ROHM
SEMICONDUCTOR

Secondary LDO Regulator Series for Local Power Supplies

1A Secondary LDO Regulators for Local Power Supplies

Pb Free — ROHM Electronic Components
RoHS Directive Compliance

BA☐☐BC0 Series,BA☐☐BC0W Series,BA00BC0W Series　　　　No.09024EAT02

●**Description**
　The BA☐☐BC0 are low-saturation regulators with an output current of 1.0 A and an output voltage accuracy of ±2%. A broad output voltage range is offered, from 1.5V to 10V, and built-in overcurrent protection and thermal shutdown (TSD) circuits prevent damage due to short-circuiting and overloading, respectively.

●**Features**
1) Output current: 1 A (min.)
2) Output voltage accuracy: ±2%
   Broad output range available: 1.5 V -10 V (BA☐☐BC0 series)
3) Low saturation-voltage type with PNP output
4) Built-in overcurrent protection circuit
5) Built-in thermal shutdown circuit
6) Integrated shutdown switch (BA☐☐BC0WT, BA☐☐BC0WT-5, or BA☐☐BC0WFP Series, BA00BC0WCP-V5)
7) Operating temperature range: −40°C to +105°C

●**Applications**
　All electronic devices that use microcontrollers and logic circuits

●**Product Lineup**

Part Number	1.5	1.8	2.5	3.0	3.3	5.0	6.0	7.0	8.0	9.0	10.0	Variable	Package
BA☐☐BC0WT	O	O	O	O	O	O	O	O	O	O	O	O	TO220FP-5
BA☐☐BC0WT-V5	O	O	O	-	O	O	-	-	-	O	-	O	TO220FP-5 (V5)
BA☐☐BC0WFP	O	O	O	O	O	O	O	O	O	O	O	O	TO252-5
BA☐☐BC0T	O	O	O	O	O	O	O	O	O	O	O	-	TO220FP-3
BA☐☐BC0FP	O	O	O	O	O	O	O	O	O	O	O	-	TO252-3
BA00BC0WCP-V5	-	-	-	-	-	-	-	-	-	-	-	O	TO220CP-V5

Part Number: BA☐☐BC0☐ ☐
　　　　　　　　 a 　　b c

Symbol	Description			
	Output voltage specification			
	☐☐	Output voltage (V)	☐☐	Output voltage (V)
a	15	1.5 V typ	60	6.0 V typ
	18	1.8 V typ	70	7.0 V typ
	25	2.5 V typ	80	8.0 V typ
	30	3.0 V typ	90	9.0 V typ
	33	3.3 V typ	J0	10.0 V typ
	50	5.0 V typ	00	Variable
b	Existence of switch　With W: A shutdown switch is provided. Without W: No shutdown switch is provided.			
c	Package　　　　T:　TO20FP-5, TO220FP-5(V5), TO220FP-3 FP: TO252-5, TO252-3 CP: TO220CP-V5			

● **Absolute Maximum Ratings** (Ta = 25°C)

Parameter		Symbol	Limits	Unit
Power supply voltage		Vcc	18[*1]	V
Power dissipation	TO252-3	Pd	1200[*2]	mW
	TO252-5		1300[*3]	
	TO220FP-3		2000[*4]	
	TO220FP-5		2000[*4]	
	TO220FP-5 (V5)		2000[*4]	
	TO220CP-V5		2000[*4]	
Operating temperature range		Topr	−40 to +105	°C
Ambient storage temperature		Tstg	−55 to +150	°C
Maximum junction temperature		Tjmax	150	°C

*1 Must not exceed Pd.
*2 Derated at 9.6mW/°C at Ta>25°C when mounted on a glass epoxy board (70 mm × 70 mm × 1.6 mm).
*3 Derated at 10.4mW/°C at Ta>25°C when mounted on a glass epoxy board (70 mm × 70 mm × 1.6 mm).
*4 Derated at 16mW/°C at Ta> 25°C

● **Recommended Operating Conditions**

Parameter	Symbol	Min.	Max.	Unit
Input power supply voltage	Vcc[*5]	3.0	16.0	V
Input power supply voltage	Vcc[*6]	Vo+1.0	16.0	V
Output current	Io	-	1	A
Variable output voltage setting value	Vo	1.5	12	V

*5 When output voltage is 1.5 V, 1.8 V, or 2.5 V.
*6 When output voltage is 3.0 V or higher.

● **Electrical Characteristics**
BA□□BC0FP/T/WFP/WT (−V5)
(Unless otherwise specified, Ta = 25°C; VCTL = 3 V; VCCDC[*7])

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Output voltage	Vo	Vo (T) ×0.98	Vo (T)	Vo (T) × 1.02	V	Io = 200mA
Shutdown circuit current	Isd	-	0	10	μA	VCTL = 0 V while in off mode
Minimum I/O voltage difference[*8]	ΔVd	-	0.3	0.5	V	Io = 200 mA, Vcc = 0.95 × Vo
Output current capacity	Io	1	-	-	A	
Input stability[*9]	Reg.I	-	15	35	mV	Vcc = Vo+1.0V→16V, Io = 200mA
Load stability	Reg.L	-	35	75	mV	Io = 0 mA →1 A
Temperature coefficient of output voltage[*10]	Tcvo	-	±0.02	-	%/°C	Io = 5 mA、Tj = 0°C to 125℃

Vo (T): Set output voltage
*7   Vo = 1.5 V, 1.8 V, 2.5 V : Vcc = 3.3 V, Vo = 3.0 V, 3.3 V : Vcc = 5 V,
      Vo = 5.0 V : Vcc : 8 V, Vo = 6.0 V : Vcc = 9 V, Vo = 8.0 V : Vcc = 11 V,
      Vo = 9.0 V : Vcc = 12 V, Vo = 10.0 V : Vcc = 13 V
*8   Vo ≥ 3.3 V
*9   Change Vcc from 3.0 V to 6 V if 1.5 V ≤ Vo ≤ 2.5 V.
*10   Operation guaranteed

BA00BC0WFP/WT (−V5)/CP-V5
(Unless otherwise specified, Ta = 25°C, Vcc = 3.3 V, VCTL = 3 V, R1 = 30 kΩ, R2 = 30 kΩ[*11])

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Shutdown circuit current	Isd	-	0	10	μA	VCTL = 0 V while in OFF mode
Reference voltage	Vc	1.225	1.250	1.275	V	Io = 50 mA
Minimum I/O voltage difference	ΔVd	-	0.3	0.5	V	Io = 500 mA, Vcc = 2.5V
Output current capacity	Io	1	-	-	A	
Input stability	Reg.I	-	15	30	mV	Vcc = Vo + 1.0 V→16V, Io = 200 mA
Load stability	Reg.L	-	35	75	mV	Io = 0 mA →1A
Temperature coefficient of output voltage[*12]	Tcvo	-	±0.02	-	%/°C	Io = 5mA, Tj=0°C to 125°C

*11 VOUT = Vc × (R1 + R2) / R1 (V)
*12 Operation guaranteed

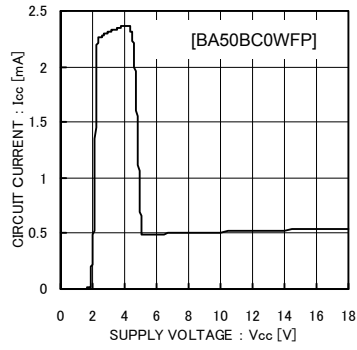●**Electrical Characteristics Curves** (Unless otherwise specified, Ta = 25°C, Vcc = 8 V, VCTL = 2 V, Io = 0 mA)
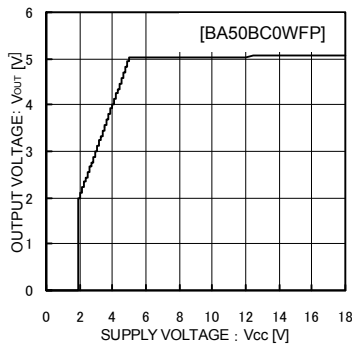

Fig.1 Circuit Current

Fig.2 Input Stability(Io=0mA)
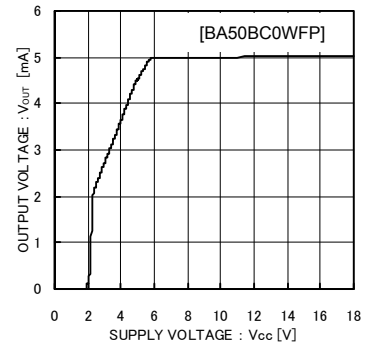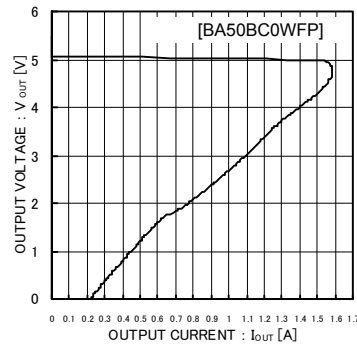

Fig.3 Input Stability(Io = 1 A)
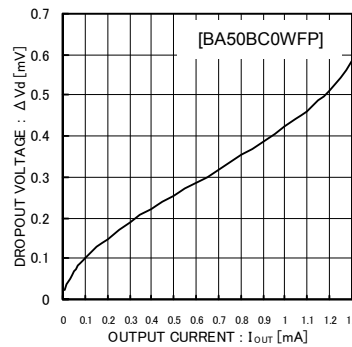

Fig.4 Load Stability
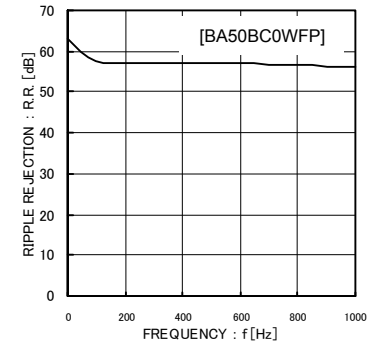

Fig.5 I/O Voltage Difference
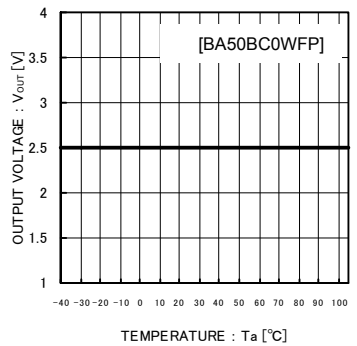

Fig.6 Ripple Rejection
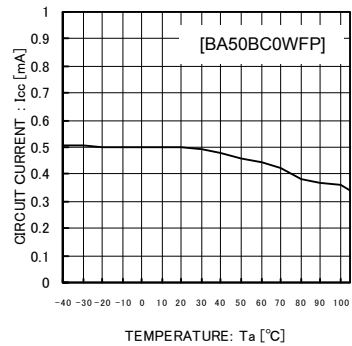

Fig.7 Output Voltage vs Temperature
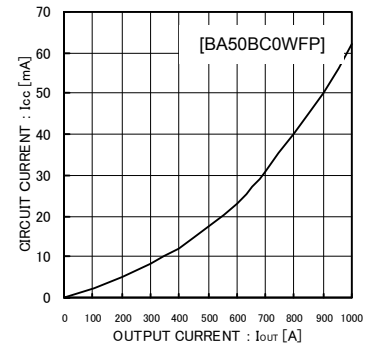

Fig.8 Circuit Current Temperature

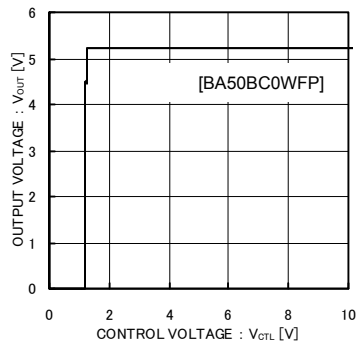Fig.9 Circuit Current Classified by Load

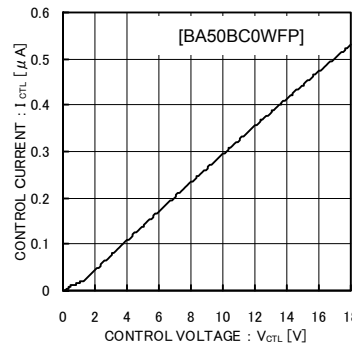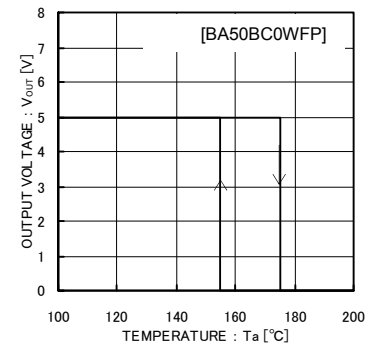Fig.10 CTL Voltage vs Output Voltage

Fig.11 CTL Voltage vs CTL Current

Fig.12 Thermal Shutdown Circuit

●**Block Diagrams / Standard Example Application Circuits**

[BA☐☐BC0T] / [BA☐☐BC0FP]

Fig.13

TOP VIEW

TO252-3　　TO220FP-3

Pin No.	Pin name	Function
1	Vcc	Supply voltage input
2	N.C./GND	NC pin/GND [*1]
3	OUT	Voltage output
FIN	GND	GMD[*2]

*1 NC pin for TO252-3 and GND pin for TO220FP-3 and TO220FP-5 (V5).
*2 TO252-3 only.

PIN	External capacitor setting range
Vcc (1 Pin)	Approximately 0.33 μF.
OUT (3 Pin)	22 μF to 1000 μF

[BA☐☐BC0TWT] / [BA☐☐BC0WT-V5] / [BA☐☐BC0WFP]

Fig.14

TOP VIEW

TO252-5

TO220FP-5　TO220FP-5 (V5)

Pin No.	Pin name	Function
1	CTL	Output voltage on/off control
2	Vcc	Supply voltage input
3	N.C./GND	NC pin/GND[*1]
4	OUT	Power supply output
5	N.C.	NC pin
FIN	GND	GND[*2]

*1 NC pin for TO252-5 and GND pin for TO220FP-5 and TO220FP-5 (V5).
*2 TO252-5 only.

PIN	External capacitor setting range
Vcc (2 Pin)	Approximately 0.33 μF.
OUT (4 Pin)	22 μF to 1000 μF

[BA00BC0WT] / [BA00BC0WFP]

Fig.15

TOP VIEW

TO220CP-V5　TO252-5

TO220FP-5　TO220FP-5 (V5)

Pin No.	Pin name	Function
1	CTL	Output voltage on/off control
2	Vcc	Supply voltage input
3	N.C./GND	NC pin/GND[*1]
4	OUT	Power supply output
5	C	ADJ pin
FIN	GND	GND[*2]

*1 NC pin for TO252-5 and GND pin for TO220FP-5 and TO220FP-5 (V5).
*2 TO252-5 only.

PIN	External capacitor setting range
Vcc (2 Pin)	Approximately 0.33 μF.
OUT (4 Pin)	22 μF to 1000 μF

●**Input / Output Equivalent Circuit Diagrams**

* For the BA00BC0WT, connect R1 and R2 externally between the C and GND pins and between the OUT and C pins.

Equation: VOUT = Vc × (R1 + R2) / R1
(Vc = 1.25 V (Typ.))
The recommended R1 value is approximately 30 kΩ to 150 kΩ.

Fig.16   Fig.17
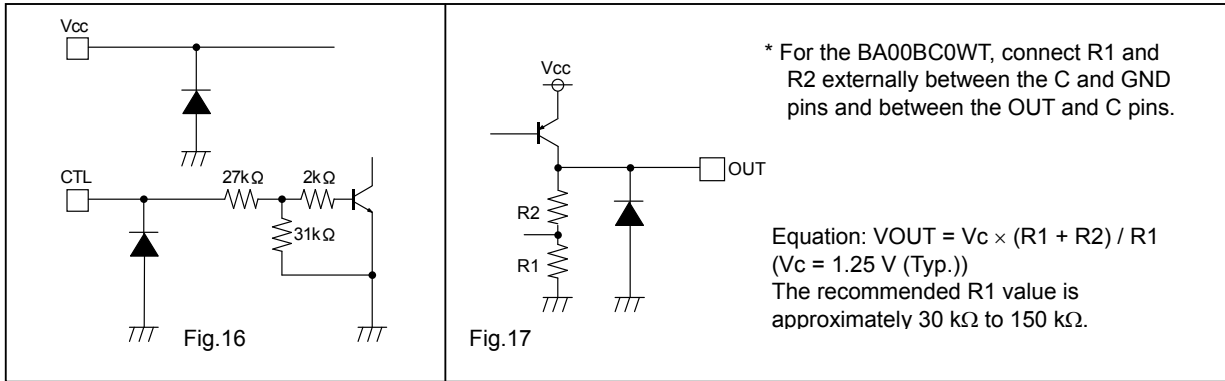
●**Thermal Derating Curves**

• TO220FP-3/TO220FP-5/TO220FP-5·V5）

(1) When using an infinite heat sink.
θj-c = 6.25 (°C/W)
(2) During IC without heat sink operation.
θj-a = 62.5 (°C/W)

(1)20.0
(2)2.0

POWER DISSIPATION : Pd [W]
AMBIENT TEMPERATURE : Ta [°C]
Fig.18

• TO252-3/TO252-5

IC mounted on a ROHM standard board
Board size: 70 × 70 × 1.6 mm
Copper foil area: 7 × 7 mm
TO252-5 θja=96.2 (°C/W)
TO252-3 θja＝104.2 (°C/W)

1.30

TO252-5
TO252-3

POWER DIDDIPATION : Pd [W]
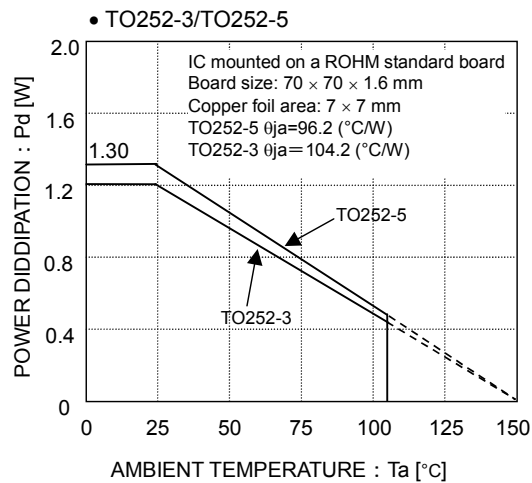AMBIENT TEMPERATURE : Ta [°C]
Fig.19

The characteristics of the IC are greatly influenced by the operating temperature. If the temperature exceeds the maximum junction temperature Tjmax, deterioration or damage may occur. Implement proper thermal designs to ensure that power dissipation is within the permissible range in order to prevent instantaneous damage resulting from heat and maintain the reliability of the IC for long-term operation.

The following method is used to calculate the power consumption Pc (W).

Pc = (Vcc – Vo) × Io + Vcc × Icca
Power dissipation Pd ≥ Pc

Vcc : Input voltage
Vo : Output current
IO : Load current
Icca : Circuit current

The load current Io is calculated:

$$Io \leq \frac{Pd - Vcc \times Icca}{Vcc - Vo}$$

Calculation Example:
Vcc = 6.0 V and Vo = 5.0 V at Ta = 85°C

$$\frac{0.676 - 6.0 \times Icca}{6.0 - 5.0}$$

θja = 96.2°C/W → −10.4 mW/°C
25°C = 1300 mW → 85°C = 676 mW

Io ≤ 550 mA (Icca ≈ 20 mA)

Refer to the above and implement proper thermal designs so that the IC will not be used under excessive power dissipation conditions under the entire operating temperature range.
The power consumption Pc of the IC in the event of shorting (i.e. the Vo and GND pins are shorted) can be obtained from the following equation:
Pc = Vcc × (Icca + Ishort) (Ishort: short current).

●**Notes for use**

• Vcc pin

Insert a capacitor (0.33 μF approx.) between VCC and GND.

The capacitance will vary depending on the application. Use a suitable capacitance and implement designs with sufficient margins.

• GND pin

Verify that there is no potential difference between the ground of the application board and the IC.

If there is a potential difference, the set voltage will not be output accurately, resulting in unstable IC operation.

Therefore, lower the impedance by designing the ground pattern as wide and as short as possible.
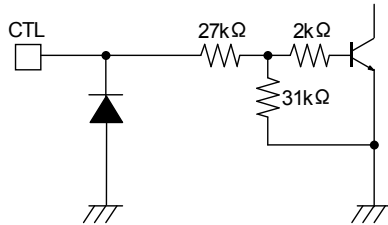
• CTL pin

The CTL pin turns on at an operating power supply voltage of 2.0 V or higher and turns off at 0.8 V or lower. There is no particular order when turning the power supply and CTL pins on or off.

Fig.20 Input Equivalent Circuit

●**Vo pin**

Iinsert a capacitor between the Vo and GND pins in order to prevent output oscillation.
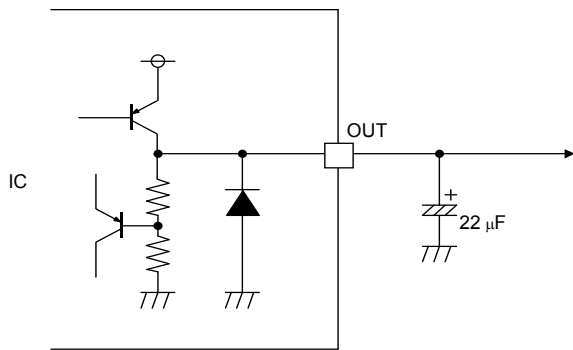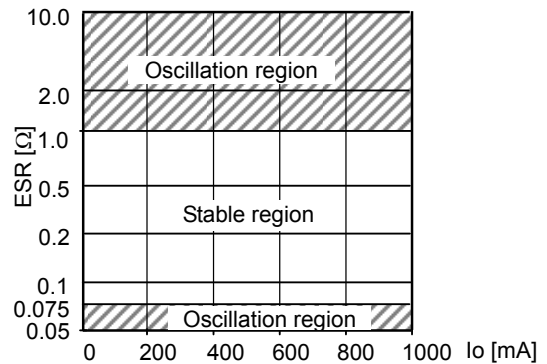
Fig.21 Output Equivalent Circuit

Fig.22 ESR vs IO(22 μ F)

The capacitance may vary greatly with temperature changes, thus making it impossible to completely prevent oscillation. Therefore, use a tantalum aluminum electrolytic capacitor with a low ESR (Equivalent Serial Resistance). The output will oscillate if the ESR is too high or too low, so refer to the ESR characteristics in Fig. 20 and operate the IC within the stable region. Use a capacitor within a capacitance between 22μF and 1,000μF.

Below figure,it is ESR-to-Io stability Area characteristics,measured by 22μ F -ceramic-capacitor and resistor connected in series. This characteristics is not equal value perfectly to 22μ F -aluminum electrolytic capacitor in order to measurement method. Note, however, that the stable range suggested in the figure depends on the IC and the resistance load involved, and can vary with the board's wiring impedance, input impedance, and/or load impedance. Therefore, be certain to ascertain the final status of these items for actual use.

Keep capacitor capacitance within a range of 22μF～1000μF. It is also recommended that a 0.33μF bypass capacitor be connected as close to the input pin-GND as location possible. However, in situations such as rapid fluctuation of the input voltage or the load, please check the operation in real application to determine proper capacitance.

●**Notes for use**

1. Absolute maximum ratings
   An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down the devices, thus making impossible to identify breaking mode, such as a short circuit or an open circuit. If any over rated values will expect to exceed the absolute maximum ratings, consider adding circuit protection devices, such as fuses.

2. GND voltage
   The potential of GND pin must be minimum potential in all operating conditions.

3. Thermal design
   Use a thermal design that allows for a sufficient margin in light of the power dissipation (Pd) in actual operating conditions.

4. Inter-pin shorts and mounting errors
   Use caution when positioning the IC for mounting on printed circuit boards.
   The IC may be damaged if there is any connection error or if pins are shorted together.

5. Actions in strong electromagnetic field
   Use caution when using the IC in the presence of a strong electromagnetic field as doing so may cause the IC to malfunction.

6. Testing on application boards
   When testing the IC on an application board, connecting a capacitor to a pin with low impedance subjects the IC to stress. Always discharge capacitors after each process or step. Always turn the IC's power supply off before connecting it to or removing it from a jig or fixture during the inspection process. Ground the IC during assembly steps as an antistatic measure. Use similar precaution when transporting or storing the IC.

7. Regarding input pin of the IC
   This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of these P layers with the N layers of other elements, creating a parasitic diode or transistor. For example, the relation between each potential is as follows:
       When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
       When GND > Pin B, the P-N junction operates as a parasitic transistor.
   Parasitic diodes can occur inevitable in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Accordingly, methods by which parasitic diodes operate, such as applying a voltage that is lower than the GND (P substrate) voltage to an input pin, should not be used.

8. Ground Wiring Pattern
   When using both small signal and large current GND patterns, it is recommended to isolate the two ground patterns, placing a single ground point at the ground potential of application so that the pattern wiring resistance and voltage variations caused by large currents do not cause variations in the small signal ground voltage. Be careful not to change the GND wiring pattern of any external components, either.

9. Thermal shutdown circuit
   The IC incorporates a built-in thermal shutdown circuit (TSD circuit). The thermal shutdown circuit (TSD circuit) is designed only to shut the IC off to prevent thermal runaway. It is not designed to protect the IC or guarantee its operation. Do not continue to use the IC after operating this circuit or use the IC in an environment where the operation of this circuit is assumed.

10. Overcurrent Protection Circuit
    An overcurrent protection circuit is incorporated in order to prevention destruction due to short-time overload currents. Continued use of the protection circuits should be avoided. Please note that the current increases negatively impact the temperature.

11. Damage to the internal circuit or element may occur when the polarity of the Vcc pin is opposite to that of the other pins in applications. (I.e. Vcc is shorted with the GND pin while an external capacitor is charged.) Use a maximum capacitance of 1000μF for the output pins. Inserting a diode to prevent back-current flow in series with Vcc or bypass diodes between Vcc and each pin is recommended.
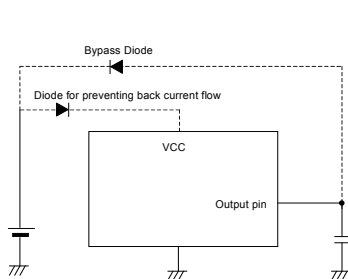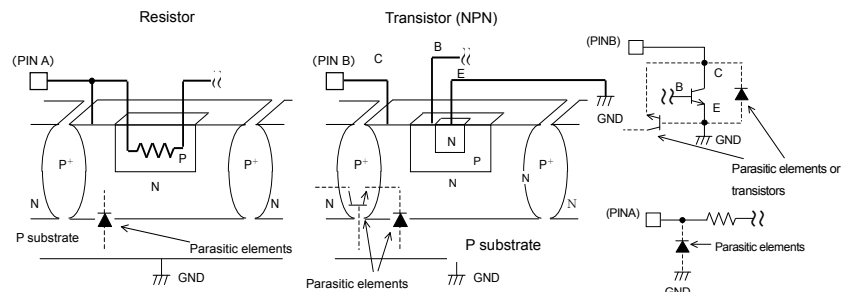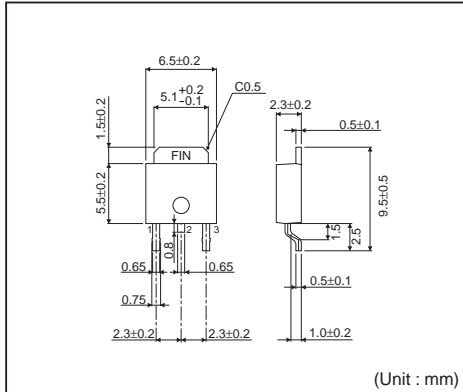

Fig.23 Bypass Diode

Fig.24 Example of Simple Bipolar IC Architecture

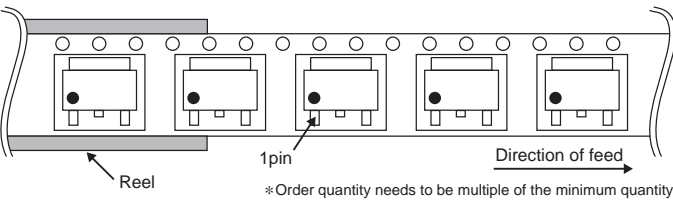● **Ordering part number**

| B | D | | 1 | 8 | | B | C | 0 | | W | | F | P | - | E | 2 |

Part number

Output voltage
00:Variable
Other:Fixed

Current capacity
BC0 : 1A

Shutdown switch
W : Include

パッケージ
FP : TO252-3
       TO252-5
T   : TO220FP-3
       TO220FP-5
       TO220FP-5(V5)
CP : TO220CP-V5

Packaging and forming specification
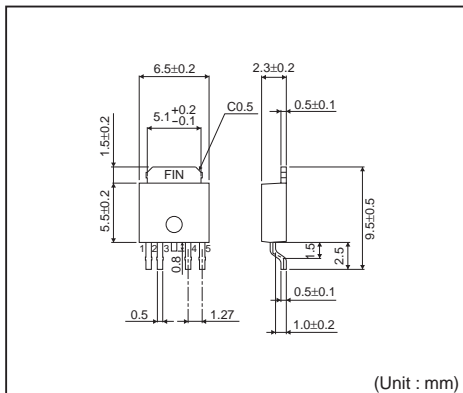E2: Embossed tape and reel
None: Container tube

TO252-3

<Tape and Reel information>

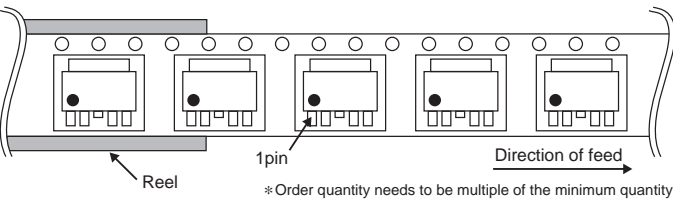| Tape	Embossed carrier tape
Quantity	2000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the lower left when you hold reel on the left hand and you pull out the tape on the right hand)

1pin   Direction of feed
Reel
＊Order quantity needs to be multiple of the minimum quantity.

TO252-5

<Tape and Reel information>

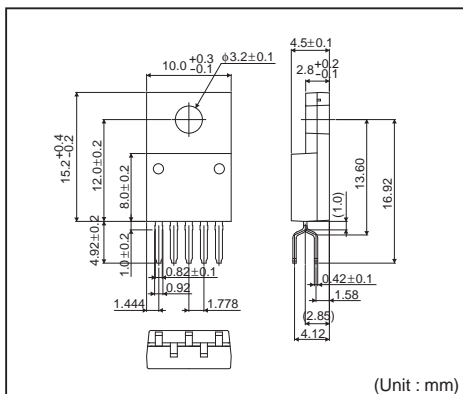| Tape	Embossed carrier tape
Quantity	2000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the lower left when you hold reel on the left hand and you pull out the tape on the right hand)

1pin   Direction of feed
Reel
＊Order quantity needs to be multiple of the minimum quantity.

TO220CP-V5

<Tape and Reel information>

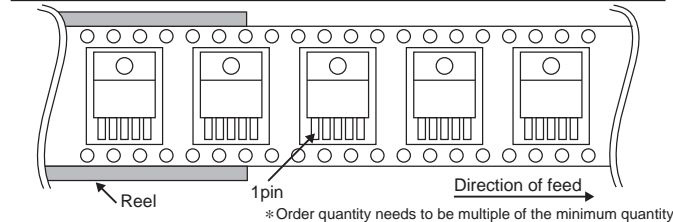| Tape	Embossed carrier tape
Quantity	500pcs
Direction of feed	E2 The direction is the 1pin of product is at the lower left when you hold reel on the left hand and you pull out the tape on the right hand

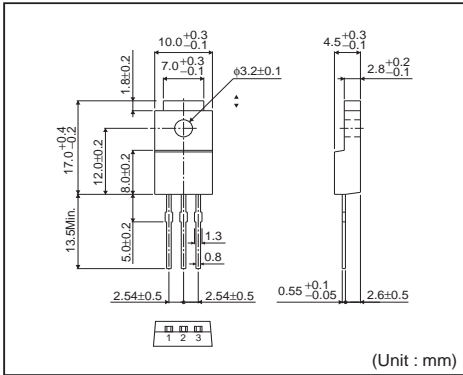1pin   Direction of feed
Reel
＊Order quantity needs to be multiple of the minimum quantity.

TO220FP-3

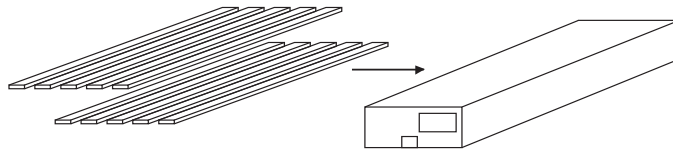(Unit : mm)

<table>
<tr><td colspan="2"><Tape and Reel information></td></tr>
<tr><td>Container</td><td>Tube</td></tr>
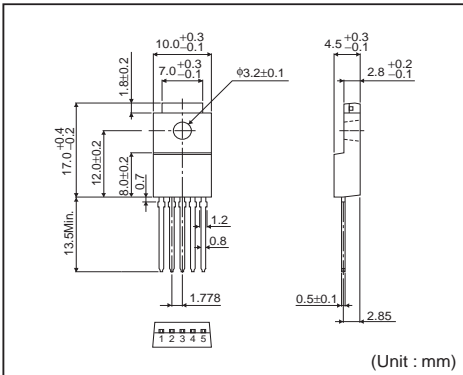<tr><td>Quantity</td><td>500pcs</td></tr>
<tr><td>Direction of feed</td><td>Direction of products is fixed in a container tube</td></tr>
</table>

∗Order quantity needs to be multiple of the minimum quantity.

TO220FP-5

(Unit : mm)

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<tr><td>Quantity</td><td>500pcs</td></tr>
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</table>

∗Order quantity needs to be multiple of the minimum quantity.

TO220FP-5(V5)

(Unit : mm)

<table>
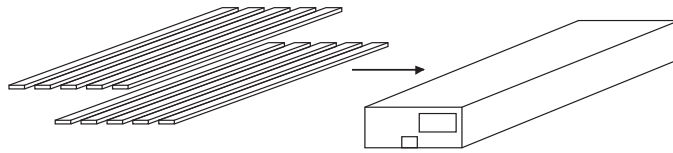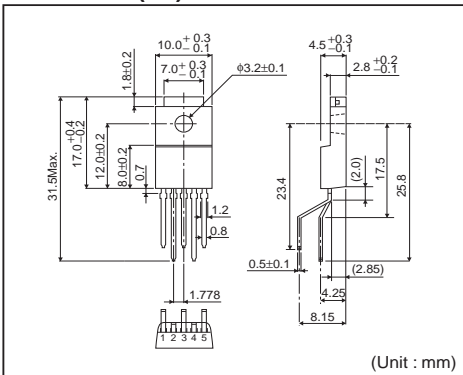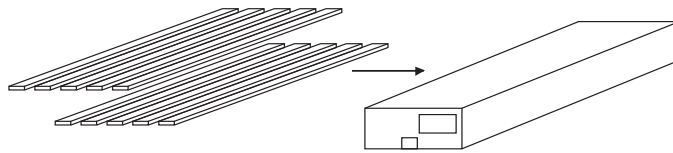<tr><td colspan="2"><Tape and Reel information></td></tr>
<tr><td>Container</td><td>Tube</td></tr>
<tr><td>Quantity</td><td>500pcs</td></tr>
<tr><td>Direction of feed</td><td>Direction of products is fixed in a container tube</td></tr>
</table>

∗Order quantity needs to be multiple of the minimum quantity.

2009.04 - Rev.A

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