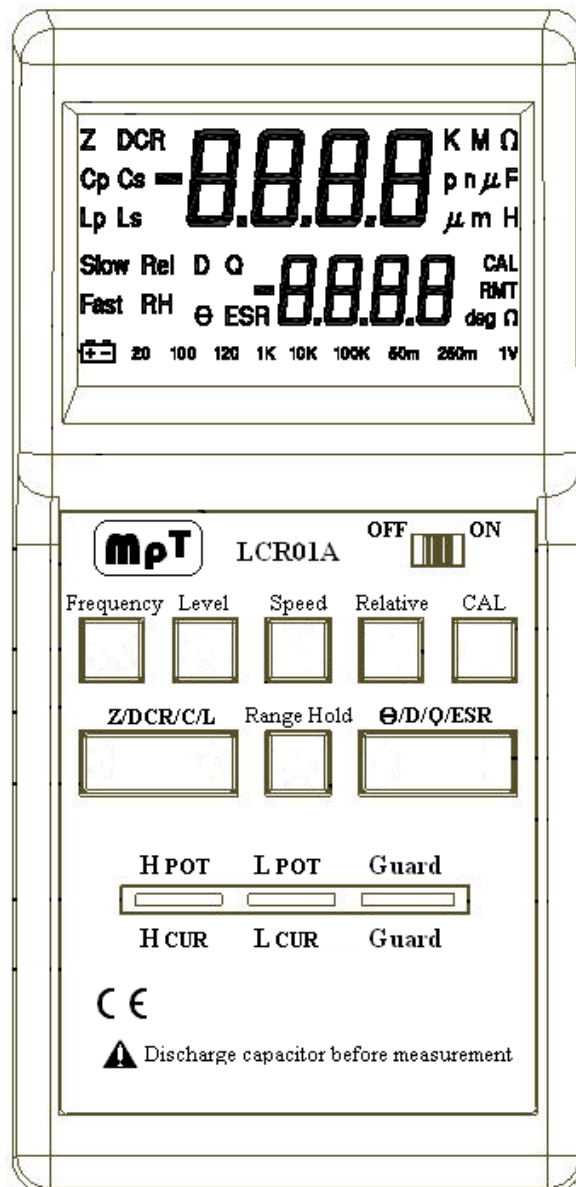


# MPT LCR01A/B

## Handheld LCR bridge meter

### User manual



Featured :

1. Adapt DSP technology to achieve fast measuring speed, high accuracy and high reliability. Measuring frequency can be set at 100K/10K/1K/120/100/20 Hz (LCR01A) or 1M/500K/100K/10K/1K/100Hz (LCR01B) .
2. Measuring parameter : Main parameter Z , Lp , Ls , Cp , Cs , DCR and subparameter ESR , D , Q ,  $\theta$  can be displayed in any combination.

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Ls-D , Ls-Q , Ls- $\theta$  , Ls-ESR

Parallel mode : Cp-D , Cp-Q , Cp- $\theta$   
Lp-D , Lp-Q , Lp- $\theta$

## 1.2. Impedance parameter definition

According to the different measuring signal of impedance meter , It can be separated DC and AC impedance meter . The popular multimeter in market is a DC resistance meter ; The MPT LCR01A/B is an AC/DC impedance meter . For electronic Circuit , component and material , impedance is an important parameter .

In engineering , vector is used to express impedance , It analysed real part Resistance(R) and imagine part reactance(X) ; And the polar express impedance(Magnitude) and Theta(Phase) . Diagrams below show the relation .

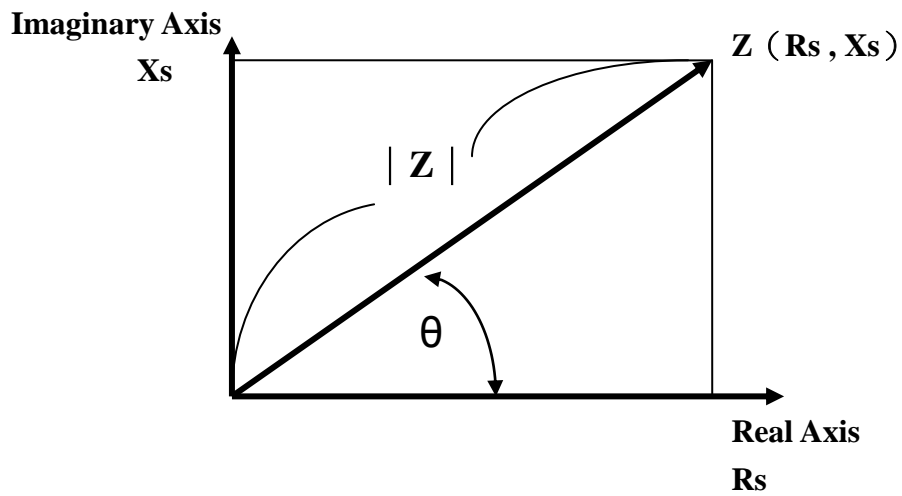


圖 一

$$\mathbf{Z} = \mathbf{R}_s + j\mathbf{X}_s = |\mathbf{Z}| \angle \theta \quad (\Omega)$$

$$\mathbf{R}_s = |\mathbf{Z}| \cos\theta \quad |\mathbf{Z}| = \sqrt{\mathbf{R}_s^2 + \mathbf{X}_s^2}$$

$$\mathbf{X}_s = |\mathbf{Z}| \sin\theta \quad \theta = \tan^{-1} (\mathbf{X}_s/\mathbf{R}_s)$$

**Z** : Impedance

**Rs** : Resistance

**Xs** : Reactance

**Ω** : Unit Ohm

Reactance can be separated as(Inductive)  $X_L$  and(Capacitive)  $X_C$  . The definition as :

$$X_L = \omega L = 2\pi fL \quad \text{and} \quad L : \text{Inductance (H)}$$

$$X_C = (\omega C)^{-1} = (2\pi fC)^{-1} \quad C : \text{Capacitance (F)}$$

$$f : \text{Frequency (Hz)}$$

Additional , other parameters are attached to passive component , Quality factor(Q) and Dissipation Factor(D) . Both are defined the purity of reactance , that is the energy storage(reactance) and the energy consumption(resistance)ratio , defined as follow :

$$Q = D^{-1} = (\tan \delta)^{-1}$$

$$= |X_s| \cdot R_s^{-1} = \omega \cdot L_s \cdot R_s^{-1} = (\omega \cdot C_s \cdot R_s)^{-1}$$

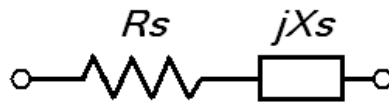
$$= |B| \cdot G^{-1}$$

$$= R_p \cdot |X_s|^{-1} = R_p \cdot (\omega \cdot L_p)^{-1} = \omega \cdot C_p \cdot R_p$$

Quality factor is applied on inductive components , and Dissipation factor is applied on capacitive components . Both are reciprocal each other .

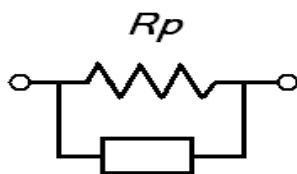
Traditional , component can be analysed as series equivalent and parallel equivalent . Both defined as follow .

#### Series connection



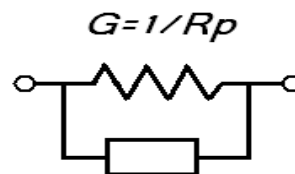
$$Z = R_s + jX_s$$

#### parallel connection



$$jX_p$$

$$Y = \frac{1}{R_p} + \frac{1}{jX_p}$$



$$jB = 1/jX_p$$

$$Y = G + jB$$

### 1.3. Specification and Accuracy

●LCD display :

parameter	Range
Z	0.000Ω ~ 9999MΩ
L	0.000μH ~ 9999H(LCR01A) 0.0xxnH ~ 9999H(LCR01B)
C	0.000pF ~ 9999F
DCR	0.000Ω ~ 9999MΩ
ESR	0.000Ω ~ 9999Ω
D	0.000 ~ 9999
Q	0.000 ~ 9999
∅	- 180.0° ~ 180.0°

●Accuracy (Ae) :

Ae	Z <sub>x</sub>	20M	10M	750K	100K	20K	10	1
		∫ 10M (Ω)	∫ 750K (Ω)	∫ 100K (Ω)	∫ 20K (Ω)	∫ 10 (Ω)	∫ 1 (Ω)	∫ 0.1 (Ω)
DCR		2% ±	1% ±	0.5%	0.2%	0.2%	0.5% ± 1	1% ± 1
20Hz(LCR01A)/100Hz		1*	1	±1	±1	±1	*	*
120Hz(LCR01A)								
1KHz								
10KHz		5% ± 1*	2% ± 1					
100KHz		UnD	5% ± 1*	2% ± 1	0.4% ±1	0.4% ±1	2% ± 1*	5% ± 1 *
500KHz (LCR01B)		UnD	UnD	2% ±1	1% ± 1	0.5% ±1	2% ± 1*	5% ± 1 *
1MHz (LCR01B)		UnD	UnD	UnD	1% ± 1	0.5% ±1	2% ± 1 *	5% ±1*

Accuracy show above is true when 1Vrms measuring level used ◦

Ae X 1.25 if 250mVrms measuring level used ◦

Ae X 1.50 if 50mVrms measuring level used ◦



measuring L and C , if  $D_x > 0.1$ , then  $A_e X = \sqrt{1+D_x^2} \cdot$

Measuring ESR , if  $Q_x > 0.1$ , then  $A_e X = \sqrt{1+Q_x^2} \cdot$

\* Measuring level set to 50mV,  $A_e$  undefined .

Z accuracy : shown on table 1.

C accuracy :

$$|Z_x| = (2 \cdot \pi \cdot f \cdot C_x)^{-1} \quad (\Omega)$$

$CA_e = A_e$  of  $|Z_x|$

f : frequency(Hz)

$C_x$ :The measured capacitance(F)

$|Z_x|$  : The measured impedance( $\Omega$ )

Above accuracy is true when  $D_x < 0.1$  , if  $D_x > 0.1$  then  $CA_e X = \sqrt{1+D_x^2} \cdot$

Example : C accuracy calculate

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Capacitance under test : 100nF

Then

$$\begin{aligned} |Z_x| &= (2 \cdot \pi \cdot f \cdot C_x)^{-1} \\ &= (2 \cdot \pi \cdot 10^3 \cdot 100 \cdot 10^{-9})^{-1} = 1590 \quad (\Omega) \end{aligned}$$

look up on table 1:

$CA_e = \pm 0.2$  (%)



L accuracy :

$$|Z_x| = 2 \cdot \pi \cdot f \cdot L \quad (\Omega)$$

$$L_{Ae} = A_e \text{ of } |Z_x|$$

f : Frequency(Hz)

Lx: The measured inductance(H)

| Zx | : The measured impedance( $\Omega$ )

Above accuracy is true when  $D_x < 0.1$  , if  $D_x > 0.1$  then  $C_{Ae} X \sqrt{(1+D_x^2)}$  .

Example : L accuracy calculation

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Inductance under test : 1mH

then

$$|Z_x| = 2 \cdot \pi \cdot f \cdot L_x$$

$$= 2 \cdot \pi \cdot 10^3 \cdot 10^{-3} = 6.283 (\Omega)$$

look up on table 1:

$$L_{Ae} = \pm 0.5 (\%)$$

ESR accuracy :

$$\pm X_x \cdot A_e \cdot 100^{-1} \quad (\Omega)$$

$$X_x = 2 \cdot \pi \cdot f \cdot L_x = (2 \cdot \pi \cdot f \cdot C_x)^{-1}$$

f : Frequency(Hz)

X<sub>x</sub>:The measured impedance( $\Omega$ )

L<sub>x</sub>:The measured inductance(H)

C<sub>x</sub> : The measured capacitance(F)

Above accuracy is true when  $D_x < 0.1$  °

Example : Cs-ESR accuracy calculation

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Capacitance under test : 100nF

then

$$\begin{aligned} |Z_x| = X_x &= (2 \cdot \pi \cdot f \cdot C_x)^{-1} \\ &= (2 \cdot \pi \cdot 10^3 \cdot 100 \cdot 10^{-9})^{-1} = 1590 \quad (\Omega) \end{aligned}$$

look up on table 1:

$$CA_e = \pm 0.2 \quad (\%)$$

$$ESR_{A_e} = \pm X_x \cdot A_e / 100$$

$$= \pm 1590 \times 0.2 / 100 = \pm 3.18 \quad (\Omega)$$

D accuracy :

$$D_e = \pm A_e / 100$$

Above accuracy is true when  $D_x < 0.1$  , if  $D_x > 0$ . then  $C A_e \times (1 + D_x)$  °

Example : C-D accuracy calculation

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Capacitance under test : 100nF

then

$$\begin{aligned} |Z_x| &= (2 \cdot \pi \cdot f \cdot C_x)^{-1} \\ &= (2 \cdot \pi \cdot 10^3 \cdot 100 \cdot 10^{-9})^{-1} = 1590 (\Omega) \end{aligned}$$

look up on table 1:

$$C A_e = \pm 0.2 (\%)$$

$$D A_e = \pm C A_e / 100$$

$$= \pm 0.2 / 100 = \pm 0.002$$

Q accuracy :

$$Q_e = \pm(Q_x^2 \cdot D_e) / (1 \mp Q_x \cdot D_e)$$

$Q_x$  : The measured Q value °

$D_e$ :relative D accuracy °

Above accuracy is true when  $Q_x \cdot D_e < 1$  °

Example : C-Q accuracy calculation

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Inductance under test : 1mH

then

$$|Z_x| = 2 \cdot \pi \cdot f \cdot L_x$$

$$= 2 \cdot \pi \cdot 10^3 \cdot 10^{-3} = 6.283 (\Omega)$$

look up on table 1:

$$L_{Ae} = \pm 0.5 (\%)$$

$$D_e = \pm L_{Ae} / 100 = \pm 0.005$$

If the measured  $Q_x = 20$

$$Q_{Ae} = \pm(Q_x^2 \cdot D_e) / (1 \mp Q_x \cdot D_e) = \pm (2 / (1 \mp 0.1))$$

⊖ accuracy :

$$\theta_e = (180/\pi)/(A_e/100) \text{ (Deg)}$$

Example : Z-⊖ accuracy calculation

Measuring condition :

Frequency : 1KHz

Level : 1Vrms

Speed : Slow

Capacitance under test : 100nF

then

$$\begin{aligned} |Z_x| &= (2 \cdot \pi \cdot f \cdot C_x)^{-1} \\ &= 1/(2 \cdot \pi \cdot 10^3 \cdot 100 \cdot 10^{-9}) = 1590 \text{ } (\Omega) \end{aligned}$$

look up on table 1:

$$Z_{Ae} = \pm 0.2 \text{ } (\%)$$

$$\theta_{Ae} = \pm (180/\pi)/(Z_{Ae}/100) = \pm 0.115 \text{ } (\text{Deg})$$

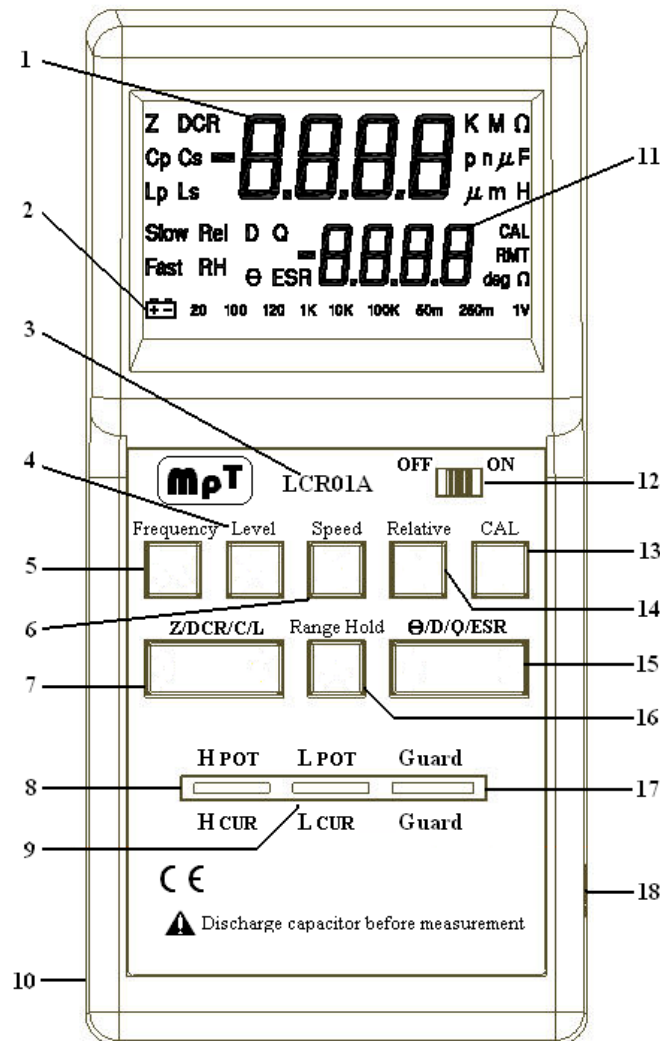
- measuring signal :
  - Level accuracy : 10%
  - Frequency accuracy : 0.01%
- Output impedance :  $100\Omega \pm 5\%$
- Measuring speed : depend on frequency
  - Fast : 5 times/second(10 KHz)
  - Slow : 2 ~ 5 times/second(10 KHz)
- Power low notify :
  - Input or battery power lower than 6.2Volt
- Battery :
  - Charge current : about 60mA
  - Battery type : Lithium-Ion
  - Life : 11 hr(LCR01A) , 8 hr(LCR01B)
- Adapter :
  - Input : 110V/220Vac 50/60Hz
  - Output : 12Vdc
- Operation environment :
  - Temperature : 0°C to 40°C (operation)
  - 20°C to 70°C (storage)
  - Humidity :  $\leq 85\%$  R.H. at 40°C
  - Size : 178mm × 86 mm × 45mm
  - 7" × 3.4" × 1.8" (L×W×H)
  - Weight : 300g

#### 1.4. Accessory

- LCR01A/B Operation manual
- LCR01A or **LCR01B** one set
- Lithium-Ion rechargeable battery
- Shorted Bar
- 5 wire/0.75mSMD test probe
- 5 wire/0.75m Kelvin Clips test cable
- AC power adaptor

2. User operate illustration

2.1. Panel :



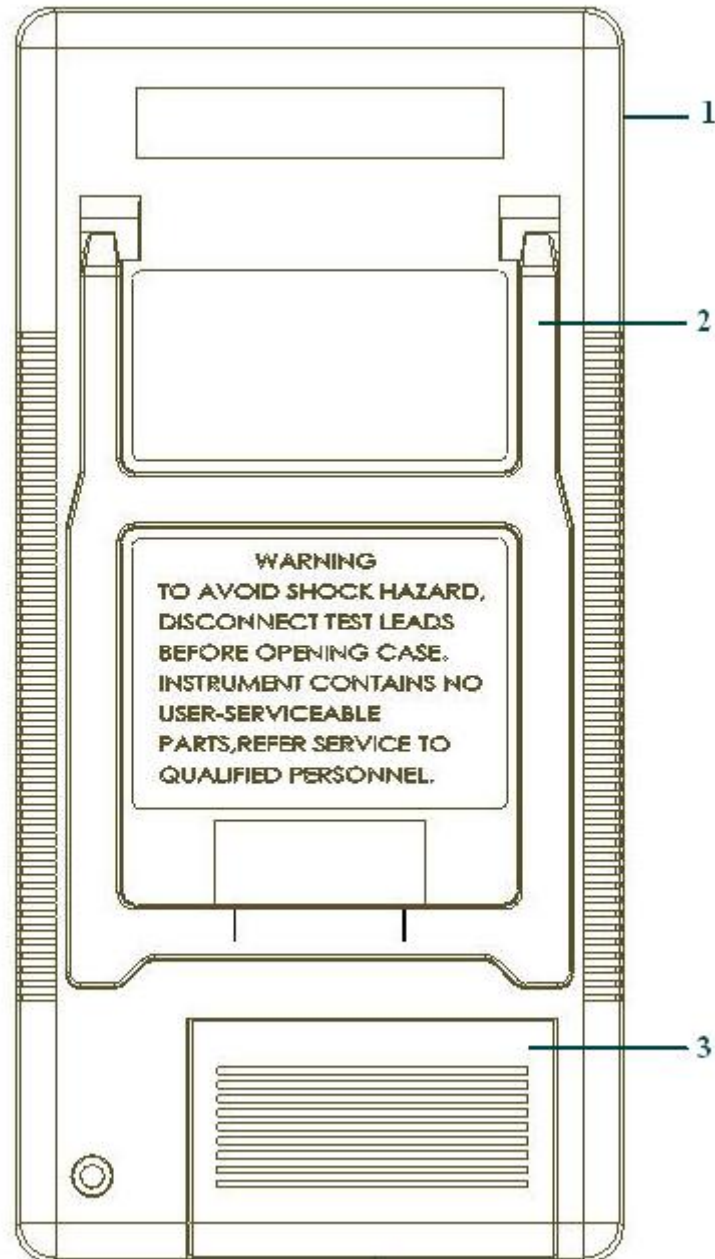
- |                                    |   |
|------------------------------------|---|
| 1. Main parameter display LCD      | 11. Subparameter display LCD                |
| 2. Low voltage indicator           | 12. Power ON/OFF switch                     |
| 3. Machine type                    | 13. Open/Short calibration button           |
| 4. Level switch button             | 14. Relative mode button                    |
| 5. Frequency switch button         | 15. $\Theta$ /D/Q/ESR display switch button |
| 6. Display speed switch Button     | 16. Auto/Range hold switch button           |
| 7. Z/DCR/C/L display switch button | 17. Guard terminal                          |
| 8. Hpot/Hcur terminal              | 18. Power adaptor input hole                |
| 9. Lpot/Lcur terminal              |   |
| 10. Battery house                  |   |



## 2.2. Power :

### ●Battery supply

Remove battery cup , clean battery house , put the pull-up tape under battery and put battery into the battery house in proper direction , then put on the battery cup . If the battery is not chargeable , remove the power adaptor input connector ; If the battery is chargeable , power adaptor input connector can be plug-in .



●Power adaptor supply

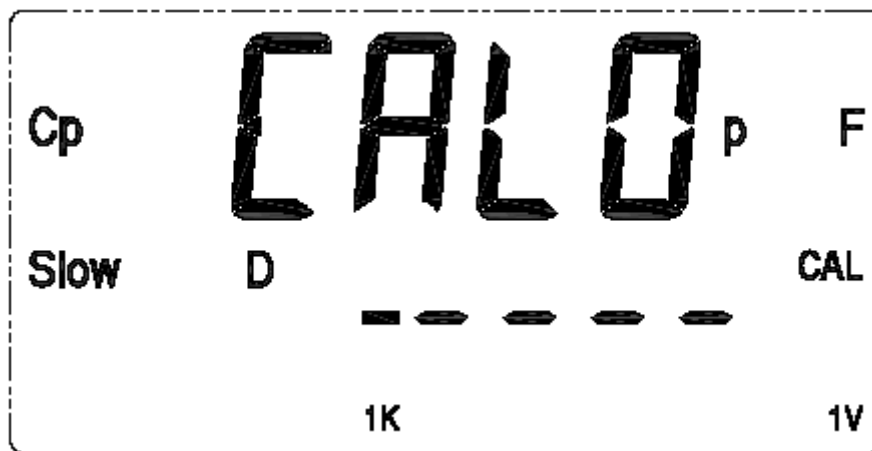
If battery not available , It can be powered by power adaptor ° If the power adaptor is plug-in and the power switch on LCR01A/B is off , It will charge battery on battery house °

### 2.3. Open/Short calibration :

LCR01A/B function with Open/Short calibration to meet the measuring of High/Low impedance measurement °

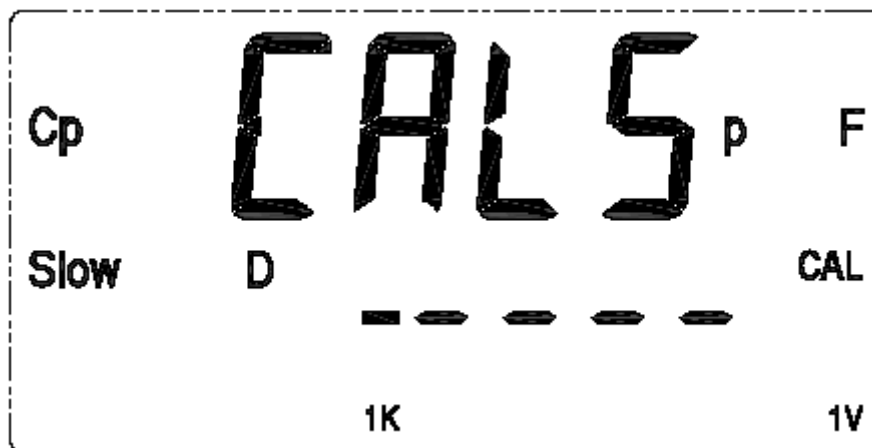
#### ●Open calibration

Clean the measuring terminal , make it on open state , press **【CAL】** button about 1 second , main parameter will display 「CALO」 and a “bi” sound will be heard , Calibration time will depend on measuring frequency , the high frequency ,the lower calibration time needed ; After calibration , a “bi” sound will be heard again °



#### ●Short calibration

Plug-in shorted bar first , press **【CAL】** about 2 seconds , till 「CALS」 shown on main display , and a “bi” sound will be heard ; After calibration , a “bi” sound will be heard again °



2.4. ●Display refresh :

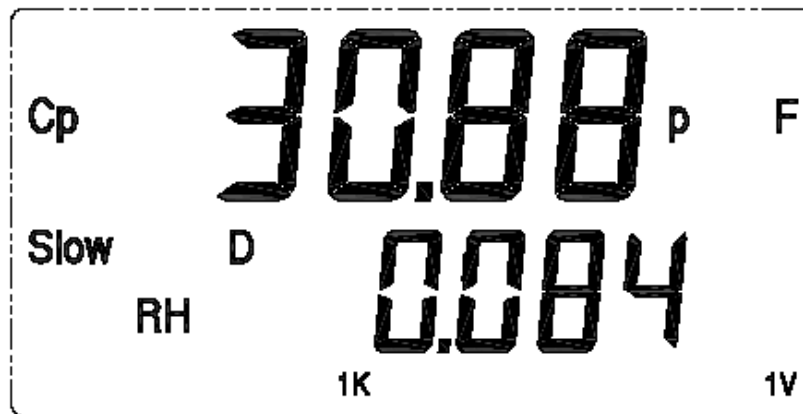
LCR01A/B functions with Fast/Slow display refresh mode , User press the 【Speed】 button will toggle speed mode . on 『Fast』 mode , the refresh speed will be twice of 『Slow』 mode , the more of the measuring frequency , the faster of the refresh speed .

2.5. ●Relative mode

LCR01A/B functions with measuring relative mode , user put a reference component on the test terminals . Then press 【Relative】 button . And remove this reference component from the test terminals , put other device under test on test terminals then , the main LCD display will display the result of subtraction of the reference value from the measuring one .

2.6. ●Range hold mode

LCR01A/B functions with autorange/range\_hold mode , put a reference component on the test terminals , then wait until display stable , press 【Range Hold】 button . 『RH』 will be shown on sub-parameter display LCD , LCR01A will set this measuring range . Remove this reference component and put other component under test on test terminals , the measured result will gotten faster . But care should be taken , the measured range should in the range 2 and 1/2 of the reference value .



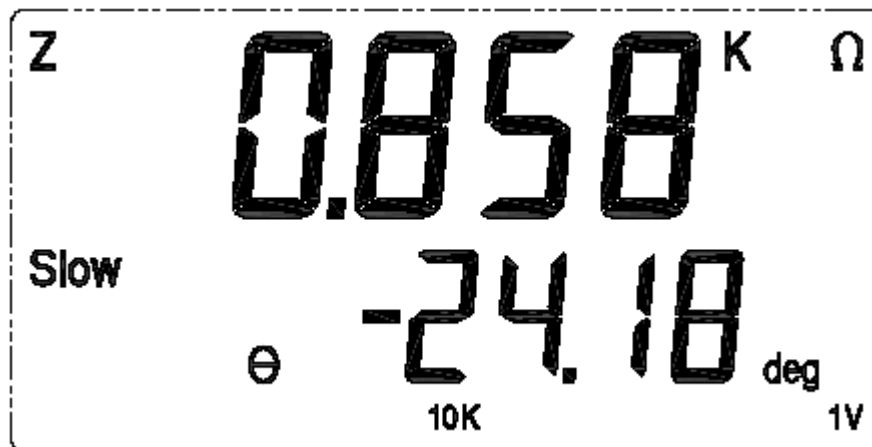
2.7. ●DC impedance measuring

Press【L/C/Z/DCR】 , till 『DCR』 shown on main parameter display LCD , then LCR01A/B will be in the DC impedance measuring mode .



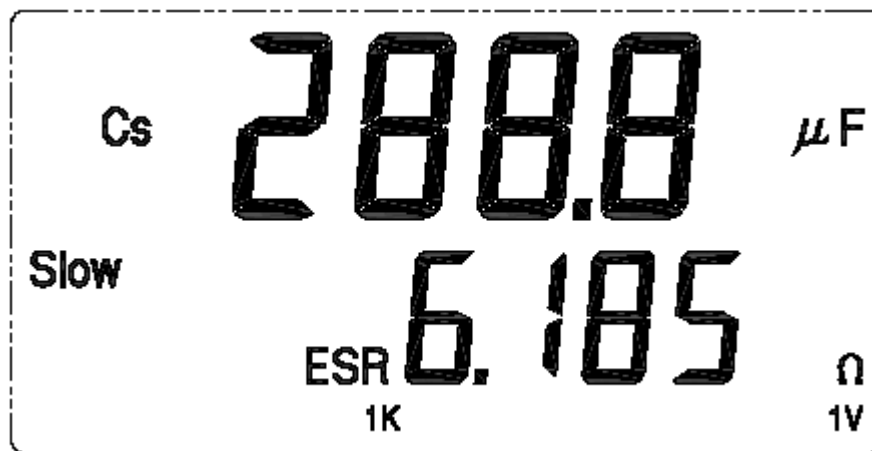
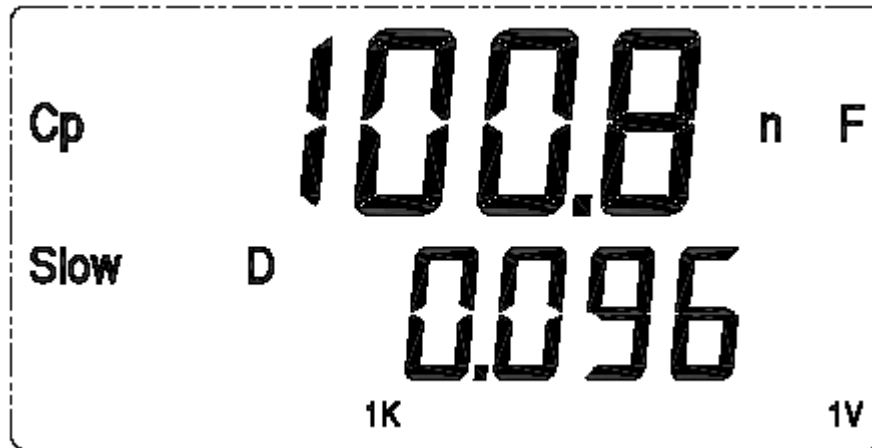
2.8. ● AC impedance measuring

Press **【L/C/Z/DCR】**, till 『Z』 shown on main parameter display LCD, then LCR01A/B will be in the AC impedance measuring mode ◦



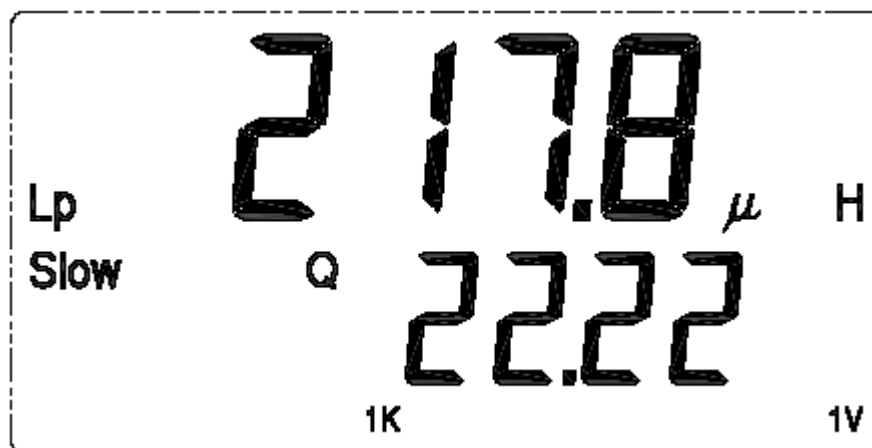
2.9. ● Capacitance measuring

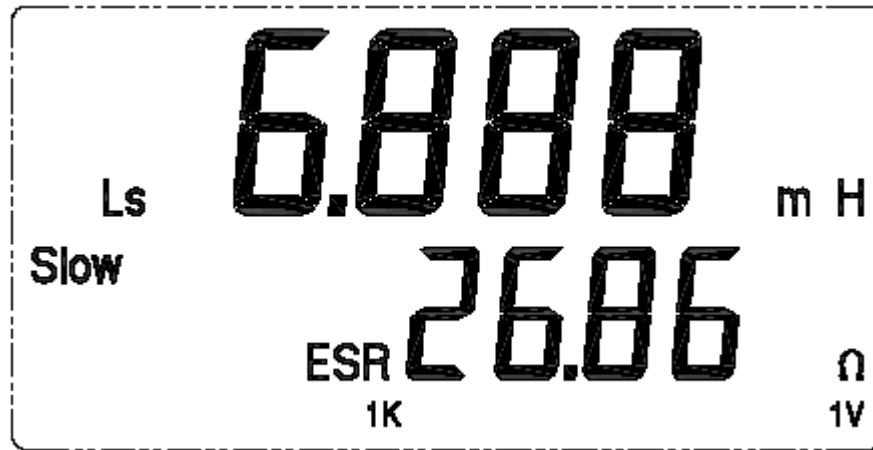
Depend on component equivalent, Capacitance measuring can be separated as (Cs, Serial Mode) and (Cp, Parallel Mode), user can press **【L/C/Z/DCR】** button as they need ◦. If 『Cs』 mode selected, then press button **【θ /D/Q/ESR】** select one of the four θ /D/Q/ESR sub-parameter ◦. If 『Cp』 mode selected, then press button **【θ /D/Q/ESR】** select one of the three θ /D/Q sub-parameter ◦.



2.10. ● Inductance measuring

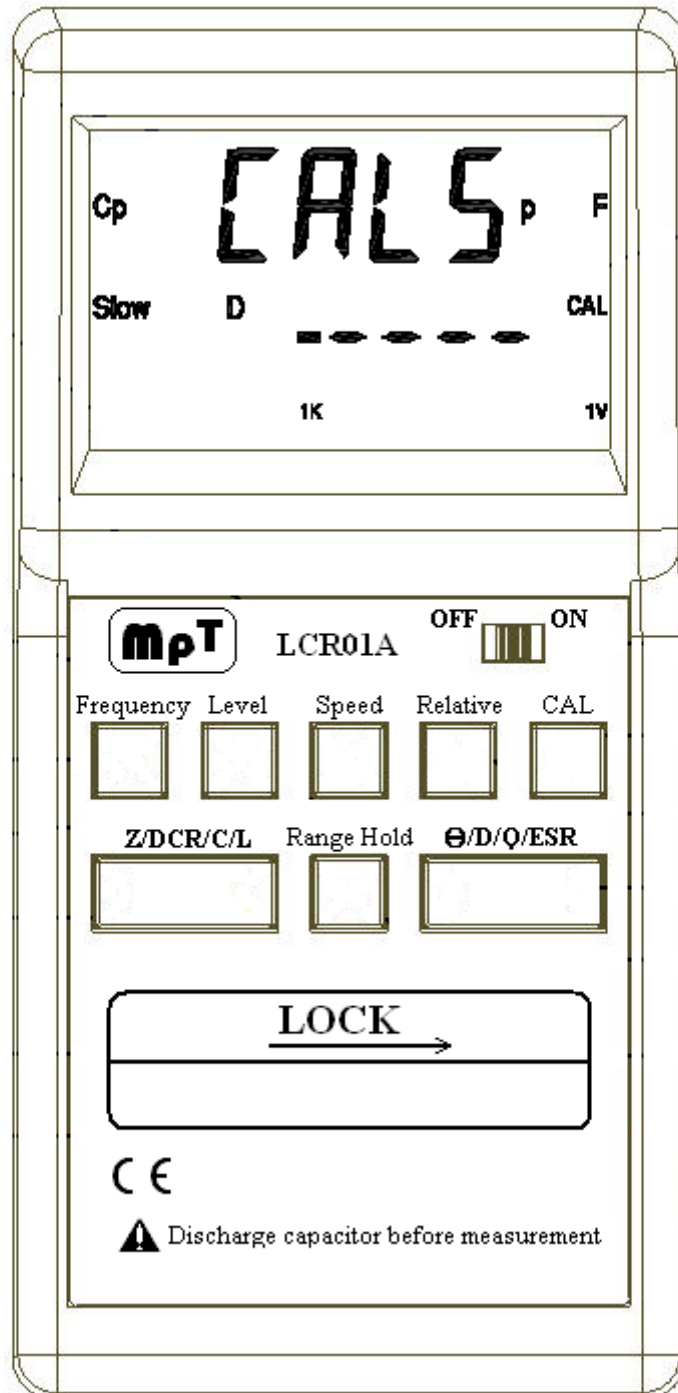
Inductance measuring can be separated as (Ls, Serial Mode) and (Lp, Parallel Mode), user can press **【L/C/Z/DCR】** button as they need. If 『Ls』 mode selected, then press button **【θ /D/Q/ESR】** select one of the four θ /D/Q/ESR sub-parameter. If 『Lp』 mode selected, then press button **【θ /D/Q/ESR】** select one of the three θ /D/Q sub-parameter. ° °





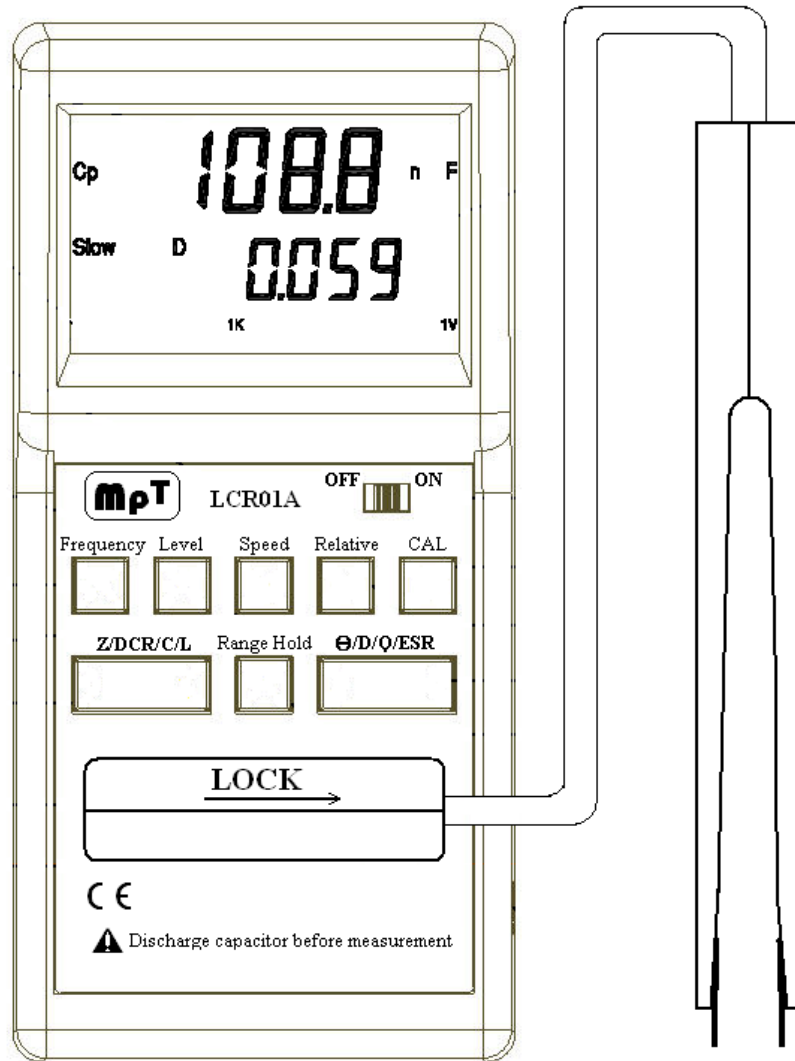
2.11. ● Accessory operation

To insure measuring accuracy and stable, perform 「LOCK」 action when test probe been used.

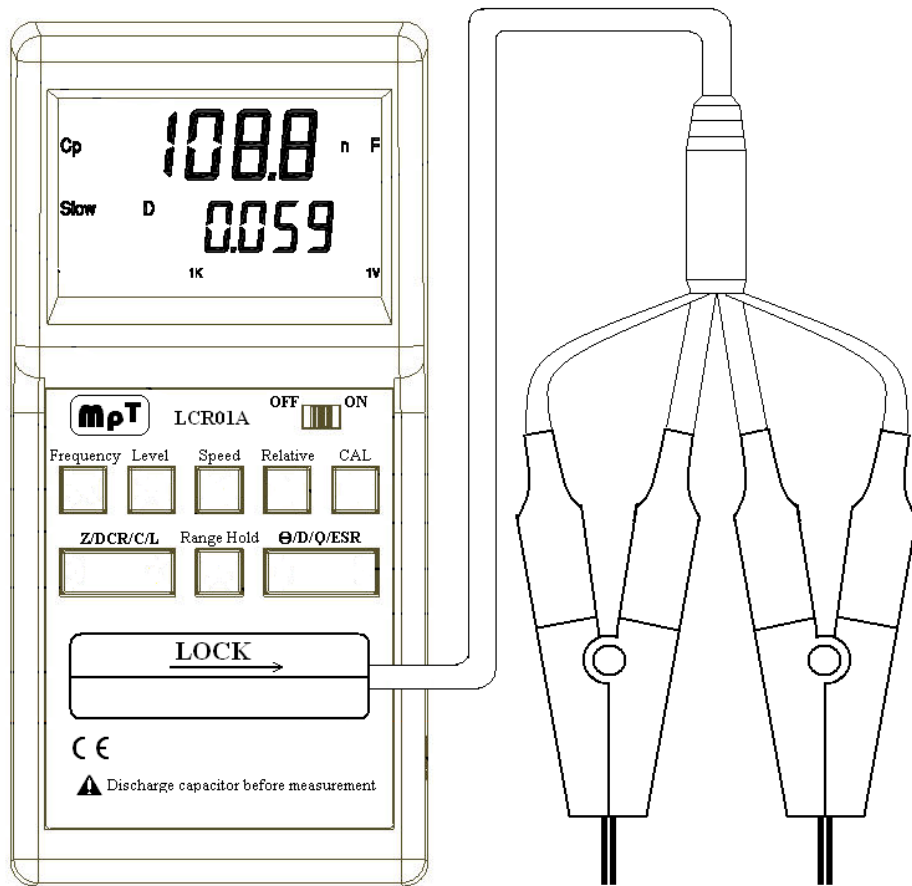


Shorted Bar





SMD Test Probe



Kelvin Clip Test Probe

3. Use noted

3.1. Service information

MPT warrants to the original purchaser that its products and the component thereof , will be free from defects in workmanship and materials for a period of one year from date of purchase °

3.2. Items notes

- Don' t open the device case beside battery cap °
- Keep measuring terminals clean to insure measuring accuracy °
- During measuring , keep hands away form device above 10cm °
- Discharge capacitor before measuring °
- When low voltage alarm , then replace battery or charge with adaptor °
- Remove battery if long period don' t use °

## Appendix Cable connection technique

—

Auto-balancing Bridge has four terminals(Hcur 、Hpot 、Lcur 、 and Lpot)to connect the device under test(DUT).It is important to understand what connection method will affect the measurement accuracy ◦

Two terminal(2T)is the simplest way to connect the DUT , but it contents many errors which are the inductor and resistor as well as the parasitic capacitor of the test leads(figure 1) ◦ Due to these errors in measurement , The effective impedance measurement range will be limit at  $100\Omega$  to  $10K\Omega$  ◦

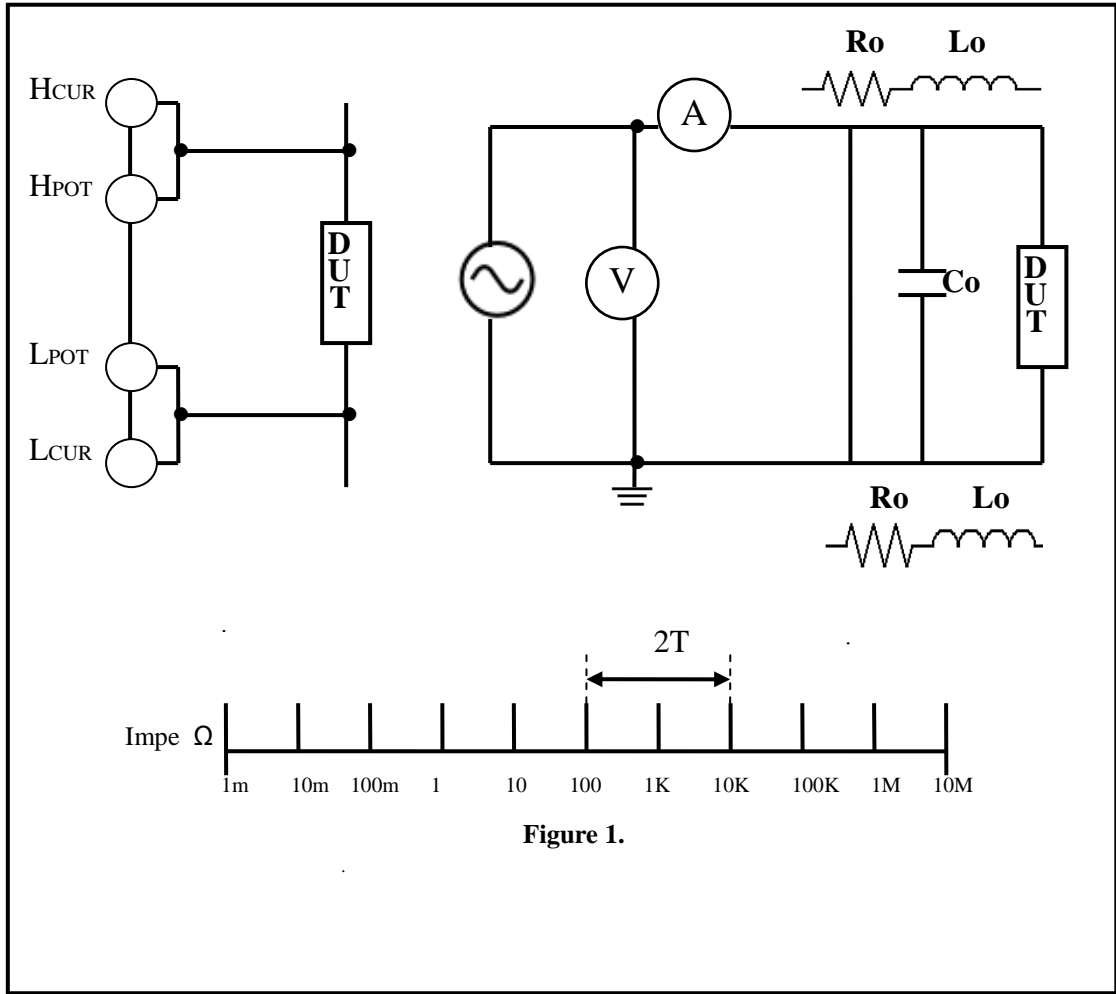
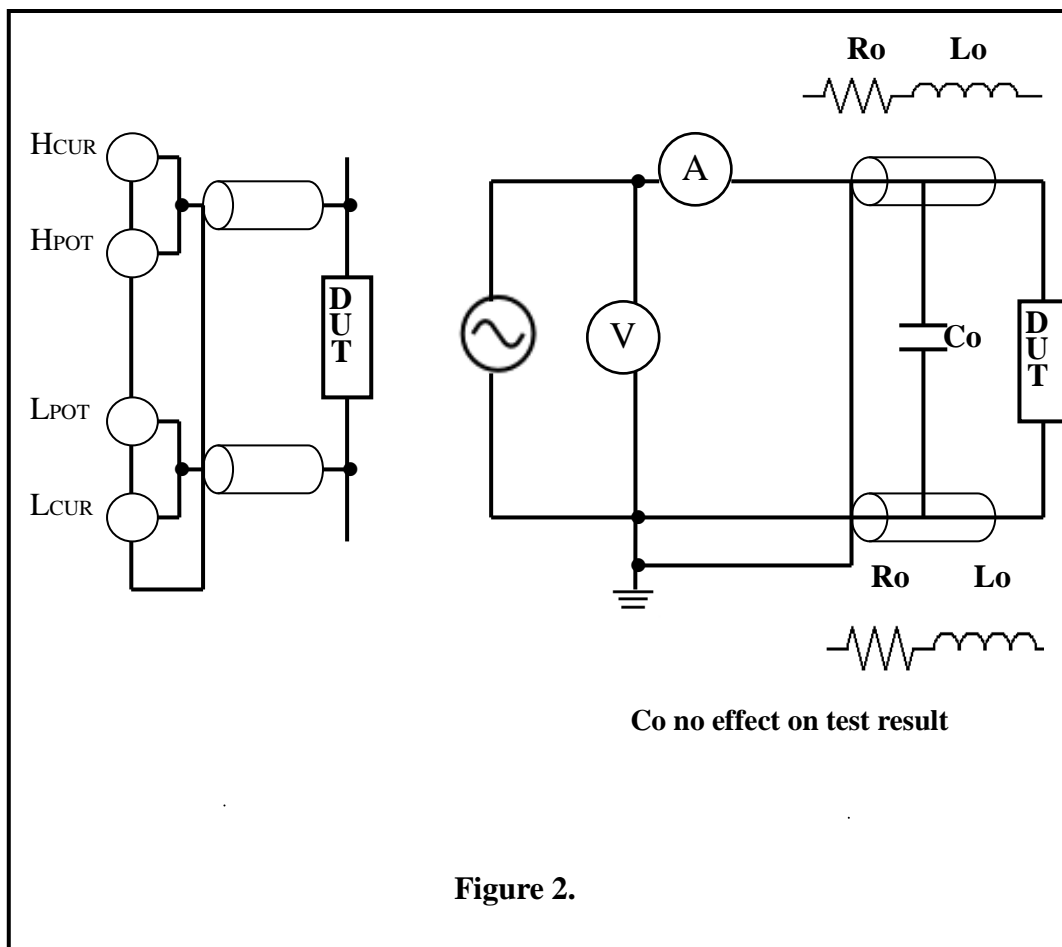


Figure 1.

3-Terminals(3T) uses coaxial cable to reduce the effect of the parasitic capacitor, the shield of the coaxial cable should be connect to Guard of the instrument to increase the measurement range up to  $10\text{ M}\Omega$  .



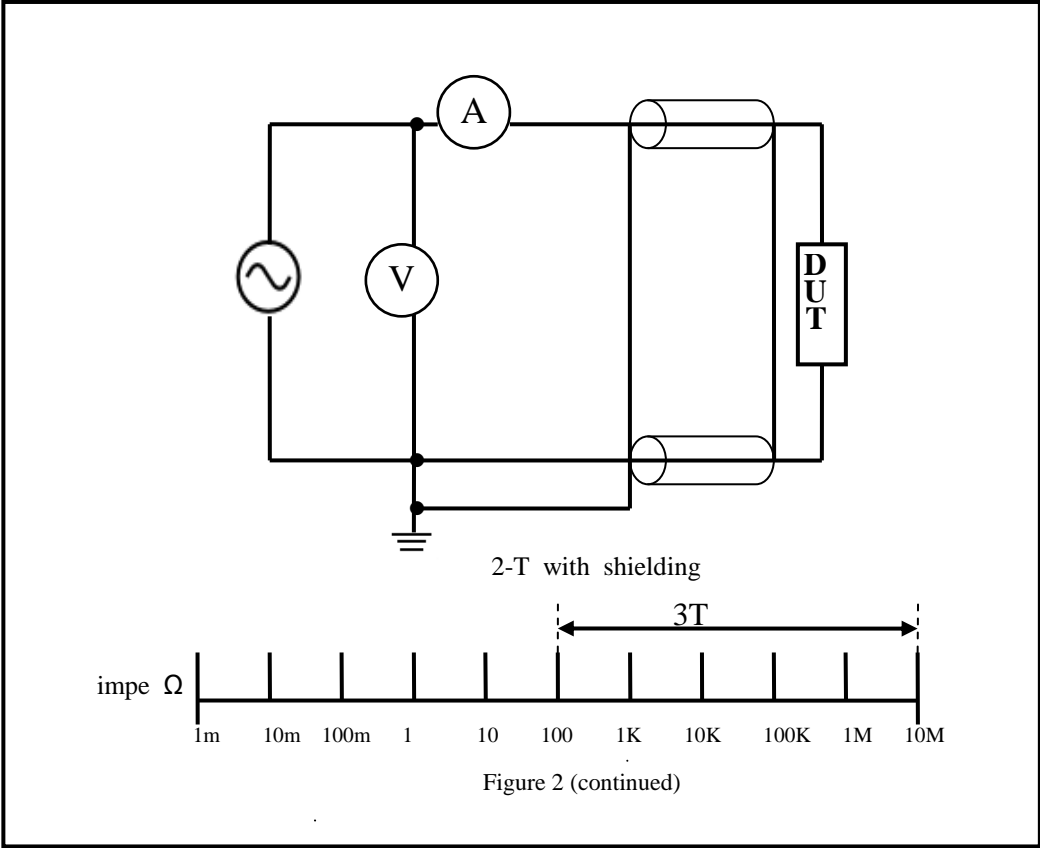
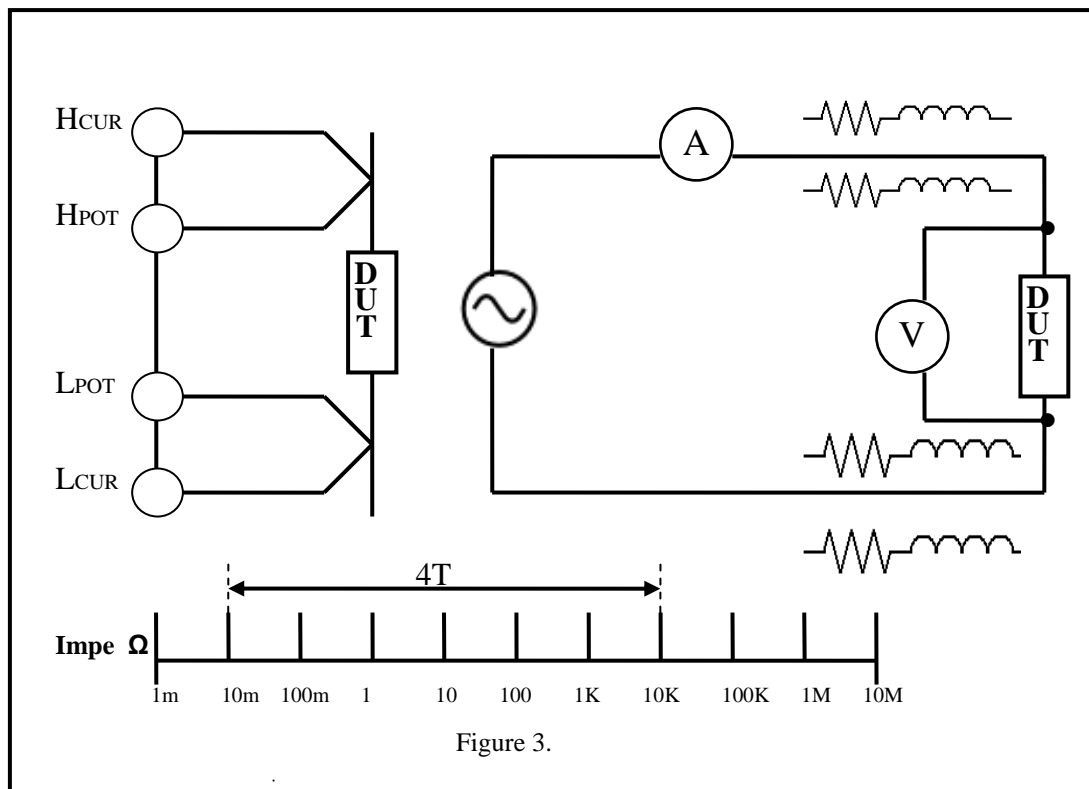


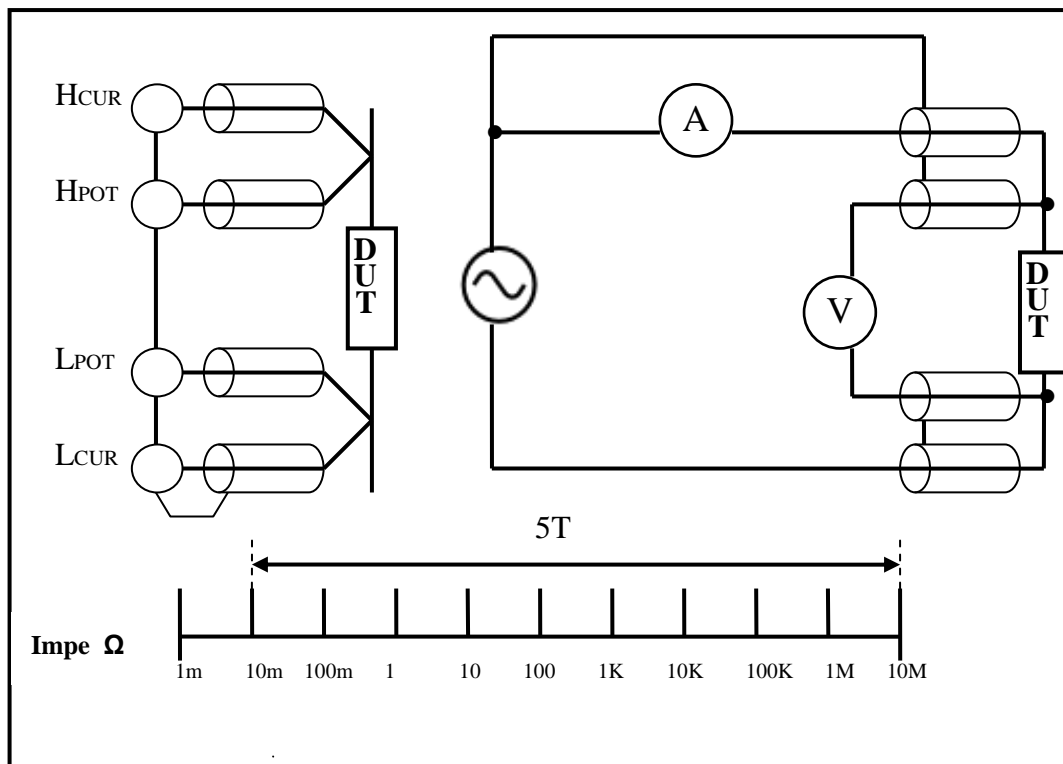
Figure 2 (continued)

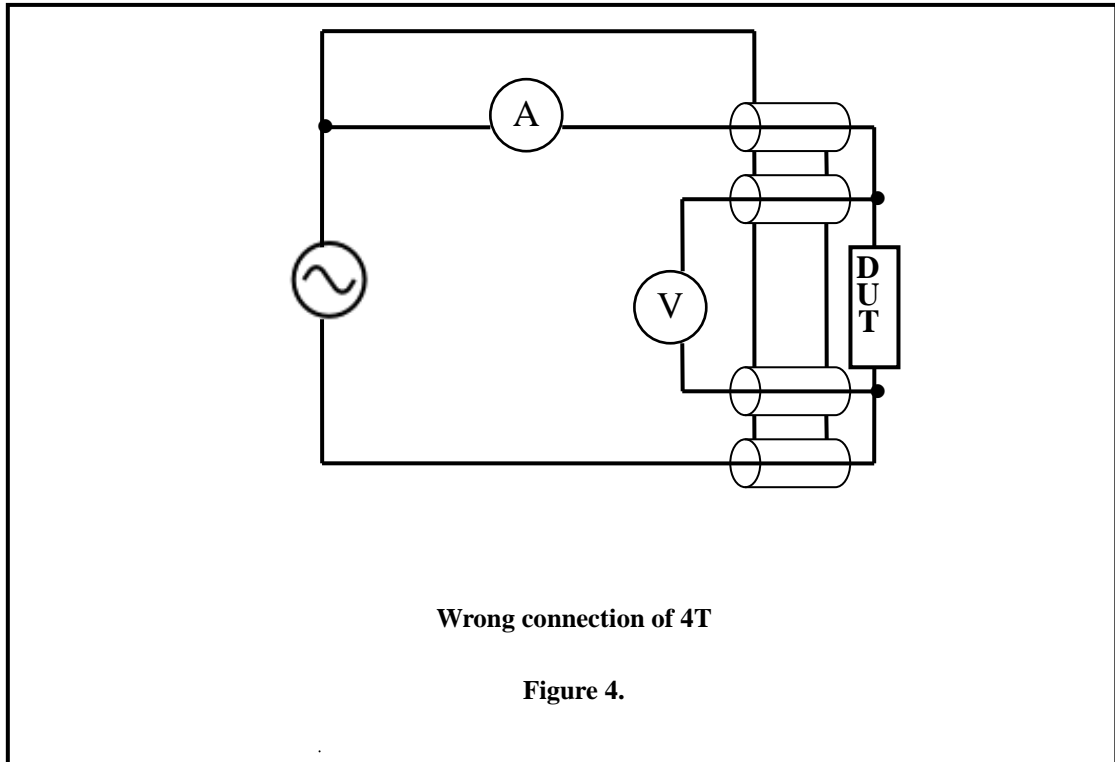
4-Terminal(4T)connection reduces the effect of the test lead resistance , this connection can improve the measurement range down to  $10\text{m}\Omega$  . However , the inductance of the test lead can not be eliminated .





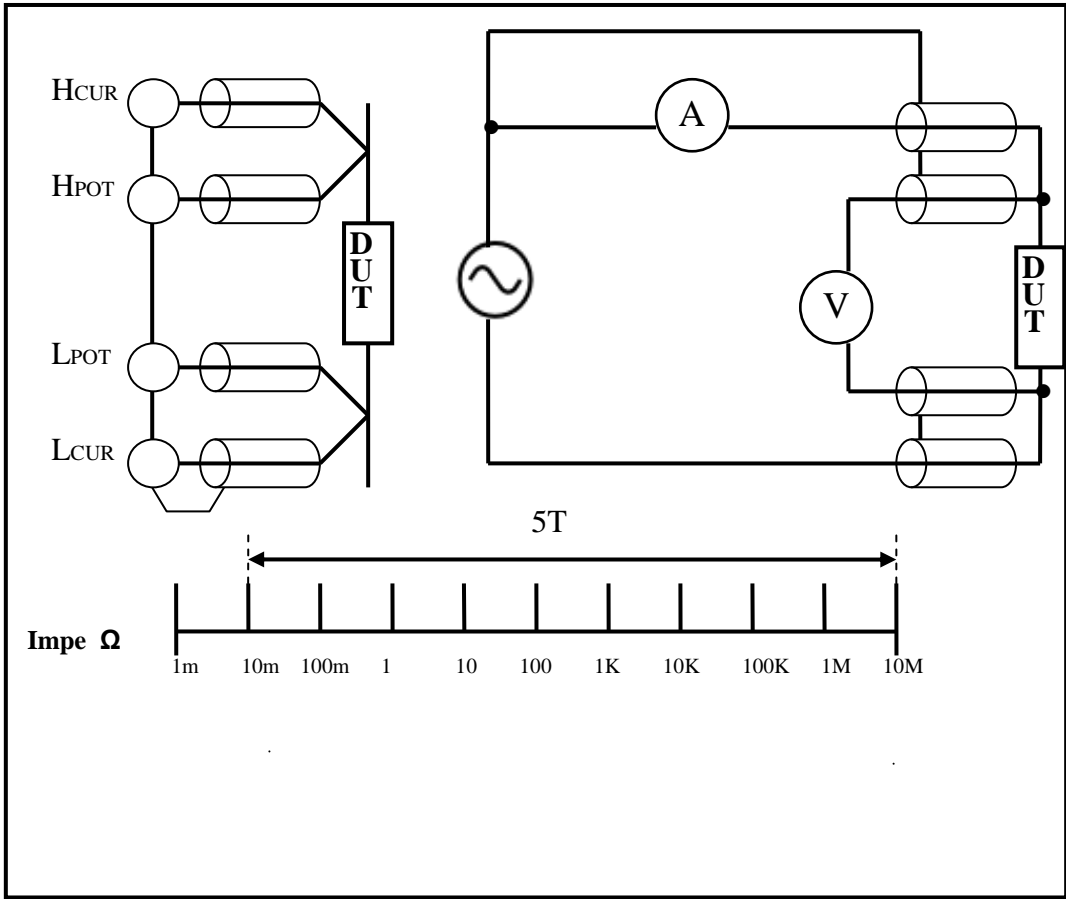
5-Terminal connection is the combination of 3T and 4T . It has four coaxial cable . Due to the advantage of 3T and 4T , this connection can widely increase the measurement range for  $10\text{m}\Omega$  to  $10\text{M}\Omega$  .

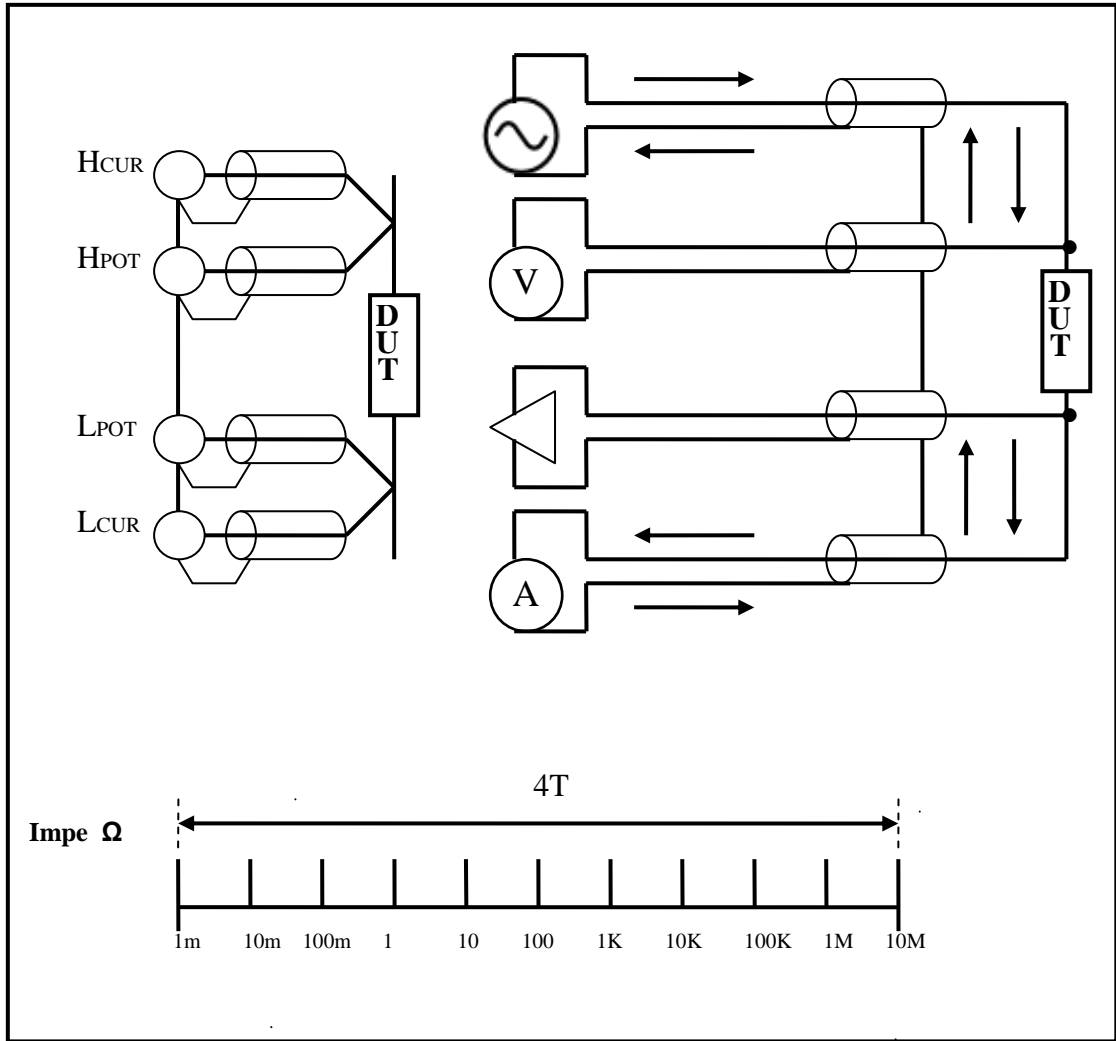




4-terminal path(4TP) connection solves the problem that caused by the test lead inductance ◦ 4TP uses four coaxial cables to isolate the current path and the voltage sense cable ◦ The return current will flow through the coaxial cable as well as the shield

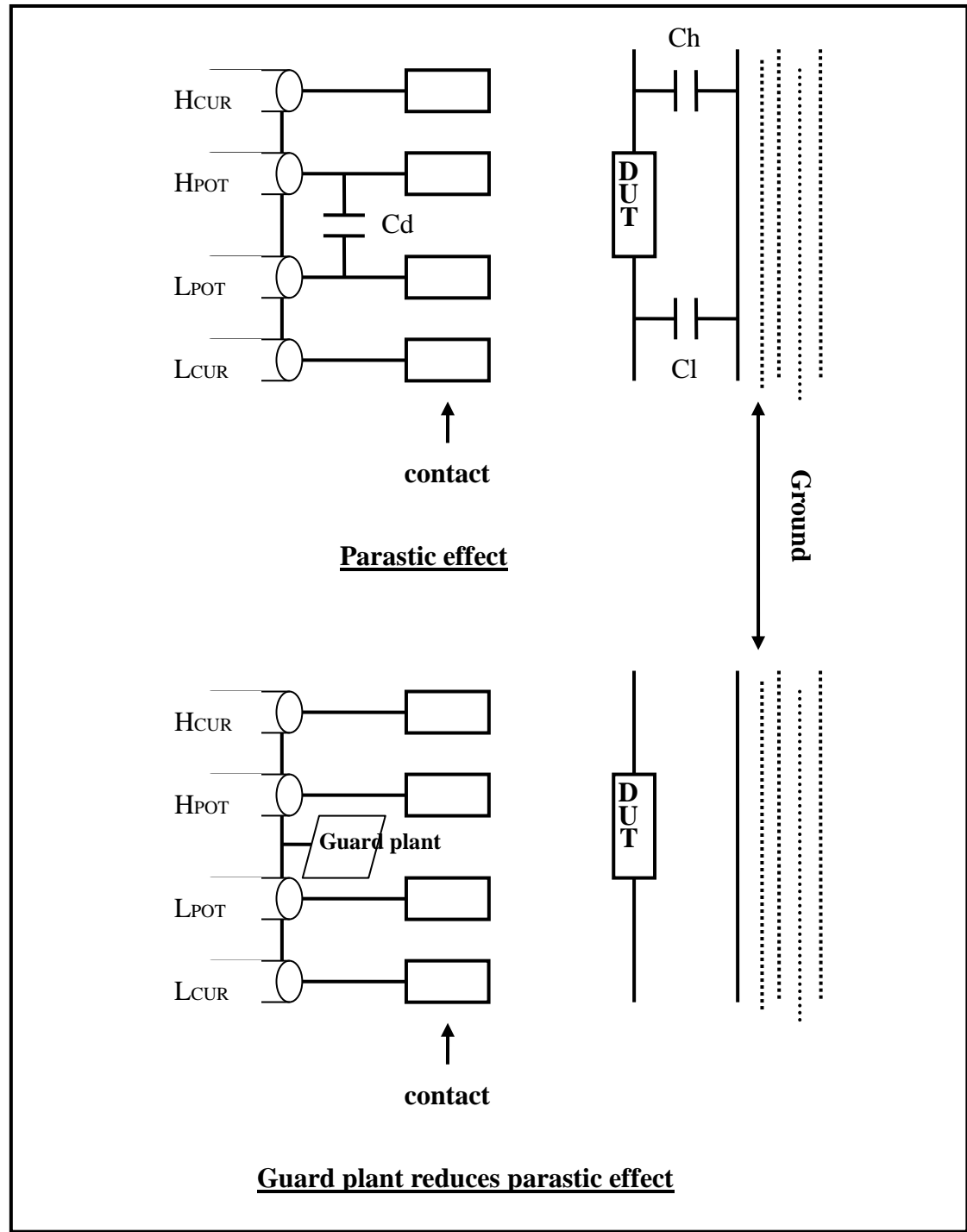
- Therefore , the magnetic flux that generated by internal conductor will cancel out the magnetic flux generated by external conductor(shield) ◦ The 4TP increase the measurement range from  $1\text{m}\Omega$  to  $10\text{M}\Omega$  ◦





### Eliminating the effect of the parasitic capacitor

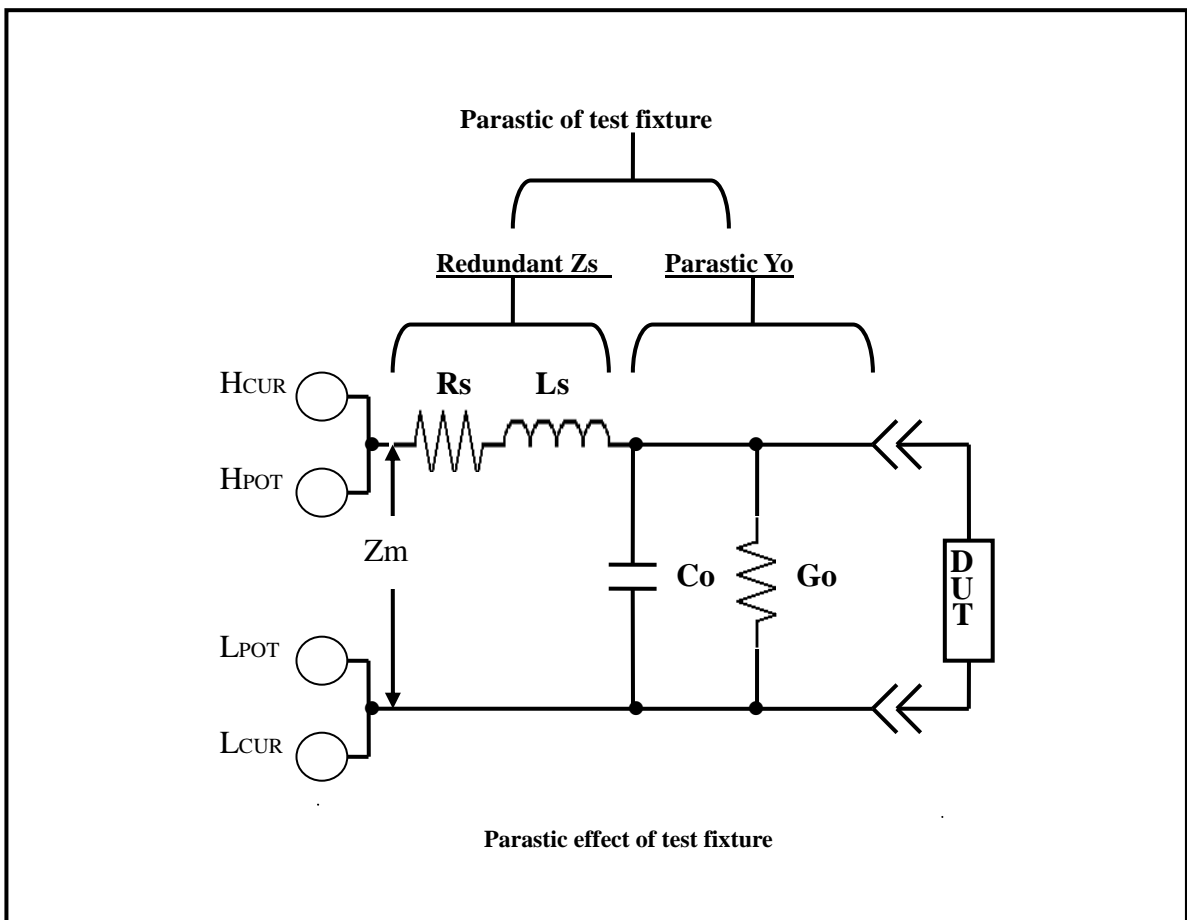
When measuring the high impedance component (i.e. low capacitor), the parasitic capacitance becomes an important issue (Figure 3.6). In figure 3.6(a), the parasitic capacitor  $C_d$  is paralleled to DUT as well as  $C_i$  and  $C_h$ . To correct this problem, add a guard plane (Figure 3.6b) in between H and L terminals to break the  $C_d$ . If the guard plane is connected to instrument guard, the effect of  $C_i$  and  $C_h$  is removed.

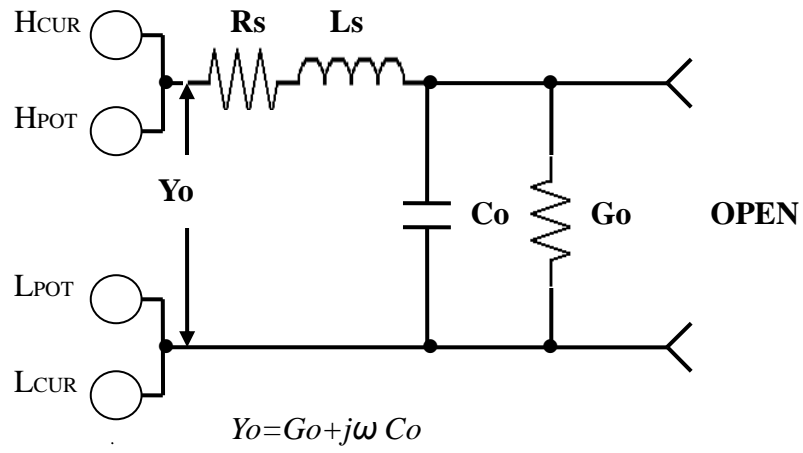


## Append Open/Short compensation

2

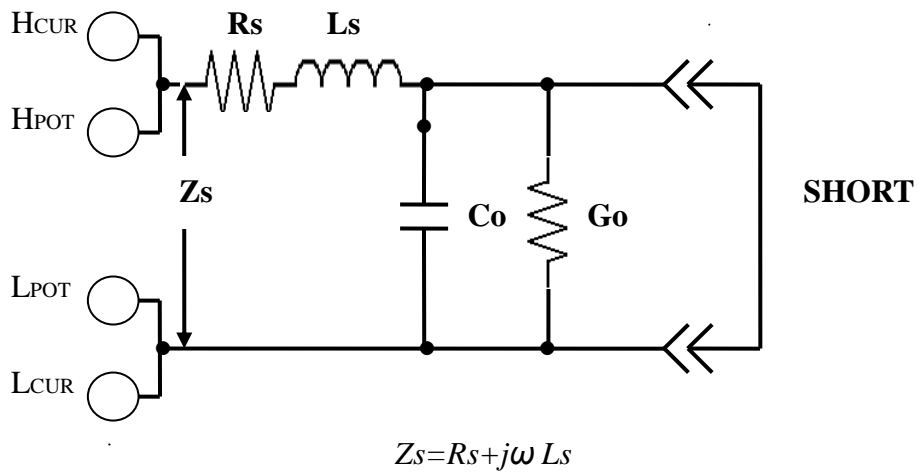
For those precision impedance measuring instrument , the open and short compensation need to be used to reduce the parasitic effect of the test fixture . The parasitic effect of the test fixture can be treated like the simple passive components in figure 3.7a . When the DUT is open , the instrument gets the conductance  $Y_p = G_p + j\omega C_p$  (Figure 3.7b) . When the DUT is short , the instrument gets the impedance  $Z_s = R_s + j\omega L_s$  (Figure 3.7c) . After open and short compensation ,  $Y_p$  and  $Z_s$  are for calculating the real  $Z_{dut}$  (Figure 3.7d) .



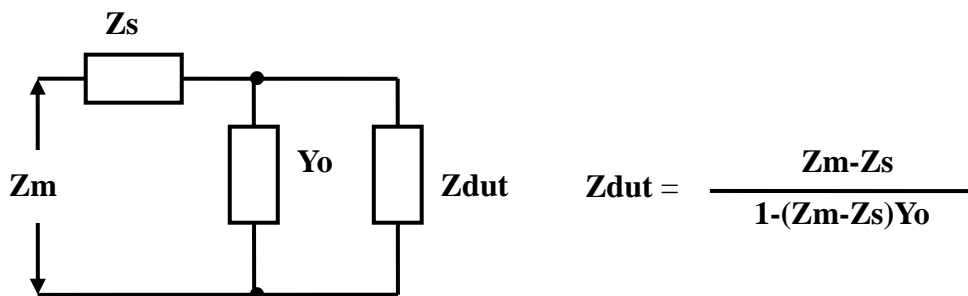


$$R_s + j\omega L_s \ll (G_o + j\omega C_o)^{-1}$$

**Open ckt**



**Short ckt**



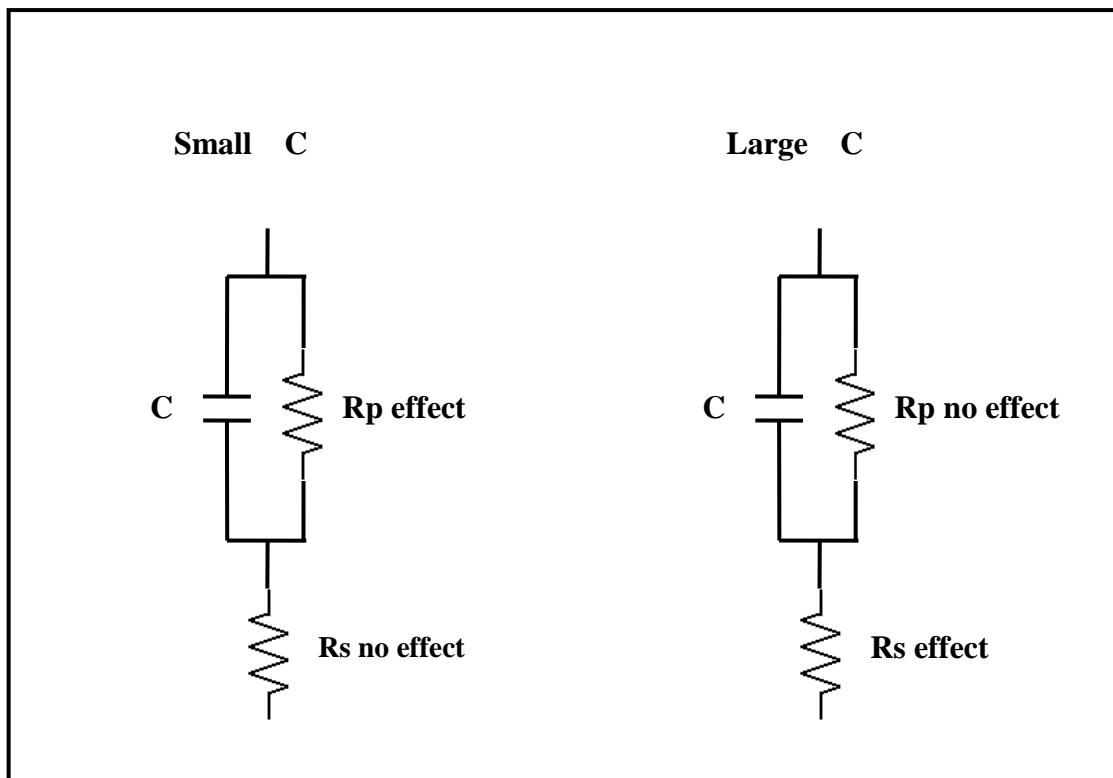
## Appendix Selecting the series or parallel mode

x 3

According to different measuring requirement, there are series and parallel modes to describe the measurement result. It is depending on the high or low impedance value to decide what mode to be used.

### ● capacitor

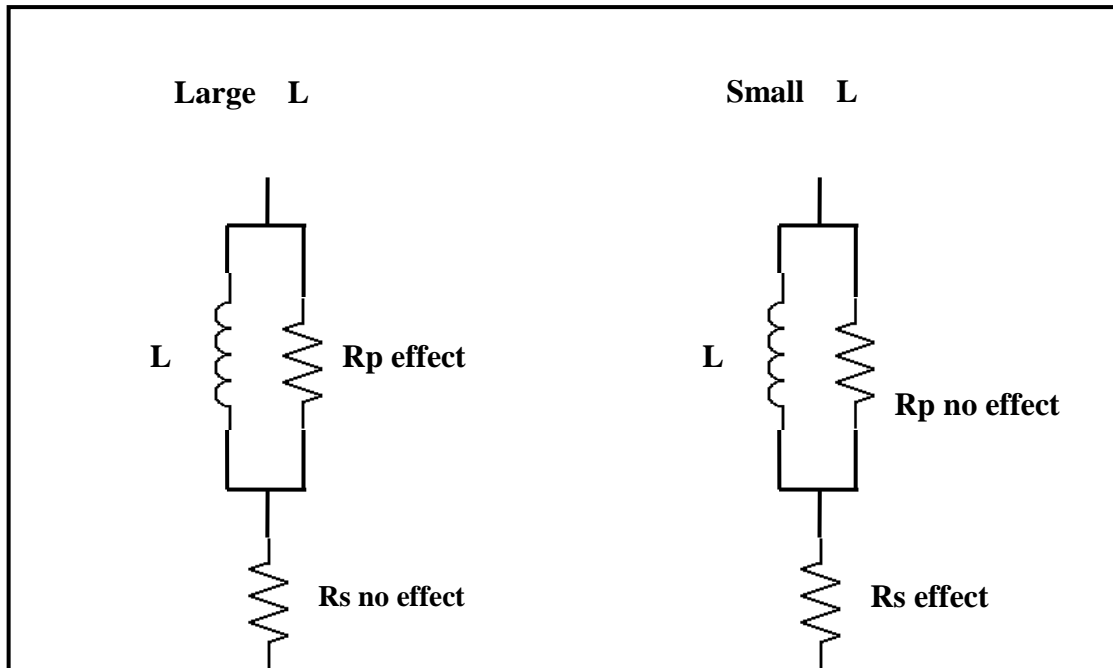
The impedance and capacitance in the capacitor are negatively proportional. Therefore, the large capacitor means the low impedance; the small capacitor means the high impedance. Figure below shows the equivalent circuit of capacitor. If the capacitor is small, the  $R_p$  is more important than the  $R_s$ . If the capacitor is large, the  $R_s$  shouldn't be avoided. Hence, uses parallel mode to measure low capacitor and series mode to measure high capacitor.





● Inductor

The impedance and inductive in the inductor are positively proportional. Therefore, the large inductor equals to the high impedance and vice versa. Figure below shows the equivalent circuit of inductor. If the inductor is small, the  $R_s$  is more important than  $R_p$ . If the inductor is large, the  $R_p$  should be taking care of. So, uses series mode to measure low inductor and parallel mode to measure high inductor.



According to analysis above :

1. Impedance below  $10\Omega$  , series mode selected .
2. Impedance above  $10K\Omega$  , parallel mode selected .
3. Between  $10\Omega$  and  $10K\Omega$  depend on needed .

Example :

$$DUT=100pF$$

$$Freq.=10KHz$$

$$Z=159.2K\Omega$$

parallel mode selected .

Example :

$$DUT=100\mu H$$

$$Freq.=10KHz$$

$$Z=6.2832\Omega$$

Serial mode selected .

C. Accuracy :						
20Hz	398 pF § 795.5 pF	795.5 pF § 10.6 nF	10.6 nF § 79.55 nF	79.55 nF § 795.5 µF	795.5 µF § 7.955 mF	7.955 mF § 79.55 mF
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
100Hz	79.57 pF § 159.1 pF	159.1 pF § 2.121 nF	1.212 nF § 15.91 nF	15.91 nF § 159.1 µF	159.1 µF § 1591 µF	1591 µF § 15.91mF
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
120Hz	66.31pF § 132.6pF	<b>132.6pF</b> § 1.768nF	1.768nF § 13. 26nF	13.26nF § 132. 6µF	132. 6µF § 1326µF	1326µF § 13.26mF
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
1KHz	7. 957 pF § 15.91 pF	15.91 pF § 212.1 pF	212.1 pF § 1.591 nF	1.591 nF § 15.91 µF	15.91 µF § 159.1 µF	159.1 µF § 1.591 mF
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
10KHz	0. 795 pF § 1.591 pF	1.591 pF § 21.21 pF	21.21 pF § 159.1 pF	159.1 pF § 1.591 µF	1.591 µF § 15.91 µF	15.91 µF § 159.1 µF
	5%±1	2%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
100KHz	NA	0.159 pF § 2.121 pF	2.121 pF § 15.91 pF	15.91 pF § 159.1 nF	159.1 nF § 1.591 µF	1.591 µF § 15.91 µF
	NA	5%±1	2%±1	0.4%±1	2%±1	5%±1
500KHz	NA	0.159 pF § 2.121 pF	2.121 pF § 15.91 pF	15.91 pF § 31.91 nF	31.91 nF § 319.1 nF	319.1 n F § 3.191 µF
	NA	2%±1	1%±1	0.5%±1	2%±1	5%±1
1MHz	NA	0.079 pF § 1.111 pF	1.111 pF § 7.999 pF	7.999 pF § 15.91 nF	15.91 nF § 159.1 nF	159.1 nF § 1.591 µF
	NA	2%	1%±1	0.5%±1	2%±1	5%±1

L Accuracy :						
20Hz	159.3 KH § 79.55 KH	79.55 KH § 5965 H	5965 H § 795.5 H	795.5 H § 79.55 mH	79.55 mH § 7.955 mH	7.955 mH § 79.55 µH
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
100Hz	31.83 KH § 15.91 KH	15.91 KH § 1193H	1193H § 159. 1 H	159. 1 H § 15. 91 mH	15. 91 mH § 1.5 91 mH	1.591 mH § 159. 1µH
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
120Hz	26.52KH § 13. 26KH	<b>13. 26KH</b> § 995H	995H § 132. 6H	132. 6H § 13. 26mH	13. 26mH § 1.326mH	1.326mH § 132. 6µH
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
1KHz	31. 83 KH § 1. 591 KH	1. 591 KH § 119.3 H	119.3 H § 15. 91 H	15. 91 H § 1. 591 mH	1. 591 mH § 159.1 µH	159.1 µH § 15. 91 µH
	2%±1	1%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
10KHz	318.3H § 159. 1 H	159. 1 H § 11.93H	11.93H § 1. 591 H	1. 591 H § 159. 1 µH	159. 1 µH § 15.91 µH	15.91 µH § 1. 591 µH
	5%±1	2%±1	0.5%±1	0.2%±1	0.5%±1	1%±1
100KHz	31. 83 H § 15. 91 H	15. 91 H § 1.193 H	1. 193H § 159. 1 mH	159. 1 mH § 15. 91 µH	15.91 µH § 1. 591 µH	1.591 µH § 0. 159 µH
	NA	5%±1	2%±1	0.4%±1	2%±1	5%±1
500KHz	NA	NA	32.26 mH § 6.363 mH	6.363 mH § 3.181 µH	3.181 µH § 0.318 µH	0.318 µH § 0.031 µH
	NA	NA	2%±1	0.5%±1	2%±1	5%±1
1MHz	NA	NA	16.13 mH § 3.181 mH	3.181 mH § 1.591 µH	1.591 µH § 0.159 µH	0.159 µH § 0. 015 µH
	NA	NA	2%±1	0.5%±1	2%±1	5%±1

D Accuracy :						
Freq. \   Z <sub>x</sub>	20M	10M	750K	100K	10	1
	Ω	Ω	Ω	Ω	Ω	Ω
20Hz	±0.020	±0.010	±0.005	±0.002	±0.005	±0.010
100Hz						
120Hz						
1KHz						
10KHz	±0.050	±0.020				
100KHz	NA	±0.050	±0.020	±0.004	±0.020	±0.050
500KHz	NA	NA	NA	±0.01	±0.050	±0.10
1MHz	NA	NA	NA	±0.01	±0.050	±0.10

⊖ Accuracy :						
Freq. \   Z <sub>x</sub>	20M	10M	750K	100K	10	1
	Ω	Ω	Ω	Ω	Ω	Ω
20Hz	±1.046	±0.523	±0.216	±0.105	±0.261	±0.523
100Hz						
120Hz						
1KHz						
10KHz	±2.615	±1.046				
100KHz	NA	±2.615	±1.046	±0.209	±1.046	±2.615
500KHz	NA	NA	NA	±0.5001	±2.001	±5.01
1MHz	NA	NA	NA	±0.500	±2.001	±5.01

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