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Green Pot : Conductive Plastic Potentiometer

Green Pot is the general term that Midori has used for conductive plastic contact potentiometer.
Green Pot is identified by Green-colored name plate attached to the part.
Conductive plastic element is the unibody element in which a purified carbonaceous filler was brought to the surface of the plastic resin as a thick film resistor using heat. There are two different types of element: Co-mold element type in which the resistive element has an extreme mirror surface sliding face, and the less expensive Screen element type in which the carbon film is printed on a plastic base to create the resistive element.

Features

1. Co-mold Element

Forming base materials, resistive element, and corrector spring are formed together. There is mechanical stability and durability against vibration and shock compared to wire wound potentiometer.

2. Screen Element

Screen element delivers equal performance to that of Co-mold Element and moreover also provides superior cost-effectiveness.

3. Resolution

Output resolution is practically infinite.

4. Long Life

Conductive plastic element has smooth surface. Therefore, there is less wear between the element surface and the wiper contact point.

5. Temperature Effect

Resistive temperature characteristic of conductive plastics is higher than that of wire wound potentiometer. There are two types: ±400ppm/K and ±1000ppm/K.
Therefore, in case of using the Green Pot as a variable resistor, effect of temperature is direct but in case of using Green Pot as potentiometer, the effect of temperature is small.

6. High Frequency Characteristic

Integral molded resistive element for Green Pot has lower inductance compared to that of wire wound and is able to create stable output under the frequency of 100kHz MAX.

7. Low Outgas Generation

In the high vacuum like in space, plastic produces gas and it has a potentially detrimental effect on electric devices.
Conductive plastic element of Green Pot produces less gas in the high vacuum, therefore it has been used in satellite application.

8. Fast Response

Since Green Pot adopted extreme mirror surface resistive element and multi-contact wiper, it is capable to measure at up to 3m/s shaft rotational speed in a single rotation. In continuous rotation, it is capable to measure at up to 1m/s shaft rotational speed.
(Take model CPP-45 for example, it is capable to read out at rotations at up to 2000rpm within a single rotation and up to 600rpm in continuous use)
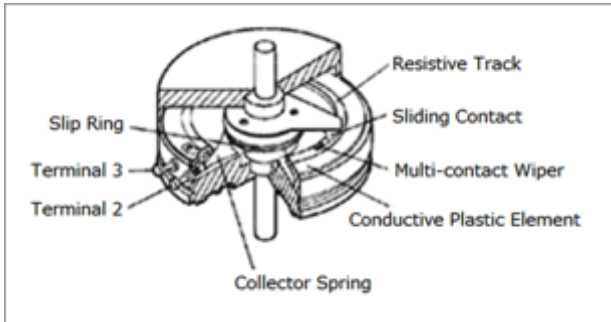
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Principle

Sliding Method

Sliding method is different slightly for each model but Green Pot has mainly adopted the following methods:

1. Angle Sensor

   Resistive Part: Noble metal alloy multi-contact wiper
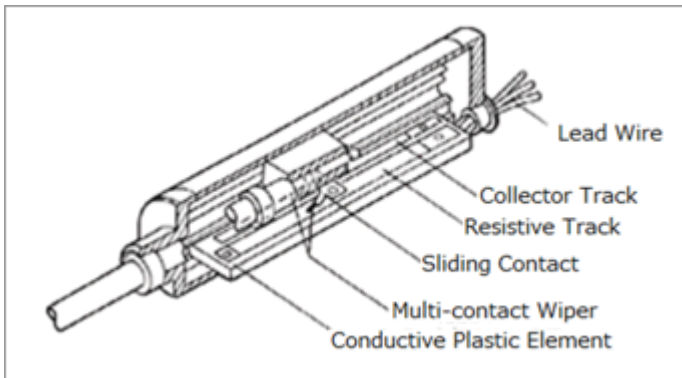
   Collector Part: Combination of a noble metal alloy spring ring and a collector spring

2. Linear Sensor

Resistive Part: Noble metal alloy multi-contact wiper

Collector Part: Combination of collector track and multi-contact wiper
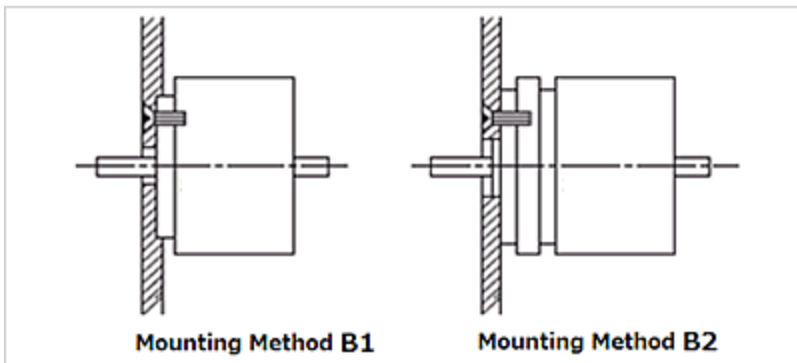
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Mounting Instruction

Mounting Method

(1) Bushing Mount (Mounting Method A)

•Insert threaded part of pot through from the back side of mounting board and fasten the pot by a nut with washer.

•Be sure to place a washer behind of the nut.

•As for the pot with a stopper pin, make a hole for a stopper pin on a mounting board.

•Do not rotate the pot itself when tightening the nut. This may cause malfunction of the sensor.

•Do not over tighten the nut. This may damage the threaded part of the pot.
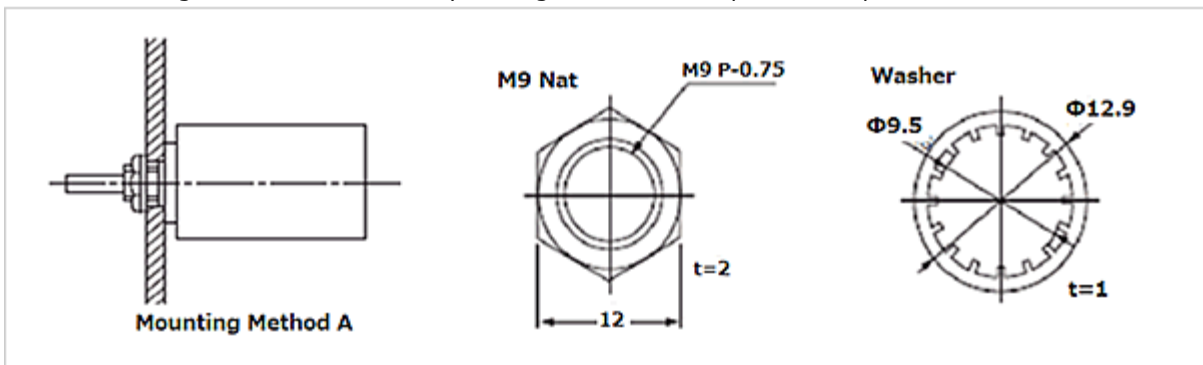

(2) Screw Mount (Mounting Method B1 and B2)

•Fasten the pot with screws into the tapped holes which is on the mounting surface of the Pot.

•Please use certain length of screw.

•In case of selecting mounting method 'B1', create a shaft hole on the mounting board which diameter is larger than the pot shaft diameter.

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(3) Servo Mount (Mounting Method C1 and C2)

•Install a pot on the mounting board using mounting cleats .

•Make hole to fit diameter of matching flange.

•Do not tighten the screws for the mounting cleats until pot body is fixed at the desired position.

•Gears or couplings on the shaft smaller than diameter of mounting hole may be more convenient for installation.

•In case of using mounting method 'C1', place a few mounting cleats equally spaced by mounting hole.

•If there is no space to place the mounting cleats, it is recommended to use mounting method 'C2'.

Mounting Method C1   Mounting Method C2
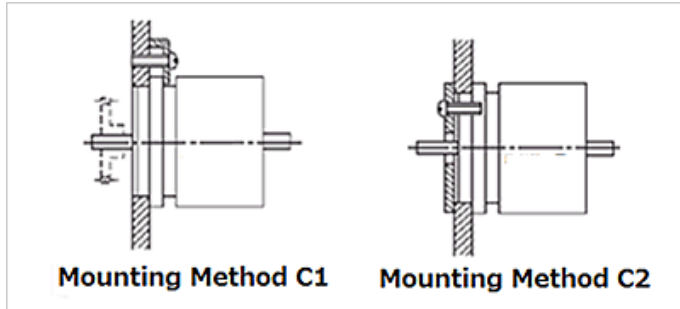
①	CP-2F	
②	Abolishment	
③	CPP-35 CPP-35B	
④	CP-45H CPP-45 CPP-45B CPP-5S	
⑤	CPP-60	

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Effects of Loading

If finite load resistance is loaded on sensor output, linearity will become distorted as expressed in the following equation.
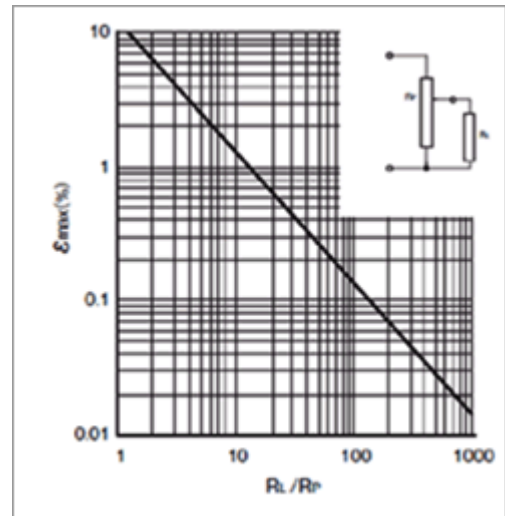
$$E \max = \frac{14.8}{\dfrac{RL}{RP} + 0.22} \ (\%)$$

Emax : Maximum linearity distortion caused by load resistance
RP : Total Resistance of Potentiometer
RL : Load Resistance

Show above equation in a graphic form, as shown right:

JEITA (Japan Electronics and Information Technology Industries Association) recommends that the added load resistance should be more than 100 times of the total resistance.

The higher the load resistance, the less effect of electrical noise on the output of the potentiometer. It is also effective in increasing the durability of the Green Pot.

Equivalence Noise Resistance and Load Resistance

Contact potentiometer generates the equivalence noise resistance because of its structure. It is possible to reduce the effect of noise resistance on the output by adding large load resistance to the potentiometer.

The equivalence noise resistance is expressed "Re" as shown the right figure.

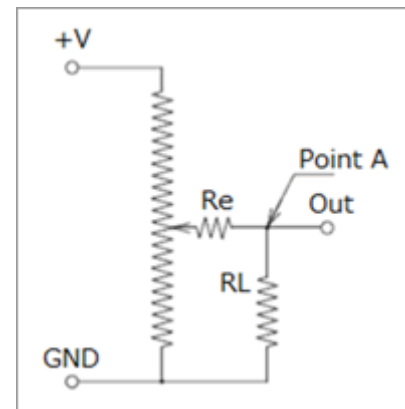Voltage at point A is divided as shown the formula below.

$$Va = RL / (Re + RL) \times Vout$$

Va: Voltage at point A
Vout: Output voltage of Potentiometer
RL: Load Resistance
Re: Equivalence Noise Resistance

For example, if +V= 10V, Re= 100Ω, and RL= 10KΩ, output of each angle is as shown below:

Pot Postion / Va (V)	Ratio Conversion (%)	Error (%)
at 10% / 0.99	9.90	-0.10
at 30% / 2.97	29.70	-0.30
at 50% / 4.95	49.50	-0.50
at 70% / 6.93	69.31	-0.69
at 90% / 8.91	89.11	-0.89

But if RL= 100KΩ then the error becomes smaller as shown below:

Pot Postion / Va (V)	Ratio Conversion (%)	Error (%)
at 10% / 1.00	9.99	-0.01
at 30% / 3.00	29.97	-0.03
at 50% / 5.00	49.95	-0.05
at 70% / 6.99	69.93	-0.07
at 90% / 8.99	89.91	-0.09

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Reducing Power

It is necessary to decrease the rated dissipation by the condition of the (1) Operating Temperature, (2) Load Resistance, (3) (4) Specifications to avoid damaging resistive element.

(1) Operating Temperature

(2) Load Resistance

(3) Electrical Travel

(4) Multi-Gang
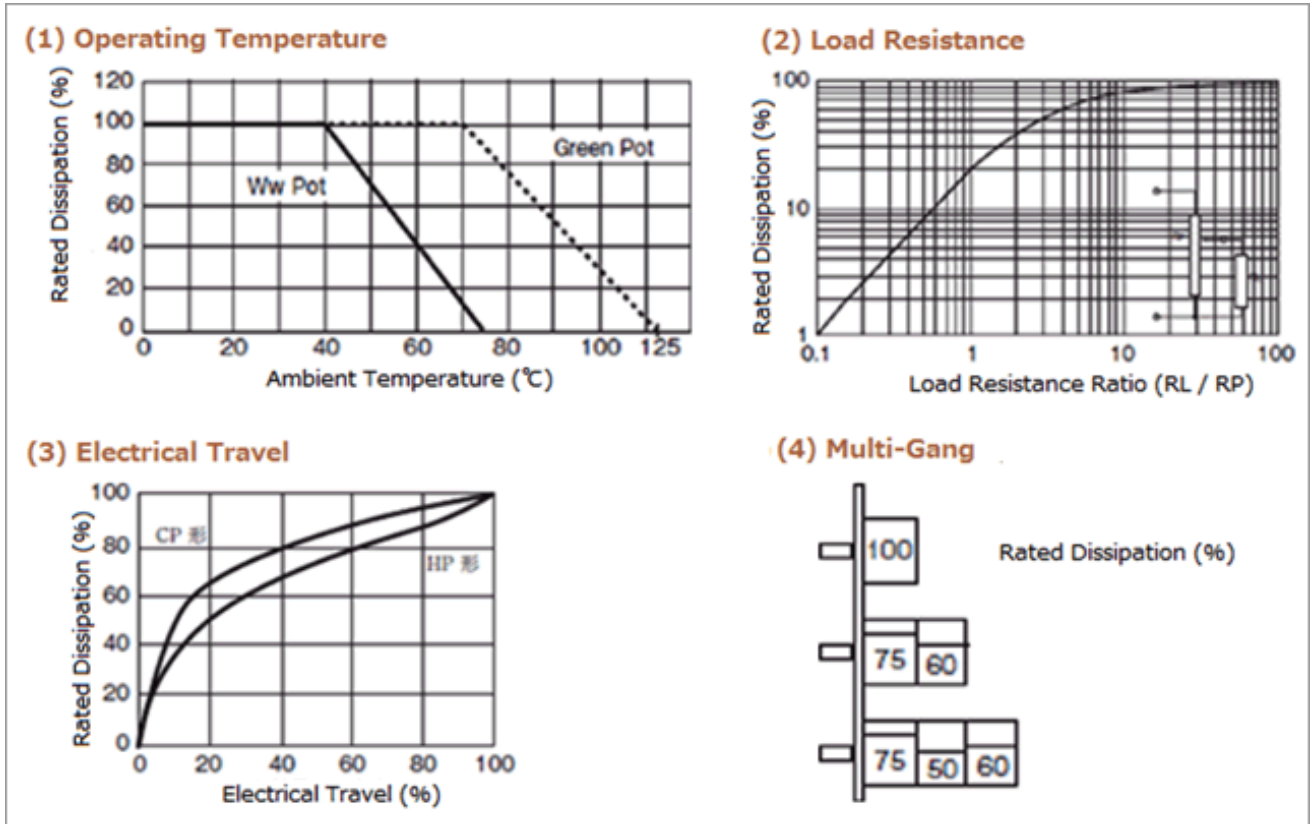
Input Voltage

Maximum input voltage (V) defined by the rated dissipation can be calculated by using the following formula.

$$V = \sqrt{W \times R}$$

V: Maximum Input Voltage

R: Total Resistance - Total Resistance Tolerance

W: Rated Dissipation

Shorted Segment

It is an area of the resistive element where the area has fixed output voltage ratio. The area is not included in the total effective electrical travel.

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The Difference between Shorted Segment and Extra Segment

Depending on the process of resistive element, extra segments might be added outside of the total electrical angle. Voltage output characteristics of short segment and extra segment are both the same but in reading resistance value, there is difference as shown in the below charts. In extra segment, it is necessary to place terminals at the designated angle.
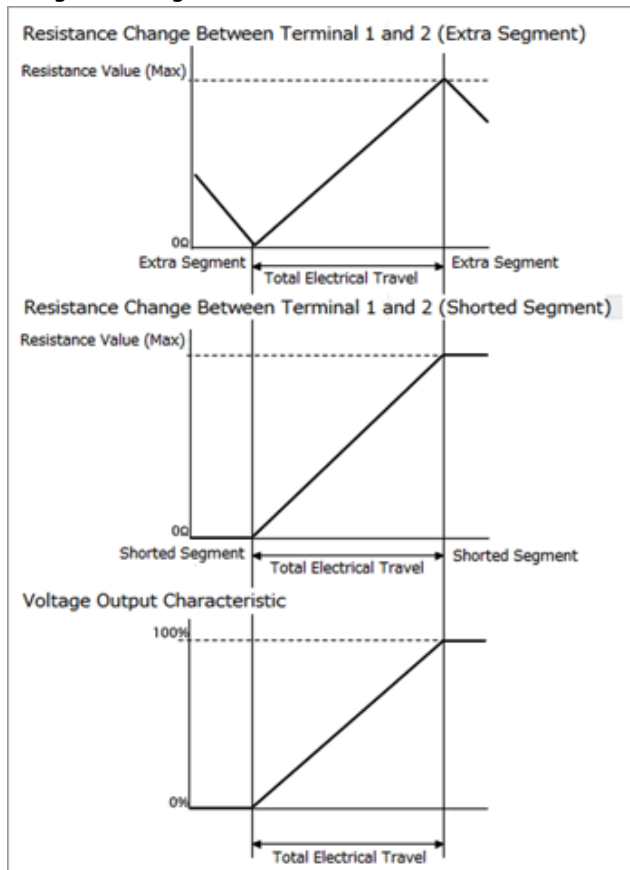
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Center Tap

Green Pot also offers the option for center tap (C.T) to de added like Wire Wound Pot. Unlike Wire Wound Pot, it is not easy to install the center tap at any position.
Conductive plastic resistive element is molded or should be printed the resistive track, the terminals, and the taps together. It is necessary to perform separate specific process even just for adding one piece of center tap.
Normally, there is shorted segment around a tap position (B-Tap). To change the process of tap addition, it is available to remove most all of the shorted segment (A-Tap). However, as for A-Tap, it has the characteristics of a slightly higher resistance value than typical pot. We will select B-Tap if tap condition is not specified.

Tap Condition
C.T (A) : There is a little resistance between tap and resistive element but this has little impact on output.
C.T (B) : Normally use for input. There is shorted segment approx. 0.5° -5° and output will be flat in the range.

Example of Schematics and Output Characteristics of Center Tap
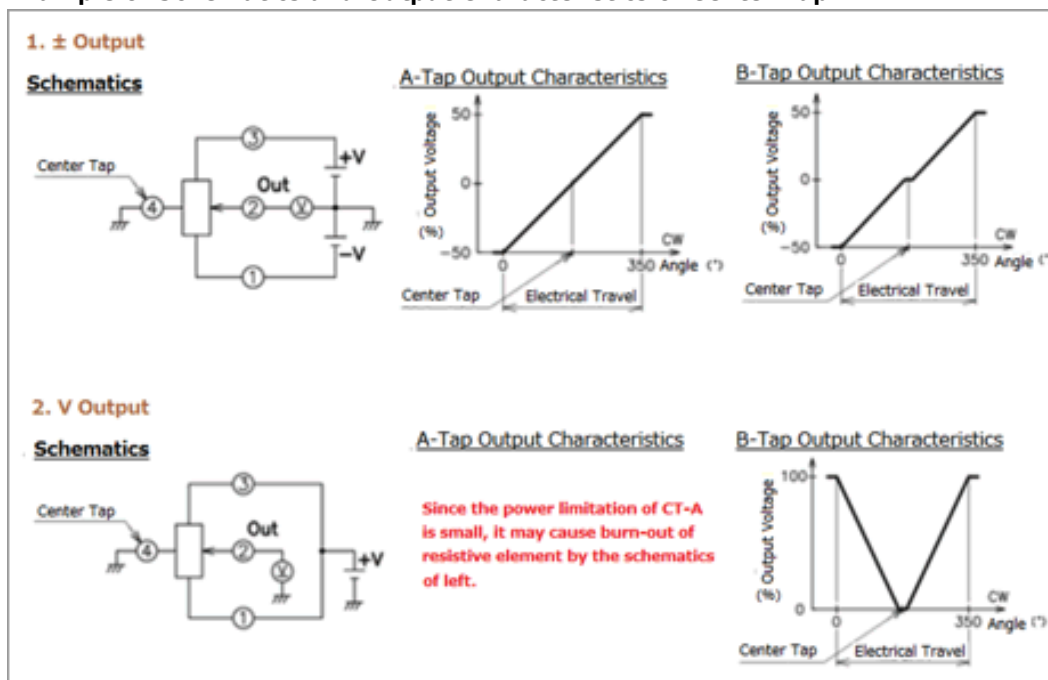
Operating Suggestions

If Green Pot is used in an environment with vibration or dither operation, resistive element may become partially worn by a sliding wiper causing shorter lifetime of the Green Pot.
Contactless sensor such as Blue Pot and Orange Pot are more suitable for those kinds of operating environment.

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Burnout of Resistive Element

1. Wiring
Potentiometer is used for obtaining output voltage ratio from input voltage. Therefore, apply DC voltage (Vin) and read out the voltage (Vout) between output terminal and GND. Do not use potentiometer as a variable resistor.

2. Load Resistance
We recommend to add load resistance that is more than 100 times of the total resistance value. If added load resistance is low, current flow at power-supply line (Terminal 1 to 3 or lead wire black to red) will flow to the output line (Terminal 1 to 2 or lead wire white to red) and may cause burnout of resistive element when wiper at low-value resistance position. To avoid burn-out the resistive element, set wiper current lower than 1mA.

3. Miswiring
If output terminal (or output lead wire) is connected to power-supply line, it will increase the chance of burning out the resistive element.

4. Multimeter
When checking total resistance or measuring resistance value of Green Pot by analog multimeter, increase the range of the analog multimeter to make the needle move widely and higher current flow may be generated. Please use analog multimeter with lower range than 1mA or we recommend to use the digital multimeter.

5. Over Rated Dissipation
If over voltage such as surge is supplied to potentiometer, it will cause burnout of the resistive element.

Handling Instruction

Potentiometers are precisely assembled and adjusted. Please handle them carefully as a precision device.

1.
•Do not disassembling the pot.
•Do not modify the Pot
(May effect the precision and cause malfunction.)

2.
•Do not drop the Pot.
•Do not strike one part against another
(May damage the terminals or cause wires to disconnect.)

3.
•Do not apply excessive voltage or current.
(May damage resistive element an electronic Components.)
•make sure to use digital tester.
(may damage resistive element and electronic components if analog tester is used.)

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4.

•Mount without tapping or squeezing into a panel.

•Use suitable tools

(May break or cause failure.)

5.

•Use wire that has sufficient length for connection terminals.

•Use wire less than 0.3mm2 (AWG22) in cross section.

(Insufficient length of wire or use of larger wire may cause damage to the terminals or disconnection inside the pot.)

6.

•Be sure to connect appropriately.

•Do not apply voltage on output terminals.

(May damage resistive element and electronic components.)

7.

•Solder no more than 5 seconds at 300°C MAX.

(High temperature may damage inside of pot.)

8.

•Do not apply excessive torque to the mechanical stopper of rotary type pot.

(may cause breakage of stopper. Stopper strength: 0.3-0.5N.m MAX. typical)

9.

•Do not immerse in water or pour water or chemicals on the pot.

(may cause output failure)

10.

•Observe precautions for handling electrostatic discharge sensitive devices.

(Orange Pot is using the electrostatic discharge sensitive semiconductor circuits.)

11.

Do not store pot in the following conditions.

- High humidity

- Dusty environment

- Place where salinity or corrosive gases are present.

- Vibrating place

Units

The units in the web site is the International System of Units (SI).

Torque	1kgf·m＝9.80655N·m、1N·m＝0.10197kgf·m＝101.97gf·m
Force	1kgf＝9.80655N、100gf＝980.655mN、1N＝0.10197kgf＝101.97gf、5N＝approx.500gf
Acceleration	$1G=9.80655m/s^2$ 、$150m/s^2$＝approx. 15G、$500m/s^2$＝approx. 51G
Magnetic Flux Density	$1G=1x10^{-4}$ T

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In addition to the Handling Instructions in this web site, please read the following guidelines with a good understanding of its contents:
- Manufacturing date indication (JEITA RC-0901)
- Precautions of potentiometer (JEITA RCR-2191A)
- Safety Application Guide on Components for Electric Devices and Electric Manufactures (JEITA RCR-1001B)

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