AM8010 Precision Thermometer
User's Guide

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Table of Contents

1 Package List

The following items are included in this package:
- One AM8010 Precision Thermometer
- One USB cable
- Two AAA Batteries
- One 5-pin sensor connector
  - o Installed to the probe when purchasing together with an AccuMac PRT
- One CD with following software:
  - o Cool Edge USB Viewer
  - o USB driver

2 Important Safety Information

AM8010 is a high accuracy temperature measurement and calibration instrument that can be used in laboratories and the field. Users should read and understand the following warnings to avoid electrical shocks and injuries.

Warning:
- Do NOT use the instrument in applications other than specified as temperature measurement and calibrations
- Do NOT clean the instrument with solvents
- Do NOT apply voltage more than specified in this manual
- Do NOT place any weight on top of the instrument

The following precautions should be followed to avoid damage to the instrument.

Caution:
- Only use this instrument in the manufacturer's specified temperature range.
- This instrument and associated probe is sensitive to mechanical shocks. Handle with care.
- Only trained personnel can perform calibration of this instrument.

3 Introduction

AM8010 Precision Thermometer is a high performance portable instrument. It works with various types of platinum resistance thermometer (PRT) sensors for temperature measurement. Its temperature calculation is based on ITS-90 or CVD formula. AM8010 Precision Thermometer can be connected to a computer using an USB cable to do real-time temperature data acquisition.

The main features of the AM8010 Precision Thermometer include the following:

- High accuracy, up to 0.03 ºC
- High resolution 0.01 ºC
- Flexible sensor selection:
  - 100 ohm PRT with temperature coefficient α=0.00385.
  - 100 ohm SPRT or PRT with temperature coefficient α=0.003925
- 2.7 inch LCD display
  - Display with backlight when used with external power adapter or an USB cable connected to a computer.
- Multi-line information display
- Large size touch pad for function controls and parameter adjustments
- USB interface with a computer for data acquisition and display using provided software
- Dual power supply
  - 2 AAA batteries
  - External power adapter/computer USB interface
- ISO/IEC 17025 accredited calibration included

3.1 Specifications

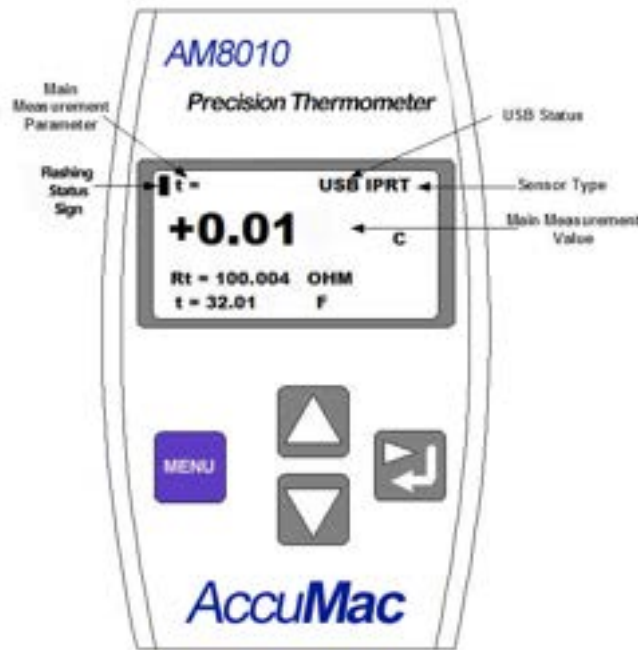| Model	AM8010
Temperature Range	-200°C to 850°C
Accuracy (meter only)	±0.04°C at -200°C ±0.03°C at 0°C ±0.04°C at 232°C ±0.05°C at 420°C ±0.06°C at 660°C
Resolution	0.01 °C (0.001 Ω) over full range
Stability	±0.01 °C per year
Probe	100 Ω RTD, PRT, or SPRT
Characterizations	ITS-90 coefficients, Callendar-Van Dusen coefficients, IEC-751 (DIN 385)
Sample Interval	1 second
Display	2.7 inch OLED
Display Units	°C, °F, Ω
Excitation Current	1 mA, reversing
Operation Range	15°C to 35°C
Thermometer Input Connectors	5-PIN plug
Power Requirements	100-240 V
Battery Life	Approx. 90 hours
Dimensions	141mm (L) x 25mm (H) x 89mm (W)
Weight	0.2 kg (0.5 lbs)

3.2 Display

Figure 3-1: AM8010 Front Panel

Figure 3-1 shows the front panel of AM8010 and its parameter display. There are four function keys that are defined as follows:

MENU : MENU KEY,

△ : INCREMENT KEY,

▽ : DECREMENT KEY, and

↵ : RIGHT SHIFT and RETURN KEY.

The top panel of AM8010 is shown in Figure 3-2. There are three interfaces: "SENSOR", "USB or EXT POWER" and the power switch "OFF/ON".
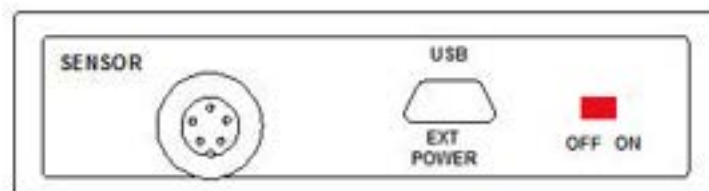

Figure 3-2: AM8010 Top Panel

A foldable tilt foot support is mounted on the back of AM8010. It helps the user to put the meter in a stable position with a display angle.

There is a battery cover on the back side of AM8010 Precision Thermometer. Two AAA size batteries are used to power the meter. A sliding switch besides the battery holder can be seen when the battery cover is opened. This switch is used for calibration only.

Warning: Inappropriate setting change to this switch can cause loss of calibration data. Instructions for using this switch are shown in 4.1.

4 General Operation

4.1 Mode Switch Setting

There are two operating modes of AM8010: <u>Measurement Mode</u> and <u>Calibration Mode</u>. Users can switch the mode by using the <u>Mode Switch</u>. The <u>Mode Switch</u> is located near the battery holder. The default mode is set to <u>Measurement Mode</u>.

Note: Only trained calibration personnel can set the switch to "<u>Calibration Mode</u>". See detailed instructions of calibration procedure in Chapter 7.

The procedures to set this switch are as following:

1. Turn off AM8010.
2. Open the battery cover at the back side of AM8010. <u>Mode Switch</u>, which is a sliding switch, is located beside the battery holder.
3. Text "MEA" and "CAL" indicates whether AM8010 is set to "<u>Measurement Mode</u>" or "<u>Calibration Mode</u>".

4.2 Battery Installation

AM8010 works with dual power supplies: battery and USB. When AM8010 is powered by USB, the batteries are not used.

To install the batteries, open the battery cover at the back of AM8010, and follow the polarity signs on the battery holders.

AM8010 works with any type of AAA size batteries, alkaline or rechargeable batteries.

Caution: Do NOT combine different kinds of batteries together. Make sure the power switch is at the "OFF" position during battery installation.

4.3 Power with External Adapter and USB

An AC/DC adapter (AC 100V ~ 240V input, DC5V output) can be used to power AM8010.

The advantage of using the adapter is that the backlight of the LCD display will be turned on and it is suitable for dim light conditions.

The connection procedures of the AC/DC adapter are as follows:

1. Connect USB A side to the adapter USB socket.
2. Connect USB mini-B side to "USB" connector of AM8010.
3. Plug the adapter into an AC 100V ~ 240V power point. Switch on the AC power.
4. If AM8010 is not powered on, switch it on. If AM8010 is already powered by batteries and the power switch is on, the backlight of the LCD should illuminate.
5. The USB cable can be unplugged anytime. If AM8010 is powered by batteries, functionality will continue.

AM8010 can be connected to a computer with the USB interface. In this case the computer is the power source for AM8010.

4.4 Sensor Connection

PRT Sensors can be connected to the AM8010 "SENSOR" socket with a 5-pin connector that is provided in this package. Connecting steps are as follows:

1. Align the notch of sensor plug to the notch of "SENSOR" socket.
2. Push in the sensor plug. At this moment, do not turn the knob. Turning the sensor connector can cause damage to the socket and plug.
3. After the plug is fully pushed in, turn the locking ring of the plug clock-wise until it is fully tightened.

4. To remove the sensor, just do the reverse of the above procedure: turn the plug locking ring counter clock-wise, until it is free, then pull out the plug.

4.5 Power On/Off Control

The power button is on the top panel of AM8010. It is marked with "OFF/ON" text. Users can follow the sign to turn the meter on/off.

4.6 Display of Measurement Results

The temperature measurement results are displayed on the LCD screen. There are four lines of information as shown in Figure 3-1. The main information is temperature in Celsius (C), Fahrenheit (F) and sensor resistance (OHM). The other information includes sensor type, USB connection status, battery low status and no sensor indications.

The first line is the status information line. The second, third and fourth lines show the measured data, which are temperature or sensor resistance.

As shown in Figure 3-1, the top line is the status information line. The information includes:
1. Status sign. It is a flashing dot at the upper left corner. It should flash under normal conditions.
2. Main measurement parameter. It is located just to the right of the status sign. It should be either "t =" or "Rt =" which means the second line information is temperature ("t=") or sensor resistance ("Rt="). The information of the second line can be changed by users. The details are shown in "4.7 Touchpad Operation".
3. USB status. When AM8010 is connected to a computer's USB interface, "USB" will show up near the center of the first line.
4. Sensor type. Two types of sensor, "IPRT" or "PRT", are supported by AM8010. They are displayed as "IPRT" or "PRT" on the LCD near the end of the first line. Users can

configure the sensor type by following the procedures that are detailed in Chapter 6 "Sensor Parameter Input/Adjustment". "IPRT" is defined as a 100 Ω sensor with temperature coefficient α=0.00385. "PRT" is defined as a 100 Ω SPRT/PRT with temperature coefficient α=0.003925 ($W_{Ga} \geq 1.11807$).

5. "NO SENSOR" status. "NO SENSOR" will be displayed when no sensor is connected to AM8010.

6. "LOW BAT" status. "LOW BAT" is displayed when the batteries are low in power.

The second line shows the measured results with larger fonts to help users to focus on the key readings. The information of the second, third and fourth line can be scrolled up or down based on the user's preference.

4.7 Touchpad Operation

There are four touch keys on AM8010's front panel. These touch keys are used for scrolling up/down through measurement data, or for sensor parameter adjustments and calibrations.

Note: These keys are not mechanical push buttons. They are only sensitive to finger touch.

When the meter is set to <u>Measurement Mode,</u> △ and ▽ are used to select the measured readings in Celsius (C), Fahrenheit (F) or sensor resistance (OHM).

The [MENU] and [↵] keys can be used for sensor type selection and sensor parameter adjustment. These two keys are also used in <u>Calibration Mode</u> (see Chapter 6).

5 Connecting to a Computer Using the USB Interface

AM8010 is designed with a USB v2.0 compatible interface (Mini B type) and it can be connected to a PC. The USB interface serves two important functions as a power source (see Chapter 4.3) and a link for data acquisition. The free software **Cool Edge Viewer** is provided with AM8010 for real time data acquisition.

5.1 Installation of USB Driver to a Computer

Important Update: if your PC is running Windows 7 operating system (or any later versions), you can skip the USB driver installation process. These versions of Windows OS provide plug-and-play support for USB drivers. Otherwise, please follow the instructions below:

  a) Power off AM8010.
  b) Connect a USB cable (one side USB A type, the other side mini-B type) to a USB socket on a computer.
  c) Power on the computer and put the included CD into a CD drive. Here we assume the CD drive is E.
  d) Connect USB mini-B side to AM8010. Switch on AM8010, AM8010 LCD display should show "USB" on the first line. The computer also should show "Found New Hardware".

e) Select "No, not this time", then click on "Next".
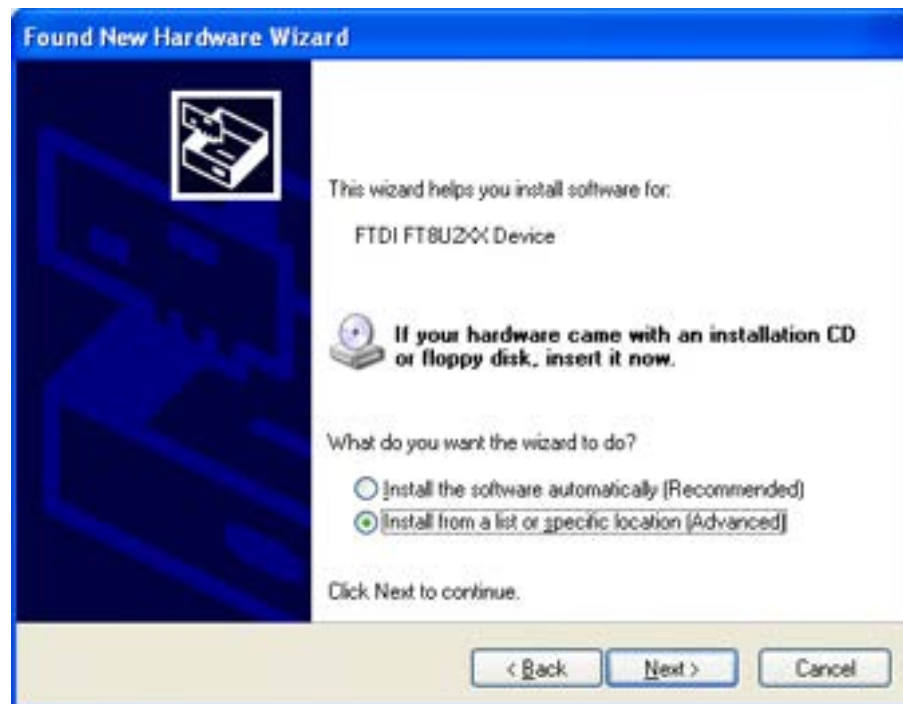
f) Select "Install from a list or specific location (Advanced)" and then click on "Next".

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g) Use "Browse" to find the driver in E (refer to the above figure), then click on "Next".

h) Select "Continue Anyway". The computer may request another file "FTD2XX.sys".

i) Use "Browse" to search the E drive to find and select FTD2XX.sys, then click on "OK". After the installation, the computer should show:

j) Click "Finish" to end the installation.
k) The computer should show "Your new hardware is ready to use" to indicate that the installation is finished.

5.2 Cool Edge USB Viewer Software

"Cool Edge USB Viewer" enables AM8010 to communicate with a computer USB interface and display the measurement results on a computer monitor. It also enables users to save the captured data to a file. Details of setting up the data acquisition system using the software are as follows:

    a) Turn on the computer and copy the software "**Cool Edge USB Viewer"** from the CD provided to the desktop.

    b) Connect a USB cable between the computer and AM8010.

    c) Turn on AM8010. After a few seconds, the first line of AM8010's LCD display will show "USB".

    d) Double click the icon of **"Cool Edge USB Viewer"** on the desktop to start the software.

    e) **Cool Edge USB Viewer** should start and show the following:
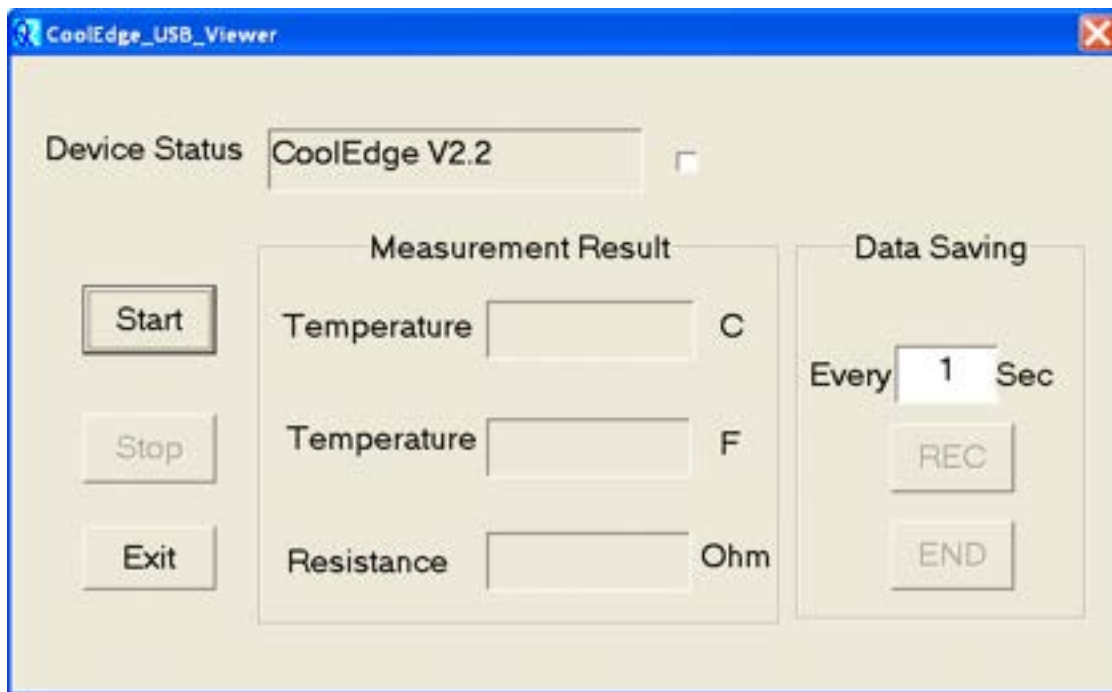
f) Click on the "Start" button. The software should show the measurement data as follows:
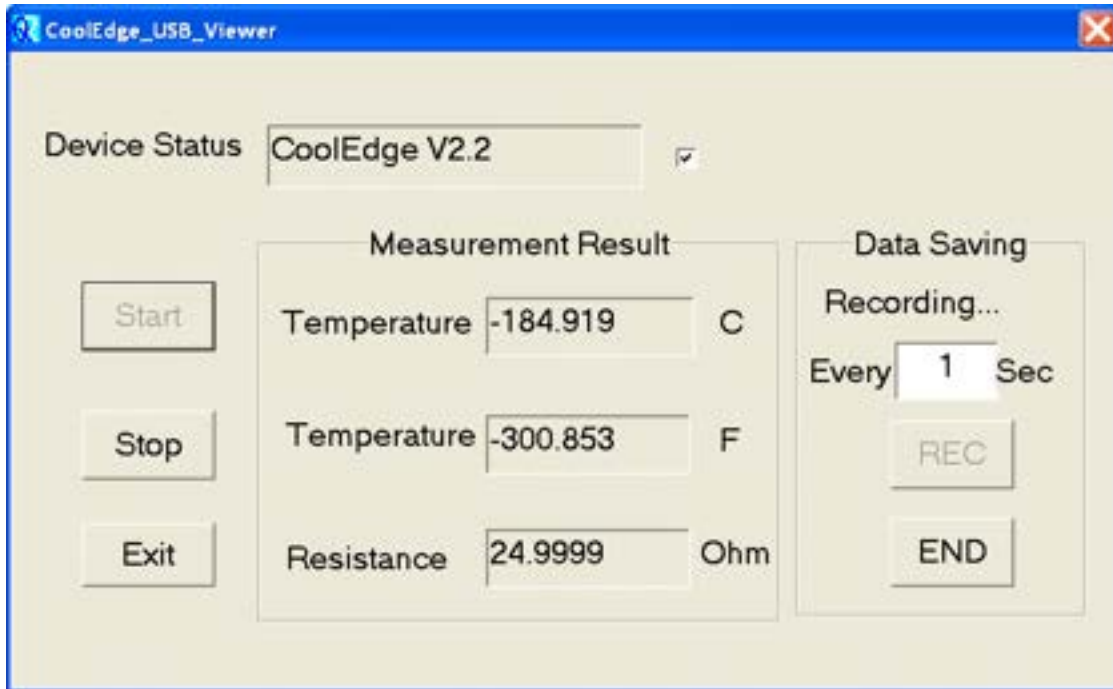
g) Users can use the "Data Saving" function at the right side to save the data if needed. The first step is to set the sampling rate. The above Figure shows the "Data Saving". The default sampling rate is 1 second. If other sampling rates are required, users can key in other integer numbers between 1 to 65,535 seconds. Users can start to record data by clicking on the "REC" button. To end the data recording, click on the "END" button. The captured data are saved to a file named "cool_data.txt".

h) To stop data measurement, click on "Stop".

i) To quit the software, click on "Exit".

6 Sensor Parameters Input/Adjustment

AM8010 supports two types of sensors: IPRT and PRT.

IPRT: a high precision 100 ohm Platinum Resistance Thermometer or Industrial 100 ohm Platinum Resistance Thermometer with temperature coefficient of α=0.00385. The temperature is calculated based on the CVD formula. Users can input/adjust following parameters of an IPRT: R0, A, B and C.

PRT: a high precision 100 ohm Platinum Resistance Thermometer or 100 ohm standard Platinum Resistance Thermometer (SPRT) with temperature coefficient of α=0.003925 ($W_{Ga} \geq 1.11807$). The temperature is calculated based on the ITS-90 formula. Users can input/adjust the following parameters:

- Rtp: the sensor's triple point of water.
- a4, b4: low temperature range parameters.
- a, b, c: high temperature range parameters (for some types of sensors, b and c may equal to 0. Refer to ITS-90 for details).

After users input/adjust the correct parameters the sensor type is displayed on the LCD of AM8010 and the parameters are used in the calculation.

Note: Users need to set the parameters corresponding to the sensor to get the optimal measurement. These parameters can be obtained from qualified calibration institutes.

The detailed procedure to set the sensor type and parameters are as follows:

1. Power off AM8010. Install batteries in the AM8010, or connect AM8010 to a power adapter or a running computer USB interface. Make sure each battery has enough power. It is suggested to use new batteries for parameter setting or calibration.

2. Set the Mode Switch to Measurement Mode. Refer to 4.1 Mode Switch Setting.

3. Power on AM8010. If a sensor is connected to AM8010, the LCD should display the measurement reading. See the following figure as an example. If no sensor is connected users can still set parameters of a sensor.

4. Press and hold the [MENU] key for more than 3 seconds, the bottom right corner of the LCD should show "MENU".

```
t=                    IPRT

27.09                   C

Rt = 110.650          OHM
t = 80.77             F
                      MENU
```

Continue holding the [MENU] key and also press the [↵] key at the same time. AM8010 should enter into the adjustment program.

5. The following will be displayed on the LCD after step 4. If no adjustment or setting is needed, press the [△] or [▽] key to move the highlight line to "EXIT" and then press the [↵] key. AM8010 will go back to measurement mode.

```
* MAIN MENU

SENSOR SETTING

   EXIT


            Enter = Yes
```
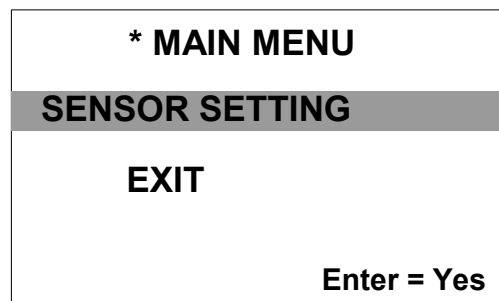
6. Move the highlight line to "SENSOR SETTING" and press the ↵ key to adjust the sensor's settings. The following will be displayed:

```
SENSOR  =              IPRT

 IPRT

 PRT


 Menu = Exit        Enter = Yes
```

7. As illustrated in the above Figure, the first line shows the current sensor type. If the connected sensor type is different from the current setting (IPRT for example), the sensor type needs to be changed. Move the highlight line to the correct line by pressing △ or ▽, and then press the ↵ key to select. The program will move into the parameter adjustment section as illustrated in step 8.

8. For example, if IPRT is selected, the LCD displays the following:

```
        IPRT SETTING

 SET R0

   SET A

   SET B

```

The user can adjust R0, A, B and C in this section. Press the ↵ key to select, and press the MENU key to go back to the previous screen when adjustments are done.

9. If PRT is selected, the LCD displays the following:

```
┌────────────────────────────────┐
│      PRT SETTING               │
├────────────────────────────────┤
│ SET Rtp                        │
│                                │
│ SET a                          │
│ SET b                          │
│                                │
└────────────────────────────────┘
```

The user can adjust Rtp, A4, B4, A, B and C in this section. Press the ⏎ key to select, and press the [MENU] key to go back to the previous screen when adjustments are done.

10. The following are examples of setting R0 and A4 values. The adjustment of the other parameters can be done in similar way.
   I. R0 adjustment:
      i. Continue from 6.1.8. Press the ⏎ key and the LCD will show:

```
┌────────────────────────────────┐
│ R0                      OHM    │
│                                │
│   100.0100                     │
│                                │
│                                │
│ Menu = Save      Enter = Shift │
└────────────────────────────────┘
```

      ii. The value of the second line shows the current R0 value. The cursor shows the adjust position. To modify the value, press the △ or ▽ keys to adjust the value up or down. Pressing ⏎ will shift the cursor to the next position. After the last digit is finished, pressing ⏎ again will move the cursor to the left-most position. There is no left shift key.

iii. After R0 is adjusted, press the [MENU] key and the LCD should show:

```
SAVE R0

100.0000


Menu = No          Enter = Yes
```

iv. The second line should flash to remind the user to save the new value. If users do not want to save this value, press [MENU] to quit the adjustment; if users want to save this new value, press the [↵] key. The new R0 value will be saved into the meter. The program will go back to 6.1.8.

II. To adjust a4 value, continue from 6.1.9.

i. Move the highlight line by pressing the [▽] key multiple times until "SET a4" is highlighted. Press the [↵] key to select, the LCD should show:

```
a4= - 4.129934e-05

    SET a4 =0
    ADJUST  a4


Menu = Exit        Enter = Yes
```

ii. The first line is the current a4 value. The second line should be selected if a4=0. The third line allows the user to adjust the a4 value. Press the [△] or [▽] to move the highlight line. If a4 needs to be adjusted, move the highlight line to "ADJUST a4" then press the [↵] key. The LCD should show:

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```
        SET  a4

- 4.129934 e - 05




Menu = Save          Enter = Shift
```

iii. The flashing cursor shows the adjustable digit. Pressing △ or ▽ changes the value up or down. Pressing ⤶ will move the cursor to the right position. If the cursor is at the far right position, pressing the ⤶ key again will move the cursor to the left-most position. After the a4 adjustment is done, press the MENU key and the LCD should show:

```
        SAVE a4

- 4.129934 e - 05




Menu = Exit          Enter = Yes
```

iv. The first line displays "SAVE" to remind the user that the meter is preparing to save the new a4 value, the flashing second line is to remind the user to make a decision.

v. Press MENU to exit without saving. Press ⤶ to save the new a4 value to AM8010.

The other parameters can be adjusted in a similar way as above.

7 Calibration

AM8010 is designed for temperature measurement by measuring the probe resistance and converting it into a temperature. Consequently, the resistance measurement is very critical, and the instrument must be calibrated correctly. Every AM8010 is calibrated before shipment.

AM8010 needs regular calibration performed by qualified professionals. A one year calibration interval is recommended.

Users can calibrate AM8010 using standard resistors with calibrated values. Users can choose to do one of two calibrations: Instrument Calibration or System Calibration.

7.1 Instrument Calibration

Instrument Calibration is to calibrate the resistance measurement accuracy of AM8010.

Note: a standard resistor with resistance of 100 ohm is required for the Instrument Calibration.

Set AM8010 to **Calibration Mode** before starting the calibration (See Chapter 4.1). Calibration steps are as follows:

1. Connect a 100 ohm standard resistor with four-wire configuration to AM8010. In the illustrations below a standard resistor with 100.0038 ohm resistance is used as an example. It is suggested to use the external power adapter or to connect the AM8010 to a USB interface on a running computer during calibration. If battery power is used make sure the batteries are not running low.

   Power on AM8010, and the LCD should display:

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```
        * CALIB MENU



 CALIBRATION

                       Enter = Yes
```
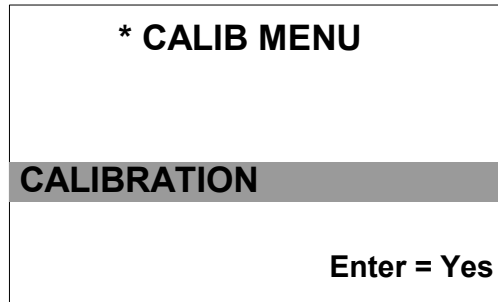
2. Press the ⏎ key, the display will show:

```
 Rs =                    OHM

 99.9999


 Rt = 99.9888    OHM
```
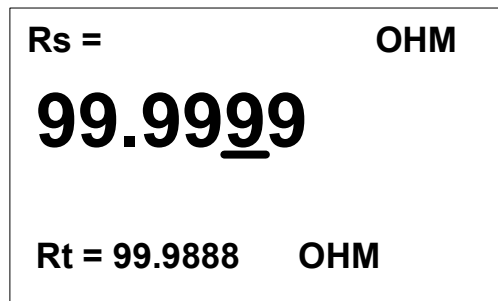
3. The second line shows the internal reference Rs value (value may be different from meter to meter). The third line shows the current external standard resistor resistance reading Rt = 99.9888 ohm, which is not equal to the real external standard resistor value 100.0038 ohm. The following <u>Instrument Calibration</u> procedures are to adjust the Rs value to make the Rs value equal to 100.0038 ohm and save the new Rs to the instrument.

4. Press the △ or ▽ key to adjust the Rs value at the cursor position. Press the ⏎ key to right shift the cursor for a new position during the adjustments.

5. After the adjustment, the second line value should be 100.0038 ohm.

```
▮  Rs =                    OHM

    100.0038


Rt = 100.0038          OHM
```
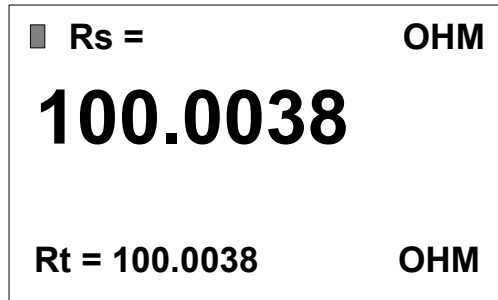
6. Wait for Rt and Rs to be stable (the status sign should flash around 10times), then press [MENU], the LCD should display:

```
SAVE Rs

    100.0038


Menu = No      Enter = Yes
```
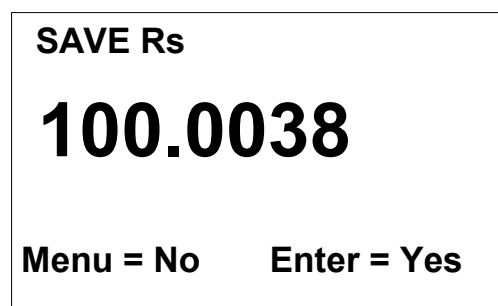
The second line should be flashing. Press the [↵] key to save the new Rs. Press the [MENU] key to exit without saving.

After the calibration, turn AM8010 off and change the <u>Mode Switch</u> back to <u>Measurement Mode</u>.

7.2 System Calibration

System Calibration is based on the Instrument Calibration. It is to integrate a particular PRT sensor with AM8010 after Instrument Calibration to form a temperature measurement system. This system is to be calibrated at certain temperature points to calculate the sensor's coefficients based on AM8010's readings. These coefficients are then saved in AM8010 after calibration to achieve better measurement performance as a system.

The advantage of System Calibration is that it can achieve higher accuracy with lower cost because the sensor doesn't need additional calibrations before System Calibration.

The following sections illustrate the System Calibration procedure with the two types of sensors "IPRT" and "PRT".

7.2.1 Calibration with IPRT (high precision 100 ohm or industrial 100 ohm Platinum Resistance Thermometer with α=0.00385)

1. Turn off the power of AM8010, make sure it is set to <u>Measurement Mode</u> (see Chapter 4.1 for details).

2. Connect the sensor to AM8010. Power on AM8010, and put the sensor into a temperature bath or fixed point cell.

3. High temperature range calibration: three temperature points are needed which are ice point (triple point of water), a temperature close to the probe's upper limit, and a point in between. Note down the measurement results at all these three points.

   For example, the following three temperature points from 0ºC to 300ºC are selected and after the calibration, the following group of data is acquired.

Standard temperature t	AM8010 measured R(t) resistance value
0ºC	R（0ºC）
150ºC	R（150ºC）
300ºC	R（300ºC）

   Apply the above data to:

   $$R(t)=R(0ºC)*(1+At+Bt^2)$$

   Then parameters A and B can be calculated.

4. Low temperature range calibration: Measure another temperature point that is close to the probe's lower temperature limit using AM8010.

For example, the following data is acquired:

Standard temperature t	AM8010 measured R(t) resistance value
-60ºC	R (-60ºC)

Apply the calculated A and B, together with the new low temperature data to:

$$R(t)=R(0ºC)*[1+At+Bt^2+C(t-100)t^3]$$

Then C value can be calculated.

5. Key in the A, B, C and R0 to AM8010. The system calibration is done.

6. Turn off the power after calibration.

7.2.2 Calibration of PRT (high precision 100 ohm or standard 100 ohm Platinum Resistance Thermometer) with temperature coefficient α=0.003925（W_{Ga}>1.11807）

1. Turn off the power of AM8010, and set it to Measurement Mode. (See Chapter 4.1)

2. Connect the sensor to AM8010. Power on AM8010, and put the sensor into a temperature bath or fixed point cell.

3. Choose more than three temperature points to measure based on the sensor's temperature range and ITS-90 standards.

4. These measurement data can be applied to the calculation of the sensor's temperature coefficients based on the ITS-90 formula.

For example, the following data are acquired between 0ºC to 300ºC.

Standard temperature t	AM8010 measured R(t) resistance value
0.01ºC	R（0.01ºC）
150ºC	R（150ºC）
300ºC	R（300ºC）

Apply the above data to the ITS-90 formula:

$$W\text{-}W_r = a(W\text{-}1) + b(W\text{-}1)^2 - c(W\text{-}1)^3$$

where, $W = R(t)/R(0.01)$, and

$$W_r = C_0 + \sum_{i=1}^{9} C_i \left(\frac{T_{90} - 754.15}{481} \right)^i$$

C_0 and C_i are constant values, $T_{90} = t + 273.15$, R(0.01) is the sensor's triple point of water, and R(0.01) is named as Rtp in AM8010. The details can be found in ITS-90 standards.

The sensor's parameters a, b and c can be calculated based on the above data and formula.

5. Key in the a, b, c and Rtp into AM8010. After the parameters are saved, the system calibration is done.

More details about the coefficients and temperature calculations can be found in ITS-90 standards.

Turn off the power after calibration.

8 Sensor Connector Assembly and Pin Configuration

The sensor connector is a 5-pin round connector with retention relief. The assembly drawing is shown in the following figure.
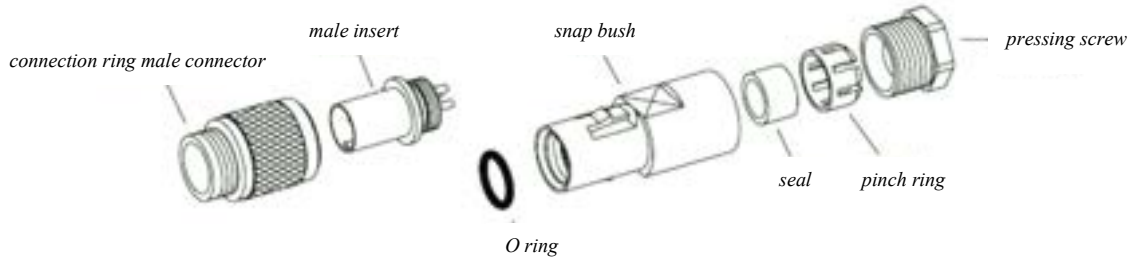

Figure 8-1: sensor connector assembly drawing.

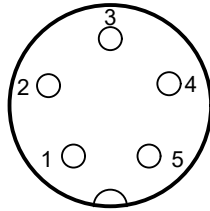The pin configuration of the connector is shown as in Figure 8-2.

Figure 8-2: Rear view of the 5-pin connector.

There are 5 pins on the connector. For a 4-wire platinum sensor, pin1 and pin2 should be one end of the sensor, and pin4 and pin5 should be the other end of the sensor. Pin3 can be optionally connected to a cable shield or left open. One example of pin configuration is shown in the following:

Table 8-1: pin configuration of 4-wire platinum sensor.

Pin Number	Wire color
1	Red
2	Black
3	Shield, or open
4	White
5	Green

After assembly with PRT sensors, the resistance between the red and black pair, or the white and green pair, should be < 2 ohm. The resistance between either black or red and either white or green should be around 110 ohm (for a 100 ohm PRT).

9 Limited Warranty & Limitation of Liability

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