SD card real time datalogger

3 Channels
PRESSURE DATA RECORDER
Model : MPS-384SD

Your purchase of this 3 CHANNELS PRESSURE MONITOR with SD CARD DATA RECORDER marks a step forward for you into the field of precision measurement. Although this DATALOGGER is a complex and delicate instrument, its durable structure will allow many years of use if proper operating techniques are developed. Please read the following instructions carefully and always keep this manual within easy reach.

OPERATION MANUAL

TABLE OF CONTENTS

1. FEATURES

* Monitor with real time data logger, save the measuring data along the time information (year, month, date, hour, minute, second) into the SD memory card and can be down load to the Excel, extra software is no need. user can make the further data or graphic analysis by themselves.
* Show 3 channels (CH 1, CH 2, CH 3) pressure value in the same LCD.
* Cooperate with the optional 2 wires pressure transmitter.
* SD card capacity : 1 GB to 16 GB.
* * Sampling adjustment : 5/10/30/60/120/300/600 seconds and auto function.
* Large LCD display, easy readout.
* Microcomputer circuit, high accuracy.
* Low power consumption and long battery life when use battery power.
* DC 1.5V (UM-4, AAA) battery x 6 PCs or DC 9V adapter in.
* RS232/USB computer interface.
* Full range, optional 2 wires pressure transmitter.
* Patented

2. SPECIFICATIONS

2-1 General Specifications

Circuit	Custom one-chip of microprocessor LSI circuit.
Display	LCD size : 60 mm x 50 mm
Measurement	Pressure
Memory Card	SD memory card. 1 GB to 16 GB.
Input Signal CH1, CH2, CH3	Linear, 4 to 20 mA
Accuracy	± (0.5% + 2 d) ** Meter only, 23 ± 5 ℃*

Datalogger Sampling Time	5/10/30/60/120/300/600 seconds or Auto. * *The " Auto " sampling . means when the measuring value is changed (> ± 10 digits) will save the data one time only.*
Data error no.	≦ 0.1 % no. of total saved data typically.
Advanced setting	* SD memory card Format * Set clock time (Year/Month/Date, Hour/Minute/ Second) * Set sampling time * Set beeper sound ON/OFF * Set SD card Decimal character * Set CH1 sensor type * Set CH2 sensor type * Set CH3 sensor type * Set pressure unit * Set RS232 data output ON/OFF
Update Time of Display	Approx. 1 second if measuring data is changed.
Data Output	RS 232/USB PC computer interface. * *Connect the optional RS232 cable UPCB-02 will get the RS232 plug.* * *Connect the optional USB cable USB-01 will get the USB plug.*
Operating Temperature	0 to 50 ℃.
Operating Humidity	Less than 85% R.H.

Power Supply ** Meter & probe*	* DC 9V adapter input. (AC/DC power adapter is included).
Power Supply ** Clock backup battery*	* Alkaline or heavy duty DC 1.5 V battery (UM4, AAA) x 6 PCs, or equivalent.
Weight	199 g/0.44 LB.
Dimension	132 x 80 x 32 mm (5.2 x 3.1 x 1.3 inch)
Accessories Included	* Instruction manual..... 1 PC * AC to DC 9V adapter.....1 PC * Hanging unit (with sticker).....1 PC
Optional Accessories	* SD Card (2 GB) * 2 wires pressure transmitter, TR-PS2W * USB cable, USB-01. * RS232 cable, UPCB-02. * Data Acquisition software, SW-U801-WIN. * Excel Data Acquisition software, SW-E802.

2-2 Electrical Specifications (23± 5 ℃)

Sensor type	**2 bar**		**5 bar**		**10 bar**	
	Max. range	Reso-lution	Max. range	Reso-lution	Max. range	Reso-lution
bar	2	0.002	5	0.005	10	0.01
PSI	29	0.02	72.5	0.1	145	0.2
Kg/cm^2	2.040	0.002	5.095	0.005	10.19	0.01
mm Hg	1500	2	3750	5	7500	10
inch Hg	59.05	0.05	147.6	0.1	295.2	0.2
meter H20	20.40	0.02	50.95	0.05	101.9	0.1
inch H20	802	1	2006	2	4010	5
ATP (Atmosphere)	1.974	0.002	4.935	0.002	9.87	0.01
kPa	200.0	0.2	500.0	0.5	1000	1

Sensor type	**20 bar**		**50 bar**		**100 bar**	
	Max. range	Reso-lution	Max. range	Reso-lution	Max. range	Reso-lution
bar	20	0.02	50	0.05	100	0.1
PSI	290	0.2	725	1	1450	2
Kg/cm^2	20.40	0.02	50.95	0.05	101.9	0.1
mm Hg	15000	20	37500	50	75000	100
inch Hg	590.5	0.5	1476	1	2952	2
meter H20	204.0	0.2	509.5	0.5	1019	1
inch H20	8020	10	20050	20	40100	50
ATP (Atmosphere)	19.74	0.02	49.35	0.05	98.7	0.1
kPa	2000	2	5000	5	10000	10

Sensor type	**200 bar**		**400 bar**			
	Max. range	Reso-lution	Max. range	Reso-lution		
bar	200	0.2	400	0.5		
PSI	2900	2	5800	5		
Kg/cm^2	204.0	0.2	408.0	0.5		
mm Hg	150000	200	300000	500		
inch Hg	5905	5	11810	10		
meter H20	2040	2	4075	5		
inch H20	80200	100	160600	200		
ATP (Atmosphere)	197.4	0.2	394.5	0.5		
kPa	20000	20	40000	50		

Remark :

Sensor type select to " 200 bar and the unit is " mm Hg "
or
Sensor type select to " 400 bar and the unit is " mm Hg " or " inch H20 ",
if the LCD reading value flashing along the mark " x 100 ", it means the real measurement value should multiply 100.

3. FRONT PANEL DESCRIPTION

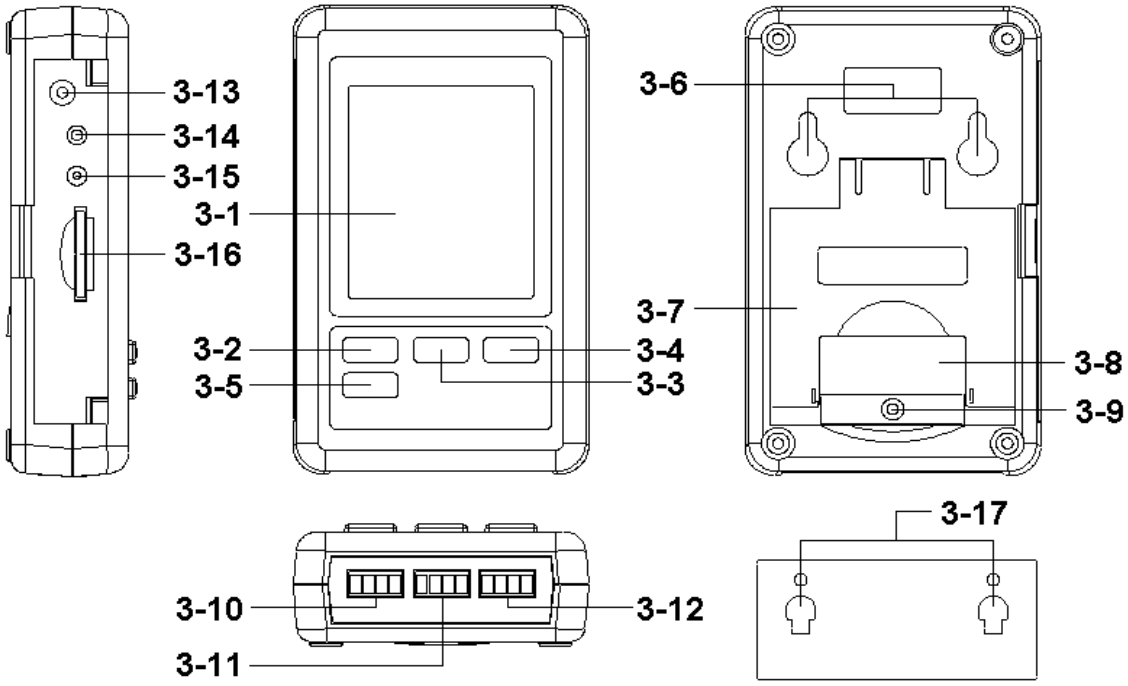


Fig. 1

3-1 Display
3-2 Logger button (Enter button)
3-3 ▲ Button (Time Button)
3-4 ▼ Button (Back Light Button)
3-5 SET Button
3-6 Hanging holes
3-7 Stand
3-8 Battery cover/Battery compartment
3-9 Screw of the battery cover
3-10 Pressure transmitter input socket /CH 1
3-11 Pressure transmitter input socket /CH 2
3-12 Pressure transmitter input socket /CH 3
3-13 DC 9V power adapter input socket
3-14 Reset Button
3-15 RS-232 Output Terminal
3-16 SD card socket
3-17 Hanging unit (with sticker)

4. MEASURING PROCEDURE

1) Power supply installation :

* The meter's power supply should install the batteries and connect " AC to DC adapter " together.
* The batteries are the power of " Clock ", if meter install the batteries only and not connect the " AC to DC adapter ", then the Display will show the " Clock " value only and it can not show other function.

Batteries

Install the batteries into the battery compartment :

* Loose the " Screw of the battery cover " (3-9, Fig. 1) and take away the " Battery Cover " (3-8, Fig. 1) from the meter.
* Replace with DC 1.5 V battery (UM4/AAA, Alkaline/Heavy duty type) x 6 PCs, and reinstate the cover.
* Make sure the battery cover is secured after changing the battery.

AC to DC adapter

* The " AC to DC adapter " is the standard accessory.
* Plug the output plug of " AC to DC adapter " into the " DC 9V power adapter input socket " (3-13, Fig. 1)

2) Connect the optional 2 wires 4-20 mA pressure transmitter, TR-PS2W (or other similar item) to " Pressure transmitter input socket /CH 1 " (3-10, Fig. 1)

* *Input terminal (MPS-384SD) " S+ " connect to output terminal (TR-PS2W) " Sig + "*
* *Input terminal (MPS-384SD) " S- " connect to output terminal (TR-PS2W) " Sig - "*

* **When connect the signal wires to the meter, please make the attention of the wire's polarity (+, -).**
* **If you have other Pressure transmitters, then connect to " Pressure transmitter input socket/CH 2 " (3-11, Fig. 1) and " Pressure transmitter input socket/CH 3 " (3-12, Fig. 1).**

Remark :
* *The up Display value will present the CH1 pressure value.*
* *The middle Display value will present the CH2 pressure value.*
* *The low Display value will present the CH3 pressure value.*

5. DATALOGGER

5-1 Preparation before execute datalogger function

a. Insert the SD card
Prepare a " SD memory card " (1 GB to 16 GB, optional), insert the SD card into the " SD card socket " (3-16, Fig. 1) with the correct direction exactly.

**** It recommend use memory card's capacity is ≦ 4 GB.***

b. SD card Format
If SD card just the first time use into the meter, it recommend to make the " SD card Format " at first, please refer chapter 7-1 (page 13).

**** It recommend strongly, do not use memory cards that have been formatted by other meter or by other installation (such as camera...). Reformat the memory card with your meter.***
**** If the SD memory card exist the trouble during format by the meter, use the Computer to reformat again can fix the problem.***

c. Time setting

If the meter is used at first time, it should to adjust the clock time exactly, please refer chapter 7-2 (page 13).

d. Decimal format setting

The numerical data structure of SD card is default used the " . " as the decimal, for example "20.6" "1000.53" . But in certain countries (Europe ...) is used the " , " as the decimal point, for example " 20, 6 " , "1000,53". Under such situation, it should change the Decimal character at first, details of setting the Decimal point, refer to Chapter 7-5, page 15

e. 3 Information of LCD display

* If the Display show :

Ch-CArd

It means that the SD card exist the problem or the SD card memory is full, it should change SD memory card.

* If the Display show :

LobAt

It means that the battery is low voltage.

* If the Display show :

no CArd

It means that the SD card is not plugged into the meter.

5-2 Datalogger

a. Start the datalogger

Press the " Logger button (3-2, Fig. 1) > 2 seconds continuously, until the Display show the indicator " DATALOGGER ", release the " Logger Button " (3-2, Fig. 1), then the measuring data along the time information will be saved into the memory circuit.

Remark :

- ** How to set the sampling time, refer to Chapter 7-3, page 14.*
- ** How to set the beeper sound is enable, refer to Chapter 7-4, page 14.*

b. Finish the Datalogger

During execute the Datalogger function (Display show the " Datalogger " indicator), press the " Logger button " (3-2, Fig. 1) > 2 seconds continuously, until the Display indicator " DATALOGGER " is disappeared, release the " Logger Button " will finish the Datalogger function.

Before take away the SD card from the meter, it should execute the procedures of " Finish the Datalogger ",
(It should wait for the Display counter to count down to zero value.)
otherwise some existing recent save data may loss.

5-3 Check time information

Press " Time button " (3-3, Fig. 1) > 2 seconds continuously, the LCD display will present the time information of Year/Month/Date, Hour/Minute/Second and the sampling value.

5-4 SD Card Data structure

1) When the first time, the SD card is used into the meter, the SD card will generate a folder :

   PSB01

2) If the first time to execute the Datalogger, under the route PSB01\, will generate a new file name PSB01001.XLS.
   After exist the Datalogger, then execute again, the data will save to the PSB01001.XLS until Data column reach to 30,000 columns, then will generate a new file, for example PSB01002.XLS

3) Under the folder PSB01\, if the total files more than 99 files, will generate anew route, such as PSB02\ .....

4) The file's route structure :

```
PSB01\
   PSB01001.XLS
   PSB01002.XLS
   .....
   PSB01099.XLS
PSB02\
   PSB02001.XLS
   PSB02002.XLS
   .....
   PSB02099.XLS
PSBXX\
   .....
```

Remark :
XX : Max. value is 10.

6. Saving data from the SD card to the computer (EXCEL software)

1) After execute the Data Logger function, take away the SD card out from the " SD card socket " (3-16, Fig. 1).
2) Plug in the SD card into the Computer's SD card slot (if your computer build in this installation) or insert the SD card into the " SD card adapter ". then connect the " SD card adapter " into the computer.
3) Power ON the computer and run the " EXCEL software ". Down load the saving data file (for example the file name : PSB01001.XLS, PSB01002.XLS) from the SD card to the computer. The saving data will present into the EXCEL software screen (for example as following EXCEL data screens) , then user can use those EXCEL data to make the further Data or Graphic analysis usefully.

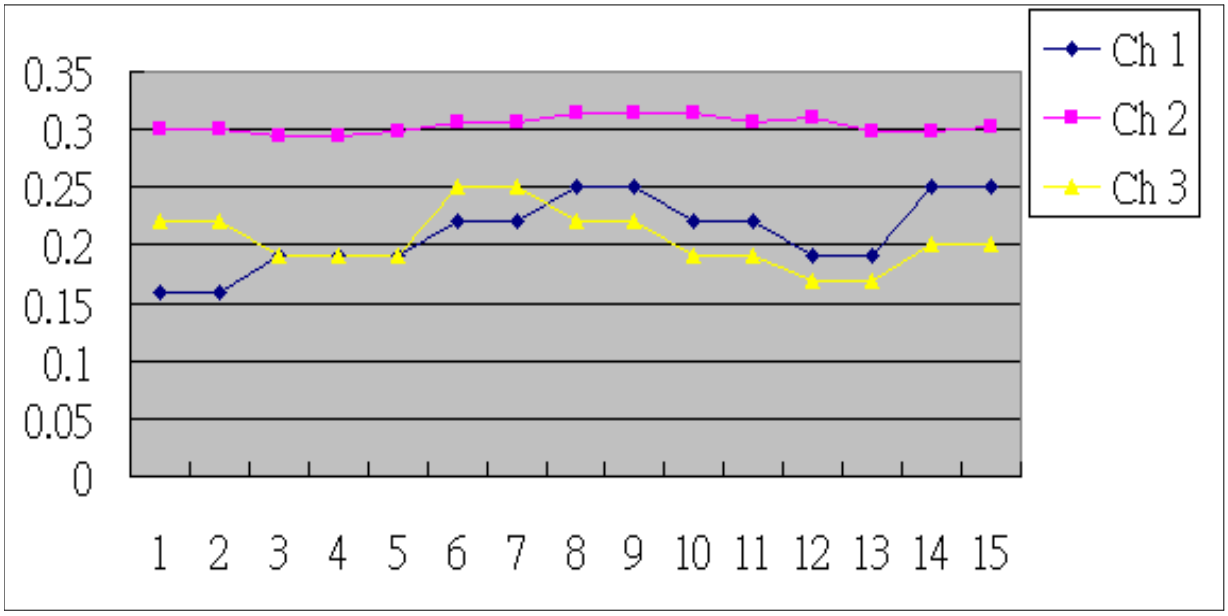
EXCEL data screen (for example)

Microsoft Excel - PSB01001

M7 =

	A	B	C	D	E	F	G	H	I
1	Position	Date	Time	Ch1_Value	Ch1_Unit	Ch2_Value	Ch2_unit	Ch3_Value	Ch3_unit
2	1	2011/11/22	10:28:14	0.16	Bar	0.3	Bar	0.22	Bar
3	2	2011/11/22	10:28:25	0.16	Bar	0.3	Bar	0.22	Bar
4	3	2011/11/22	10:28:35	0.19	Bar	0.294	Bar	0.19	Bar
5	4	2011/11/22	10:28:45	0.19	Bar	0.294	Bar	0.19	Bar
6	5	2011/11/22	10:28:55	0.19	Bar	0.298	Bar	0.19	Bar
7	6	2011/11/22	10:29:05	0.22	Bar	0.306	Bar	0.25	Bar
8	7	2011/11/22	10:29:15	0.22	Bar	0.306	Bar	0.25	Bar
9	8	2011/11/22	10:29:25	0.25	Bar	0.314	Bar	0.22	Bar
10	9	2011/11/22	10:29:35	0.25	Bar	0.314	Bar	0.22	Bar
11	10	2011/11/22	10:29:45	0.22	Bar	0.314	Bar	0.19	Bar
12	11	2011/11/22	10:29:55	0.22	Bar	0.306	Bar	0.19	Bar
13	12	2011/11/22	10:30:05	0.19	Bar	0.31	Bar	0.17	Bar
14	13	2011/11/22	10:30:15	0.19	Bar	0.298	Bar	0.17	Bar
15	14	2011/11/22	10:30:25	0.25	Bar	0.298	Bar	0.2	Bar
16	15	2011/11/22	10:30:35	0.25	Bar	0.302	Bar	0.2	Bar

EXCEL graphic screen (for example)



7. ADVANCED SETTING

Under do not execute the Datalogger function, press the " SET button " (3-5, Fig. 1) > 2 seconds continuously will enter the " Setting " mode., then release the " SET button ". Following press the " SET button " (3-5, Fig. 1) once a while in sequence to select the seven main function, the display will show :

Sd F..... SD memory card Format
dAtE..... Set clock time (Year/Month/Date, Hour/Minute/ Second)
SP-t..... Set sampling time
bEEP..... Set beeper sound ON/OFF
dEC..... Set SD card Decimal character
rS232... Set RS232 data output ON/OFF
tyPE CH1..... Set CH 1 pressure sensor type
tyPE CH2..... Set CH 2 pressure sensor type
tyPE CH3..... Set CH 2 pressure sensor type
unit..... Set Pressure unit.

Remark :
During execute the " Setting " function, if within 5 seconds , do not press any buttons further, the LCD Display will return to normal screen.

7-1 SD memory card Format

When the Display show " Sd F "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper value to " yES " or " no ".

   yES - Intend to format the SD memory card
   no - Not execute the SD memory card format

2) If select the upper to " yES ", press the " Enter Button " (3-2, Fig. 1) once again, the Display will show text " yES Enter " to confirm again, if make sure to do the SD memory card format, then press " Enter Button " once will format the SD memory clear all the existing data that already saving into the SD card.

7-2 Set clock time (Year/Month/Date, Hour/Minute/ Second)

When the Display show " dAtE "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to adjust the value (Setting start from Year value). After the desired value is set, press the " Enter button " (3-2, Fig. 1) once will going to next value adjustment (for example, first setting value is Year then next to adjust Month, Date, Hour, Minute, Second value).

Remark :
The adjusted unit will be flashed.

2) After set all the time value (Year, Month, Date, Hour, Minute, Second), press the " SET button " (3-5, Fig. 1) once will save the time value, then the screen will jump to Sampling time " setting screen (Chapter 7-3).

Remark :
After the time value is setting, the internal clock will run precisely even Power off if the battery is under normal condition (No low battery power).

7-3 Set sampling time

When the Display show " SP-t "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to adjust the sampling value :

5 seconds, 10 seconds, 30 seconds, 60 seconds, 120 seconds, 300 seconds, 600 seconds, Auto.

After the desired value is set, press the " Enter Button " (3-2, Fig. 1) to save the adjusting value with default.

Remark :
The " Auto " sampling time means when the measuring value is changed (> ± 10 digits) will save the data to the memory circuit one time.

7-4 Set beeper sound ON/OFF

When the Display show " bEEP "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the data to " yES " or " no ".

yES - Meter's beep sound will be ON with default.
no - Meter's beep sound will be OFF with default.

2) After select the upper text to " yES " or " no ", press the " Enter Button " (3-2, Fig. 1) will save the setting function with default.

7-5 Decimal point of SD card setting

When the Display show " dEC "

The numerical data structure of SD card is used the " . " as the decimal with default, for example "20.6" "1000.53" . But in certain countries (Europe ...) is used the " , " as the decimal point, for example " 20,6 " "1000,53". Under such situation, it should change the Decimal character at first.

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper text to " USA " or " Euro ".

USA - Use " . " as the Decimal point with default.
Euro - Use " , " as the Decimal point with default.

2) After select the text to " USA " or " Euro ", press the " Enter Button " (3-2, Fig. 1) will save the setting function with default.

7-6 Set RS232 data output ON/OFF

When the Display show " rS232 "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper Display text to "yES " or " no ".

   yES - RS-232 output terminal (3-15, Fig. 1) will send the RS232 signal output.
   no - RS-232 output terminal (3-15, Fig. 1) will not send the RS232 signal output.

2) After Display text is selected to " yES " or " no ", press the " Enter Button " (3-2, Fig. 1) will save the setting function with default.

7-7 Set CH 1 pressure sensor type

When the Display show " tyPE Ch-1 "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper Display text to " 2, 5, 10. 20. 50. 100, 200, 400 " bar for selecting pressure sensor type of channel 1.
2) After the desired value (pressure sensor type) of channel 1 is selected, press the " Enter Button " (3-2, Fig. 1) will save the setting value with default.

7-8 Set CH 2 pressure sensor type

When the Display show " tyPE Ch-2 "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper Display text to " 2, 5, 10. 20. 50. 100, 200, 400 " bar for selecting pressure sensor type of channel 2.
2) After the desired value (pressure sensor type) of channel 2 is selected, press the " Enter Button " (3-2, Fig. 1) will save the setting value with default.

7-9 Set CH 3 pressure sensor type

When the Display show " tyPE Ch-3 "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the upper Display text to " 2, 5, 10. 20. 50. 100, 200, 400 " bar for selecting pressure sensor type of channel 3.
2) After the desired value (pressure sensor type) of channel 3 is selected, press the " Enter Button " (3-2, Fig. 1) will save the setting value with default.

7-10 Set Pressure unit

When the Display show " unit "

1) Use the " ▲ Button " (3-3, Fig. 1) or " ▼ Button " (3-4, Fig. 1) to select the Display unit to

   bar, PSI, Kg/cm^2 , mmHg, inHg,
   meterH_2O, inH_2O, ATP (Atmosphere), KPa

   for selecting pressure unit of both channel 1, channel 2, channel 3.

2) After the desired value pressure unit is selected, press the " Enter Button " (3-2, Fig. 1) will save the setting value with default.

8. POWER SUPPLY from DC ADAPTER

The meter also can supply the power supply from the DC 9V Power Adapter. Insert the plug of Power Adapter into " DC 9V Power Adapter Input Socket " (3-13, Fig. 1).

9. BATTERY REPLACEMENT

1) When the left corner of LCD display show "  ", it is necessary to replace the battery. However, in-spec. measurement may still be made for several hours after low battery indicator appears before the instrument become inaccurate.
2) Loose the " Screw of the battery cover " (3-9, Fig. 1) and take away the " Battery Cover " (3-8, Fig. 1) from the instrument and remove the battery.
3) Replace with DC 1.5 V battery (UM4/AAA, Alkaline/heavy duty) x 6 PCs, and reinstate the cover.
4) Make sure the battery cover is secured after changing the battery.

10. SYSTEM RESET

If the meter happen the troubles such as :

CPU system is hold (for example, the key button can not be operated...).

Then make the system RESET will fix the problem.
The system RESET procedures will be either following method :

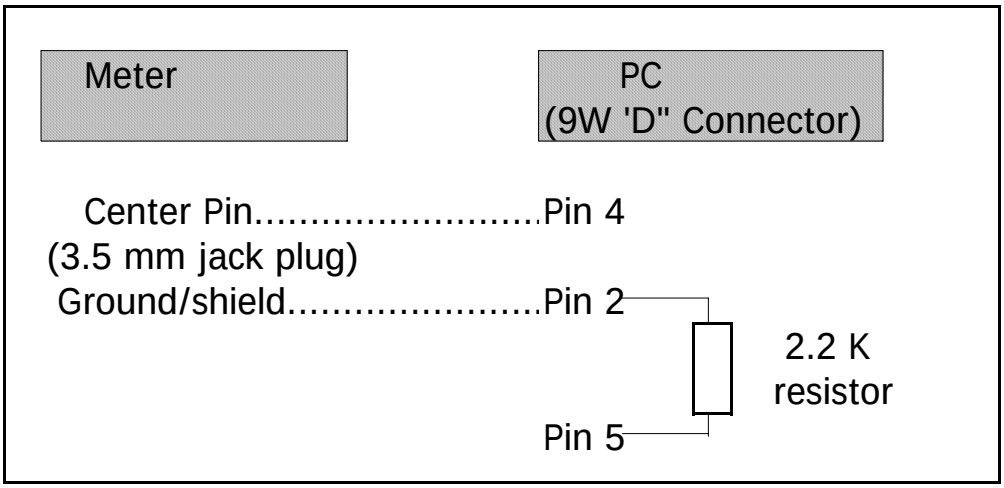
During the power on, use a pin to press the " Reset Button " (3-14, Fig. 1) once a while will reset the circuit system.

11. RS232 PC SERIAL INTERFACE

The instrument has RS232 PC serial interface via a 3.5 mm terminal (3-15, Fig. 1) if the RS232 function already select to " ON ", refer to chapter 7-6, page 16.

The data output is a 16 digit stream which can be utilized for user's specific application.

A RS232 lead with the following connection will be required to link the instrument with the PC serial port.



The 16 digits data stream will be displayed in the following format :

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Each digit indicates the following status :

D0	End Word		
D1 & D8	Display reading, D1 = LSD, D8 = MSD For example : If the display reading is 1234, then D8 to D1 is : 00001234		
D9	Decimal Point(DP), position from right to the left 0 = No DP, 1= 1 DP, 2 = 2 DP, 3 = 3 DP		
D10	Polarity 0 = Positive 1 = Negative		
D11 & D12	Annunciator for Display		
	Bar = 22	mm Hg = 78	inch H2O = 25
	Psi = 23	inch Hg = 80	ATP = 26
	Kg/cm^2 = 77	meter H20 = 79	kPA = 88
D13	When send the up display data = 1 When send the middle display data = 2 When send the low display data = 3		
D14	4		
D15	Start Word		

RS232 FORMAT : 9600, N, 8, 1

Baud rate	9600
Parity	No parity
Data bit no.	8 Data bits
Stop bit	1 Stop bit

12. Optional 2 wires pressure transmitter

SPECIFICATIONS		
Measuring range Model	*Measuring Range*	*Model*
	2 BAR (29 PSI)	TR-PS2W-2BAR
	5 BAR (72.5 PSI)	TR-PS2W-5BAR
	10 BAR (145 PSI)	TR-PS2W-10BAR
	20 BAR (290 PSI)	TR-PS2W-20BAR
	50 BAR (725 PSI)	TR-PS2W-50BAR
	100 BAR (1450 PSI)	TR-PS2W-100BAR
	200 BAR (2900 PSI)	TR-PS2W-200BAR
	400 BAR (5800 PSI)	TR-PS2W-400BAR
Output	4 - 20 mA 4 mA = 0 BAR 20 mA = Full scale pressure	
Supply voltage	DC 9V to 30 V ** Protected against reverse polarity*	
Wire numbers	2 wires, both for signal and power supply.	
Port connector	1/4" NPT or PS 1/4", 19 teeth per inch. ** Included one adapter connector that convert the 1/4" NPT to 1/4 " PS.*	
Span and Zero adjustment	Span and Zero can be adjustment by multi turns VR.	
Accuracy	± 1.5 % full scale (transducer only).	
Span	± 1 % F.S. ** Within 10 ℃ to 40 ℃.*	
Zero	± 2 % F.S. ** Within 10 ℃ to 40 ℃.*	
Load impedance requirement	Load up to 500 ohms.	
Operating Temperature	-20 ℃ to 80 ℃ (-4 ℉ to 176 ℉).	
Operating Humidity	Less than 80% RH.	

Size	34 mm dia. x 134 mm (1.3 inch dia. x 5.3 inch)
Weight	220 g.
Output connector	Socket
Wire Connection	*2 wires :* Connection 1 : Power + and signal Connection 2 : Power -
Application	** Measure Pneumatic Pressures.* ** Measure Automobile Engine Vacuum Pressures.* ** Pressure for Super Heat Measurements* ** Hydraulic Servo controls* ** Refrigeration* ** Air conditioning* ** Food Processing*

13. PATENT

The meter (SD card structure) already get patent or patent pending in following countries :

Germany	Nr. 20 2008 016 337.4
JAPAN	3151214
CHINA	ZL 2008 2 0189918.5 ZL 2008 2 0189917.0
USA	Patent pending