



# Introduction

Thank you very much for purchasing Sanwa Model PC20TK Digital Multimeter Kit.

The PC20TK is a digital multimeter kit that we have developed for educational use through a wealth of our experiences and achievements.

Although primarily designed as a kit, this product provides eight modes including voltage and current, as well as high durability, allowing you to use it for a broad range of purposes.

In order to ensure its best performance as a finished product, you need to learn the procedures for properly assembling, adjusting and handling the PC20TK and making measurements.

Please thoroughly read this manual and make the best use of the PC20TK.

The instruction manual should be carefully kept along with the PC20TK.

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# [1] Warnings for Safe Use of Multimeter

**(Be sure to read this section before using the multimeter.)**


The instructions given in the text under  Warning and  Caution must be observed to prevent burns, electric shocks and other similar accidents.


## 1-1 Explanation of symbols

The symbols and their meanings used on the PC20TK and the instruction manual are shown below:


 : Indicates information that is particularly important for safe use.

- A warning message is given to prevent burns, electric shock and other accidents resulting in injury or death.
- A cautionary message is given relating to any possibility of damaging this product.

 : Indicates that this part is potentially dangerous because it may be charged with high voltage.

 : Double insulation or reinforced insulation


 : Fuse

 : Buzzer

+ : Positive

 : Ground

 : AC

 : Diode

- : Negative

$\Omega$  : Resistance

 : DC

 : Capacitor

## 1-2 Warning messages

### **Warning**

The following warning messages are given to prevent accidents resulting in injury or death owing to burns, electric shock or other. Be sure to observe these instructions along with the ones included in this instruction manual.

1. Do not use the PC20TK with any power line exceeding 6 kVA.
2. Be careful about voltage of 33 VAC rms (46.7 Vpeak) or 70 VDC minimum because it is dangerous to the human body.
3. Do not input any signal exceeding the maximum rated input value.
4. Do not try to measure a line (e.g., to a motor) where induced voltage or surge voltage may occur, because the maximum overload input value might be exceeded.
5. Do not use the PC20TK if its main body or test lead is damaged or broken.
6. Do not use the PC20TK with its case removed.
7. Do not use any substitute for a fuse or connect wire for non-electrical use.
8. During measurement, do not hold any portion of the test pin beyond the test lead.
9. Do not input voltage to the current measurement connector. Inputting voltage to that connector will result in a short-circuit, blowing out the built-in fuse. However, this may involve a danger.
10. Do not change over to any other mode during measurement.
11. Ensure that you have selected the proper range and mode for each measurement run.
12. Use the specified type (TL-21) of test lead.
13. Do not try to make a measurement with the PC20TK or your hand being wet.
14. Use the PC20TK indoors.
15. Check the appearance and the display of each mode (range) at least once a year.

### **Caution**

The PC20TK is not provided with an automatic power-off capability. Be sure to turn OFF the Function switch after measurement has been finished, because the batteries will otherwise run out earlier.

### **Note**

Prior to the assembling of the PC20TK, check the parts in accordance with paragraph (2) in "4-5 Preparations for assembling."

## [2] Using the PC20TK

### 2-1 Intended uses and features

1. The PC20TK is a kit for a general-purpose digital multimeter (DMM), which has been designed for educational uses. Once assembled, it may be used as a normal small-capacity DMM for low-voltage measurements.
2. The PC20TK features the auto mode that automatically selects an appropriate measurement range in accordance with the measured value. It may also be used in the manual mode (measurement range fixed or manually selectable) that allows for faster measurements.
3. The PC20TK allows the user to measure electric capacitance of a capacitor, which is often used with a resistor as a circuit component.
4. The current measurement connector is provided with a safety cover that prevents the user from inserting a test lead into it by mistake.
5. If you connect the PC20TK to your PC by using the optionally available PC link (software) and PC link cable, changes in electric quantity can be displayed as values or graphs on the PC monitor.

### 2-2 Names of various parts

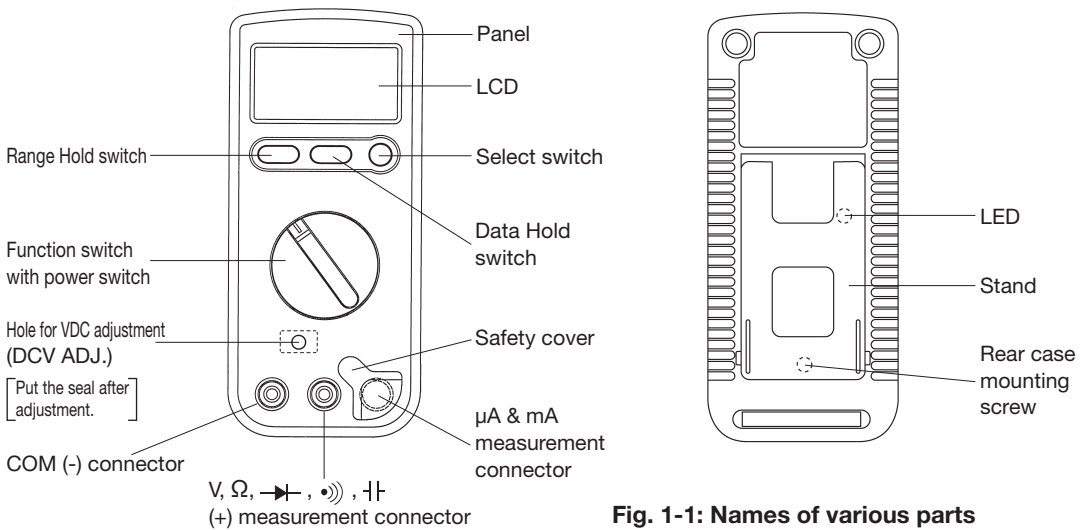


Fig. 1-1: Names of various parts

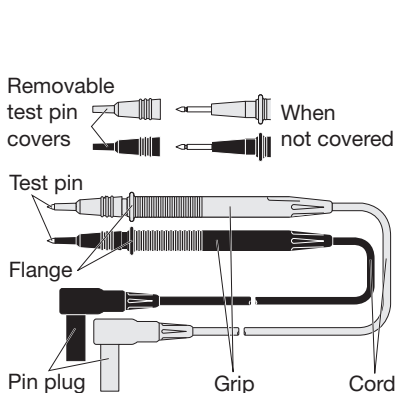


Fig. 1-2: Test leads (TL-21)

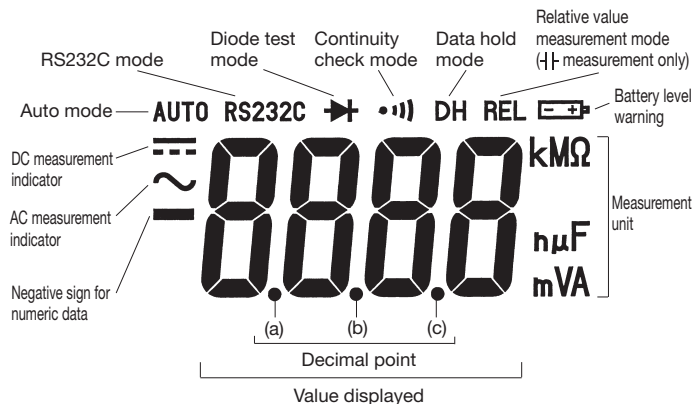






Fig. 1-3: Readout


Operating system	$\Delta \Sigma$ system
Readout	4,000 counts (with unit and symbol)
Mode selection	Auto or manual; only the auto mode is available for electric capacitance.
Overflow value	The O.L. mark appears (except in the 750 V range for both DC and AC)
Polarity	The "-" mark appears only for negative input.
Battery level	When the built-in batteries runs out, the  mark appears to warn the user.
Sampling rate	3 times per second
Power supply	2 pieces of size AA manganese dry cells (1.5 V each)
Power consumption and battery life	About 7 mW in a DC range; about 150 hours of continuous operation with manganese dry cells.
Built-in fuse	1 piece of 0.5 A/250 V fuse (glass tube: 6.3 mm dia. x 30 mm)
Operating temperature and humidity range	0 °C to 40 °C; 80 % RH maximum without condensation
Storage temperature and humidity range	-10 °C to 50 °C; 70 % RH maximum without condensation
Dimensions and mass	158 (h) x 70 (W) x 41 (D) mm; approx. 230 grams
Accessories	TL-21 test leads (1 set) and instruction manual (1 volume)
Accessories sold separately	See paragraph 8-4.

## 2. Measurement range and accuracy

(accuracy-warranted temperature and humidity ranges: 23 °C  $\pm$  5 °C; 80 % maximum without condensation)

Mode	Range	Input resistance, etc.	Accuracy	Maximum overload protection input
DC voltage	400.0 mV	100 M $\Omega$ min.	$\pm(1.0 \%rdg+2dgt)$	1000 VDC 750 VAC or peak max 1000 V
	4.000 V	About 11 M $\Omega$		
	40.00 V	About 10 M $\Omega$		
	400.0 V			
	750 V			
AC voltage	4.000 V	About 11 M $\Omega$	$\pm(1.5 \%rdg+9dgt)$	
	40.00 V	About 10 M $\Omega$	$\pm(1.5 \%rdg+5dgt)$ Sinusoidal AC 40 to 400 Hz	
	400.0 V			
	750 V			
DC current	400.0 $\mu$ A	About 100 $\Omega$		
	4000 $\mu$ A	About 1 $\Omega$ (Except for fuse resistance)		
	40.00 mA			
	400.0 mA			
AC current	400.0 $\mu$ A	About 100 $\Omega$	$\pm(2.0 \%rdg+5dgt)$ Sinusoidal AC 40 to 400 Hz	
	4000 $\mu$ A	About 1 $\Omega$ (Except for fuse resistance)		
	40.00 mA			
	400.0 mA			
Resistance $\Omega$	400.0 $\Omega$	Open-circuit voltage: About 0.4 V	$\pm(1.5 \%rdg+5dgt)$	500 VDC or VAC or peak max 700 V
	4.000 k $\Omega$		$\pm(1.8 \%rdg+2dgt)$	
	40.00 k $\Omega$			
	400.0 k $\Omega$			
	4.000 M $\Omega$		$\pm(3.0 \%rdg+2dgt)$	
40.00 M $\Omega$				
Continuity check 		Open-circuit voltage: About 0.4 V	Sounds below the range of 10-120 $\Omega$ .	
Diode test 		Open-circuit voltage: About 1.5 V		
Electric capacitance $\text{—}  \text{—}$	40.00 nF	(Auto-range operation only)	$\pm(8 \%rdg+10dgt)$	
	400.0 nF			
	4.000 $\mu$ F		$\pm(7 \%rdg+6dgt)$	
	40.00 $\mu$ F			
100.0 $\mu$ F				
(Temperature $^{\circ}$ C)	-50~300 °C	(A separately sold probe is used.)	$\pm 1.5 \%rdg \pm 4.8$ °C	

 The input time of the maximum allowable load shall be within 1 minute. Adding the load exceeding this time limit may result in burning internal components.

 About a battery at the time of the shipment. There is a case that the battery does not reach mentioned battery life, because a battery for monitors is incorporated at the time of factory shipment.

\* A battery for monitors is a battery to check a function and the performance of the product.

## 2-4 Explanation of functions

### 1. Overflow (O.L.) value

- The O.L. mark appears on the readout when the input value exceeds 4,000 counts in each measurement range with the manual mode selected. It does not appear in the 750 VDC or VAC range.
- The O.L. mark appears when the maximum measurement range exceeds 4,000 counts with the auto mode selected. You need to note that the O.L. mark does not appear in the voltage mode.
- When the measurement connector is released, the O.L. mark appears in the  $\Omega$ ,  $\rightarrow\text{H}$ , or  $\bullet\text{))}$  mode.

### 2. Sounding of buzzer

- The buzzer sounds momentarily when the Range Hold, Data Hold, or Select switch is pressed.
- In the  $\bullet\text{))}$  mode, the buzzer sounds when a resistance value is below 10-120  $\Omega$  (which varies individually).

### 3. Counts

- Regardless of the position of the decimal point, the value on the readout is represented by "counts." (2dgt and 5dgt as shown in the column on the previous page are equivalent to 2 counts and 5 counts, respectively.)

### 4. Accuracy

- Accuracy as used in "2-3 Specification" is represented by the sum of certain percentage of  $\pm$  rdg (reading) against the value shown on the PC20TK (measured value) plus certain  $\pm$  counts dgt (digits).

- [Calculation example]

Now let us check the accuracy assuming that the reading was 106.6 V when certain standard voltage (true value) was measured in the 400 VAC range of the PC20TK.

The accuracy of the 400 VAC range of the PC20TK is  $\pm (1.5 \% \text{rdg} + 5 \text{dgt})$ .

1dgt in the 400 V range is equivalent to 0.1 V. Hence,

$$(\pm 1.5 \% \times 106.6 \text{ V}) + (\pm 0.1 \text{ V} \times 5) = (\pm 1.6 \text{ V}) + (\pm 0.5 \text{ V}) = \pm 2.1 \text{ V}$$

The true value therefore exists in the range of  $106.6 \text{ V} \pm 2.1 \text{ V} = 104.5$  to  $108.7 \text{ V}$  (provided that it falls within the accuracy-warranted temperature and humidity ranges and that for AC, it is of sinusoidal AC within the range of 40 to 400 Hz). If the true value does not fall within these ranges, the reading on the PC20TK deviates from the standard.

### 5. Sampling rate

This is the number of times when an input analog signal is converted into a digital one per second by the analog-digital converter.

### 6. Low power ohm

Silicone transistors and diodes are generally brought into complete conduction at voltage of about 0.7 V. Measurements using voltage that does not cause such conduction (0.4 V maximum in general) are called low power ohm measurements. Low power ohm measurements allow you to perform resistance measurements and conductivity checks in the circuit network with the minimal effects of transistors and diodes.

### 7. Data holding capability (DH: Data Hold)

Pressing the Data Hold switch during measurement locks the reading on the readout regardless of changes in input signal (the DH mark appears on the readout).

### 8. Range hold capability (Range Hold)

- Auto mode

The suitable range for the current input signal is automatically selected (the AUTO mark appears on the readout).

- Manual mode

In this mode, the user should press the Range Hold switch to select the suitable range by predicting the magnitude of input signal. The measurement range will be locked (held) and the AUTO mark will disappear. In this state, pressing the Range Hold switch toggles between ranges. If this switch is held down exceeding 1 second, the manual mode is canceled and the auto mode becomes active.

## 9. Select switch

Pressing this switch toggles the functional modes in the following order:

Functional mode	Toggleing order
V  / $\sim$	→ $\sim$ →  → $\sim$
$\Omega$ /  /	$\Omega$ →  →  → $\Omega$
	(Without symbol) → REL → (Without symbol) → REL
400 / 4000 $\mu$ A  / $\sim$	→ $\sim$ →  → $\sim$
40 / 400 mA  / $\sim$	

⚠ Immediately after the Function switch has been changed, the leftmost functional mode in the right column of the above table is selected in the auto mode.

⚠ **The PC20TK provides no automatic power-off capability. After finishing measurement, be sure to turn OFF the Function switch.**

## 2-5 Preparations for measurement

### Connecting the test leads

Connect the black plug of the test lead to the COM (-) connector. Change the connection of the red plug in accordance with the functional mode to be used, as follows:

To measure current, fully connect the red plug into the  $\mu$ A & mA measurement connector. To make measurements for voltage, resistance, a diode check, and others, fully connect the plug into the V,  $\Omega$ , , , and (+) measurement connector, respectively.

## 2-6 Measuring procedure

When the Function switch is set to a desired functional mode, the power switch is turned ON and the reading and others are displayed on the readout.

Immediately after the switch has been changed, any selected functional mode becomes active in the auto mode (with the AUTO mark displayed on the upper left part of the readout). "RS232C" is also displayed for any functional mode. This indicates that the measured values are output as digital signals through the LED located on the rear of the PC20TK (see 9 on page 10).

The following explanation is made assuming that the auto mode is active:

⚠ When the mark appears on the upper right part of the readout, the built-in batteries have run out. Replace the batteries.

⚠ Be sure to turn OFF the Function switch after finishing measurement. The batteries would otherwise be consumed.

### 1. Measuring DC voltage - DCV (V ) (see Fig. 2-1)

This functional mode is used to measure the voltage of a battery, that in a DC circuit of a device, or other voltage.

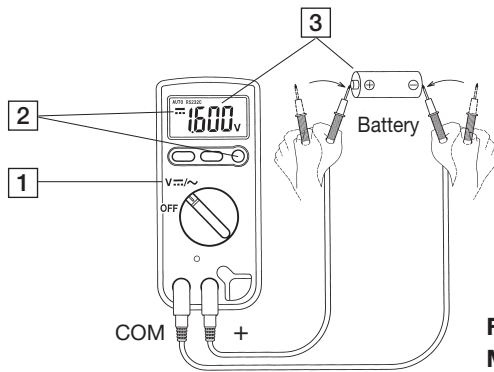
⚠ **Warning:** Be sure to measure voltage in parallel with the object under measurement (e.g., power source).

⚠ **Warning:** The O.L. mark does not appear even if overvoltage of 750 V or more is applied to the input connector.

⚠ If voltage with reversed polarities is applied to the measurement connectors, the negative (-) signal is displayed with the reading.

⚠ In the auto mode, the reading fluctuates when the test leads are released, but this is not a malfunction.

- (1) Set the Function switch to V /  $\sim$ .
- (2) Press the Select switch to display on the upper left part of the readout.
- (3) Make the test pins contact with the object under measurement and then read the value displayed.



**Fig. 2-1:**  
**Measuring DC voltage (DCV)**

## 2. Measuring AC voltage - ACV (V ~ ) (see Fig. 2-2)

This functional mode is used to measure the voltage of a lamp line, the tap voltage of a small transformer, and other sinusoidal AC voltage.

⚠ **Warning:** Be sure to measure voltage in parallel with the object under measurement (e.g., power source).

⚠ **Warning:** The O.L. mark does not appear even if overvoltage of 750 V or more is applied to the input connector.

⚠ A measurement error occurs if non-sinusoidal voltage is measured, because the PC20TK operates with the mean value.

⚠ The accuracy is warranted in the frequency range of 40-400 Hz.

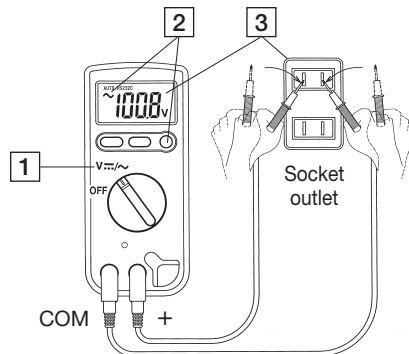
⚠ At input of 0 V, a number equivalent to about 3 counts remains in the 4 VAC range, but this is not a malfunction.

⚠ In the manual mode, the 400 mV range may be selected, but the accuracy is not warranted.

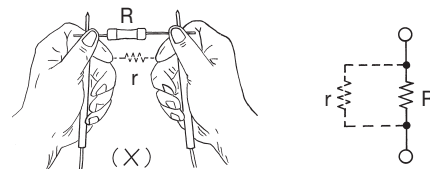
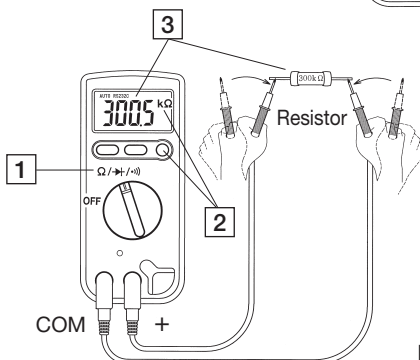
(1) Set the Function switch to V  $\sim$  /  $\sim$ .

(2) Press the Select switch to display  $\sim$  on the upper left part of the readout.

(3) Make the test pins contact with the object under measurement and then read the value displayed.



**Fig. 2-2:**  
**Measuring AC voltage (ACV)**



If you make a measurement while touching the test leads with your fingers, the resistance of your body is placed in parallel with the object under measurement (e.g., a resistor), resulting in a measurement error.

**Fig. 2-3: Measuring resistance ( $\Omega$ )**



### 3. Measuring resistance ( $\Omega$ ) (see Fig. 2-3)

This functional mode is used to measure the resistance of a resistor, a circuit or a circuit component.

- ⚠ **Warning:** Measuring any live part is not possible and such an attempt is dangerous.
- ⚠ An error will result if you make a measurement while touching the test pins.
- ⚠ The O.L. mark appears with nothing connected to the test pins.
- ⚠ The open-circuit voltage of the measurement connector is 0.4 V. Therefore, neither diodes nor transistors can be checked.

- (1) Set the Function switch to  $\Omega$  /  $\rightarrow|$  /  $\bullet\bullet\bullet$ ).
- (2) Press the Select switch to display  $M\Omega$  on the upper right part of the readout.
- (3) Make the test pins contact with the object under measurement and then read the value displayed.

### 4. Diode ( $\rightarrow|$ ) test (see Fig. 2-4)

This functional mode is used to determine whether the p-n junction of a single diode or transistor is acceptable.

- ⚠ **Warning:** Making a test with voltage applied to the diode or transistor under measurement is not possible and such an attempt is dangerous.
- ⚠ Positive voltage is output at the measurement connector and the open-circuit voltage 1.1 to 1.5 V (the LCD shows RS232C  $\rightarrow|$  OL V when the measurement connector is released).
- ⚠ Voltage drop in the forward direction of the diode becomes a measured value of 0.2 to 0.5 V, which is almost constant for each diode type. For voltage drop in the reverse direction, the O.L. mark appears.
- ⚠ No LED can be tested.

- (1) Set the Function key to  $\Omega$  /  $\rightarrow|$  /  $\bullet\bullet\bullet$ ).
- (2) Press the Select switch to display  $\rightarrow|$  on the upper part of the readout.
- (3) For measurements in the forward direction, make the black test pin contact with the cathode (K) of the diode and make the red one contact with the anode (A) and then read the value displayed.

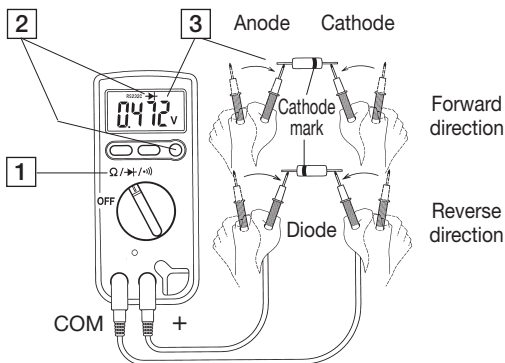


Fig. 2-4: Diode ( $\rightarrow|$ ) test

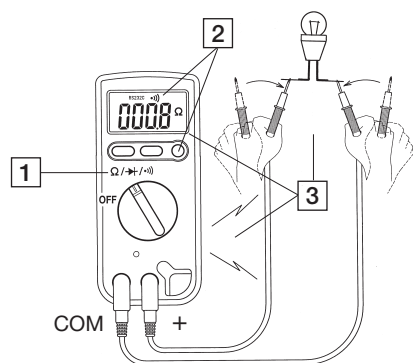


Fig. 2-5: Continuity ( $\bullet\bullet\bullet$ ) test

## 5. Continuity test (•••) test (see Fig. 2-5)

This functional mode is used to check electrical continuity of wiring, a switch or other.

**⚠ Warning:** Checking any live part for continuity is not possible and such an attempt is dangerous.

**⚠** The buzzer sounds when the resistance at the check point is approximately below the range of 10-60  $\Omega$ . If the resistance exceeds the operating range of the buzzer, the buzzer does not sound. If this is the case, use the resistance mode to measure the resistance and determine whether the object under measurement has no continuity (i.e., whether the wire is broken).

**⚠** The reading shows the resistance at the check point.

**⚠** The open-circuit voltage of the connector is approximately 0.4 V.

- (1) Set the Function key to  $\Omega / \rightarrow | \leftarrow / \bullet \bullet \bullet$ .
- (2) Press the Select switch to display  $\bullet \bullet \bullet$  on the upper part of the readout.
- (3) Make the test pines contact with the object under measurement and check for continuity based on whether the buzzer sounds and the reading (400  $\Omega$  maximum).

## 6. Measuring electric capacitance (||) (see Fig. 2-6)

This functional mode is mainly used to measure the electric capacitance of a capacitor.

**⚠ Warning:** For safety, ensure that the electric charge in the capacitor is discharged prior to measurement.

**⚠** The electric capacitance (||) measurement function is only available in the auto mode.

**⚠** The measurement time becomes longer for larger electric capacitance.  
(e.g.) 2 to 4 seconds for 10  $\mu\text{F}$  and 13 to 16 seconds for 100  $\mu\text{F}$

- (1) Set the function switch to ||.
- (2) Press the Select switch to display 00.00 nF ("REL" appears on the upper right part of the readout).
- (3) Make the test pines contact with the lead wires of the capacitor. After the reading becomes stable, read the measured value.

**⚠ Caution:** To measure a capacitor with polarities (positive and negative), connect the red test pin (positive measurement terminal) to the positive side of the capacitor.

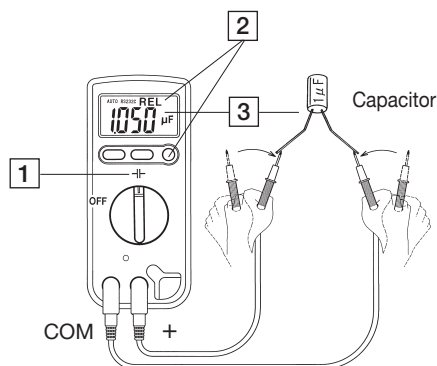


Fig. 2-6: Measuring electric capacitance (||)

## 7. Measuring DC current: DC $\mu\text{A}$ and DC mA ( $\mu\text{A} \equiv$ and mA $\equiv$ ) (see Fig. 2-7)

This functional mode is used to measure the DC current of a power circuit or other.

**⚠ Warning:** Be sure to measure current in series with the load. An attempt to measure current in parallel with the load is dangerous as large current would flow through the PC20TK.

**⚠** If a current range is connected, its internal resistance may cause a smaller current value than the actual one to be displayed.

**⚠** Turn the safety cover counterclockwise and use the  $\mu\text{A}$  & mA measurement connector (with a 0.5 A/250 V fuse).

- (1) Set the function switch to 400-4000  $\mu\text{A}$  or 40-400 mA.
- (2) Press the Select switch to display  $\equiv$  on the left part of the readout.
- (3) Connect the test pins to the object under measurement and then read the value displayed.

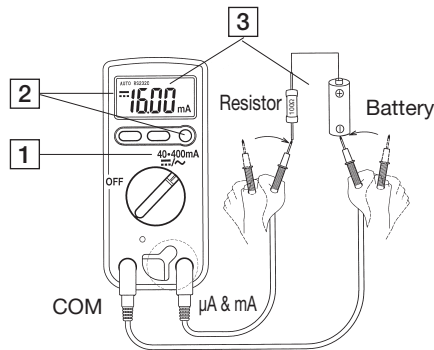


Fig. 2-7: Measuring DC current (DC  $\mu\text{A}$ -mA)

## 8. Measuring AC current: AC $\mu\text{A}$ and AC mA ( $\mu\text{A} \sim$ and mA $\sim$ ) (see Fig. 2-8)

This functional mode is used to measure sinusoidal AC current in a small transformer circuit or other.

**⚠ Warning:** Be sure to measure current in series with the load. An attempt to measure current in parallel with the load is dangerous as large current would flow through.

**⚠** An error occurs if any current with non-sinusoidal waves is measured.

**⚠** The accuracy is warranted within the frequency range of 40-400 Hz.

**⚠** Turn the safety cover counterclockwise and use the  $\mu\text{A}$  & mA measurement connector (with a 0.5 A/250 V fuse).

- (1) Set the function switch to 400-4000  $\mu\text{A}$  or 40-400 mA.
- (2) Press the Select switch to display  $\sim$  on the left part of the readout.
- (3) Connect the test pins to the object under measurement and then read the value displayed.

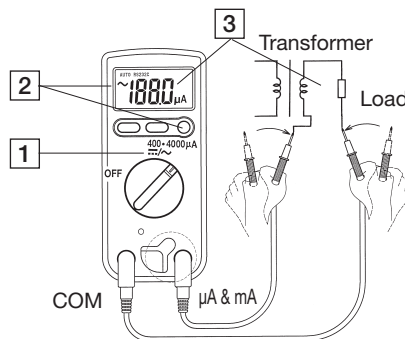


Fig. 2-8: Measuring AC current (AC  $\mu\text{A}$ -mA)

## 9. Connecting to PC: PC Link

As one of the features of the PC20TK, the PC20TK may be connected to your PC using the KB-RS1 PC connection cable (sold separately) and software called PC Link (sold separately) to upload the data output from the PC20TK to the PC and then display the data on the monitor, print or save it.

The data may be continuously uploaded for long hours and processed.

\* Fig. 2-9 shows an example of acquired data that is displayed in a window.

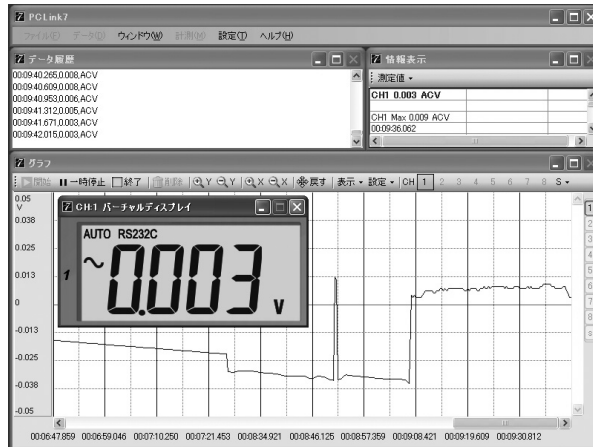


Fig. 2-9: An example of data displayed

\* Connecting procedure

- (1) Open the stand located on the rear of the PC20TK.
- (2) Attach the cable box to the rear case of the PC20TK by using the screw provided with the cable box.
- (3) Connect the cable connector to the PC.
- (4) In using the PC20TK, prop it against the stand.

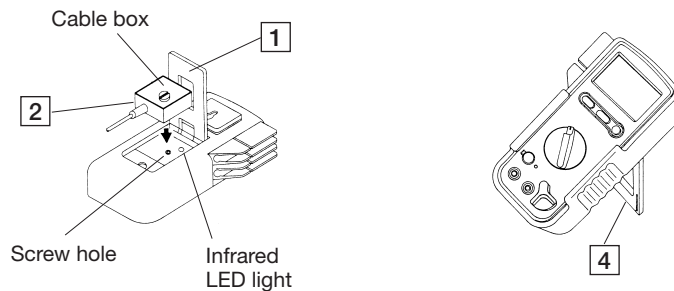


Fig. 2-10: Connecting procedure

\* Infrared LED light

The digital signals output from the PC20TK is converted into infrared signals through the LED light (D4 in the circuit diagram), which are then sent to the PC through the light receiving element in the cable box and the cable.

⚠ For using PC Link, refer to the instruction manual for PC Link, which is sold separately.

⚠ PC Link is Sanwa's original software product.

## 2-7 Replacing the fuse and batteries

### ⚠ Warning

1. In order to prevent electric shock, be sure to separate the test pins from the object under measurement before removing the rear case, and then turn OFF the Function switch on the PC20TK.
2. Do not remove the rear case except when performing the assembling procedures described in the instruction manual or replacing the fuse or batteries.

### ⚠ Warning

**To replace the fuse and batteries, be sure to use the specified rated products.**

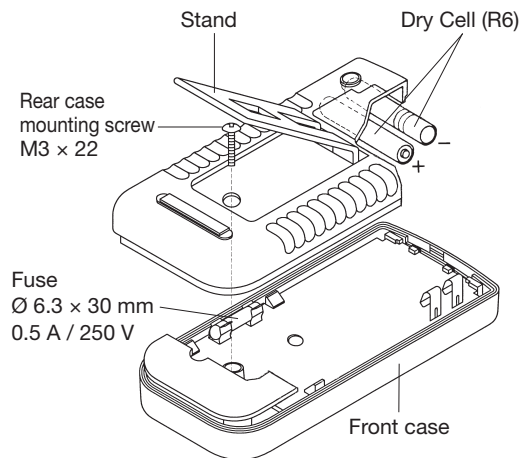
- Rating of fuse: 0.5 A/250 V, 6.3 mm dia. x 30 mm (in glass tube)
- Rating of battery: R6 (AA size) manganese dry cell; 1.5 V x 2 pieces

- (1) Disconnect the test leads from the PC20TK and turn OFF the Function switch.
- (2) Open the stand, loosen the rear case securing screw and then remove the rear case.
- (3) Replace the fuse or batteries.
- (4) Attach the rear case back in place and secure it with the screw.

### ⚠ Reference: Checking the fuse for continuity

- (1) Remove only the fuse from the PC20TK.
- (2) Attach the rear case to the PC20TK and set the Function switch to  $\bullet \gg \gg$ .
- (3) Check the removed fuse for electrical continuity.

⚠ **Note:** Ensure that both of the batteries are replaced with new ones. Properly place the new batteries with their polarities conforming to the ones engraved inside the rear case.



**Fig. 2-11:**  
**To replace the fuse and batteries**

## 2-8 Storage and others

**In using the PC20TK, be sure to observe the following instructions:**

- (1) Do not store the PC20TK in a place exposed to direct sunlight, high temperature (50 °C or higher), or high humidity (70 % RH or higher).
- (2) Avoid using the PC20TK in a place exposed to high or low temperature or high humidity.
- (3) If the PC20TK is not used for a long period of time, store it with the built-in batteries removed.
- (4) The PC20TK is neither dust-proof nor drip-proof.
- (5) The panel, the rear case and others are made of plastics. Therefore, do not place them near any volatile solvent or heat source.
- (6) Lightly wipe off dust and other foreign matter on the external surface of the PC20TK by using soft cloth.
- (7) The readout (LCD) is made of glass. Do not give a strong impact to it, e.g., by dropping the PC20TK.

## [3] Basic Knowledge of Digital Multimeter

### 3-1 Analog vs. digital

Quantities are roughly classified into analog quantities and digital ones. Analog quantities represent quantities having continuous intensity, such as time, length, weight, electric voltage and current. Digital quantities mean quantities having discontinuous intensity, such as 1, 2 and 3 counted for things. Visually, the former is liken to a slide, while the latter is liken to a flight of stairs. Digital display seems to be rough at a perceptual level, but the use of the present advanced electronic and digital technologies allows for measuring quantities at high accuracy because digital signals have an advantage in that noises, if included, can be easily eliminated to minimize the deterioration of signals.

### 3-2 Analog multimeter (AMT) vs. digital multimeter (DMM)

With an analog multimeter, you can accurately measure voltage or other up to a level of only 1/100 (3 digits) of the full-scale value. In addition, the reading differs depending upon individual users. In contrast, a digital multimeter displays the measured value in numerals, allowing the user to correctly read the displayed value to the full digits. Unlike an analog multimeter, a digital multimeter does not require the user to make a troublesome conversion of the reading (e.g., by multiplying it by 10 or 1/10), but allows the user to simply use the reading as it is with the corresponding unit. A digital multimeter provides other useful capabilities such as holding data, displaying the negative sign, and warning an input overflow. When popular models are compared between analog multimeters and digital multimeters, there are no differences in size and price. The following table compares the rough specifications of popular models between analog multimeters and digital multimeters.

	Digital multimeter	Analog multimeter
Construction of readout	Electronic construction using an A/D conversion LSI, an LCD, etc. (a numeric value is displayed on the readout)	Mechanical construction using a magnet, a moving coil, etc. (the pointer indicates a reading on the scale).
Main measurements	DCV, ACV, DCA, ACA, $\Omega$ , $\rightarrow$ —, $\bullet$ )))	DCV, ACV, DCA, $\Omega$ , dB, hEF, BT, (— —)
Mode selection and other operations	The auto mode is selectable. The decimal point, a unit, and a polarity can be displayed.	In general, operations are manually performed. The decimal point, a unit, a polarity and others are determined by the user when he reads what the pointer indicates.
Reading error Accuracy	In principle, there is no reading error. High	A reading error occurs from parallax and personal differences. Slightly low
Input resistance in the voltage mode	High (about 10 M $\Omega$ regardless of the range selected)	Varies depending on the range selected (2 k-10 M $\Omega$ )

Analog multimeter



Digital multimeter

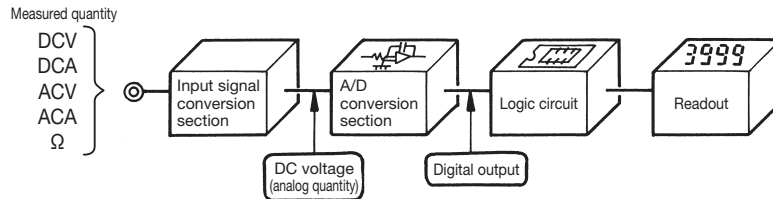


Fig. 3-1

### 3-3 Construction of digital multimeter

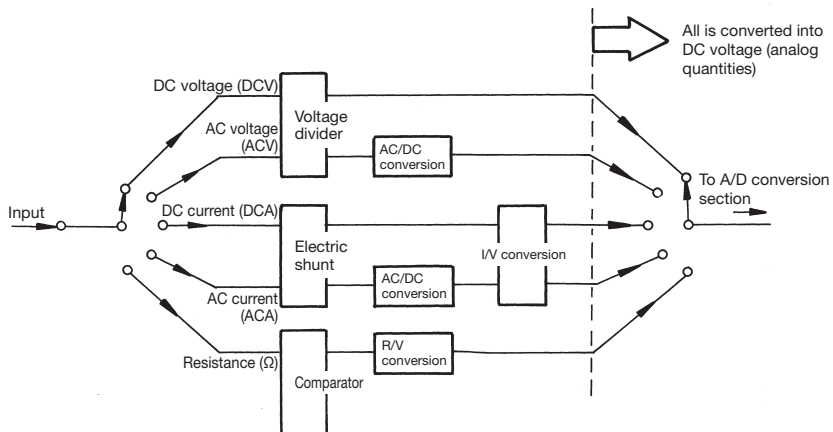
Now let us see how a digital multimeter converts an analog quantity into a digital one (A/D conversion) to display a numeric value.

The circuits of a digital multimeter are roughly divided into five blocks of an input signal conversion section, an A/D conversion section, a logic circuit, and a readout.



**Fig. 3-2: Block diagram of digital multimeter**

A digital multimeter generally allows for measuring 5 kinds of electric quantities: DC voltage (DCV), AC voltage (ACV), DC current (DCA), AC current (ACA), and resistance (Ω). The PC20TK also allows for performing a diode test (→|←) and measuring electric capacitance (|+|). Each kind of electric quantities (input signals) is selected using the Function switch, all converted into DC voltage signals of less than several 100 mV through a voltage divider, an electric shunt, an AC/DC converter (rectifier), or the like, and then added to the input connector of the analog-digital converter.



**Fig. 3-3: Input signal conversion section**

Further information on each item will be given below:

### 3-4 Working of input signal conversion section

The following typical example is assumed to explain how each input signal is processed to obtain DC voltage that will be applied to the A/D conversion section.

#### 1. DC voltage (DCV)

For measurements of DV voltage, the user selects the most suitable range in accordance with the voltage level to be measured. A voltage divider is used to provide different ranges and this circuit is also known as an attenuator. As shown in Figs. 3-4 and 3-5, resistors are connected in series to divide input voltage  $V_i$  into smaller voltage using the resistors. SW stands for a selector switch that is used to select the most suitable range.

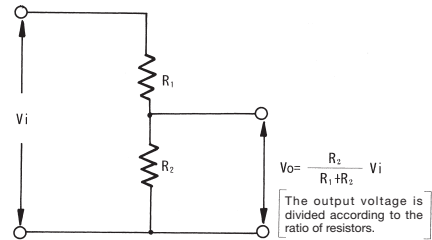


Fig. 3-4: Dividing voltage with resistors

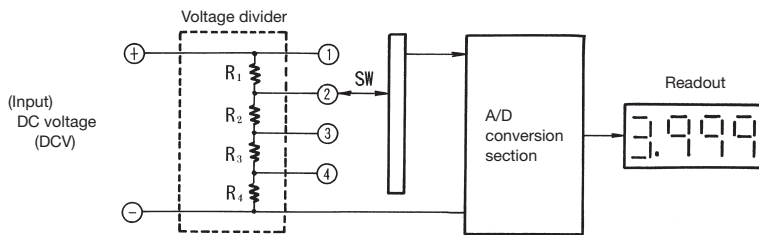


Fig. 3-5: Measuring circuit for DC voltage (DCV)

#### 2. AC voltage (ACV)

For measurements of AC voltage, the input voltage is divided with the voltage divider as shown in Fig. 3-6 and then AC voltage (ACV) is converted into DC voltage (DCV) with a rectification circuit.

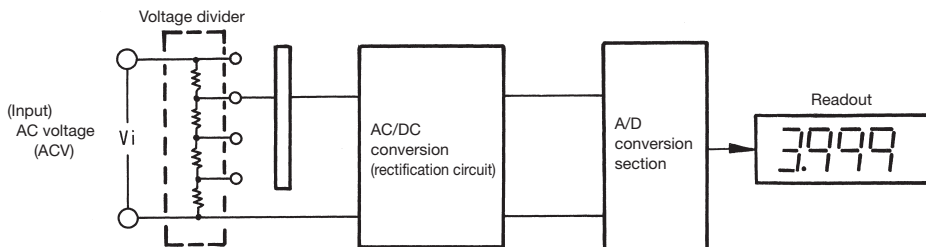
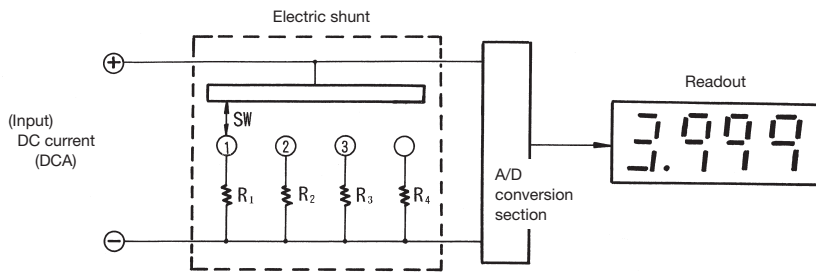


Fig. 3-6: Measuring circuit for AC voltage (ACV)

#### 3. DC current (DCA) and AC current (ACA)

When current flows through a resistor, voltage drop occurs in proportion to that current. This means that current has been converted into voltage (current/voltage conversion). For measurements of current, such voltage is used. Fig. 3-7 shows an example of a DC current measuring circuit, which uses several resistors of accurate values (electric shunt) so as to enable the user to select the most suitable range in accordance with the current to be measured. For measurements of AC current, a rectification circuit is added following the electric shunt, to convert AC voltage into DC voltage.

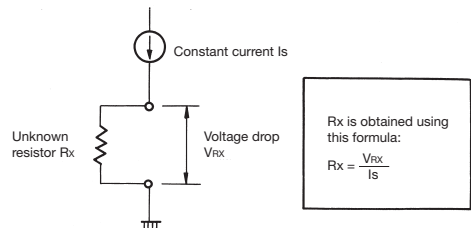




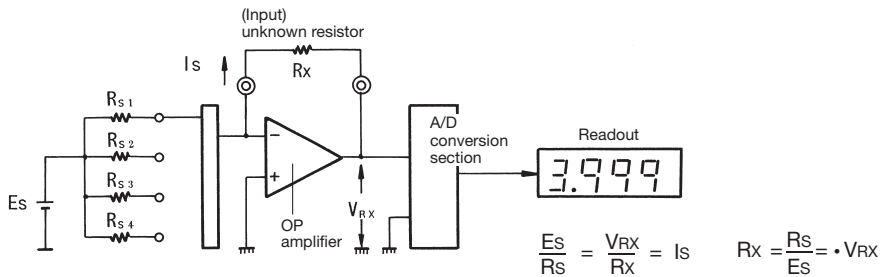
**Fig. 3-7: Measuring circuit for DC current (DC  $\mu$ A & mA)**

#### 4. Resistance ( $\Omega$ )

For measurements of resistance, a resistor/voltage conversion (R/V conversion) circuit is used to convert into DC voltage in proportion to the resistance value. As a typical example among several conversion methods available, the method shown in Fig. 3-9 is explained because it is easily understandable. As shown in Fig. 3-8, accurate constant current  $I_s$  is sent to unknown resistor  $R_x$  and then DC voltage is obtained indirectly from voltage drop  $V_{RX}$  that occurs in proportion to the resistance value of that resistor. Fig. 3-9 shows an example of a resistance measuring circuit that applies the above voltage drop.



**Fig. 3-8: Principle of resistance measurements (constant current method)**



**Fig. 3-9: Resistance ( $\Omega$ ) measuring circuit**

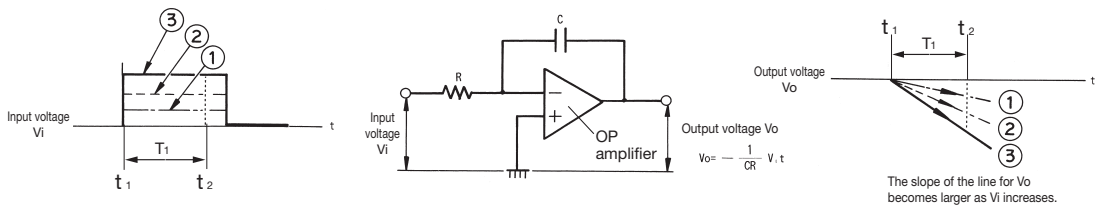
### 3-5 Working of A/D conversion section

The A/D conversion section converts DC voltage (analog quantity) that has been input from the input signal conversion section into a pulse number (digital quantity) in proportion to the intensity of that voltage. The available A/D conversion methods include the integration, comparison, and  $\Delta \Sigma$  methods. The PC20TK uses the  $\Delta \Sigma$  method. In this paragraph, however, the double integration method is explained because it is used for a large number of digital multimeters and theoretically easier to understand.

#### 1. Operation of each section of double integration circuit

##### • Integration circuit

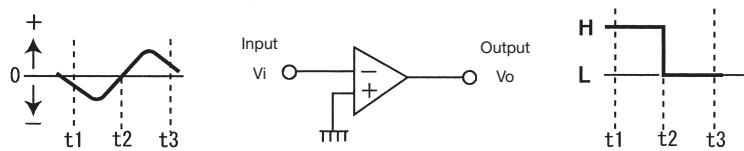
This circuit consists of a resistors, a capacitor and an OP amplifier. It outputs a voltage value in proportion to the product obtained by multiplying the intensity of signal (DC voltage) applied to the input connector by time ( $V_o = 1/CR \cdot V_i \cdot T_1$ ).



**Fig. 3-10: Integration circuit**

• **Comparator (0-detector)**

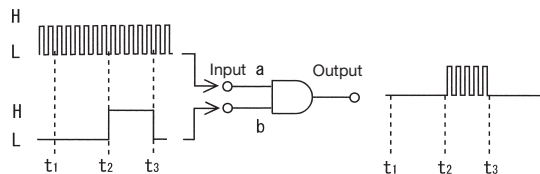
The comparator has an inverting input terminal (negative) and a non-inverting input terminal (positive). If the former has higher electric potential than the latter, the output decreases nearly to negative electric potential of the power source (L). In the opposite case, the output decreases nearly to positive electric potential of the power source (H). In the case shown in Fig. 3-11, the non-inverting input terminal (positive) is at 0 electric potential (grounded). Therefore, when the inverting input terminal (negative) has positive electric potential (voltage), even if only slightly, the output becomes L. When the inverting input terminal has negative electric potential, the output becomes H.



**Fig. 3-11: Comparator**

• **AND gate**

When a digital signal H (high electric potential) is simultaneously applied to two input terminals a and b, the output becomes H. If either of the two input terminals is H and the other input terminal is L or if both terminals are L, then the output becomes L.



**Fig. 3-12: AND gate circuit**

• **Control circuit**

This circuit consists of a logic circuit and outputs various kinds of control signals in response to input signals.

• **Counter**

This is a digital counter that measures the number of pulses (clock pulses) that have been received at accurate frequency from the pulse generator.

• **Readout**

For a digital multimeter, a LCD readout is used to enable efficient reading of the measured value.

## 2. Principle of double integration circuit

$V_i$  : Input voltage under measurement

$T_1$  : Integration period (constant)

$V_{ref}$  : Reference voltage (constant)

$T_2$  : Reverse integration period

Given the above conditions, the output voltage of the integration circuit is 0 V at the end point of reverse integration (point  $t_3$  in Fig. 3-15). Hence,

$$\frac{1}{CR} \cdot V_i \cdot T_1 + \frac{1}{CR} \cdot (-V_{ref}) \cdot T_2 = 0$$

When this equation is transformed into:

$$V_i = \frac{T_2}{T_1} \cdot V_{ref}$$

$V_{ref}$  and  $T_1$  are constants with known values.

This means that when  $T_2$  is found,  $V_i$  can be calculated.

$T_2$  is measured as a pulse number by the counter by converting it into the pulse number.

Since  $T_2$  has a proportional relationship with  $V_i$ , it is finally displayed as the measured input.

This concept may be simplified, for example, as shown in the following Fig. 3-13:

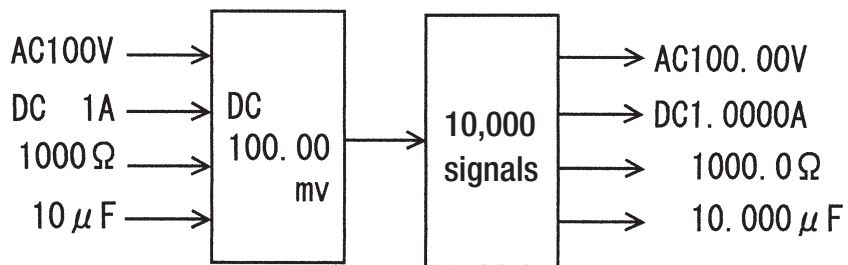


Fig. 3-13: Signal changes

### 3. Comprehensive operation of double integration circuit

Figs. 3-14 and 3-15 are diagrams showing the operations of double integration. The PC20TK uses one (single-chip) LSI that incorporates a circuit equivalent to the whole circuit identified by enclosing it with dotted lines on the left side, although the components are different between the two.

- (1) First the counter and the integration circuit are reset to the zero state.
- (2) The switching signal from the control circuit changes the input selection switch to the input signal position (SW1).
- (3) With the input signal of DC voltage with a positive polarity, the integration circuit starts integration (charging) with  $t_1$ . With the output side being negative, the integration capacitor is charged. Therefore, the comparator has 0 electric potential at its positive input terminal and negative electric potential (voltage) at its negative input terminal. Thus, the output becomes positive electric potential.
- (4) The counter measures the specified number of clock pulses from the pulse generator (for constant time:  $t_1$ - $t_2$ ), and then returns to zero and simultaneously outputs the point  $t_2$  detection signal. The measured value at this time is not displayed because of the working of the latch circuit. The time between points  $t_1$  and  $t_2$  is set to a constant value regardless of the input signal. The voltage to be integrated therefore becomes a value that is in proportion to the input signal.
- (5) With the point  $t_2$  detection signal from the counter, the control circuit changes the input selection switch to the reference voltage position.
- (6) Since reference voltage with a negative polarity is applied, the integration circuit performs reverse integration (discharging) at a constant rate. The output voltage (electric potential) increases, changing from a negative value to a positive one at point  $t_3$ . As illustrated, the time between points  $t_2$  and  $t_3$  is in proportion to the input signal.  
\* Since two operations, integration and reverse integration, are performed, this is called double integration.
- (7) The comparator changes its output from a positive value to a negative one when the input voltage from the integration circuit becomes positive. At the moment when the comparator's output changes from a positive value to a negative one (point  $t_3$ ), the voltage 0 detection signal is sent to the control circuit.
- (8) The control circuit continues to output the gate opening signal to terminal a of the gate during the period between points  $t_2$  and  $t_3$ .
- (9) The gate allows clock pulses applied to terminal b to pass through so far as the above signal is output (between points  $t_2$  and  $t_3$ ). The number of pulses that pass through the gate is in proportion to the time between points  $t_2$  and  $t_3$  and therefore in proportion to the input signals. This means that the input signals have been converted into digital signals.
- (10) The counter measures pulses in proportion to the input signals that have passed through the gate.
- (11) With the latch signal that is output from the controller immediately after the 0-signal detection signal, the latch circuit temporarily retains the data measured by the counter until the next new measurement data is received.
- (12) The controller outputs the reset signal following the latch signal to reset the counter and the integration circuit (to zeros). It simultaneously changes the input switch to the input signal position.
- (13) The data, functional mode, unit symbol, decimal point, input overflow signal and others, which are stored in the latch circuit, are added to the readout, which then displays a value for the original input analog signal (V, A,  $\Omega$ ,  $\frac{1}{\text{Hz}}$ , etc.) rather than the input signal converted into DC voltage.
- (14) The same sequence is repeated again from the beginning. The number of times when this repetition is made per second is called a sampling rate. The PC20TK does not use the double integration method, but its sampling rate is 3 times per second.

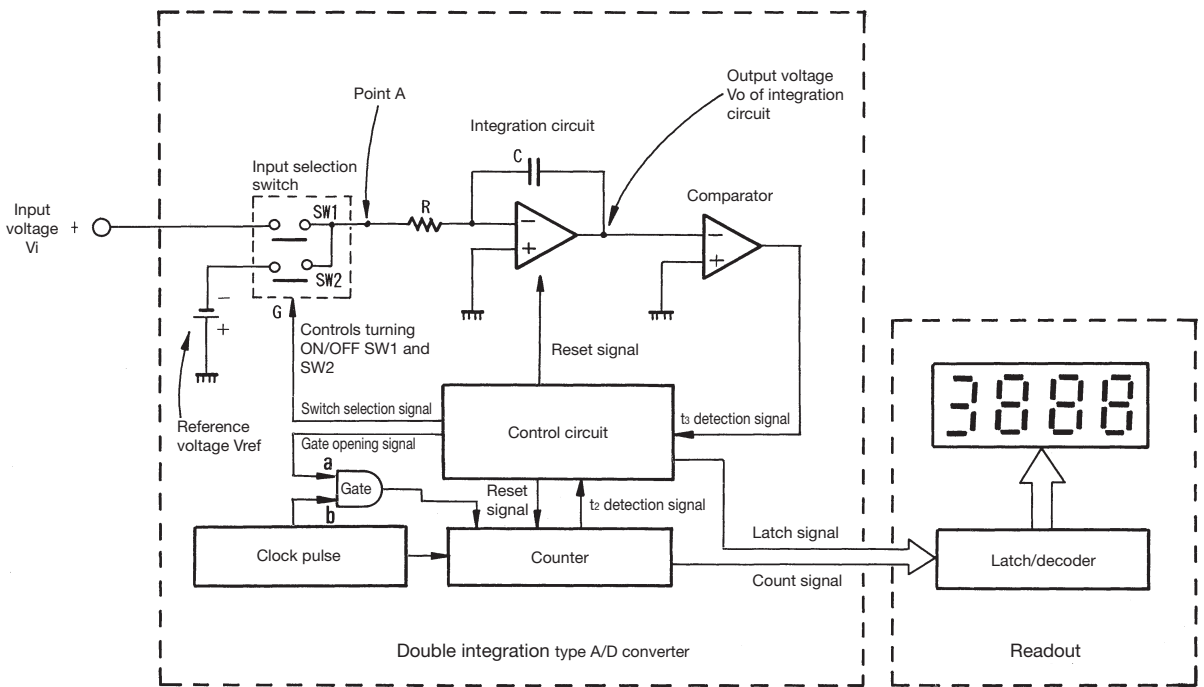


Fig. 3-14: Diagram showing the operation of double integration

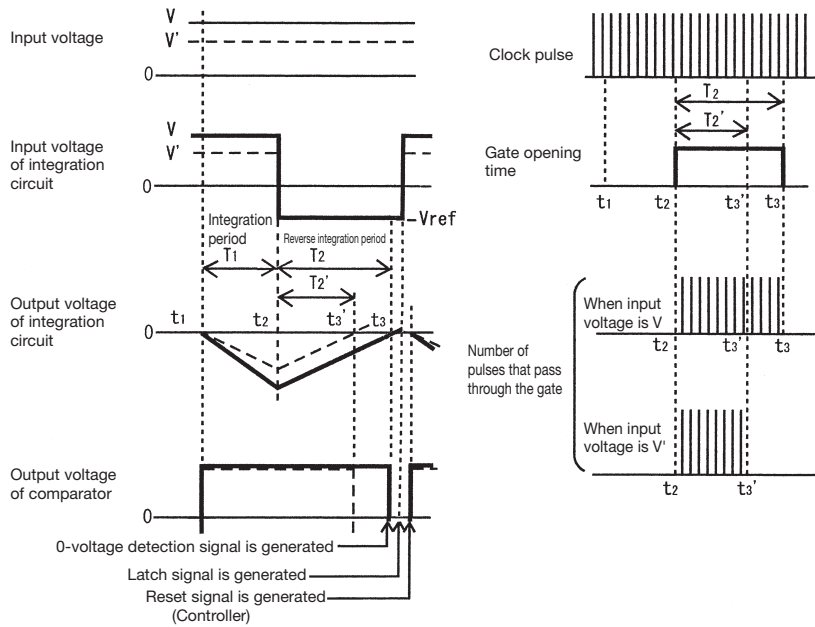


Fig. 3-15: Timing chart for double integration

## [4] Assembling

### 4-1 Soldering

Soldering is important work in assembling the multimeter. Incomplete soldering of parts can cause a problem by causing the multimeter to fail to operate or malfunction during use. Solder is alloy with a low melting point, which uses lead and tin as main ingredients to electrically and mechanically connect metal to metal (a component to a component). Solder wire is solder alloy formed into wire, which includes flux to ensure and facilitate successful soldering. Flux reduces and removes oxides on the metal surface to be soldered and improves the affinity between solder and metal. Precautionary instructions on the soldering work are given below:

1. Remove foreign matter and rust on the surface of the metal to be soldered, by using cloth or abrasive paper.
2. Control the temperature of the soldering iron.

Use the following criteria to determine whether the temperature of the tip is appropriate:

- **Too high temperature:** The tip is blackened with oxidization in several minutes and cannot be coated with solder.
- **Too low temperature:** Solder melts too slowly and the soldering tip becomes sharp-pointed or dull-colored.

To control the temperature of a soldering iron that has no automatic temperature control, use a voltage regulator or change the length of the exposed tip of the soldering iron. In controlling the temperature with the length of the tip, longer length of the exposed portion decreases the temperature, while shorter one increases the temperature.

3. If the tip of a soldering iron is dirty or coated with excessive solder, soldering cannot be performed properly. Use wet cloth or the like to wipe off foreign matter and then carry out soldering.
4. If the tip is difficult to coat with solder, apply preliminary solder to the tip to ensure efficient soldering.

**⚠ Memo:** Soldering is work that is done to joint metal to metal by applying solder to the part to be soldered. Hold the soldering iron tip on the metal surface, wait for the temperature of the surface to become high enough to melt solder, and then apply solder. This will result in successful soldering. In other words, feed solder a little later than making the soldering iron tip contact with the metal surface.

### 4-2 Soldering procedure

Successful soldering results in forming a crest with a glossy surface.

#### 1. Component with lead wire

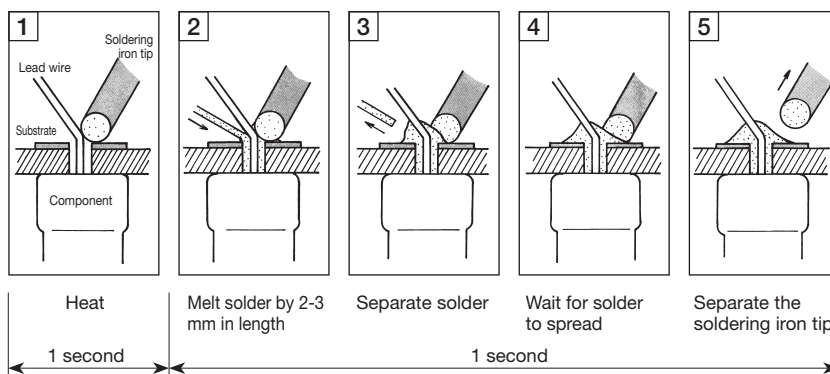
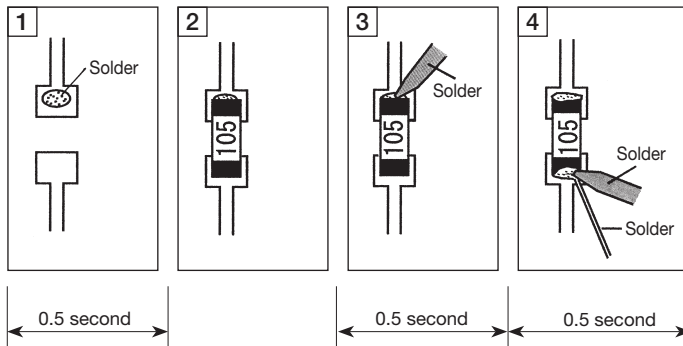


Fig. 4-1

## 2. Chip component



- 1 Apply a small amount of preliminary solder to one end of land.
- 2 Amount a component and press it with your fingers.
- 3 Melt the preliminary solder with the soldering iron tip to solder the component.
- 4 Solder the other end by applying the soldering iron tip and solder.

Fig. 4-2

## 4-3 Precautionary instructions for assembling

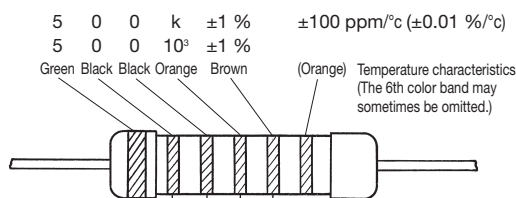
1. For an LSI, avoid touching any of its pins, wherever possible, because it might be damaged electrostatically. In particular, care must be taken in the winter season when static electricity is more likely to be generated under the dry condition.
2. In the 750 VDC or VAC range or the 40 MΩ range, the circuit resistance is so high that a leak might take place. Avoid touching the surface of a printed circuit board with a bare hand, wherever possible. Prior to work, be sure to wash your hands and dry them.
3. A printed circuit board is of through holes. If any incorrectly mounted component is removed by pulling it with excessive force, the continuity between the top and the bottom is broken.
4. If solder is not successfully absorbed with a solder absorber, apply additional solder to that part and then try to absorb the increased solder.

⚠ **Memo:** The time required to hold the soldering iron tip on the part to be soldered varies depending upon the size of the component to be mounted. Use the time values shown in Figs. 4-1 and 4-2 for reference only.

## 4-4 Color codes and symbols of components

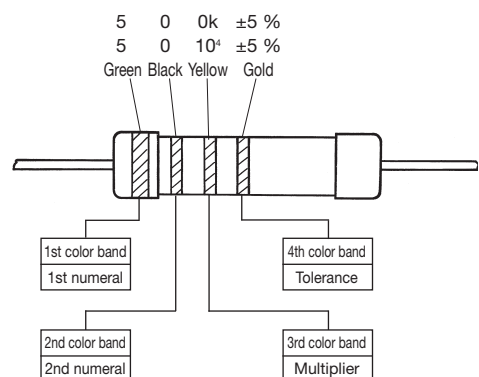
### 1. Identifying a resistor

[Example of identifying a precision resistor: 500 kΩ F]



Color	1st color band	2nd color band	3rd color band	4th color band	5th color band
	1st numeral	2nd numeral	3rd numeral	Multiplier	Tolerance
Black	0			10 <sup>0</sup>	—
Brown	1			10 <sup>1</sup>	±1 %
Red	2			10 <sup>2</sup>	±2 %
Orange	3			10 <sup>3</sup>	—
Yellow	4			10 <sup>4</sup>	—
Green	5			10 <sup>5</sup>	±0.5 %
Blue	6			10 <sup>6</sup>	±0.25 %
Purple	7			10 <sup>7</sup>	±0.1 %
Gray	8			10 <sup>8</sup>	—
White	9			10 <sup>9</sup>	—
Gold				10 <sup>-1</sup>	±5 %
Silver				10 <sup>-2</sup>	±10 %

[Example of identifying a consumer resistor: 500 kΩ J]

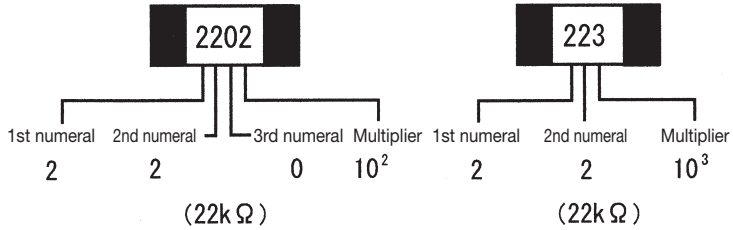


Symbols showing tolerance

B : ±0.1 %	C : ±0.25 %	D : ±0.5 %
F : ±1 %	G : ±2 %	J : ±5 %
K : ±10 %	M : ±20 %	

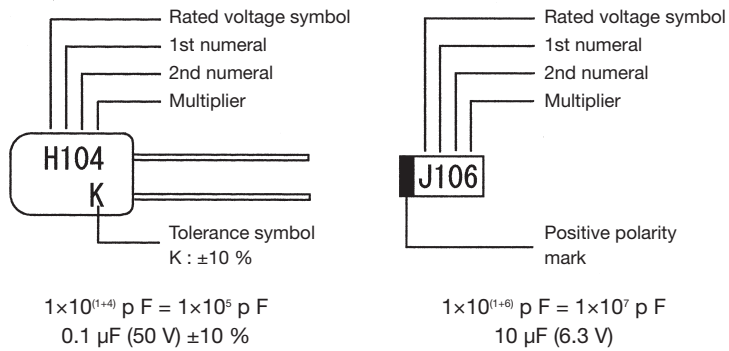
Fig. 4-3(a): Example of identification of resistor

[Example of identifying square chips: 22 kΩ]



**Fig. 4-3(b): Example of identifying resistors**

**2. Example of identifying capacitors (some capacitors have no identification)**

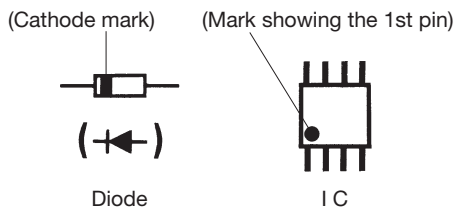


**Fig. 4-4: Example of identifying capacitors**

\* Symbols showing rated voltage

Symbol	G	J	A	C	D	H
Rated voltage	4 V	6.3 V	10 V	16 V	20 V	50 V

**3. Identifying other components**



**Fig. 4-5: Example of identifying other components**

**4. Units**

Auxiliary units used for capacitors

1 F = 10<sup>6</sup> μF = 1000000 μF  
 1 μF = 10<sup>3</sup> nF = 1000 nF  
 1 nF = 10<sup>3</sup> pF = 1000 pF

Auxiliary units used for resistors

1 MΩ = 10<sup>3</sup> kΩ = 1000 kΩ  
 1 kΩ = 1000 Ω  
 1 mΩ = 10<sup>-3</sup> Ω = 0.001 Ω



## 4-5 Preparations for assembling

### 1. Tools (supply the tools shown in the following tables)

Check	Name	Remarks
	Soldering iron	15 to 20 W
	Tweezers	Small size
	Nipper	Small size

Check	Name	Remarks
	Phillips screwdriver	Medium size
	Slotted head screwdriver for adjustment use: small size (Blade: 2-2.2 mm in width and 0.4 mm max. in thickness)	

### 2. Checking components

(Check the kinds and quantities of components by referring to the component names shown in Fig. 4-6 on page 24 through Fig. 4-19 on page 30.)

- 1 **Instruction manual for assembling (1)**
- 2 **A set of components with a paper board (1)**
- 3 **Test leads (1 set of red and black ones)**

Check that each component is mounted on the corresponding name shown on the board. Each 2 pieces of spark gaps, fuse folders and battery terminals are supplied.

Remove the temporarily assembled panel and rear case and also remove the batteries placed in the rear case. Remove the printed circuit board (small) that is temporarily attached to the panel with screws (M3 x 8). Store the removed screws (M3 x 8), which will be used in the process described in 4-9. Remove the printed circuit board (large) by extending its pawls.

#### 4 Components mounted on paper board (temporarily assembled components)

Check	Reference drawing	Name of component	Q'ty
	Fig. 4-10	Printed circuit board (small) with measurement connector	1
	Fig. 4-6	Printed circuit board (large) with circuit components	1
	Fig. 4-8	Battery pad	1
	Fig. 4-12	Zebra-striped connector	1
	Fig. 4-11	Readout (LCD)	1
	Fig. 4-12	Rubber switch	1
	Fig. 4-15	Dial	1

#### 5 Component in bag

Check	Reference drawing	Name of component	Q'ty
	Fig. 4-16	Warning label	1
	Fig. 4-16	Dial A (translucent, purple-colored)	1
	Fig. 4-16	Round rubber foot	2
	Fig. 4-15	Safety cover	1
	Fig. 4-10	Connector cover	2 red ones 1 black one
	Fig. 4-7	Buzzer	1
	Fig. 4-18	Screw M3 x 22	1
	Fig. 4-15	Screw M2 x 8	1
	Fig. 4-19	Oval seal (1 piece for spare)	2
	Fig. 4-14	Banding Band	3

#### 6 Panel (Fig. 4-11) and components mounted on the panel

Switch knob  
Brush mount (2 pieces of 2P brushes and 1 piece of 4P brush)  
Spring arm (with coil spring)

#### 7 Rear case (Fig. 4-16) and mounted components

Dry cell (Fig. 4-17): 2 pieces of R6 type in a pack are temporarily placed.  
Stand (Fig. 4-18)  
Rectangular rubber foot (Fig. 4-16)

## 4-6 Mounting and wiring components to printed circuit board (large)

### 1. Mounting components to the component mounted surface: 1 through 3

⚠ Be sure to check the polarities of the diode and then solder it.

Check	Order	Name of component
	1	Y : Quartz oscillator
	2	D5 : Diode
	3	R17 : Resistor: 1 MΩ (square chip)

⚠ After soldering, cut off the lead wire of the quartz oscillator with a nipper.

#### ⚠ Preliminary solder (see Fig. 4-2)

To solder R17 or D5:

- (1) Apply preliminary solder to one end of land.
- (2) Position the component on the land and hold it with tweezers.
- (3) Make a soldering iron tip contact with the land to which preliminary solder has been applied, thereby melting the applied preliminary solder to solder the component (the component will be secured).
- (4) Solder the other end of land (terminal) by making the soldering iron tip contact with the other end of land (terminal) together with solder.

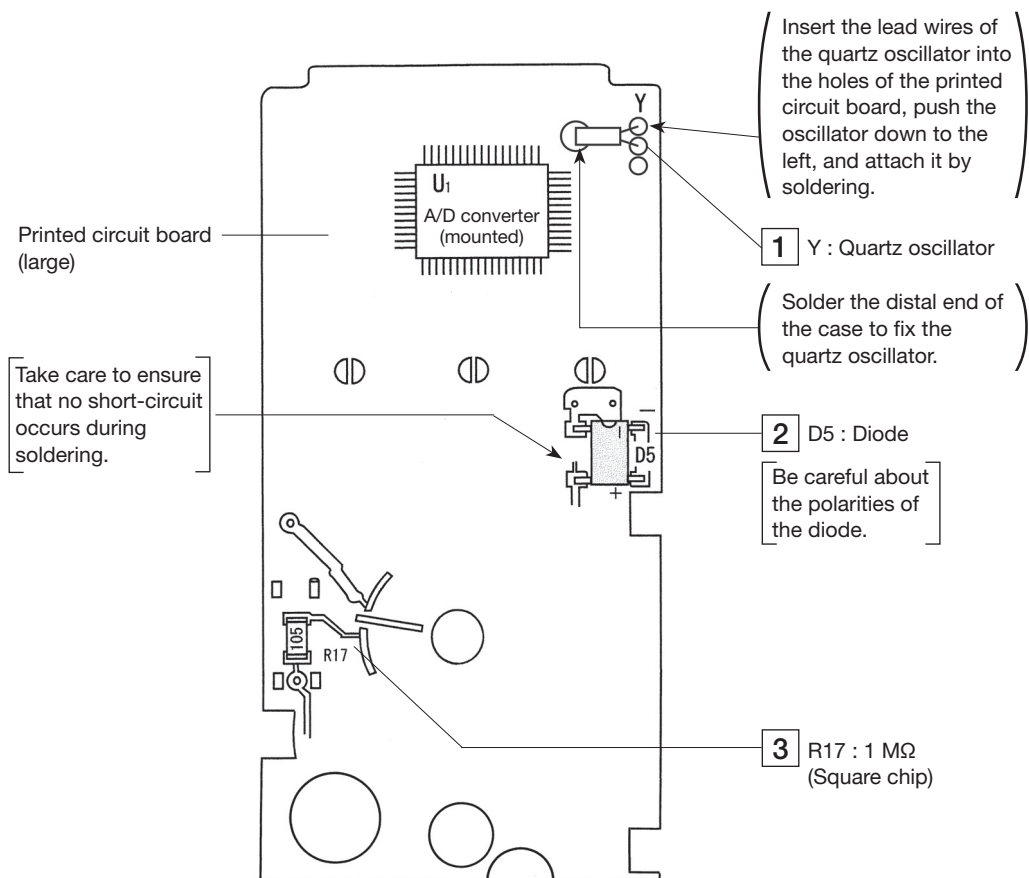


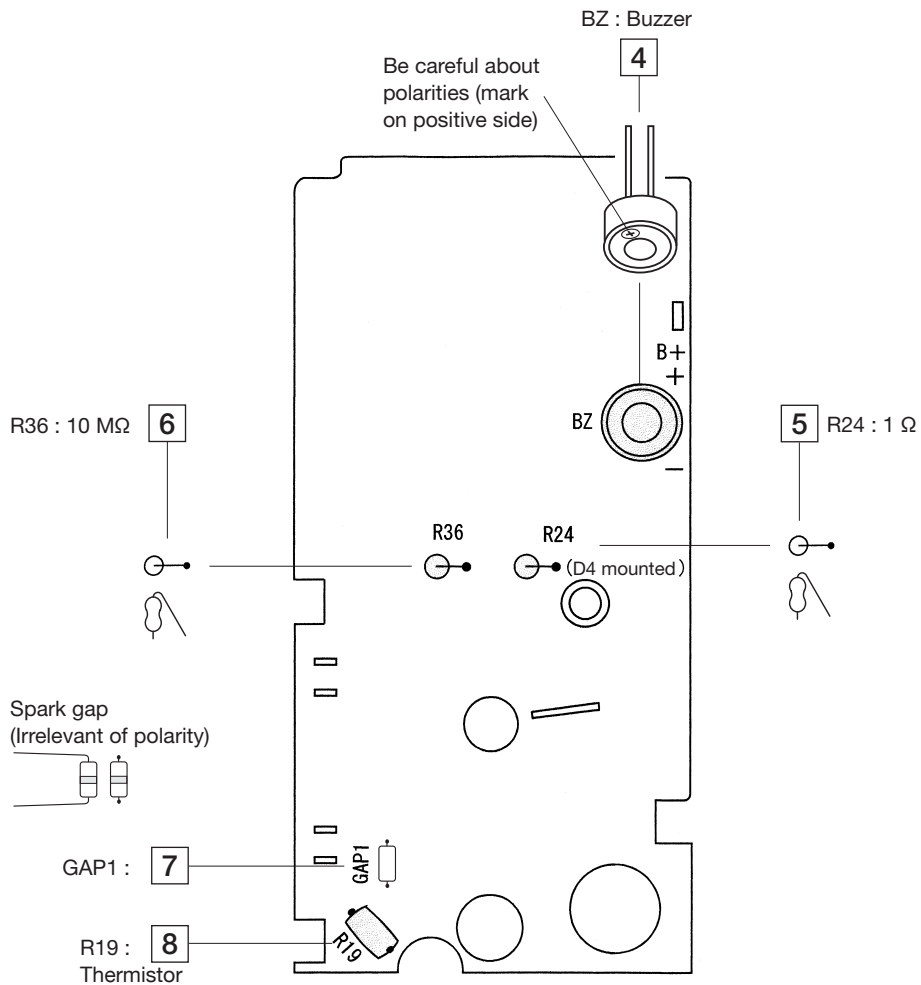
Fig. 4-6

**2. Mounting components on silk-screen printed surface (part 1):** [4] through [8]

- Insert the lead wires of each component into the specified holes in the printed circuit board and then solder them on the opposite mounted surface.
- Be sure to check the polarities of the buzzer.  
No components other than the buzzer have polarities.

Check	Order	Name of component
	4	BZ : Buzzer
	5	R24 : Resistor: 1 Ω
	6	R36 : Resistor: 10 MΩ (with lead wire)
	7	GAP1 : Spark gap
	8	R19 : Thermistor (PTC)

⚠ After soldering, cut off the protruding lead wire with a nipper.



**Fig. 4-7: (Part 1)**

### 3. Mounting components to silk-screen printed surface (part 2): 9 through 17

- Solder the battery terminals, the fuse folders and the lead wire on the opposite side.
- Insert the two fuse folders into the printed circuit board with attention to their polarities (the stoppers are positioned mutually outward).
- To solder the fuse folders, previously insert them into the circuit board and attach the fuse to them. This will facilitate your soldering work.

Check	Order	Name of component
	9	Battery terminal (2 pieces)
	10	Fuse folder (2 pieces)
	11	F : Fuse: 0.5 A/250 V
	12	V : Lead wire: black, 70 mm
	13	W : Lead wire: black, 70 mm
	14	B : Lead wire: black, 70 mm
	15	A : Lead wire: red, 43 mm
	16	COM : Lead wire: red, 85 mm
	17	Battery pad

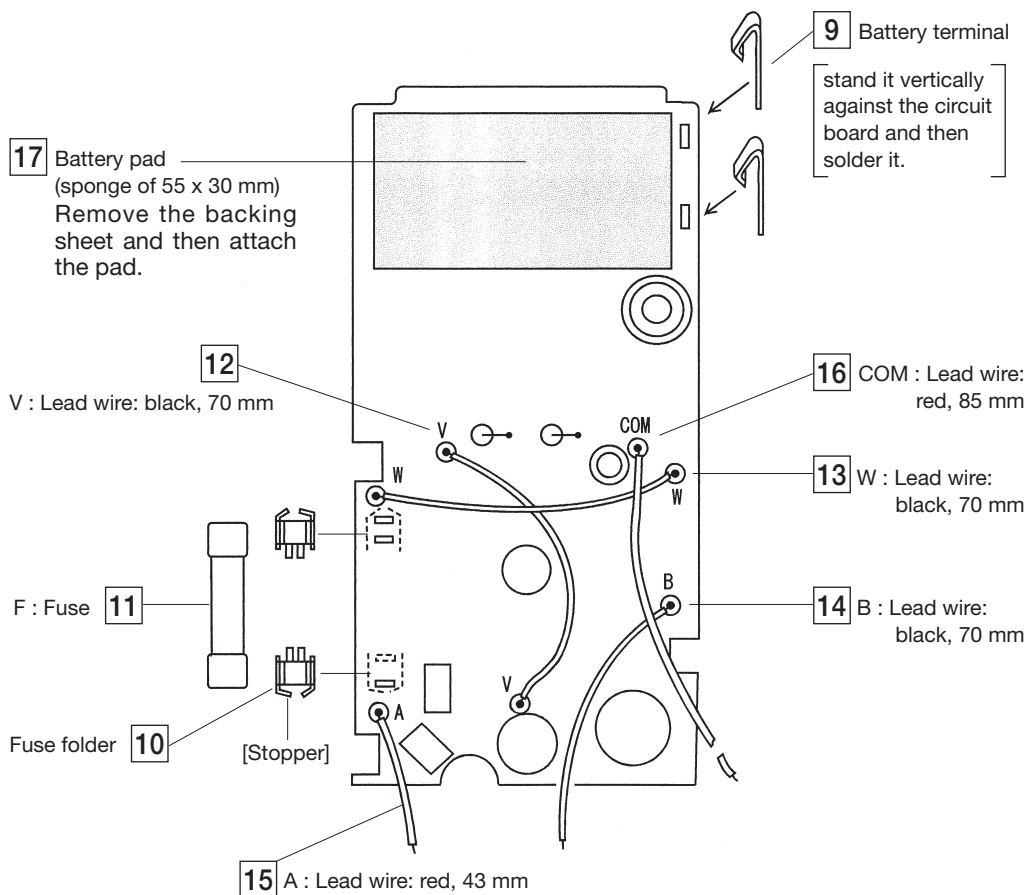


Fig. 4-8: (Part 2)

## 4-7 Wiring the printed circuit board (small) (Fig. 4-9)

Insert the lead wires from the printed circuit board (large) complete with the components soldered into the land holes marked with the corresponding symbols of the printed circuit board (small), and then solder them (3 places of A, B and COM).

## 4-8 Attaching the connector covers to the printed circuit board (small) (Fig. 4-10)

- Press one black connector cover over the COM measurement connector until its flange makes contact with the printed circuit board.
- Similarly press two red connector covers.

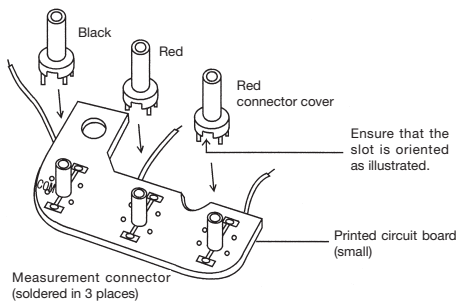


Fig. 4-10: Attaching the connector covers

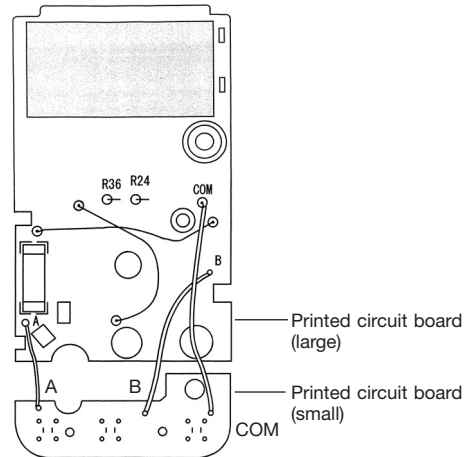


Fig. 4-9: Wiring the printed circuit board (small)

## 4-9 Mounting the readout (LCD), the printed circuit boards, and the dial plate

Fig. 4-11

- 1 Remove the protective transparent film attached to the LCD surface (do not remove the white film on the rear).
- 2 Fit the LCD at an angle of about 30 degrees into the area surrounded by the LCD securing pawls located inside the panel.
- 3 Once the lower part of the LCD is fit to the pawls, lower the upper part (stepped) to place it horizontally on the panel.

**⚠ Caution: The LCD may be broken if excessive force is applied, because it is made of glass. If the LCD is difficult to mount, hold it with your fingers from its top and bottom and then slowly snap it into place (see the right illustration).**

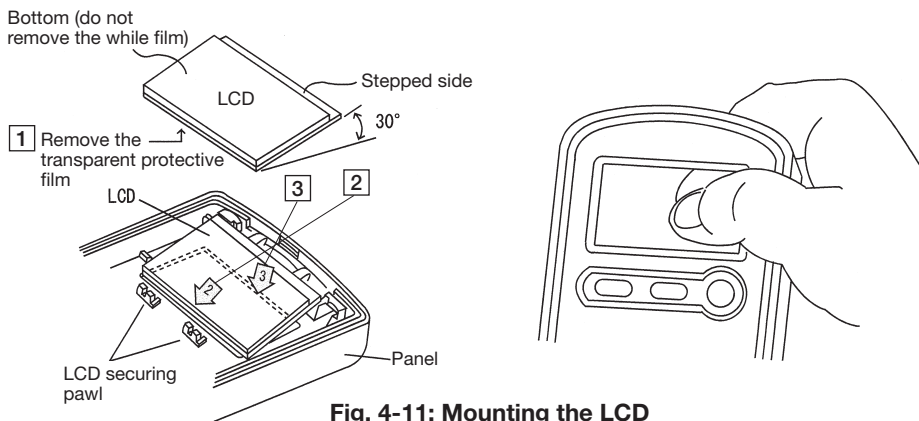


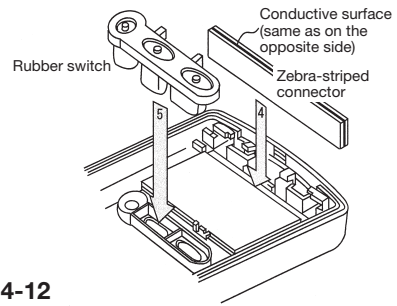
Fig. 4-11: Mounting the LCD

**Fig. 4-12**

4 Mount the zebra-striped connector onto the stepped part of the LCD that is fit into the panel.

**Caution:**  
During work, ensure that no foreign matter attaches to the conductive surface.

5 Mount the rubber switch onto the panel.



**Fig. 4-12**

**Fig. 4-13**

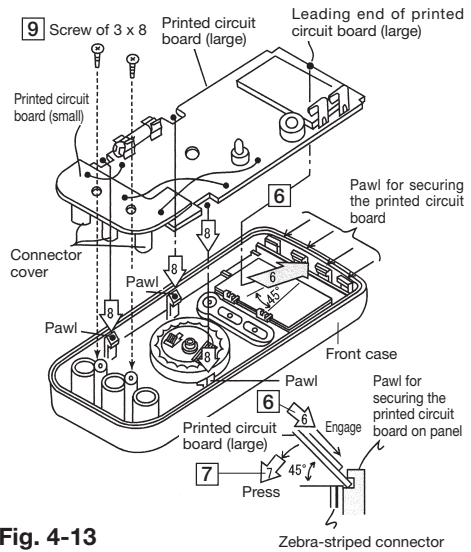
6 Fully insert the leading end of the printed circuit board (large) at an angle of about 45 degrees into the area surrounded by four circuit-board securing pawls on the panel.

7 Press the printed circuit board (large) down to the panel while strongly pressing it toward its leading end.

8 Align three notches of the printed circuit board (large) with three pawls of the panel and then snap the printed circuit board into the panel (ensure that the three notches have properly engaged with the lower parts of the pawls).

9 Attach the printed circuit board (small) to the panel by using screws of M3 x 8.

**Caution:**  
• Tighten the screws while adjusting the position of the printed circuit board (small) so that three connector covers do not deviate from the centers of their corresponding holes in the panel as viewed from the surface side of the panel.  
• Particularly note that excessively tightening the screws would damage their threads.



**Fig. 4-13**

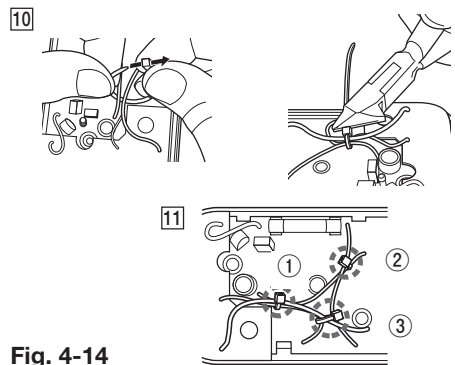
**Fig. 4-14**

10 After attaching circuit board to the front case, fasten 3 points of the cables.

11 Fasten 3 points of the cables.  
(1 V, B and COM cable, 2 V and W, 3 B, COM and W)

\*Refer page 26

**Caution:**  
Bind cables as close as possible to their roots, and cut extras.



**Fig. 4-14**

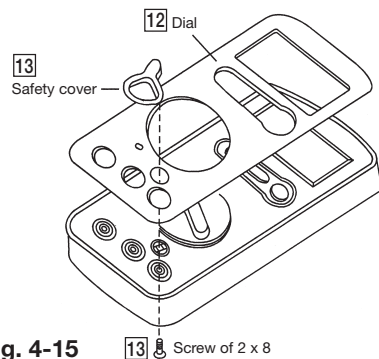
**Fig. 4-15**

12 Remove the backing sheet on the bottom of the dial and then attach the dial to the concavity in the panel.

**Caution:**  
Before attaching the dial, check that the LCD surface is free from foreign matter.

13 Pass the safety cover through the spring arm attached to the panel and then secure it with a screw of M2 x 8 from the reverse side. Once completely tighten the screw and then loose it by about a half turn to check that the safety cover rotates properly.

**Caution:**  
If the safety cover fails to return to the original position with the spring force, loosen the screw by another half turn.



**Fig. 4-15**

## 4-10 Assembling the rear case

**Fig. 4-16**

- 14 Attach the warning label after removing its backing sheet.
- 15 Remove the round rubber feet from the mounting paper board and firmly set them (2 places).
- 16 As shown in Fig. 4-18, open the stand (the figure is omitted). Attach the dial A (semitranslucent, purple-colored) to the rear case after removing the backing sheet (white) on its bottom side.  
Remove the protective film on the surface side.

**⚠ Caution:**

**Align the through-screw-hole in the dial A with the female threads in the rear case.**

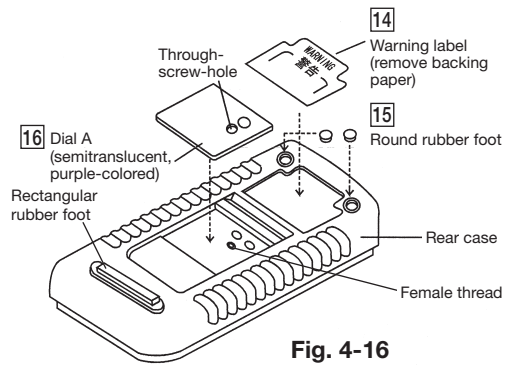
**Fig. 4-17**

- 17 Attach the battery terminals.

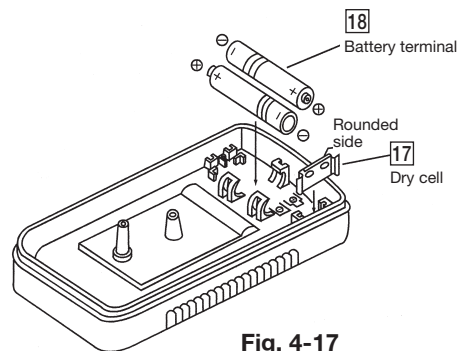
**⚠ Caution:**

**The rounded side of each battery terminal should come to the top.**

- 18 Place the dry cells with their polarities matching those engraved on the rear case.



**Fig. 4-16**



**Fig. 4-17**

## 4-11 Assembling and operation checks

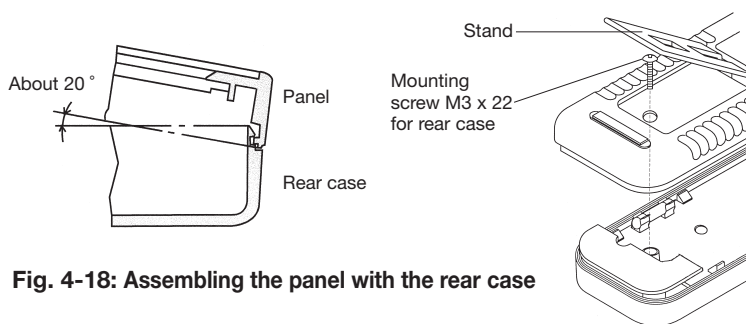
### 1. Checks before assembling the panel with the rear case (1 through 11)

Check	Order	Description
	1	Check that the printed circuit board is snapped in below 7 pawls on the panel.
	2	Check that the dial is properly attached to the panel.
	3	Check that all of the resistors and the spark gaps are soldered.
	4	Check that the connector covers do not significantly deviate from their corresponding holes in the panel.
	5	Check that the fuse is in place.
	6	Check that the battery terminals are upright before placing dry cells.
	7	Check that the polarities of the buzzer are correct.
	8	Check that the wiring lead wires are not routed above any mounting hole for the rear case or the Function switch.
	9	Check that the Function switch smoothly turns (1/3 turn).
	10	Check that the safety cover smoothly rotates (1/3 turn).
	11	Check that the rubber switch returns to the original position after it has been pressed with your finger and then released.

### 2. Assembling the panel with the rear case and subsequent work: (1) through (3)

- (1) Turn OFF the Function switch.
- (2) Completely assemble the panel with the rear case by engaging the concavity (slot) with the convexity at their respective leading ends at an angle of about 20 degrees (left side in Fig. 4-18).
- (3) Open the stand and secure the rear case to the panel by using a screw of M3 x 22 (right side in Fig. 4-18).





**Fig. 4-18: Assembling the panel with the rear case**

### 3. Checking the readout (1 through 6)

Once the reading is assembled properly, it functions as shown in the right column in accordance with the respective position of the Function switch.

Check	Order	Position of Function switch	Function
	1	V $\overline{\text{---}}$ / $\sim$	All the display elements are illuminated (see Fig. 1-3) and then AUTO RS232C $\overline{\text{---}}$ xxx.x mV is displayed (xxx.x is not constant; it always varies)
	2	$\Omega$ / $\rightarrow$ $\rightarrow$ / $\bullet$ $\rightarrow$ $\rightarrow$	AUTO RS232C O.L M $\Omega$ is displayed.
	3	$\overline{\text{---}}$ $\overline{\text{---}}$	AUTO RS232C xx.xx nF is displayed (xx.xx is not constant; it is a value approximately within the range of 00.10-00.35)
	4	400 $\bullet$ 4000 $\mu$ A $\overline{\text{---}}$ / $\sim$	AUTO RS232C $\overline{\text{---}}$ 000.0 $\mu$ A is displayed.
	5	40 $\bullet$ 400 mA $\overline{\text{---}}$ / $\sim$	AUTO RS232C $\overline{\text{---}}$ 00.00 mA is displayed.
	6	40 $\bullet$ 400 mA $\overline{\text{---}}$ / $\sim$ (Press the SELECT switch once.)	<ul style="list-style-type: none"> <li>The buzzer sounds.</li> <li>AUTO RS232C <math>\sim</math> 00.00 mA is displayed.</li> </ul>

**⚠ Caution:** If any of the display elements, which should be illuminated on the LCD in order 1, is missing, it is attributable to a contact failure due to foreign matter included somewhere between the LCD, the zebra-striped connector and the printed circuit board (large). Perform the steps in 4-9 again (page 27).

## 4-12 Adjustments

### 1. Adjustment environment

Choose an indoor location where temperature is 18-28 °C and relative humidity 75 % maximum without exposure to direct sunlight.

### 2. Order of adjustments

The PC20TK is designed to show any of the readings within the accuracy shown in "2-3 Specification" after the DCV adjustment has been completed.

(1) Set the Function switch to  $\overline{\text{---}}$  /  $\sim$  .

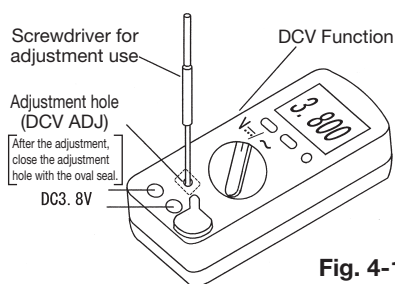
(2) Apply 3.8 VDC output from the voltage generator between the negative (COM) and positive connectors of the PC20TK.

(3) Vertically insert the insulated screwdriver (\*) for adjustment use through the DCV adjustment hole (DCV  $\bullet$  ADJ) in the panel surface and fit it into the slot in the pre-set resistor located inside. Slowly turn the screwdriver clockwise or counterclockwise so that the reading falls within the range of 3.799-3.801 V. Turning the screwdriver counterclockwise will decrease the reading, while turning it clockwise will increase the reading.

\* Applicable blade of screwdriver: 2.3 in width x 0.4-0.5 mm in thickness; shaft: 4.2 mm max. in diameter and 15 mm min. in length

(4) After the adjustment, close the adjustment hole with the oval seal (one seal is provided for spare use).

**⚠ If a standard voltage generator with high accuracy is not available, make connections as shown in (1) in Fig. 5-1 and then make an adjustment by matching the reading on the PC20TK with that of the voltmeter used as standard.**



**Fig. 4-19: DCV adjustment**



### 4-13 Layout of components on the mounting surface

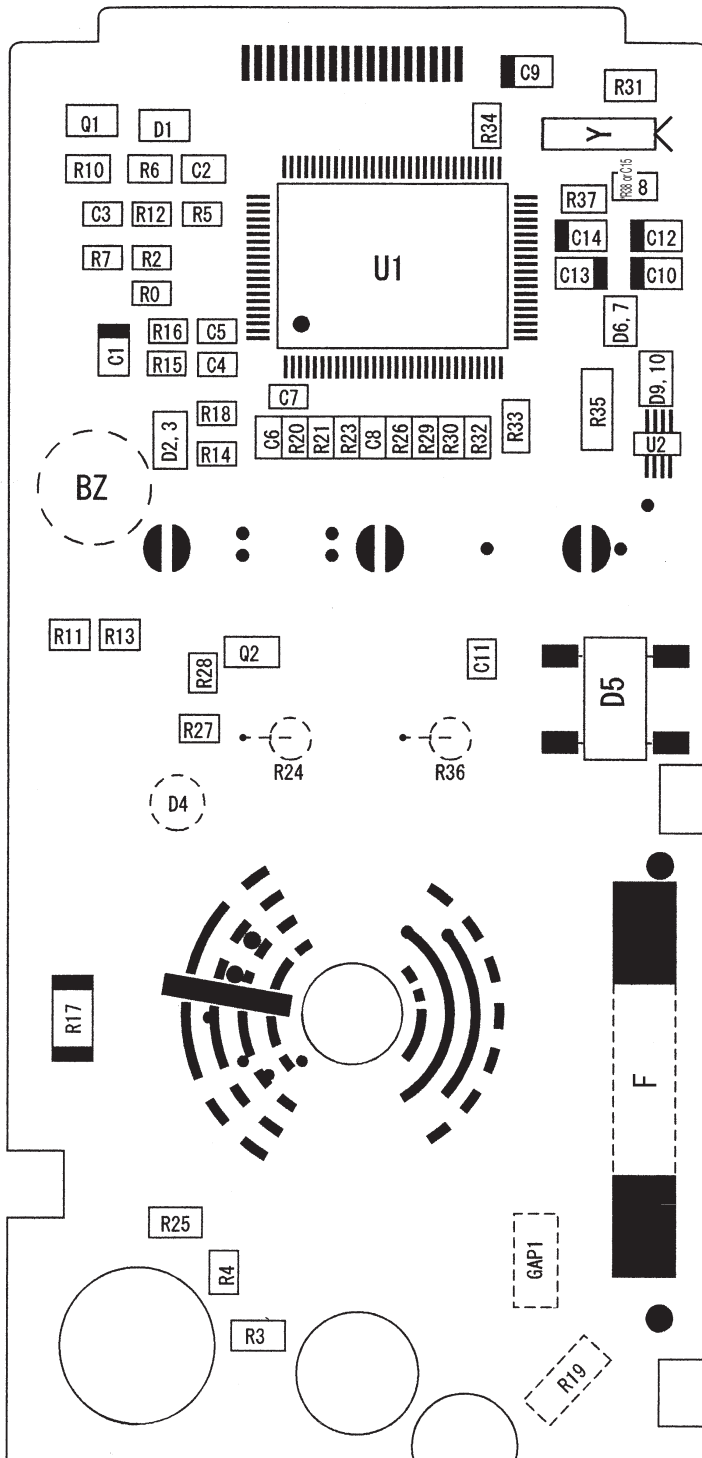


Fig. 4-20: Layout of component on the mounting surface

# 4-14 Circuit diagram of the PC20TK

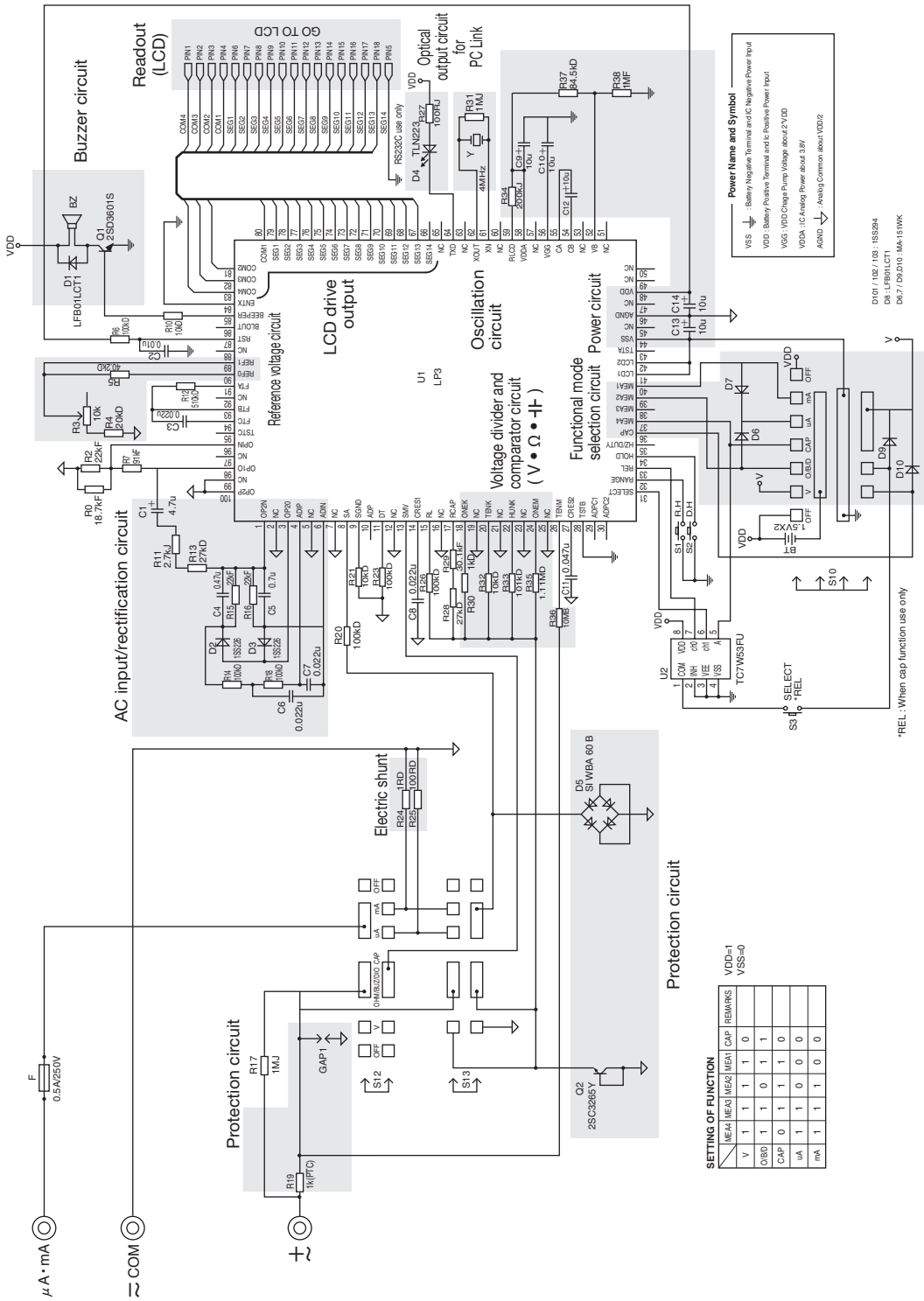


Fig. 4-21: Circuit diagram

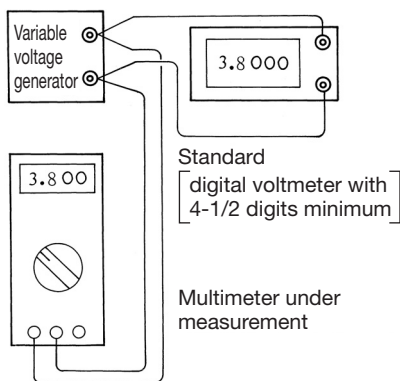
## [5] Inspection and Calibration

After the adjustments have been finished, inspect readings in each functional mode as the final stage. Based on this result, calculate error rates and accuracy, and complete "5-3 Table for test results." Obtain error rates using the equation given in "5-2 Error rate." To determine the accuracy range, perform calculations by the procedures described in "2-3 Specification" and "4 Accuracy" under "2-4 Explanation of function." If the reading on the PC20TK markedly deviates from the corresponding standard input, the possible causes include a missing component and a short-circuit due to overhanging solder in the patterns on the printed circuit boards. An error that slightly deviates from the accuracy range shown in "2-3 Specification" is attributable to a deviation as described in "4-12 Adjustments." In rare cases, the error of a circuit component is too large.

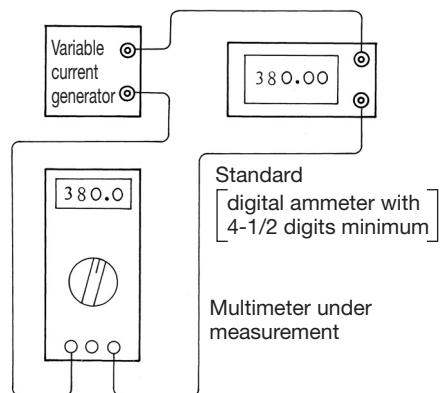
### 5-1 Calibration procedure

The PC20TK is typically calibrated by making connections as shown in Fig. 5-1, matching the reading of the unit (this multimeter) under test with the target value while changing the output from the generator, and then reading the value displayed on the generator (or reading the value displayed on the PC20TK against the standard input). Enter the calibration result as in the example of completing the table for test results on page 34. Use the test result form on page 37 or its photocopy.

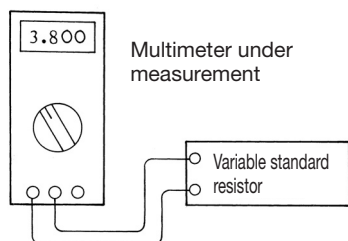
#### 1. DCV, ACV



#### 2. DC $\mu$ A • mA, AC $\mu$ A • mA



#### 3. $\Omega$



#### 4. $\ddagger$

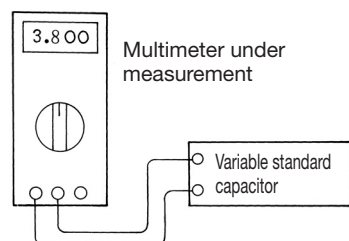


Fig. 5-1: Connections for calibration

## 5-2 Error rate

Error rate  $\varepsilon$  is represented as the percentage ratio of reading M on the unit under measurement (the PC20TK) minus true value T (reading on the standard) to true value T.

$$\varepsilon = \frac{M-T}{T} \times 100 (\%)$$

## 5-3 Example of completing the table for test results

**Table for Test Results**

Model : PC20TK Tested on : March 10, 2008  
 Serial No. : 2031234  
 Test conditions : Temperature 23 °C ; relative humidity 60 %  
 : Frequency of AC voltage and current 50 Hz Tested by: Mr. Saburo Sanwa

Functional mode /range	Reading M on PC20TK (displayed value)	Reading T on standard (true value)	Error rate $\varepsilon$	Accuracy range
DC 400 mV	380.0 mV	378.01 mV	+0.53 %	376.0~384.0 mV
DC 4 V	3.800 V	3.7752 V	+0.66 %	3.760~3.840 V
DC 40 V	38.00 V	37.732 V	+0.71 %	37.60~38.40 V
DC 400 V	380.0 V	378.21 V	+0.47 %	376.0~384.0 V
DC 750 V	600 V	594.1 V	+1.00 %	592~608 V
AC 4 V	3.800 V	3.8338 V	-0.88 %	3.734~3.866 V
AC 40 V	—	—	—	—
AC 400 V	380.0 V	384.04 V	-1.05 %	373.8~386.2 V
AC 750 V	—	—	—	—
DC 400 $\mu$ A	380.0 $\mu$ A	377.52 $\mu$ A	+0.66 %	374.1~385.9 $\mu$ A
DC 4000 $\mu$ A	—	—	—	—
DC 40 mA	38.00 mA	37.631 mA	+0.98 %	37.41~38.59 mA
DC 400 mA	—	—	—	—
AC 400 $\mu$ A	—	—	—	—
AC 4000 $\mu$ A	3800 $\mu$ A	3815.1 $\mu$ A	-0.39 %	3719~3881 $\mu$ A
AC 40 mA	—	—	—	—
AC 400 mA	380.0 mA	383.73 mA	-0.97 %	371.9~388.1 mA
† 40 nF	—	—	—	—
† 400 nF	—	—	—	—
† 4 $\mu$ F	2.200 $\mu$ F	2.1049 $\mu$ F	+4.52 %	2.040~2.360 $\mu$ F
† 40 $\mu$ F	10.00 $\mu$ F	9.761 $\mu$ F	+2.45 %	9.24~10.76 $\mu$ F
† 100 $\mu$ F	—	—	—	—
$\Omega$ 400 $\Omega$	200.0 $\Omega$	198.56 $\Omega$	+0.72 %	196.5~203.5 $\Omega$
$\Omega$ 4 k $\Omega$	—	—	—	—
$\Omega$ 40 k $\Omega$	20.00 k $\Omega$	19.901 k $\Omega$	+0.50 %	19.65~20.35 k $\Omega$
$\Omega$ 400 k $\Omega$	—	—	—	—
$\Omega$ 4 M $\Omega$	1.000 M $\Omega$	0.9906 M $\Omega$	+0.95 %	0.980~1.020 M $\Omega$
$\Omega$ 40 M $\Omega$	—	—	—	—





## [6] Calculation Problems for Input Circuit

### 6-1 Voltage measurement circuit

- When the input voltage is 1000 V in Fig. 6-1, find R in  $\Omega$  with which 1 V is obtained as the standard output (uniform different units of resistance for calculation). Assume that the input resistance of the LSI connected to the output connector is infinite ( $\infty$ ).

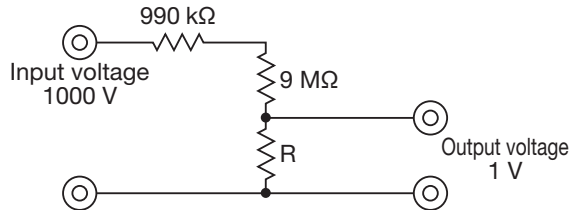


Fig. 6-1

$$1 \text{ V} = \frac{\boxed{R} \text{ k}\Omega}{990 \text{ k}\Omega + \boxed{\phantom{00}} \text{ M}\Omega + \boxed{R} \text{ k}\Omega} \cdot \boxed{\phantom{00}} \text{ V}$$

- Circuit using an OP amplifier

In Fig. 6-2, when the input voltage is 500 V, the output voltage is 0.5 V. Find the value for R. As one of the characteristics of the OP amplifier, the resistance between a and b in Fig. 6-2 is infinite ( $\infty$ ), but the electrical potential difference is 0 (this is called imaginable short).

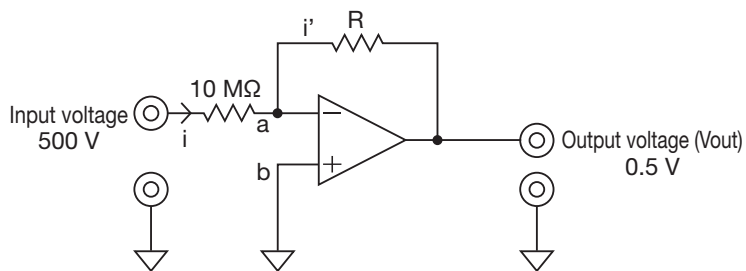


Fig. 6-2

$$i = i' \text{ hence, } \frac{500 \text{ V}}{10 \text{ M}\Omega} = \frac{V_{\text{out}}}{R}$$

## 6-2 Current measurement circuit

When the input current is 400 mA in Fig. 6-3, find electric shut resistor  $R$  in  $\Omega$  with which the output voltage of 400 mV is obtained. Create an equation to find  $R$ . Assume that the input resistance of the LSI connected to the output connector is infinite ( $\infty$ ).

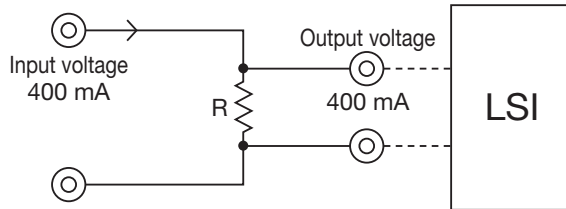


Fig. 6-3



## 6-3 Resistance measurement circuit

Assume that the output voltage is 0.5 V when resistor  $R_x$  under measurement is connected to the input connector in Fig. 6-4. Find the value for  $R_x$ . (See Fig. 3-9 on page 15.) Also find  $R_x$  when the output voltage is 0.2 V. As explained in item 2 under 6-1, the resistance between a and b in Fig. 6-4 is infinite ( $\infty$ ), but the electric potential difference is 0.

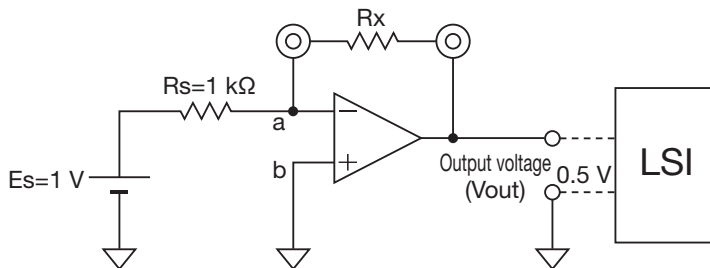


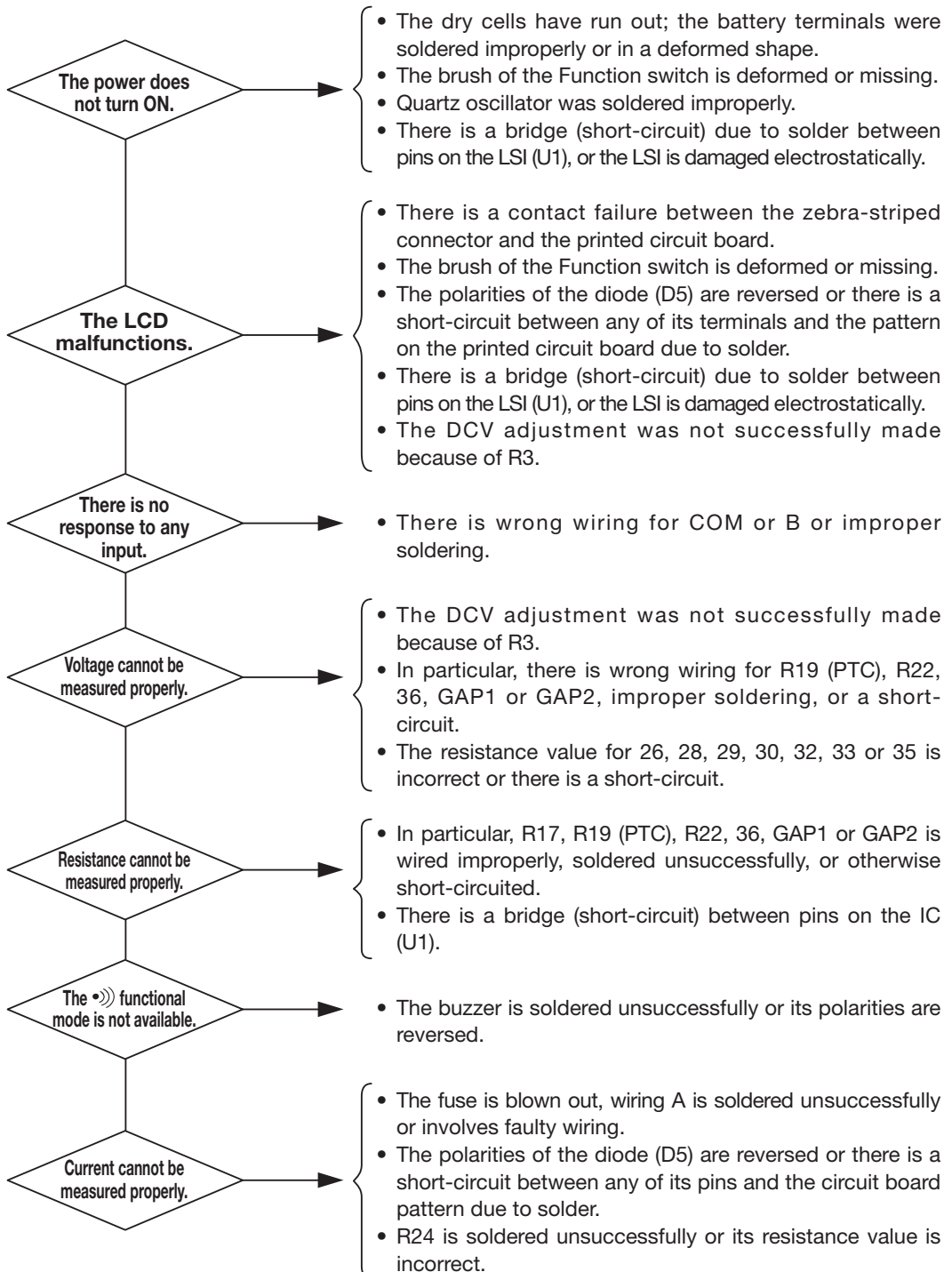
Fig. 6-4





## [7] Overview of Troubleshooting

First check that the printed circuit boards are properly snapped into the panel and that the dry cells are placed in correct polarities.



## [8] After-sale Service

### 8-1 Repair service at customer's expense

**1. Before requesting our repair service, check that:**

- the built-in fuse is not blown out;
- the built-in dry cells have not run out; and
- the test leads are not broken.

**2. Repair service period**

Repair components will be retained in stock for a minimum period of 6 years after the discontinuance of manufacture. We accept your repair request during this period. However, note that some semiconductors may become unavailable earlier because of difficulties in purchasing them.

**3. Repair service charge**

If excessively large voltage is applied exceeding the function of the overload protection circuit and damages the LSI (malfunction), the circuit boards (burned patterns), or any other expensive main component, the repair service charge may exceed the purchase cost. In such a case, it is recommended that a new product be purchased. The transportation charges for sending your PC20TK to us and returning it to you are to be borne by you along with the repair charge.

**4. Address for sending your PC20TK**

In order to ensure the safe transportation of the PC20TK, place it in a box having volume of at least 5 times the product size and fill the space with sufficient pad or filler. Mark the box as "Product to be repaired."

**Customer Service Section, Hamura Factory,  
Sanwa Electric Instrument Co., Ltd.**

4-7-15 Shinmeidai, Hamura City, Tokyo 205-8604 Japan  
TEL (042) 554-0113 / FAX (042) 555-9046

### 8-2 Repair fuses

To place an order for fuses, specify the size and rating of your fuse as well as this model and remit the amount of the fuses required.

### 8-3 Information request

Tokyo Head Office : TEL (03) 3253-4871 / FAX (03) 3251-7022  
Osaka Sales Office : TEL (06) 6631-7361 / FAX (06) 6644-3249  
E-mail : exp\_sales@sanwa-meter.co.jp  
Our website : <http://www.sanwa-meter.co.jp>

### 8-4 Accessories sold separately

- Current probes: CL-22AD, CL-20D and CL33DC
- PC connection cable for Optical Link via RS232C: KB-RS1
- Holster: H-70
- Temperature probe: T-300PC
- PC Link software
- Clip adapter: CL-11

### 8-5 Books for reference

The following reference books are available, which explain the construction and principle of testers and the relevant measuring methods in an easy-to-understand manner:

- "100 % Effective Use of Your New Tester" published by CQ Publishing Co., Ltd.
- "Effectively Using Your Digital Tester" published by Testugaku Shuppan Co., Ltd.

 **Caution**

1. To keep the panel or case clean, please wipe it with a dry, soft cloth. Do not use thinner or alcohol-based solvents because these can harm the finish.
2. Please do not leave this unit next to any direct source of high heat (like a soldering iron).
3. Please do not leave this unit in any place where it will be exposed to direct sunlight, high temperatures, high humidity, low temperatures, or dew condensation.
4. Please do not store this unit in any place where it will be exposed to too much vibration or in a place where it might fall and become damaged.
5. Please remove the internal battery before storing the unit for extended periods of time.

Class	
Name	

# sanwa®

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