# OPERATION MANUAL


## MM SERIES DC RESISTANCE METERS

## MM2010 MM2020

## MM2030 MM2040

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# Content:

# Chapter 1 Unpacking and Preparation

This chapter describes some of the tests that must be carried out after you receive the instrument, and the conditions to be understood before the installation and use of the instrument.

## 1.1 Checking the Shipment

After you receive the DC Resistance meter, please check whether the meter arrived in tact. If the contents are incomplete, if there is mechanical damaged or defect, or if the instrument does not pass the power-on self tests, please notify our company.

## 1.2 Power connection

Confirm that the power supplied to the instrument meets the following requirements:

(1) The voltage range: 100 ~120 V AC.
198 ~242 V AC.

(2) The frequency range: 47 ~63 Hz.

(3) The power consumption range: ≥30VA.

(4) The L-line, the N-line and the E-line of the input power must be the same with power supply plug.

(5) The instrument should be used in low noise environment, although it has been designed carefully to decrease the noise disturbance caused by the AC power. If you can't avoid using the instrument in high noise environment, please install the power filter.

**Note**: To avoid the damage to the instrument or harm yourself, which is caused by the leakage current, you should ensure that the ground line of the power is connected to the ground reliably.

## 1.3 The Fuse

The fuse has been set up before shipping, you should use the fuse prepared by our Company or the one with the same type. To verify and replace the fuse, remove the power lead and pull out the fuse holder.

## 1.4 Operating Environment

**The instrument must be operated under the following environment conditions:**

(1) Please don't use the instrument under those conditions: high dust level, risk of high vibrations,

(2) exposing the instrument to the intensive sunlight or corrosive environment.

(3) Operating Temperature range: 5 °C ~ 40 °C, Humidity: ≤85%R.H.

(4) Sufficient space must be kept behind the instrument to avoid obstructing the air flow of the cooling fans. The instrument should be used in low noise environment, although it has been designed carefully to decrease the noise disturbance caused by the AC power. If you can't avoid using the instrument in high noise environment, please install the power filter.

(5) If the instrument not going be used for a long time, please store the instrument under the conditions below:
Temperature: 5°C to 40°C, Humidity: ≤85%R.H. at 40°C, avoid corrosive environment, and do not expose the equipment to the direct intense sunlight.

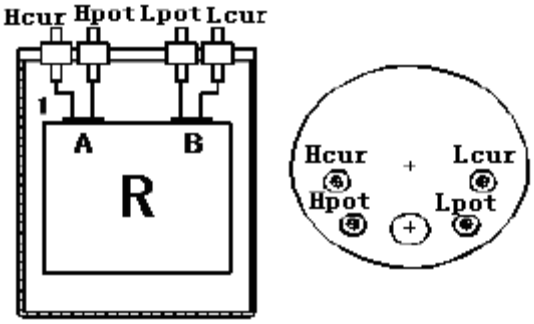
(6) The instrument, especially the test leads, must be kept away from the intense electromagnetic field to avoid the disturbance to the test.

## 1.5 Test fixture

Please use the test fixture or the test leads supplied by "KUST Elektronik GmbH". You must keep the test fixture, the test leads and the pins of the DUT clean, so that the test device can be contact the test fixture in best possible way. Connect the test fixture or the test leads to the four test terminals (Hcur、Hpot、Lcur、Lpot) on the front panel. If the DUT with shielded enclosure is tested, connect the shielded layer to the instrument ground "⊥".

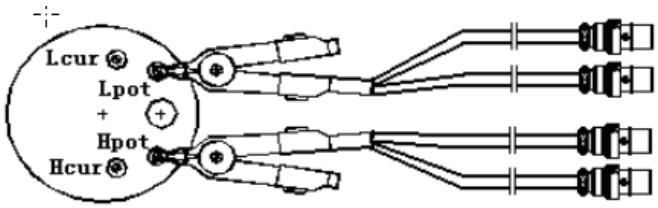
## 1.6 Accuracy guarantee

(1) To acquire the best result, the preheating time after turning on the power must be not less than 15 minutes.
(2) Please try to avoid cycling the power continuously, instrumenting works best when stabilized.
(3) Short circuit： When using the range of 20 mΩ and 200 mΩ, you should compensate the short circuit before testing.
(4) Use of shielding： When the test is of low or very high resistance, the test results may occur interference from the environment, user can implement shielding (metal case etc.). Note: at any time, the shield should not be in contact with the test connections.
(5) Avoid too long-range open of 20mΩ and 200mΩ: When using 20mΩ and 200mΩ two ranges, output test terminal voltage is clamped within 1V, if the test side for a long time open, then when the range is switched to high impedance range, test terminal open circuit digital bounce phenomenon will appear
(6) The four-terminal resistance standard test Common resistance standard is shown below, there are four test side. Hcur and Lcur are the current excitation ends. Hpot and Lpot are voltage sampling terminals. Resistance lead terminals A, B to test terminal connected by wire.

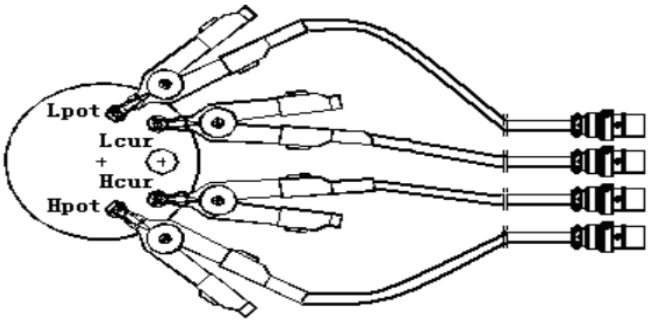



Wrong connection method:

If you press the graph method to test the connection. Test results include a Hpot, Lpot end to A, B-side lead resistance. When the measured standard resistance value is very small, it will introduce large errors.




The correct connection method as shown below, use the four separate test line, in order to eliminate the error



of the standard resistance wire.

## 1.7 Additional Features

(1) Power consumption: ≤30VA.

(2) Dimensions (W * H * D): 240mm * 100mm * 345mm; (foot support height included)

(3) Weight: about 3kg

# Chapter 2 Panel description and basic operation

This series of intelligent low resistance tester is used to test the resistance, and has the function of compare. In the compare state, the resistance value or the percentage of the value can be selected, and the value of the resistance value can be judged to be high, low or pass. In the rear panel of the machine, a sorting interface can be connected to the components of mechanical processing equipment and engaged in automatic testing.

Example of application: coils, inductors, transformers, coil, the relay contact resistance, connectors, resistor, fuse, resistance cable, printed board line resistance, resistance welding hole, conductive film, metal testing etc. Temperature compensation function eliminates the effect of temperature on the test, the temperature conversion function can effectively measure the temperature of the measured piece.

This series of instruments also have many kinds of communication interface, which is good for the function of statistical monitoring, or the automatic test system.

This series of instruments have a variety of configurations, see appendix.

## 2.1 Front Panel

Figure 2-1 shows the brief description of the MM SERIES front panel.

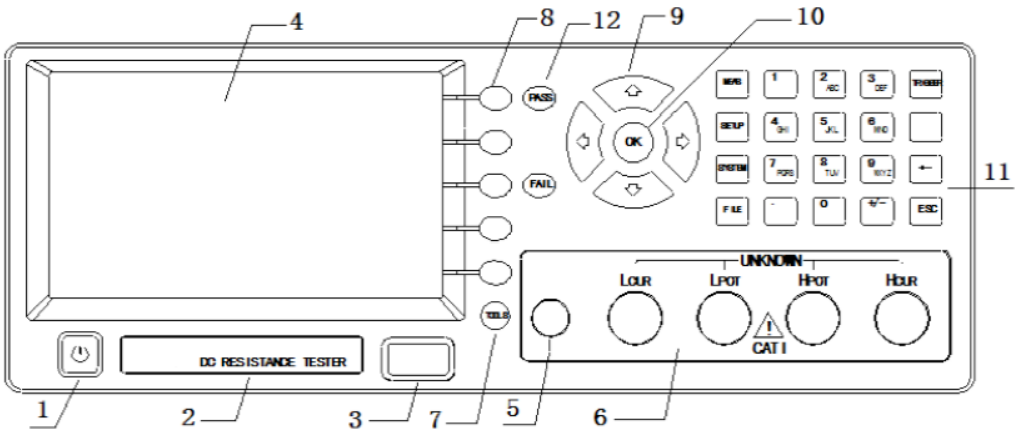



Figure 2-1 the front panel

1) Power on/off
2) Instrument type plate.
3) The USB interface is used to connect with USB disk.
4) LCD Display
5) Ground Terminal.
6) Test terminal: Lcur、Lpot、Hpot、Hcur
7) TOOLS: The tool key
8) SOFTKEYS
   Five softkeys are used to select control and parameter functions. Each softkey has a softkey label along its left side. The softkey label changes when the display page changes.
9) CURSOR Keys
   The CURSOR keys are used to move the field from one field to another field on the LCD display page.
10) The "OK" key ： Used to determine the input Numbers or letters
11) Shortcut menu keys ： ｛ MEAS、SETUP、SYSTEM 、FILE etc.｝
12) Comparison results indicating lamp: PASS、FALL

## 2.2 Rear Panel

Figure 2-2 shows the brief description of the MM Series rear panel.

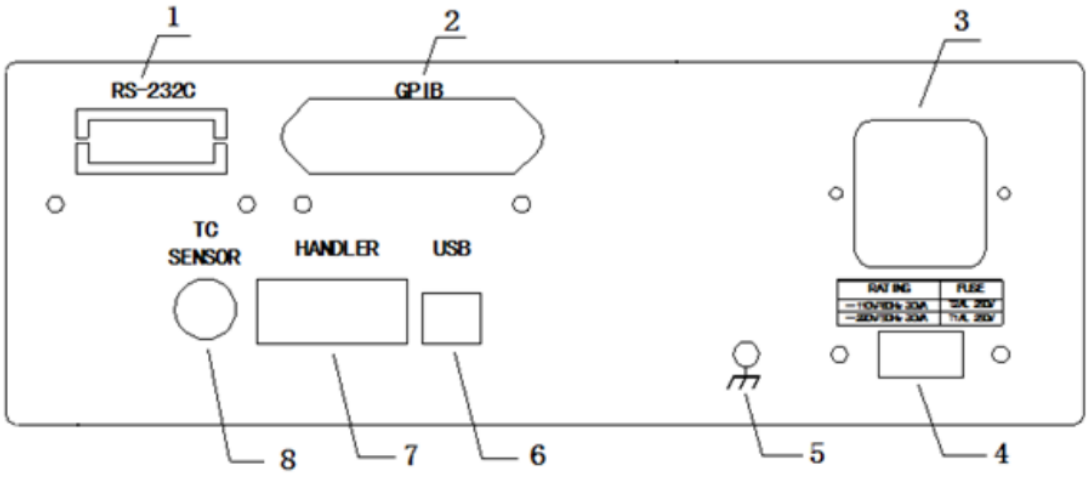



Figure 2-2 the rear pane

1) RS232C Interface Connector
   This is the RS232C interface connector used when operating on the serial interface is used.
2) GPIB interface (Optional)
   General Purpose Interface Bus (GPIB). The connection of an external controller and other devices through this connector allows you to configure an automatic measurement system.
3) LINE Input Receptacle AC power receptacle.
4) Power switch (110V/220V)
5) Ground Terminal
6) The USB device interface.
7) HANDLER Interface Connector.
   This is the HANDLER interface connector used when you perform the operation with a component handler to fully automate component testing, sorting, and quality control data processing.
8) TC SENSOR: The temperature sensor interface

## 2.3 Basic operation

The basic operation for MM SERIES is described in the following paragraphs.

(1) direction key, move the cursor to the place where it needs to be set.
(2) soft keys, used to change options.
(3) shortcut menu keys: SETUP, SYSTEM, FILE, MEAS are respectively used to directly select the < MEAS DISP >, <MEAS SETUP >, < SYSTEM SETUP >, < File Management > function page. Special note: when the instrument is in the < MEAS DISP > page, and the cursor is in < MEAS DISP >, press MEAS key, < MEAS DISP > page will display the maximum display.
(4) TOOLS key: tool key tool in the features page will be different. When press TOOLS key, soft key area will be the appropriate tool operation, short press the TOOLS button again, the Tools menu disappears. When the long press TOOLS key 1s, the instrument will enter the key lock status; long press the TOOLS key 1s, the instrument will release key lock status.

## 2.4 Format of data storage

When you use the USB to save the data in the measurement page using the TOOLS key, there will be two kinds of saving data mode. The basic form is as follows:

<A>, <COMP> [<Cp>, <CpK>, <NUM>], [<T>]

A: When the instrument displays the resistance, A as resistance value;

When the instrument displays the percentage deviation, A as a percentage value.

The difference is that "save data 1" , A is scientific notation; if "save data 2", A is a unit value (as displayed on the LCD).

COMP: 0 -- instrument is not compared 1 -- pass
2 -- high 3 -- low

When CpK does not exist, then saved as "-----."

T will be active when the instrument has temperature functions and temperature function is open.

# Chapter 3 Function description

## 3.1 <MEAS DISP> Description

The page can be set as follows:

MEAS DISP： <MEAS DISP> or <STATS DISP> can be choosed.

| | |
|---|---|
| RANGE: | AUTO, HOLD, INCR+, DECR- |
| SPEED: | FAST, MED, SLOW, [FAST2] (see appendix) |
| COMP： | ON/OFF |
| STATS： | ON, OFF, RESET |
| R： | FONT(LARGE/SMALL), DISP(ON/OFF), DEV %(ON/OFF) (NOTE1) |
| MODE: | Δ% / ΔABS (NOTE2) |
| NOM: | input by digital keys |
| HIGH/LOW: | ON/OFF or input by digital keys (NOTE 3) |
| SHORT: | ON/OFF/SHORT |
| LOAD: | ON/OFF |

**Note 1**： % when deviation is open ， the display value is

$$Percent\ deviation\ value = \frac{Test\ value}{\text{Nominal value}} * 100\%$$

**Note 2**：Δ%, a percentage comparison mode, if Percentage deviation value between [lower] and [limit], the stall owners reference qualified;

ΔABS： absolute deviation comparison mode. If values of (Test value-nominal value) between the [lower] and [limit], the stall owners reference qualified;

**Note 3**: if use statistical functions, the upper and lower limits must be set.

**Note 4**: when the cursor is located in the <MEAS DISP>, press "MEAS" menu key to display measurement results in full screen.

## 3.2 <STATS DISP> Description

The function is not standard.

Only "STATS" in this page can be operated: ON, OFF, RESET.

The page displays the parameters and state as follows:

R: measurement results, do not support the% deviation display mode.

Num: the number of statistics, the maximum of the machine are 30000 times

Cp, CpK: process capability index X: the average value of the measurement results.

σ: the overall standard deviation. S: Standard deviation.

IN: The number of qualified.

HI: product number of high then high limit. LO: product number of lower then low limit.

Max: the maximum value of the product. MaxNum: maximum number.

Min: the minimum value of the product. MinNum: the serial number of the minimum.

HIGH/LOW: the high and low limit of the statistics, computed from the limit of <MEAS DISP>.

SHORT：ON/OFF state.

LOAD：ON/OFF state.

The related computation formula is as follows:

$$\overline{x} = \frac{\sum x}{n}$$

$$\sigma = \sqrt{\frac{\sum x^2 - nx^2}{n}}$$

$$s = \sqrt{\frac{\sum x^2 - nx^2}{n-1}}$$

$$Cp = \frac{|Hi - Lo|}{6\sigma_{n-1}}$$

$$Cpk = \frac{|Ki - Lo| - |Hi + Lo - 2\overline{x}|}{6\sigma_{n-1}}$$

In the above formula, the n is a valid sample number, Hi and Lo are the high and low limit of the statistics.

CpK, Cp show the process of production capacity is qualified, usually by the following criteria:

,

$C_p, C_{Pk}$ >1.33 The process is perfect.

1.33≥ Cp, $C_{pK}$>1 Process capability

1.00 ≥ $C_p$ $C_{pK}$ Process capability is poor.

**Note:**

- Only one effective sampling, s、Cp、 CpK does not exist.
- When s=0, Cp=CpK=99.99.
- Cp, CpK maximum 99.99.
- When CpK<0, CpK=0.

## 3.3 <MEAS SETUP> Description

The page can be set as follows:

MEAS SETUP：MEAS SETUP, CORR SETUP, T SETUP (nonstandard).

AVERAGE：INCR+、DECR-，or enter a value in the 1~255 by the numeric keys (default 1).

RangeDwell：INCR+、DECR-，Or enter the value of the 0~9999 within the (default 0ms).

TrigSource：INT、EXT

TrigDelay：INCR+、DECR-, Or enter the value of the 0~9999 within the (default 0ms).

TrigEdge：RISING、FALLING

Handler：CLEAR、HOLD、PULSE

PulseWidth：INCR+、DECR-, Or enter the value of the 1~9999 within the (default 1, mS).

Station：INCR+、DECR-, Or enter a value in the 0~30 by the numeric keys (default 0).

LineFreq：50Hz、60Hz

**Note:**

(1) When the TrigSource is "INT", it means continuous measurement; when the TrigSource is "EXT", you can trig the measurement through the front panel TRIGGER key, or HANDLER trigger, or through the bus command trigger.

(2) TrigEdgeis used to determine the external HANDLER trig. Sorting interface (HANDLER) output result signals (PASS, HIGH, LOW): CLEAR: When the instrument receives the trigger signal, first reset the results of the result signals. will output a new signal; HOLD: The result signal is only changed when the instrument's result is changed, otherwise it will remain the original state;

(3) Pulse: the result signal of the instrument is a low level pulse signal.

(4) Station: can make the results of the signal output delay n times measurement,$0 \le n \le 30$.

(5) Line Freq: according to the user's power frequency to choose the working frequency. It can improve the stability of the test.

## 3.4 < CORR SETUP> Description

Note: User should be careful to use the functions in this page , wrong operation will lead to measure error. The priority of mathematical operations in the instrument: short > Load.

The page can be set as follows:

SHORT： ON, OFF, SHORT.

LOAD： ON, OFF.

RES： ON, OFF.

REF： the standard value of the resistance by the digital key input

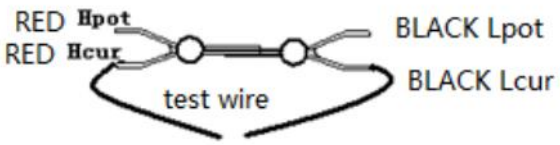
MEAS： measure the value of the resistance.

TEMP： ON, OFF. (the option is required to support the temperature function).

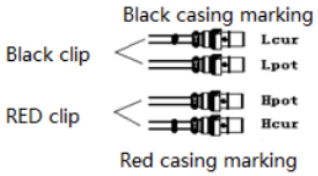
REF： the reference value of the current temperature by the digital key

MEAS： measure the value of the current temperature.

**Note:** - SHORT: when using the 20mΩ ohm and 200mΩ range， should be cleared first before tested, and in other range does not generally need to be cleared. The test clip clip together each other, so that the Hpot side and the Lpot side of direct contact, the Hcur side and the Lcur side of direct contact, and maintain good contact, and then use the short circuit operation.
Since the instrument uses a four terminal measurement method, so when using the clearing, must make the instrument of the Lpot and Hpot end direct contact, Hcur and Lcur direct contact. (the two test clip has a direct contact with the two metal sheet of the test line, and the two metal sheet without the test line have a direct contac . Otherwise, for 20mΩ and 200mΩ range, because the instrument gain is very high, the instrument will display a very unstable base.




When using KA1002, the following figure is shown below. The two test lines are connected to the red clip, which is labeled with a red sleeve for Hcur, the other is Hpot; the upper two is connected to the black clip, which is marked by black Lcur, the other is Lpot.




Load correction: (caution)

A. the user can refer to the following steps in the resistance test:

1 move the cursor to the<REF> (under the RES), and use the digital key to enter the standard values of the standard parts;
2 the tested standard is connected with test piece, move the cursor to the<MEAS>, according to the softkey "MEAS", the measurement value is obtained;
3 move the cursor to the <RES>, select ON;
4 move the cursor to the<LOAD> and select ON. After the completion of the above, the user can test the same kind of product in the same standard.

B. when the user measures temperature with different temperature sensor, can use this function to correct temperature measurement

1. to move the cursor to the< REF> (under the TEMP), with a digital key input temperature reference value;
2. move the cursor to the< MEAS>, press softkey "MEAS", get the value;
3. move the cursor to the <TEMP>, select ON;
4. move the cursor to the< LOAD>, select ON.

## 3.5 < TEMP SETUP> Description

The function is not standard.

The page can be set as follows:

- **TEMP: OFF, TC, Δt, Tm.**

  TC: the abbreviation of temperature correction, the resistance values are corrected according to the change of temperature, which is defined as the temperature compensation function.

  Δt：refers to the temperature conversion, according to the value measured in the cold resistance and heat resistance, and the environment temperature to the final measured temperature, referred to as the temperature conversion function.

  Tm：only measure temperature, without any effect on other values.

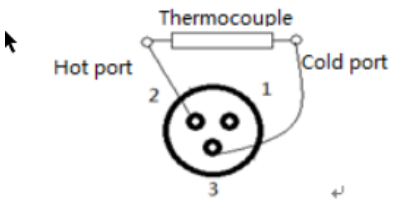
  OFF：the instrument does not conduct temperature testing.

- **SENSOR: OFF, Pt, AnLG_IN.**

  OFF：the instrument is not connected to any temperature sensor.

  Pt： the instrument uses platinum resistance.

  AnLG_IN： the thermocouple type. Users can make it according to the following figure.



- **$t_0$ and $\alpha t_0$ are used for TC.**

  $t_0$ ： enter the value of the -10~99.9 within the digital key（℃）

  $\alpha t_0$： enter the value of the -10~99.9 within the digital key（ppm）

  Temperature compensation formula is as follows:

  $$R_t=R_{t0}*\{1+\alpha_{t0}*(1-t_0)\}$$

  $R_t$: Measurement value of the DUT

  $R_{t0}$: The value of the calculated value is calculated by the modified

  $T_0$: Corrected correlation temperature

  T: Ambient temperature when measured

  $A_{t0}$: Temperature coefficient (temperature=$t_0$)

For example: if a copper to be measured at 40°C when the measuring resistance is 100 ohm, then how much it's value at 20°C (the temperature coefficient of the DUT is 3930ppm).

$$R_{t0}=\frac{R_t}{1+\alpha_{t0}\times(t-t_0)}=\frac{100}{1+(3930\times10^{-6})\times(40-20)}$$
$$=92.71$$

**Note:**

Temperature is the surrounding environment temperature, not the surface temperature of the DUT. Before the test to ensure that the instrument and temperature probe to be full preheating, measurement of the temperature probe to be as far as possible from the DUT, to have enough time to let the surrounding environment temperature stable.

Common metal temperature coefficient see appendix.

- R1、T1、K1 used for Δt

  R1: input through the digital key, 0<R1<20mΩ.

  T1: input the value of -10~99.9 by the digital keys (℃).

  K1: input through the digital key, -1000<k1<1000.

According to the IEC standard 60034, the temperature change is calculated by using the formula of resistance variation.

$$Vt=\frac{R_2}{R_1}(k+t_1)-(k+t_{a)}$$

V$t$: Temperature change (℃)

$t_1$: The temperature when the value of $R_1$ was measured.

$t_a$: Environmental temperature in the final measurement

$R_1$: The value of the resistor at $t_1$

$R_2$: The value of the resistor at $t_2$

K：The reciprocal of the temperature coefficient of electrical conductivity at 0°C

For example: when $t_1$ =20°C, $R_1$=200mΩ; when $t_a$= 25°C, $R_2$ = 210 mΩ

$$Vt = \frac{R_2}{R_1}(k + t_1) - (k + t_a)$$

$$= \frac{210 \times 10^{-3}}{200 \times 10^{-3}} \times (235 + 20) - (235 + 25)$$

$$= 7.75℃$$

$$t_R = t_a + Vt = 25 + 7.75 = 32.75℃$$

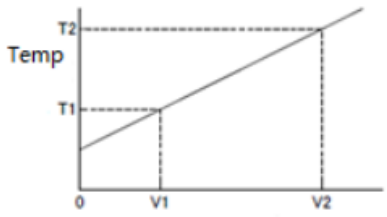
$$k = \frac{1}{\alpha_{t0}} - t_0$$

$\alpha_{to}$：The temperature coefficient of the soft copper wire at 20℃ is 3930ppm

$$k = \frac{1}{3930 \times 10^{-6}} - 20 = 234.5$$

According to the calculated K is close to the value of the copper in the IEC standard: 235。

- V1, T1, V2 and T2 used for AnLG_IN.
  V1, V2：input the value of the 0~2 (unit V) through the digital keys（V）.
  T1, T2：input the value of the -99.9~999.9 by the digital keys (℃).




Analog input voltage

According to the linear relationship between the above, the temperature can be calculated by the electric potential of the thermocouple.

## 3.6 < SYSTEM SETUP> Description

The page can be set as follows:

Theme: TRAD BLUD, TRAD BLACK
Language: English, Chinese
Key Tone: ON, OFF
Pass Tone: OFF、LONG、SHORT、TWO SHORT
Fail Tone: OFF、LONG、SHORT、TWO SHORT
ParaSave: AUTO SAVE 、AUTO LOAD
PassWord: OFF、LOCK SYSTEM、LOCK FILE、MODIFY、SAVE TO U-DISK
Date: INCR++、INCR+、DECR-、DECR--
Time: INCR++、INCR+、DECR-、DECR--

- Parameters save have two modes
  Auto save refer to save real-time measurement parameter settings, the next boot and shutdown last have the same state.
  Automatic loading: Automatically call the internal file for the last time when the boot is on.

- password:
  Lock system: including file protection and boot password.
  Lock file: file protection.
  Change Password: change password. Factory default password for example: 2517, 2518 and so on (by the instrument model).
  Saved to disk: save password to disk, such as password file called "2517.STA" (by type of instrument). When the instrument operation needs to enter a password, the instrument will automatically detect the password file is valid, so as to achieve the purpose of lifting passwords.

## 3.7 < COMM SETUP> Description

The page can be set as follows:

- Bus Mode：RS232C、GPIB、USBTMC、USBCDC
- Baudrate：INCR+、DECR-
- Data Bit：6、7、8
- Stop Bit：1、2
- Parity：None、Odd、Even
- Tx Term：LF(OxOA)、CR(OxOD)、CRLF(0x0D0A)
- Gpib Addr：INCR++、INCR+、DECR-、DECR--
- CMD Type：SCPI、2512

**Note:**

- used to RS232C: Baudrate, Data Bit, Stop Bit, Parity
- used to GPIB: GpibAddr.
- terminator: the end code of the instrument data send the data.
- For detail orders, please contact the sales staff or dealers.

## 3.8 < ABOUT SYSTEM> Description

This page displays the identity information of the instrument and some system functions the identity information as follows:

This instrument model 、Serial number 、The software version number 、The hardware version number 、The registration information etc.

system functions as follows

Reset: reset she system setup and restart the instrument.
Factory: return to the factory setting.

The firmware upgrade: upgrade of instrument software.

Exit: return to < SYSTEM SETUP > page.

## 3.9 < FILES SETUP> Description

Press "FILE" to enter < INTER Files List > page

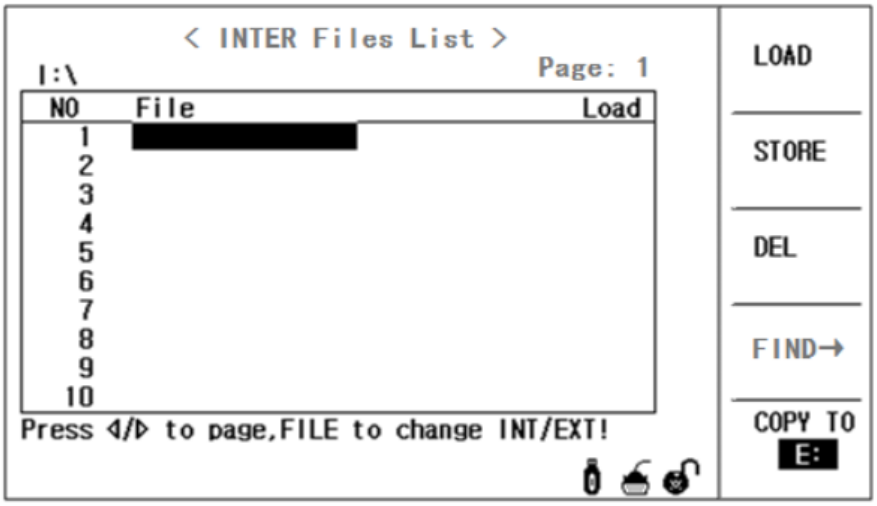



Figure 3-9-1

Press "FILE" again to change INT/EXT .

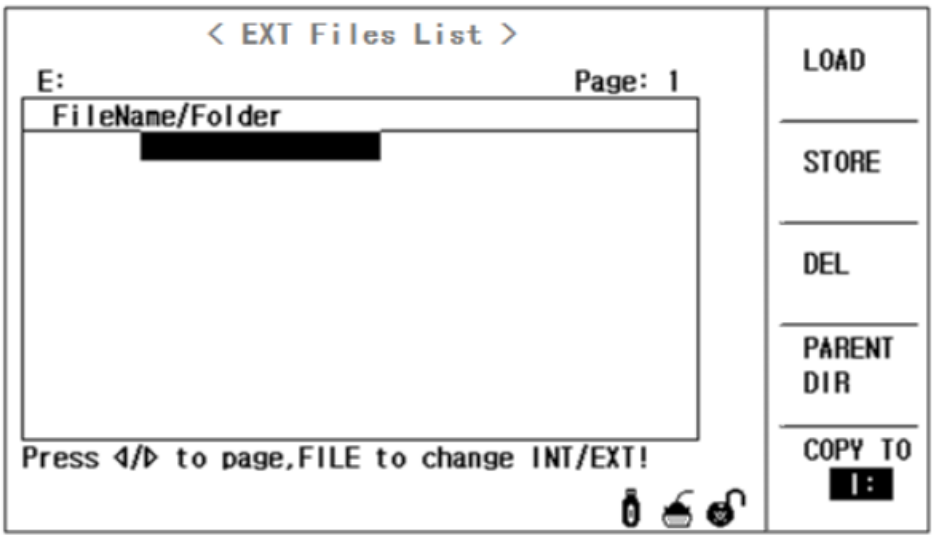



Figure 3-9-2

File operation steps:

A. Refer to the existing file

1) use direction key to check files
2) input the corresponding serial number of files, then press "OK"

B. Save parameters to files

1) move the cursor to the serial number of files which need to be stored, then press soft key of "save" .

C. load parameters from files

1) press "FILE", Switch to the page of Files list
2) move the cursor to the object file
3) press the soft key of "load"

D. Copy the file to the E (USB)

1) Connect the USB flash drive
2) move the cursor to the object file, press the soft key of "copy to E :"

# Chapter 4 performance parameter

## 4.1 Accuracy of measurement

1) Resistance Accuracy

test environment: 18 ℃to 28 ℃, RH: below 75%, test conditions: slow.

For MM2010, see then table below:

| Range | 20 mΩ | 200 mΩ | 2 Ω | 20 Ω | 200 Ω | 20 kΩ | 20 kΩ |
|---|---|---|---|---|---|---|---|
| Accuracy | ±0.1 % +3 | ±0.1% +2 | | | | | |
| Resolution | 1 μΩ | 10 μΩ | 100 μΩ | 1 mΩ | 10 mΩ | 100 mΩ | 1 Ω |
| Temperature coefficient | 100 ppm | 50 ppm | | | | | |

The other accuracy refers to the following table:

| Range | 20 mΩ | 200 mΩ | 2 Ω | 20 Ω | 200 Ω | 2 kΩ | 20 kΩ | 200 kΩ | 2 MΩ | 10 MΩ |
|---|---|---|---|---|---|---|---|---|---|---|
| Accuracy | ±0.2% +5 | ±0.1% +2 | | | | | | | ±0.2% +2 | ±0.2% +3 |
| Test current | 1 A | 100 mA | | 10 mA | 1 mA | 100’ μA | | 10 μA | 1 μA | 100 nA |
| Open-circuit voltage | < 1V | | | <4 V | | | | | | |
| Resolution | 1 μΩ | 10 μΩ | 100 μΩ | 1 mΩ | 10 mΩ | 100 mΩ | 1 Ω | 10 Ω | 100 Ω | 1k Ω |
| Temperature coefficient | 100 ppm | | | | | | | | | |

Note: range

| | |
|---|---|
| MM2020 | 20 mΩ to 2 MΩ |
| MM2010 | 200 mΩ to 200 kΩ |
| MM2030 | 20 mΩ to 10 MΩ |
| MM2040 | 200 mΩ to 200 kΩ |

2) Temperature Accuracy

- **The temperature sensor (the following indicators for the instrument at 25 ℃ measurement accuracy, using different PT1000 will produce error, please use < user > temperature correction for improving the accuracy)**

| Temp Range | -10.0～39.9 | 40.0～99.9 |
|---|---|---|
| Resolution | 0.1℃ | 0.1℃ |
| Accuracy within 6 months | ±0.30% rdg ±0.5℃ | ±0.30% rdg ±1.0℃ |
| Accuracy within 1 year | ±0.45% rdg ±0.8℃ | ±0.45% rdg ±1.5℃ |

❖ **When the temperature sensor uses analog input**

| Within 1 year | |
|---|---|
| input range | 0～2V |
| indication range | -99.9℃～999.9℃ |
| Resolution | ≤1mV |
| Accuracy | ±1%rdg ±3mV |

$$1\% \times (T_R - T_{0V}) + 0.3\% \times (T_{1V} - T_{0V})$$

**Note**: the method of temperature precision conversion:

$T_{1V}$: Temperature refer to 1V; $T_{0V}$: Temperature refer to 0V; $T_R$: current temperature

When the temperature is 0℃~18℃ and 28℃~40℃,

Temperature coefficient is ( 0.1% rdg ±0.3mV)/℃

## 4.2 Measurement Speed

1) Resistance measurement speed

The following table is a resistance test time:

| Speed / Power frequency | Fast | Medium | Slow | Fast 2 Only for 2030,2040 |
|---|---|---|---|---|
| 50Hz | 22ms | 42ms | 102ms | 7ms |
| 60Hz | 18.5ms | 35ms | 102ms | 7ms |

Resistance test time = test time + interface signal output time + display time (less than 10ms)

2) Temperature measurement speed

The temperature measurement test time = 110ms+ display time (less than 10 ms).

**Note:** in order to improve the test speed of the instrument in the automatic system, the user can display the display of a small font.

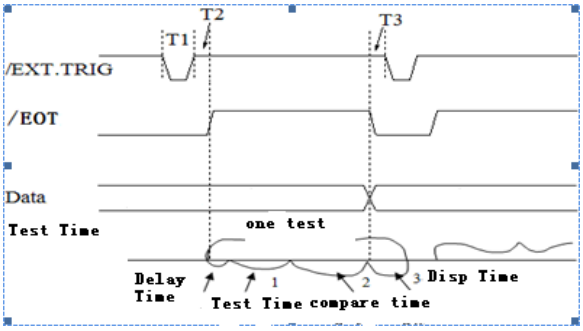
# Chapter 5 Handler

### 5.1 HANDLER Description

The output signal of Handler interface is as follows:

| PIN | signal name | Discription |
|---|---|---|
| 1 | /LOW | Low signal output |
| 2 | /HIGH | High signal output |
| 3 | /PASS | Pass signal output |
| 4 | /EOT | End of test signal output |
| 5 | /EXT.TRIG | External trigger signal input |
| 6 | +5V（VCC） | +5V power supply(output) |
| 7 | N.C. | No use |
| 8 | N.C. | No use |
| 9 | GND | Ground terminal |

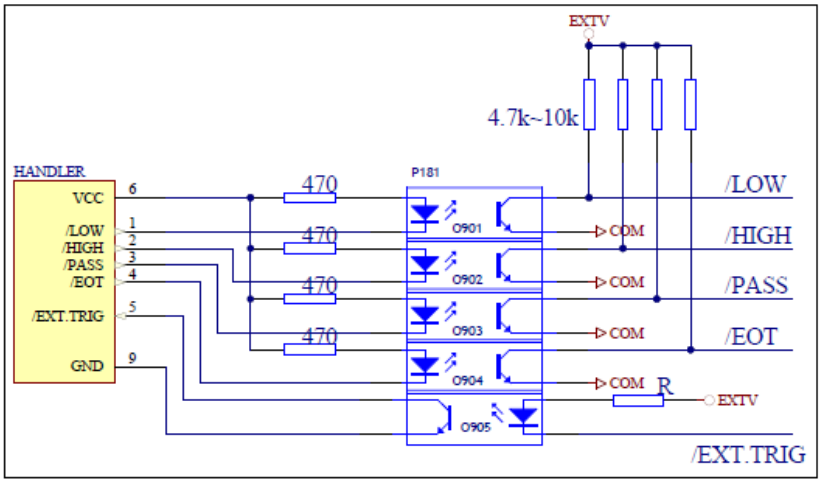
Timing of interface signal:




| time | the minimum | the maximum |
|---|---|---|
| T1: trigger pulse-width | 1us | --- |
| T2:delay time | 200us | （Display time）$^3$ + 200us |
| T3:the trigger waiting time after /EOM output | 0us | --- |

## 5.2 HANDLER Application

- Users can refer to the following circuit connection when the external voltage is used, the EXTV (5~24V) is the external power supply for the user, COM is the external power supply, you can adjust R according to the different needs (such as +5V with 470Ω, +24V with 2.2kΩ).



## 5.3 HANDLER Custom with optocoupler output

The instrument panel will be labeled " optocoupler ", see below:

| PIN | signal name | Discription |
|---|---|---|
| 1 | /LOW | Low signal output |
| 2 | /HIGH | High signal output |
| 3 | /PASS | Pass signal output |
| 4 | /EOT | End of test signal output |
| 5 | /EXT.TRIG | External trigger signal input |
| 6 | +5V（VCC） | +5V power supply output |
| 7 | EXTV. | External power input,+5V~+24V |
| 8 | COM. | External ground input, 0V |
| 9 | GND | Ground terminal |

EXTV (5~24V) provide with external power supply, COM is the external ground.

# Chapter 6 Appendix

(1) characteristics of metals and alloys

| Material | Content（%） | Density（$\times 10^3$） [kg/$m^3$] | Electrical conductivity | Temperature coefficient （20℃）[ppm] |
|---|---|---|---|---|
| Soft copper wire | copper > 99.9 | 8.89 | 1.00 ~ 1.02 | 3810 ~ 3970 |
| Hard copper wire | copper > 99.9 | 8.89 | 0.96 ~ 0.98 | 3770 ~ 3850 |
| Cadmium copper wire | Cadmium 0.7 ~ 1.2 | 8.94 | 0.85 ~ 0.88 | 3340 ~ 3460 |
| Silver plated copper wire | Silver 0.03 ~ 0.1 | 8.89 | 0.96 ~ 0.98 | 3930 |
| Chromium copper wire | Chromium 0.4 ~ 0.8 | 8.89 | 0.40 ~ 0.50<br>0.80 ~ 0.85 | 20<br>30 |
| Corrosion resistant alloy wire | nickel 2.5 ~ 4.0<br>Silicon 0.5 ~ 1.0 | | 0.25 ~ 0.45 | 980 ~ 1770 |
| soft aluminum wire ; | aluminum > 99.5 | 2.7 | 0.63 ~ 0.64 | 42 |
| hard aluminium wire | aluminum > 99.5 | 2.7 | 0.60 ~ 0.62 | 40 |
| Aluminium alloy wire | Silicon 0.4 ~ 0.6<br>Magnesium 0.4 ~ 0.5<br>the rest is Aluminium | | 0.50 ~ 0.55 | 36 |

Electrical conductivity of copper wire:

| Diameterd[mm] | Soft copper wire | Tin plated copper wire | Hard copper wire |
|---|---|---|---|
| $0.01 \le d < 0.26$ | 0.98 | 0.93 | — |
| $0.26 \le d < 0.5$ | 0.993 | 0.94 | 0.96 |
| $0.5 \le d < 2$ | 1.00 | 0.96 | 0.96 |
| $2 \le d < 8$ | 1.00 | 0.97 | 0.97 |

Because the change of temperature coefficient is based on temperature and electrical conductivity, the temperature coefficient is calculated according to the formula:

$$\alpha_{ct} = \frac{1}{\frac{1}{\alpha_{20} \times C} + (t - 20)}$$

(C for conductivity)