decibel for current ratio $db_{(I)}$ are as follows:

$$db_{(V)}=20\cdot\log_{10}\frac{V_2}{V_1}$$

$$db_{(I)}=20\cdot\log_{10}\frac{I_2}{I_1}$$

There are two operation-methods in the decibel calculation. One is performed by using the L and D scales, viz. centering the slide, the mantissa of a given voltage or current ratio is read directly on the L scale, opposite a given ratio on the D scale.

Example 1. In a radio frequency amplifier the input voltage is 5 volts. The output voltage is 12 volts. Find the decibel voltage gain. Answer 7.6 db

Voltage ratio is $\frac{12}{5}=2.4$.

Move hairline to 2.4 on D,
under hairline find 0.38 on L,
read answer as $20\times0.38=7.6$.

Another method is performed by using the LL and C scales. The calculation of the decibel is easily carried out as follows:

Example 2. Find the decibel voltage gain, given $\frac{V_2}{V_1}=380$. Answer 51.6 db

Move hairline to 10 on LL_3,
set 2 on C under hairline,
move hairline to 380 on LL_3,
under hairline find 5.16 on C,
read answer as 51.6.

Example 3. Find the decibel current gain, given $\frac{I_2}{I_1}=1.07$. Answer 0.587 db

Move hairline to 10 on LL_3,
set 2 on C under hairline,
move hairline to 1.07 on LL_1,
under hairline find 5.87 on C,
read answer as 0.587.

4. VECTOR PROBLEMS

(1) The Absolute Value of Vector

The absolute value of vector, represented in the type form of $a+jb$, is equal to $\sqrt{a^2+b^2}$, and by the use of the P_1, P_2 and Q scales this value can be computed very easily in the same operation as ordinary multiplication and division.

To calculate $\sqrt{a^2+b^2}$,
move hairline to a on P_1,
set b on Q under hairline,
opposite right index of Q read the answer as $\sqrt{a^2+b^2}$ on P_1.
Or opposite left index of Q read the answer as $\sqrt{a^2+b^2}$ on P_2.

Example 4. Find the absolute value of $0.4+j0.3$. Answer 0.5.

Move hairline to 0.4 on P_1,
set 0.3 on Q under hairline,
opposite right index of Q read answer as 0.5 on P_1.

Example 5. $0.664+j0.588=0.887$

Move hairline to 0.664 on P_1,
set 0.588 on Q under hairline,
opposite right index of Q read answer as 0.887 on P_1.

Example 6. $\sqrt{0.876^2+0.932^2}=1.279$

Move hairline to 0.876 on P_1,
set 0.932 on Q under hairline,
move hairline to left index of Q,
under hairline read answer as 1.279 on P_2.

Example 7. $7.45+j7.17=10.34$

Move hairline to 0.745 on P_1,
set 0.717 on Q under hairline,
move hairline to left index of Q,
under hairline find 1.034 on P_2,
read answer as 10.34.

Example 8. $\sqrt{1.180^2+0.678^2}=1.361$

Move hairline to 1.180 on P_2,
set 0.678 on Q under hairline,
move hairline to right index of Q,
under hairline read answer as 1.361 on P_2.

(2) Phase Angle of Vector

In the vector of the type form of $a+jb$, the phase angle θ is represented as follows:

$$\theta=\tan^{-1}\frac{b}{a}$$

To find the phase angle θ,
opposite a on A right or left, set left index of BI,
move hairline to b on BI,
under hairline read answer θ on $\underline{|\theta_1}$ (red),
or opposite a on A right or left, set right index of BI,
move hairline to b on BI,
under hairline read answer θ on $\underline{|\theta_2}$ (red).

Example 9. $\tan^{-1}\frac{3.6}{2.5}=55.2^\circ$

Opposite 2.5 on A left, set left index of BI,

move hairline to 3.6 on BI right,
under hairline read answer as 55.2 on $\underline{|\theta_1}$ (red).

Fxample 10. $\tan^{-1}\frac{2.5}{3.6}=34.8^\circ$

Opposite 3.6 on A left, set right index of BI.
move hairline to 2.5 on BI right,
under hairline read answer as 34.8 on $\underline{|\theta_2}$ (red).

Example 11. $\tan^{-1}\frac{1.51}{11.8}=7.3^\circ$

Opposite 11.8 on A right, set right index of BI,
move hairline to 1.51 on BI right,
under hairline read answer as 7.3 on $\underline{|\theta_2}$ (red).

Example 12. $\tan^{-1}\frac{12.3}{4.24}=71^\circ$

Opposite 4.24 on A lelt, set left index of BI,
move hairline to 12.3 on BI left,
under hairline read answer as 71 on $\underline{|\theta_1}$ (red).

(3) Conversion of Coordinate System

From the following relations;

$$a+jb=\sqrt{a^2+b^2}\,\underline{\left|\tan^{-1}\frac{b}{a}\right.}=R\underline{/\theta}$$

here: $R=\sqrt{a^2+b^2}$

$$\theta=\tan^{-1}\frac{b}{a}$$

$$R\underline{/\theta}=R\cdot\cos\theta+jR\cdot\sin\theta$$

the conversion of vector in polar coordinate system to rectangular coordinate system and its reverse computation can be easily done.

Example 13. $25.1+j16.4=30\underline{/33.2^\circ}$

Move hairline to 0.251 on P_1,
set 0.164 on Q under hairline,

opposite right index of Q find 0.3 on P_1,
read answer as 30.
Opposite 25.1 on A right, set right index of BI,
move hairline to 16.4 on B left,
under hairline read answer as 33.2 on $\underline{/\theta_2}$ (red).

Example 14. $0.664+j0.588=0.887\ \underline{/41.5^\circ}$
Move hairline to 0.664 on P_1,
set 0.588 on Q under hairline,
opposite right index of Q read answer as 0.887 on P_1.
Opposite 66.4 on A right, set right index of BI,
move hairline to 58.8 on BI left,
under hairline read answer as 41.5 on $\underline{/\theta_2}$ (red).

Example 15. $-7.5+j6.0=9.61\ \underline{/180^\circ-38.7^\circ}$
Move hairline to 0.75 on P_1,
set 0.60 on Q under hairline,
opposite left index of Q find 0.961 on P_1,
read answer as 9.61.
Opposite 7.5 on A left, set right index of BI,
move hairline to 6.0 on BI right,
under hairline read 38.7 on $\underline{/\theta_2}$ (red),
thus phase angle is equal to $180^\circ-38.7^\circ$.

Example 16. $25\ \underline{/52^\circ}=15.4+j19.7$
Move hairline to 38 (=90−52) on S,
under hairline find 6.16 on C,
read as $\cos 38^\circ=0.616$,
move hairline to 52 on S,
under hairline find 7.88 on C,
read as $\sin 52^\circ=0.788$,
thus, real part is calculated as $25\times0.616=15.8$ and imaginary part $j25\times0.788=j19.7$.

(4) Multiplication and Division of Vectors

Multiplication and division of two vectors have been computed from the following formulas:

$$R_1\underline{/\theta_1}\times R_2\underline{/\theta_2}=R_1\cdot R_2\underline{/\theta_1+\theta_2}$$

$$\frac{R_1\underline{/\theta_1}}{R_2\underline{/\theta_2}}=\frac{R_1}{R_2}\underline{/\theta_1-\theta_2}$$

Example 17. Calulate the current in an electric circuit, which impedance is $4+j2.6$ and the potential difference between its terminals is $5+j9$. Answer $\dot{I}=1.907+j1.013$

$$\dot{I}=\frac{\dot{E}}{\dot{Z}}=\frac{5+j9}{4+j2.6}=\frac{\sqrt{5^2+9^2}\left/\tan^{-1}\left(\frac{9}{5}\right)\right.}{\sqrt{4^2+2.6^2}\left/\tan^{-1}\left(\frac{2.6}{4}\right)\right.}$$

$$=\frac{10.295\ /61^\circ}{4.775\ /33^\circ}=2.16\ \underline{/28^\circ}$$

$$=2.16\times\cos 28^\circ+j2.16\times\sin 28^\circ$$

$$=2.16\times0.883+j2.16\times0.469$$

$$=1.907+j1.013$$

Example 18. Compute the resultant current $\dot{I}$, of $\dot{I}_1=2+j3$ and $\dot{I}_2=3+j4$ in polar coordinate.
Answer $\dot{I}=8.60\ \underline{/54.5^\circ}$

$$\dot{I}=\dot{I}_1+\dot{I}_2=(2+j3)+(3+j4)=5+j7$$

$$=\sqrt{5^2+7^2}\underline{\left/\tan^{-1}\left(\frac{7}{5}\right)\right.}=8.60\ \underline{/54.5^\circ}$$

5. PROBLEMS OF ALTERNATING CURRENT CIRCUIT

By the use of the gauge mark "f", the problems of an alternating current circuit with inductance and capacitance

can be easily done.

(1) **Inductive Reactance**

Example 19. Find the inductive reactance x_L in an alternating current circuit with 30 mH inductance under 60 cycles frequency. Answer 11.3 Ω

Calculate as $x_L=2\pi fL=2\pi\times60\times30\times10^{-3}$.
Move hairline to 1 on D,
set 6 on C under hairline,
move hairline to 3 on D,
under hairline find 1.13 on C (extension part),
read answer as 11.3 Ω.

(2) **Condensive Reactance**

Example 20. Find the condensive reactance x_c in an alternating current circuit with static capacity of 2.5 μF under 60 cycles frequency. Answer 1061 Ω

Calculate as $x_c=\dfrac{1}{2\pi fc}=\dfrac{1}{2\pi\times60\times2.5\times10^{-6}}$.
Move hairline to f on D,
set 6 on C under hairline,
move hairline to 2.5 on CI,
under hairline find 1.061 on D,
read answer as 1061 Ω.

(3) **Resonance Frequency**

Example 21. Find the series resonance frequency in an alternating current circuit with inductance $L=150$ mH and static capacity $C=230\,\mu$F. Answer 27.1 cycles

Calculate as $f=\dfrac{1}{2\pi\sqrt{LC}}$

$=\dfrac{1}{2\pi\times\sqrt{150\times10^{-3}\times230\times10^{-6}}}$

$=\dfrac{1}{2\pi\times\sqrt{15\times2.3\times10^{-3}}}$.

Move hairline to 15 on A right,
set 2.3 on B right under hairline,
move hairline to f on D,
under hairline find 2.71 on C,
read answer as 27.1 cycles.

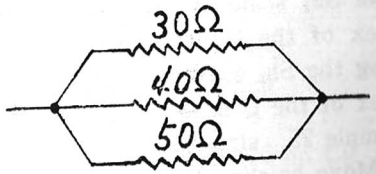
(4) **Surge Impedance**

Example 22. Find the surge impedance Z_0, if $L=280$ mH and $C=330$ pF are given. Answer 29.15 kΩ

Calculate as $Z_0=\sqrt{\dfrac{L}{C}}=\sqrt{\dfrac{280\times10^{-3}}{330\times10^{-12}}}=\sqrt{\dfrac{280}{33}}\times10^4$.
Opposite 2.8 on A left, set left index of BI,
move hairline to 33 on BI left,
under hairline find 2.915 on D,
read answer as 29.15 kΩ.

(5) **Parallel Resistance**

Example 23.



Determine the resultant resistance R in the following figure. Answer $R=12.8\,\Omega$

Calculate as $\dfrac{1}{R}=\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}$

$=\dfrac{1}{30}+\dfrac{1}{40}+\dfrac{1}{50}$.

Opposite 300 on I (on stock), set left index of I (on slide),
move hairline to 400 on I (on slide),
set left index of I (on slide) under hairline,
move hairline to 500 on I (on slide),
under hairline find 128 on I (on stock),
read answer as 12.8Ω.

Example 24. $\frac{1}{R}=\frac{1}{400}+\frac{1}{50}=\frac{1}{44.4}$

Opposite 400 on I (on stock), set left index of I (on slide),
move hairline to 50 on I (on slide),
under hairline read answer as 44.4Ω.

6. HYPERBOLIC FUNCTIONS

The logarithmic scales Sh_1, Sh_2 and Th are used for the computations of the hyperbolic functions.

(1) **Sinh x**

The Sh_1 and Sh_2 scales give the value of $\sinh x$. When using the Sh_1 scale to read the value of $\sinh x$, read the left index of the D scale as 0.1 and the right index as 1, and using the Sh_2 scale to read the value of $\sinh x$, read the left index of the D scale as 1 and the right index as 10.

Example 25. $\sinh 0.362=0.370$
Move hairline to 0.362 on Sh_1,
under hairline find 3.70 on D,
read answer as 0.370.

Example 26. $\sinh 2.56=6.42$
Move hairline to 2.56 on Sh_2,
under hairline read answer as 6.42 on D,

(2) **Tanh x**

The Th scale gives the value of $\tanh x$. When using the Th scale to read the value of $\tanh x$, read the left index of the D scale as 0.1 and the right index as 1.

Example 27. $\tanh 0.183=0.181$
Move hairline to 0.183 on Th,
under hairline find 1.81 on D,
read answer as 0.181.

(3) **Cosh x**

The value ot $\cosh x$ can be computed from the following formula:

$$\cosh x=\frac{\sinh x}{\tanh x}$$

$$\therefore \quad \frac{\tanh x}{\frac{1}{\cosh x}}=\frac{\sinh x}{1}$$

Therefore, move the hairline to x on the Sh_1 or Sh_2 scale, set the right or left index of the CI scale under the hairline, move the hairline to x on the Th scale, under the hairline read the value of $\cosh x$ on the CI scale.

Example 28. $\cosh 0.575=1.170$
Move hairline to 0.575 on Sh_1,
set right index of CI under hairline,
move hairlene to 0.575 on Th,
under hairline read answer as 1.170 on CI.

Example 29. $\cosh 1.65=2.70$
Move hairline to 1.65 on Sh_2,
set left index of CI under hairline,
move hairline to 1.65 on Th_1,
under hairline read answer as 2.70 on CI.

7. HYPERBOLIC FUNCTIONS OF COMPLEX QUANTITIES

The hyperbolic functions of the complex quantities are easily given the use of the unlogarithmic scales (X_1, X_2, Y, P_1 and P_2) and the logarithmic scales (|X, $|\theta_1$, $|\theta_2$ and |Y).

(1) **Sinh** $(a+jb)$

Example 30. $\sinh(0.7+j0.61)=0.951\,/0.858=0.951\,/49.1^\circ$

Move hairline to 0.7 on X_1,
set 0.61 on Y under hairline,
opposite right index of Q read answer as 0.951 on P_1.
Move hairline to 0.61 on |Y,
set 0.7 on |X under hairline,
move hairline to right index of |X,
under hairline read answer as 0.858 on |Y.
Move hairline to left index of I (on slide),
under hairline read answer as 49.1 on $|\theta_2$ (black).

Example 31. $\sinh(0.43+j0.68)=0.769\,/1.106=0.769/63.4^\circ$

Move hairline to 0.43 on X_1,
set 0.68 on Y under hairline,
opposite right index of Q read answer as 0.769 on P_1.
Move hairline to 0.68 on |Y,
set 0.43 on |X under hairline,
move hairline to right index of |X,
under hairline read answer as 1.106 on |Y.
Move hairline to left index of I (on slide),
under hairline read answer as 63.4° on $|\theta_2$ (black).

(2) **Cosh** $(a+jb)$

Example 32. $\cosh(0.7+j0.61)=1.117\,/0.4=1.117\,/22.9^\circ$

Move hairline to 0.7 on X_1,
set right index of Q under hairline,
move hairline to 0.61 on Y,

under hairline read answer as 1.117 on P_2.
Move hairline to 0.61 on |Y,
set right index of |X under hairline,
move hairline to 0.7 on |X,
under hairline read answer as 0.4 on |Y.
Move hairline to 0.61 on |Y,
set left index of I (on slide) under hairline,
move hairline to 0.7 on |X,
under hairline read answer as 22.9° on $|\theta_1$ (black).

Example 33. $\cosh(0.75-j1.24)=0.884\backslash 1.075=0.884\backslash 61.6^\circ$

Move hairline to 0.75 on X_1,
set left index of Q under hairline,
move hairline to 1.24 on Y,
under hairline read answer as 0.884 on P_1.
Move hairline to 1.24 on |Y,
set right index of |X under hairline.
move hairline to 0.75 on |X,
under hairline read answer as 1.075 on |Y.
Move hairline 1.24 on |Y,
set right index of I (on slide) under hairline,
move hairline to 0.75 on |X,
under hairline read answer as 61.6° on $|\theta_2$.

(3) **Tanh** $(a+jb)$

The type form of $\tanh(a+jb)$ is computed from the following formula:

$$\tanh(a+jb)=\frac{\sinh(a+jb)}{\cosh(a+jb)}$$

Example 34. $\tanh(0.56+j0.85)=1.08\,/0.628$

Calculate as $\tanh(0.56+j0.85)=\dfrac{\sinh(0.56+j0.85)}{\cosh(0.56+j0.85)}$.

Calculate $\sinh(0.56+j0.85)=0.955\,/\underline{1.152}$.
Move hairline to 0.56 on X_1,
set 0.85 on Y under hairline,
opposite right index of Q read answer as 0.955 on P_1.
Move hairline to 0.85 on |Y,
set 0.56 on |X under hairline,
move hairline to right index of |X,
under hairline read answer as 1.152 on |Y.
Calculate $\cosh(0.56+j0.85)=0.885\,/\underline{0.524}$
Move hairline to 0.56 on X_1,
set left index of Q under hairline,
move hairline to 0.85 on Y,
under hairline read answer as 0.885 on P_1.
Move hairline to 0.85 on |Y,
set right index of |X under hairline,
move hairline to 0.56 on |X,
under hairline read answer as 0.524 on |Y.

$$\therefore \quad \frac{0.955\,/1.152}{0.885\,/\underline{0.524}}=\frac{0.955}{0.885}\,/\underline{1.152-0.524}=1.08\,/\underline{0.628}$$

(4) **Tanh^{-1}** $(a+jb)$

The calculation of the type form of $\tanh^{-1}(a+jb)$ is worked out the following procedures:

Let $\tanh^{-1}(a+jb)=x+jy$,

above relation can be set up as follows;

$$x=\frac{1}{2}\log_e R,\quad y=\frac{\theta}{2}$$

and $$\frac{1+(a+jb)}{1-(a+jb)}=R\,/\underline{\theta},$$

$\therefore$ i) calculate $$\frac{1+(a+jb)}{1-(a+jb)}=R\,/\underline{\theta},$$

ii) calculate $x=\frac{1}{2}\log_e R$,

iii) calculate $y=\frac{\theta}{2}$.

Example 35. $\tanh^{-1}(0.2+j0.4)=0.1735+j0.393$

$1+(0.2+j0.4)=1.2+j0.4=1.265\,/\underline{18.4°}$
Move hairline to 1.2 on P_2,
set 0.4 on Q under hairline,
move hairline to right index of Q,
under hairline read answer as 1.265 on P_2.
Opposite 1.2 on A left, set left index of BI,
move hairline to 40 on BI left,
under hairline read answer as 18.4 on $|\theta_2$ (red).
$1-(0.2+j0.4)=0.8-j0.4=0.895\,/\underline{-26.6°}$
Move hairline to 0.8 on P_1,
set 0.4 on Q under hairline,
opposite right index of Q read answer as 0.895.
Opposite 80 on A right, set right index of BI,
move hairline to 40 on BI left,
under hairline read answer as 26.6 on $|\theta_2$ (red).

$$\therefore \quad \frac{1.265\,/18.4°}{0.895\,/\underline{-26.6°}}=\frac{1.265}{0.895}\,/\underline{18.4°+26.6°}=1.415\,/\underline{45°}$$

$$x=\frac{1}{2}\log_e 1.415=\frac{1}{2}\times 0.347=0.1735$$

Move hairline to 1.415 on LL_2,
set 2 on C under hairline,
opposite left index of C find 1.735 on D,
read answer as 0.1735.

$$y=\frac{45°}{2}=\frac{0.786}{2}=0.393$$

Thus, the answer is;

$\tanh^{-1}(0.2+j0.4)=0.1735+j0.393$

Example 36. Determine the unit line constant per km from the following values, with the line length of 85km under 60 cycles.

Admittance $Y_0=230.25\times10^{-6}\,/90^\circ$ ℧

Impedance $Z_s=78.5\,/73.6^\circ\,\Omega$

Answer $Z=0.920\,/73.8^\circ\,\Omega/\text{km}$

$Y\fallingdotseq j2.70\times10^{-6}$ ℧

The values of admittance Y_0 and impedance Z_s are given the following formulas;

$$Y_0=\frac{\tanh\xi D}{R},\quad Z_s=R\tanh\xi D$$

From the above relations, we can find the values of Y and Z by using the following formulas:

$$Y=\frac{\xi}{D},\quad Z=\xi R$$

Firstly, calculate R and ξD.

$$R=\sqrt{\frac{Z_s}{Y_0}}=\sqrt{\frac{78.5\,/73.6^\circ}{230.25\times10^{-6}\,/90^\circ}}$$

$$=\sqrt{\frac{78.5}{230.25}}\times10^{3}\Big/\frac{73.6^\circ-90^\circ}{2}$$

$$=\mathbf{0.584\times10^{3}\,\backslash 8.2^\circ}$$

$$\tanh\xi D=\sqrt{Y_0\cdot Z_s}$$

$$=\sqrt{230.25\times10^{-6}\times78.5\,/90^\circ+73.6^\circ}$$

$$=\sqrt{2.3025\times78.5\times10^{-4}\,/163.6^\circ}$$

$$=\sqrt{2.3025\times78.5}\times10^{-2}\Big/\frac{163.6^\circ}{2}$$

$$=13.44\times10^{-2}\,/81.8^\circ$$

$$=0.1344\,/81.8^\circ$$

$$=0.01918+j0.1331$$

$\therefore\ \xi D=\tanh^{-1}(0.01918+j0.1331)$

$$\frac{1+(0.01918+j0.1331)}{1-(0.01918+j0.1331)}=\frac{1.01918+j0.1331}{0.98082-j0.1331}$$

$$=\frac{1.028\,/7.44^\circ}{0.990\,\backslash 7.73^\circ}$$

$$=1.038\,/7.44^\circ+7.73^\circ$$

$$=1.038\,/15.17^\circ$$

$$\therefore\ \frac{1}{2}\log_e 1.038=\frac{1}{2}\times0.0373=0.01865$$

$$\frac{15.17^\circ}{2}=\frac{0.265}{2}=0.1325$$

$\therefore\ \xi D=\tanh^{-1}(0.01918+j0.1331)$

$$=0.01865+j0.1325=0.1339\,/82^\circ$$

therefore, $\xi=\dfrac{0.1339\,/82^\circ}{85}=\mathbf{1.575\times10^{-3}\,/82^\circ}$

from above values;

$$Z=\xi R=(1.575\times10^{-3}\,/82^\circ)\times(0.584\times10^{3}\,\backslash 8.2^\circ)$$

$$=1.575\times0.584\,/82^\circ-8.2^\circ$$

$$=0.920\,/73.8^\circ$$

$$=0.0257+j0.883\,\Omega/\text{km}$$

$$Y=\frac{\xi}{R}=\frac{1.575\times10^{-3}\,/82^\circ}{0.584\times10^{3}\,\backslash 8.2^\circ}$$

$$=\frac{1.575}{0.584}\times10^{-6}\,/82^\circ+8.2^\circ$$

$$=2.70\times10^{-6}\,/90.2^\circ$$

$$\fallingdotseq j2.70\times10^{-6}\text{ ℧}$$

.....Answers

— THE END —

APPENDIX

(1) Legend Numbers

There are the legend numbers on the right ends of your slide rules. The following is the brief description of the legend numbers.

scale mark	legend number	explanation
S	0.1→0.1	.....When using the S scale to read the value of $\sin\theta$, read the left index of C as 0.1 and the right index as 1.0.
ST	0.01→0.1	.....When using the ST scale to read the value of $\sin\theta$ or $\tan\theta$, read the left index of C as 0.01 and the right index as 1.0.
T	0.1→1.0	.....When using the T scale to read the value of $\tan\theta$, read the left index of C as 0.1 and the right index as 1.0.
(red) T	10.0←1.0	.....When using the (red) T scale to read the value of $\tan\theta$, read the right index of C as 1.0 and the left index as 10.0.
LL_3	1.0→10.0	.....When using the LL_3 scale to read the value of e^x, indicate the range of x which is set on the D scale, namely read the left index of D as 1.0 and the right index as 10.0.
LL_2	0.1→1.0	.....When using the LL_2 scale to read the value of e^x, read the left index of D as 0.1 and the right index as 1.0.
LL_1	0.01→0.1	.....When using the LL_1 scale to read the value of e^x, read the left index of D as 0.01 and the right index as 0.1.

(2) Scale Marks on Runner.

To aid the operator in remembering, the scale marks are written on the runner glasses.

(3) Proper Care and Adjustment for Bamboo Slide Rule

Your slide rule should always be kept in a dry cool place and do you not expose slide rule to direct rays of the sun or extreme heat.

If the slide rule has to be kept in a damp place, or if the slide does not move with ease, it is good that some paraffin wax isapplied to the tongues of the slide and the grooves of the stocks.

Dusts or stains on the surface of the slide rule can be removed with cloth moistened with small amount of linseed oil. Alcoholic must be avaided as it tends to dissolve celluloid.

If the slide is too stiff or too loose, loosen the screw first at one end of the top of the L-type bracket of the upper stock, moving that end a very slight amount either to decrease or to increase the pressure of the upper stock against the slide. Tighten the screw and repeat the per formance at the other end. Do not loosen both screws at the same time.

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