
T1
T2
K
A Lf
B Cf
F
CI
C Lx Xc
D XL Cx
L DB1 DB2
S
6504型无线电与电工计算尺
工农兵
天津市计算尺厂
LL01
LL02
LL03
SG1
SG2
SG2
C
R1
R2
LL3
LL2
LL1

How to Use The Special Scales of 6504&6508 Slide Rule

For Radio and Electrician

Brand "Squirrel" or "Gong Nong Bing"

Tianjian, China

I. Scales of the 6504 and 6508

The Tianjin Slide Rule Factory Former name was No 11 Plastic Manufactory of Tianjin. The slide rules of Brand "Squirrel" were made by No 11 Plastic Manufactory of Tianjin before 1966. In 1966, the Manufactory changed the name into The Tianjin Slide Rule Factory. And, the brand was changed into "Gong Nong Bing (Worker, Farmer Soldier)". The Model 6504 and 6508 slide rules have same scales, they are using for radio and electronic engineer with some special scales besides the generals. The special scales are F, Lf, Cf, Lx, Xc, Xl, Cx, DB1, DB2, R_1, R_2, SG_1, SG_2 SG_2'. The general scales are T_1, T_2, K, A, B, C, D, L, S, LL_{01}, LL_{02}, LL_{03}, LL_1, LL_2, LL_3. Here, only the usage of special scales will be given out in this Manual.

II. Usage of F scale.

The number on the F scale is increase from right to left. The useful number are from 1.592 to 15.92, the number from 1.5 to 16 were scored on the rule. Indeed, this scale is a fold the CI scale from $1/2\pi$.

1. It can be using for calculating the inductance L, capacitance C, syntonic frequency f_0 on a shunt circuit, or, connected in series.

1) The formula is: $$f_0 = \frac{1}{2\pi}\sqrt{LC} \qquad \text{(f-1)}$$

2) Before calculating, change the L into $a \times 10^{-m} H$, and, C into $b \times 10^{n} F$.

The a and b should be changed into 1 or 2 digital number, on both the m and n are even concurrence, or, are odd concurrence. Then, use the Lf , Cf scales calculating the f.

The formula is: Lf+Cf=F (f-2)

Method: Set Cf:b on Lf:1 (or Lf:100), against Lf:a read F:C.

3) Decide the digital: $f_0=c\times10^{k}$Hz, The C can read on F scale, There are two status of the K,

a) When pull the slide to right:

$$K = \frac{m+n}{2} - 3 \qquad \text{(f-3)}$$

b) When pull the slide to left or no move the slide:

$$K = \frac{m+n}{2} - 2 \qquad \text{(f-4)}$$

4) If known the f_0 and C, the L can be calculated. If known the f_0 and L, the C can be calculated. The way is a inverse operation of above mothed.

Ex.1: Known: L=5μH, C=35pF, find f_0=?

First: $L=5\times10^{-6}$H, i.e. a=5, m=6

$C=35\times10^{-12}$F, i.e. b=35, n=12

Set Cf:35 on Lf:100, against Lf:5 read F:12.03. There, the slide was moved to right, using the formula (f-3), $K = \frac{6+12}{2} - 3 = 6$

So: $f_0=12.03\times10^{6}$Hz=12.03MHz

Ex.2: Known: f_0=10.6MHz, C=15pF, find L=?

First: $f_0=10.6\times10^{6}$Hz, i.e. c=10.6, K=6,

$C=1.5\times10^{-11}$F, i.e. b=1.5, n=11

Set Cf:1.5 on Lf:1, against F:10.6 read Lf:1.5. There, the slide was moved to left, using the inverse operation of formula (f-2), m=2(K+2)-n=2×(6+2)-11=5

So: $L=1.5\times10^{-5}$H=15μH

2. When known the inductance L, syntonic frequency f， find the impedance of inductance X_L.

1) The formula is: $X_L=2\pi fL$ (f-5)

2) Before calculating, change the L into $a \times 10^{-m} H$, and, f into $c \times 10^{K} Hz$.

Here, a should be one digital number, and, c should be a number between 1.592 thro 15.92. Use the Lx, and X_L scales to get X_L = $d \times 10^{p}\Omega$

The formula is: $X_L=L_X-F$ (f-6)

Method: Set F:c on X_L:1 , against L_X:a read X_L:d.

3) Decide the digital: $f_0=c\times10^kHz$, The C can read on F scale, There are two status of the K,

a) When pull the slide to right or no move the slide:

P=K-m+1 (f-7)

b) When pull the slide to left:

P=K-m+2 (f-8)

4) Same above, it can be used for the inverse operation.

Ex.3: Known f=120Hz, L=5H find X_L=?

First, $f=12\times10^1Hz$, i.e. c=12, K=1

$L=5\times10^0H$, i.e. a=5, m=0

Set F:12 on Lx:1, against Lx:5 read X_L:3.77. There, the slide was moved to left, using the formula (f-8), p=K-m+2=1-0+2=3

So: $X_L=3.77\times10^3\Omega=3.77k\Omega$

Ex.4: Known f=2.5MHz, $X_L=267\Omega$ find L=?

First, $f=2.5\times10^6Hz$, i.e. c=2.5, K=6

$X_L=2.67\times10^2\Omega$, i.e. d=2.67, p=2

Set F:2.5 on X_L:10, against X_L:2.67 read Lx:1.7. There, the slide was moved to right, using the inverse operation of formula (f-7), m=K+1-p=6+1-2=5

So: $Lx=1.7\times10^{-5}H=17\mu H$

2. When known the capacitance, syntonic frequency f，find the impedance of capacitance X_C.

1) The formula is: $X_C=1/(2\pi)fC$ (f-9)

2) Before calculating, change the C into $b\times10^{-n}F$, and, f into $c\times10^{K}Hz$.

Xc into $d\times10^{p}\Omega$. Use the Xc, and Cx scales to get Xc = $d\times10^{p}\Omega$

The formula is: Xc=F－Cx (f-10)

Method: Set F:c on Cx:b , against Cx:1 read Xc:d.

3) Decide the digital:

a) When pull the slide to right: P= -(K-n)-3 (f-11)

b) When pull the slide to left or no move the slide, and, the Xc is at Cx:1: P= -(K-n)-2 (f-12)

4) Same the above, it can be used for the inverse operation.

Ex.5: Known f=2.5MHz, C=4000PF find Xc=?

First, $f=2.5\times10^6Hz$, i.e. c=2.5, K=6

$C=4\times10^{-9}F$, i.e. b=4, n=9

Set F:2.5 on Cx:4, against Cx:1 read Xc:1.59. There, the slide was moved to left, using the formula (f-12), p= -(K-n)-2=-(6-9)-2=1

So: $Xc=1.59\times10^1\Omega=15.9\Omega$

Ex.6: Known $Xc=355k\Omega$, C=560PF find f=?

First, $Xc=3.55\times10^5\Omega$, i.e. d=3.55, p=5

$C=5.6\times10^{-10}F$, i.e. b=5.6, n=10

Set Xc:3.55 on Cx:10, against Cx:5.6 read F:8. There, the slide was moved to right, using the inverse operation of formula (f-12), K=n-p-3=10-5-3=2

So: $f=8\times10^2H=800Hz$.

III Usage of DB1 and DB2 scales

DB1 and DB2 scales are using the same scale with L. Both the two scale are read from left to right. The scale will be 0-10 for DB1, The scale will be 0-20 for DB2.

1. On a circuit, if the input power is P1, the output power is P2, Then, The Neper will be:

N(db)=10lg(P2/P1)

Use the DB1 scale. If the P1<P2, then, N(db) will be a positive number, if P1>P2, then, N(db)will be a negative.

Let: N(db)=K×10+Q (f-13)

1) Find Q=?

a) When P1<P2, set C:P1 on D:P2, against C:1 or C:10 read DB1:Q.

b) When P1>P2, set C:P2 on D:P1, against C:1 or C:10 read DB1:-Q.

2) Decide the digital K: Suppose the digital of P1 is n, the digital of P2 is m. and the dimensions are same.

a) When pull the slide to right: K=m-n (f-14)

b) When pull the slide to left: $K=m-n-1$ for $P1<P2$) (f-15)

$K=m-n+1$ for $P1>P2$ (f-16)

Ex. 7 Known P1=0.3W, P2=1503.6W find N(db)=?

$P1<P2$, so, N(db) is a positive number.

Set C:0.3 on D:1503.6, against C:10 read DB1:7. There, the slide was moved to left, using the formula (f-15), $K=m-n-1=4-0-1=3$

So: $N(db)=3\times10+7=37$db.

Ex. 8 Known P1=0.2W, P2=2.62mW =0.00262W find N(db)=?

$P1>P2$, so, N(db) is a negative number.

Set C:0.00262 on D:0.2, against C:10 read DB1:-8.82. There, the slide was moved to left, using the formula (f-15), $K=m-n-1=-2-0+1=-1$

So: $N(db)=-1\times10+(-8.82)=-18.82$db.

2. On a circuit, if the input impedance equals the output impedance, and, the operating mode is matching, Then, The Neper will be:

$N(db)=20\lg(U2/U1)=20\lg(I2/I1)$

Use the DB2 scale. If the $U1<U2$ ($I1<I2$), then, N(db) will be a positive number, if $U1>U2$ ($I1>I2$), then, N(db) will be a negative.

Let: $N(db)=K\times10+Q$ (f-17)

1) Find Q=?

a) When $U1(I1)<U2(I2)$, set C:U1(I1) on D:U2(I2), against C:1 or C:10 read DB2:Q.

b) When $U1(I1)>U2(I2)$, set C:U2(I2) on D:U1(I1), against C:1 or C:10 read DB2:-Q.

2) Decide the digital K: Suppose the digital of U1(I1) is n, the digital of U2(I2) is m. and the dimensions are same. There,

a) When pull the slide to right: $K=2(m-n)$ (f-18)

b) When pull the slide to left:

$K=2(m-n-1)$ for $U1(I1)<U2(I2)$ (f-19)

$K=2(m-n+1)$ for $U1(I1)>U2(I2)$ (f-20)

Ex. 9 Known U1=3mV, U2=1.893V=1893mV find N(db)=?

$U1<U2$, so, N(db) is a positive number.

Set C:3 on D:1893, against C:10 read DB2:16. There, the slide was moved to left, using the formula (f-19), $K=2(m-n-1)=2(4-1-1)=4$

So: $N(db)=4\times10+16=56$db.

IV Usage of R1 and R2 scales

The graduations of R1 and R2 are same. Both these two scales are from 0.5 thru ∞. These two scales is using for calculating the resistance of a parallel connection or in series circuit.

The formula: $1/R=1/r_1+1/r_2+1/r_3+\ldots\ldots$ (f-21)

$1/C=1/c_1+1/c_2+1/c_3+\ldots\ldots$

Take the (f-21) as a example explain the way for calculation: Set R1: ∞ on R2:r_2, move the hairline over R1:r_1, then, reset R1: ∞ under the same hairline, against R1:r_3 read R2:R, the rest may be deduced by analogy.

Ex. 10 Known $r_1=10k\Omega$, $r_2=8k\Omega$ find parallel connection R=?

Set R1: ∞ on R2:8, against R1:10 read R2:4.44,

∴ $R=4.44k\Omega$

Ex. 11 Known $r_1=250\Omega$, $r_2=500\Omega$, $r_3=690\Omega$, find parallel connection R=?

Set R1: ∞ on R2:5, move the hairline over R1:2.5, reset R1: ∞ under the same hairline, against R1:6.9 read R2:1.34 is the answer.

∴ $R=134\Omega$

V Usage of SG1,SG2 and SG2' scales

All of this three scale are increase from left to right. SG1 and SG2 are from 0 thru 10, SG2' is from 10 thru 14.14. These three scales may called P, Q, Q' scales on other slide rules. That means Pythagoras theorem. In china, this scales is called SG, because Shang Gao, an archaian Chinese, found this theorem was earlier 300 more years than Pythagoras.

On radio and electronic engineering, the theorem $c^2=a^2+b^2$ will be used frequently.

The method is: Set SG2 : a or SG2' :a on SG1:0, opposite SG1:b read SG2(SG2'):c.

Ex.12 A triangle, Known one right angle side a=12, other right angle side b=5, find the hypotenuse c=?

Solution: $c=\sqrt{a^2+b^2}$, SetSG2:12 On SG1:0, opposite SG1:5 read SG2:13 is the answer.

∴ c=13

Ex.13 A triangle, Known hypotenuse c=5，one right angle side a=4， find the other right angle side b=?

Solution: $b=\sqrt{c^2-a^2}$, SetSG2:4 On SG1:5, opposite SG2:0 read SG1:3 is the answer.

∴ b=3

VI Solution of Vector

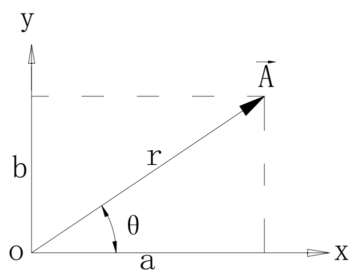
Solution of the Vector is relative to trangles problem,

$$\dot{A}=re^{j\theta}=r(\cos\theta+j\sin\theta)=a+jb$$

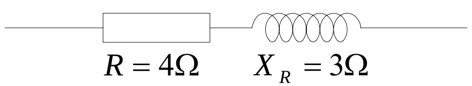
1. Convert the right angle coordinate into polar coordinate, the following formulae can be used.

$$r=\sqrt{a^2+b^2}=a/\cos\theta=b/\sin\theta$$

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



Ex.14 Known R=4Ω, X_R=3Ω, Convert the resistance in series circuit into polar coordinates.



Solution: $Z=(4+j3)\Omega=re^{j\theta}\Omega$,

Set C:1 on D:3, move the hairline over CI:4(red) , under the hairline read T1:36.88 is the θ, remove the hairline over S:36.87(black), under the hairline read CI:5 is the r.

And, The way of Ex.12 can be used for finding r.

Use the measures those been given on over, the r = 5, and θ=36.87° can be found.

2. Convert the polar coordinate into right angle coordinate the following formulae can be used.

$$a=r\cos\theta,\qquad b=r\sin\theta$$

Ex.15 Know $I=5e^{-j23^\circ}A$, Convert the current in series circuit into right angle coordinates.

$$Z=(4+j3)\Omega=re^{j\theta}\Omega,$$

Solution: $I=5e^{-j23^\circ}A=[5\cos(-23^\circ)+j5\sin(-23^\circ)]A$

Set C:5 on D:10, move the hairline over S:23(red) , under the hairline read C:4.6 is the a, remove the hairline over S:23(black), under the hairline read C:1.95 is the b.

∵ sin(-23°)=-sin23°, cos(-23°)=cos23°

∴ I=(4.6-j1.95)A