

# 7 Circuits Darlington Transistor Array

**BA12003DF-Z BA12004DF-Z**

## General Description

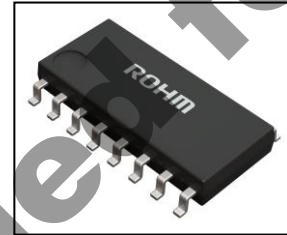
BA12003DF-Z, BA12004DF-Z are darlington transistor array consist of 7circuits, input resistor to limit base current and output surge absorption clamp diode.

## Packages

SOP-J16A

W(Typ) x D(Typ) x H(Max)

9.90mm x 6.00mm x 1.725mm



SOP-J16A  
BA12003DF-Z / BA12004DF-Z

## Features

- Built-in 7 circuits
- High output break down voltage
- High DC output current gain
- Built-in input resistor to limit base current
- Built-in output surge absorption clamp diode

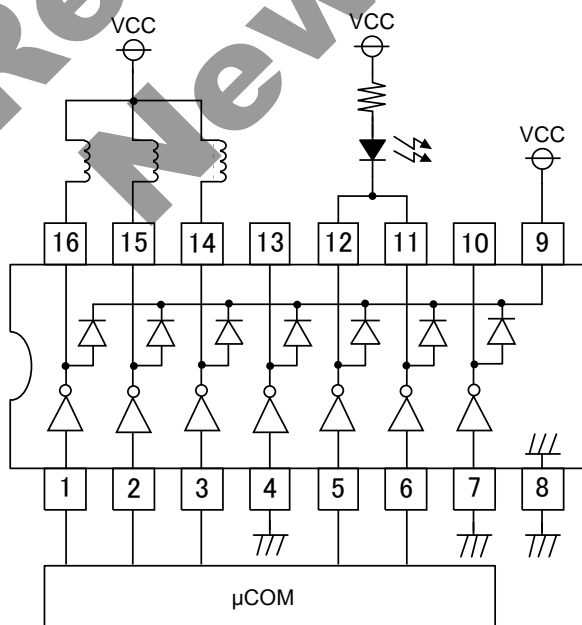
## Applications

- Motor Drivers
- LED Drivers
- Solenoid Drivers
- Low Side Switch

## Key Specifications

- Output break down voltage :  $V_{CE}=60V(\text{max})$
- Output current :  $I_o=500\text{mA}/\text{ch}(\text{max})$
- Operating supply voltage range :  $-0.5V$  to  $+30V$
- Operating temperature range :  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- DC current gain :  $h_{fe}=1000(\text{min})$
- Input resistor : BA12003DF-Z  $R_{in}=2.7\text{k}\Omega$   
BA12004DF-Z  $R_{in}=10.5\text{k}\Omega$

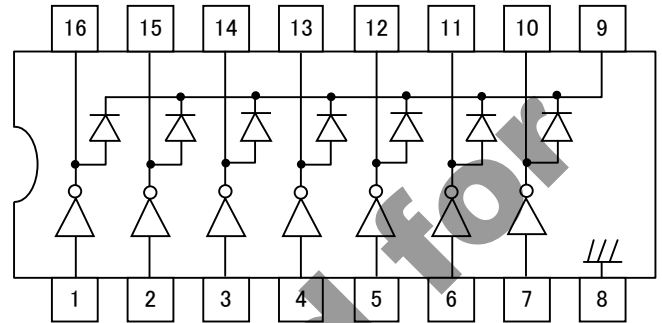
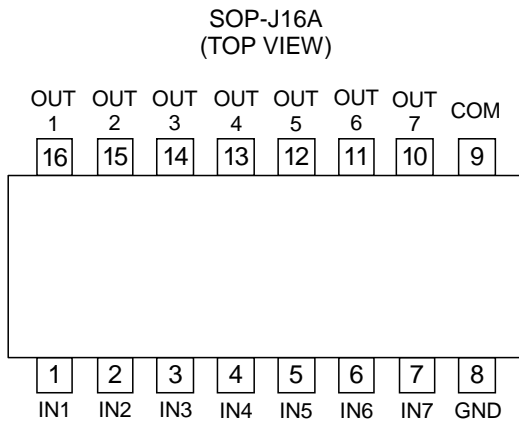
## Typical Application Circuit



○Product structure: Silicon integrated circuit ○This product has not designed protection against radioactive rays

Pin Configuration

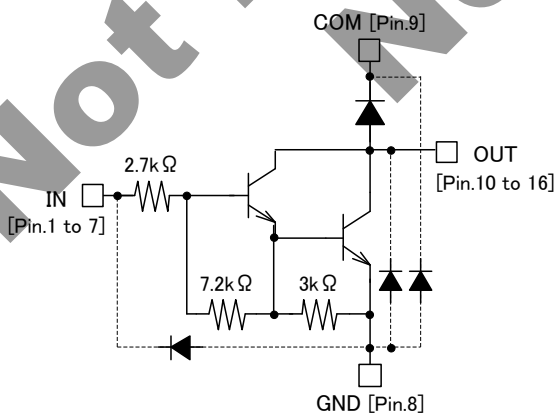
Block Diagram



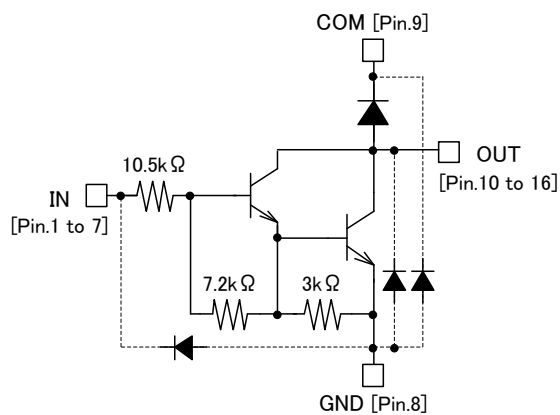
Pin Description

| Pin No. | Pin Name | Function | Pin No. | Pin Name | Function            |
|---------|----------|----------|---------|----------|---------------------|
| 1       | IN1      | Input 1  | 9       | COM      | Clamp diode cathode |
| 2       | IN2      | Input 2  | 10      | OUT7     | Output 7            |
| 3       | IN3      | Input 3  | 11      | OUT6     | Output 6            |
| 4       | IN4      | Input 4  | 12      | OUT5     | Output 5            |
| 5       | IN5      | Input 5  | 13      | OUT4     | Output 4            |
| 6       | IN6      | Input 6  | 14      | OUT3     | Output 3            |
| 7       | IN7      | Input 7  | 15      | OUT2     | Output 2            |
| 8       | GND      | Ground   | 16      | OUT1     | Output 1            |

I/O Equivalence Circuit



BA12003DF-Z



BA12004DF-Z

Note : The diode indicating the junction with a dotted line is a parasitic element.  
 Note : The input and output parasitic diodes cannot be used as clamp diodes.

**Absolute Maximum Ratings (T<sub>A</sub>=25°C)**

| Parameter             | Symbol           | Rating      | Unit        |
|-----------------------|------------------|-------------|-------------|
| Output Voltage        | V <sub>CE</sub>  | -0.5 to +60 | V           |
| Output Current        | I <sub>o</sub>   | 500         | mA/circuit  |
| Input Voltage         | V <sub>I</sub>   | -0.5 to +30 | V           |
| Diode Reverse Voltage | V <sub>R</sub>   | 60          | V           |
| Diode Forward Current | I <sub>F</sub>   | 500         | mA/ circuit |
| GND Terminal Current  | I <sub>GND</sub> | 2.3(Note 1) | A           |
| Operating Temperature | T <sub>opr</sub> | -40 to +85  | °C          |
| Storage Temperature   | T <sub>stg</sub> | -55 to +150 | °C          |

(Note 1) Pulse width≤20ms, Duty Cycle≤10%, 7 circuits flow the same current.

**Caution:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Thermal Resistance**(Note 1)

| Parameter  | Symbol          | Thermal Resistance (Typ) |                          | Unit |
|--|-----------------|--------------------------|--------------------------|------|
|  |                 | 1s <sup>(Note 3)</sup>   | 2s2p <sup>(Note 4)</sup> |      |
| SOP-J16A   |                 |                          |                          |      |
| Junction to Ambient  | θ <sub>JA</sub> | 169.7                    | 115.4                    | °C/W |
| Junction to Top Characterization Parameter <sup>(Note 2)</sup> | Ψ <sub>JT</sub> | 21                       | 20                       | °C/W |

(Note 1)Based on JESD51-2A(Still-Air)

(Note 2)The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 3)Using a PCB board based on JESD51-3.

| Layer Number of Measurement Board | Material | Board Size                 |
|-----------------------------------|----------|----------------------------|
| Single                            | FR-4     | 114.3mm x 76.2mm x 1.57mmt |

| Top                   |           |
|-----------------------|-----------|
| Copper Pattern        | Thickness |
| Footprints and Traces | 70µm      |

(Note 4)Using a PCB board based on JESD51-7.

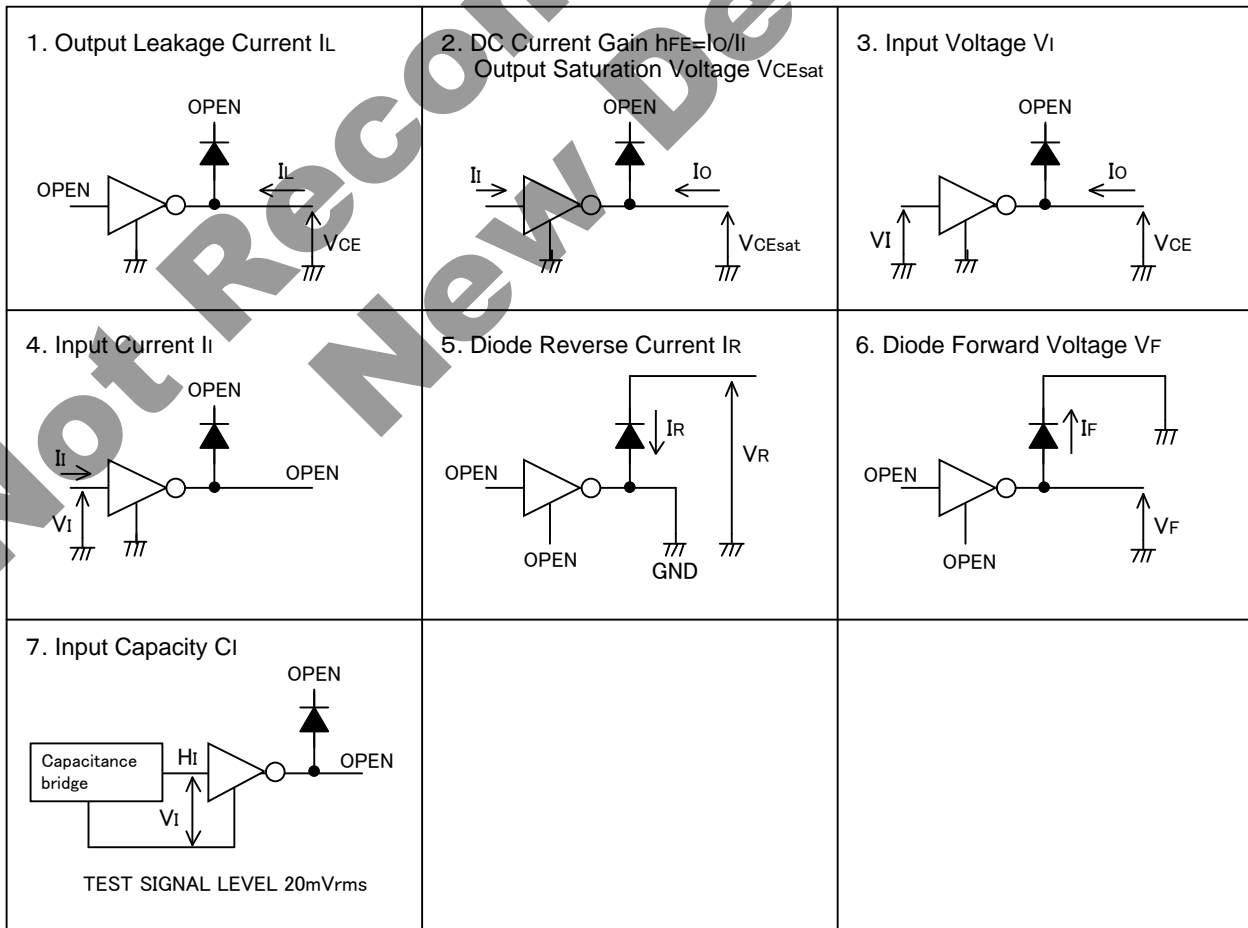
| Layer Number of Measurement Board | Material | Board Size                |
|-----------------------------------|----------|---------------------------|
| 4 Layers                          | FR-4     | 114.3mm x 76.2mm x 1.6mmt |

| Top                   |           | 2 Internal Layers |           | Bottom          |           |
|-----------------------|-----------|-------------------|-----------|-----------------|-----------|
| Copper Pattern        | Thickness | Copper Pattern    | Thickness | Copper Pattern  | Thickness |
| Footprints and Traces | 70µm      | 74.2mm x 74.2mm   | 35µm      | 74.2mm x 74.2mm | 70µm      |

Electrical Characteristics (Unless otherwise specified, GND=0V T<sub>A</sub>=25°C)

| Parameter                  | Symbol              | Limit           |      |      | Unit | Conditions                                    | Test Circuit                                 |   |
|----------------------------|---------------------|-----------------|------|------|------|---|--|---|
|                            |                     | Min             | Typ  | Max  |      |   |  |   |
| Output Leakage Current     | I <sub>L</sub>      | -               | -    | 10   | μA   | V <sub>CE</sub> =60V                          | 1  |   |
| Output DC Current Gain     | h <sub>FE</sub>     | 1000            | 2400 | -    | -    | V <sub>CE</sub> =2.0V, I <sub>O</sub> =350mA  | 2  |   |
| Output Saturation Voltage1 | V <sub>CEsat1</sub> | -               | 0.94 | 1.1  | V    | I <sub>O</sub> =100mA, I <sub>I</sub> =250 μA | 2  |   |
| Output Saturation Voltage2 | V <sub>CEsat2</sub> | -               | 1.14 | 1.3  | V    | I <sub>O</sub> =200mA, I <sub>I</sub> =350 μA | 2  |   |
| Output Saturation Voltage3 | V <sub>CEsat3</sub> | -               | 1.46 | 1.6  | V    | I <sub>O</sub> =350mA, I <sub>I</sub> =500 μA | 2  |   |
| Input Voltage1             | BA12003D            | V <sub>I1</sub> | 2.0  | -    | -    | V   | V <sub>CE</sub> =2.0V, I <sub>O</sub> =100mA | 3 |
|                            | BA12004D            |                 | 5.0  | -    | -    |   |  |   |
| Input Voltage2             | BA12003D            | V <sub>I2</sub> | 2.4  | -    | -    | V   | V <sub>CE</sub> =2.0V, I <sub>O</sub> =200mA | 3 |
|                            | BA12004D            |                 | 6.0  | -    | -    |   |  |   |
| Input Voltage3             | BA12003D            | V <sub>I3</sub> | 3.4  | -    | -    | V   | V <sub>CE</sub> =2.0V, I <sub>O</sub> =350mA | 3 |
|                            | BA12004D            |                 | 8.0  | -    | -    |   |  |   |
| Input Current              | BA12003D            | I <sub>I</sub>  | -    | 0.90 | 1.35 | mA  | V <sub>I</sub> =3.85V                        | 4 |
|                            | BA12004D            |                 | -    | 0.39 | 0.5  |   | V <sub>I</sub> =5.0V                         |   |
| Diode Reverse Current      | I <sub>R</sub>      | -               | -    | 50   | μA   | V <sub>R</sub> =60V                           | 5  |   |
| Diode Forward Voltage      | V <sub>F</sub>      | -               | 1.73 | 2.0  | V    | I <sub>F</sub> =350mA                         | 6  |   |
| Input Capacity             | C <sub>I</sub>      | -               | 30   | -    | pF   | V <sub>I</sub> =0V, f=1MHz                    | 7  |   |

Test Circuit



Typical Performance Curve (Reference Data)

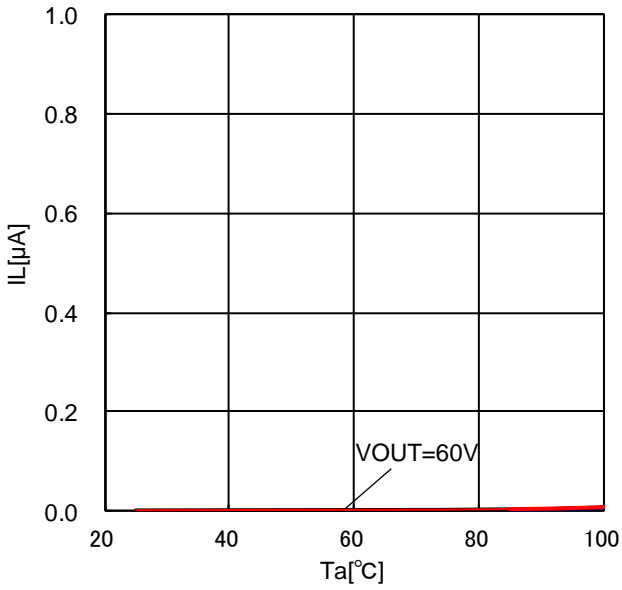


Figure 1 .  
Output Leakage Current vs Ambient Temperature

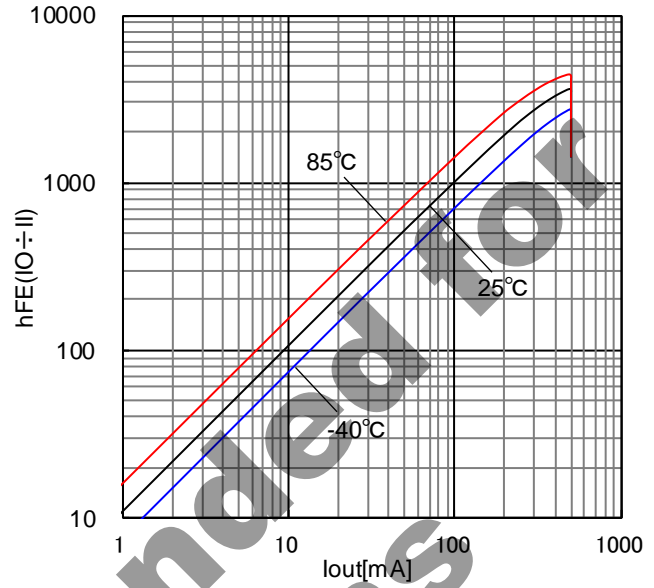


Figure 2 .  
Output DC Current Gain vs Output Current

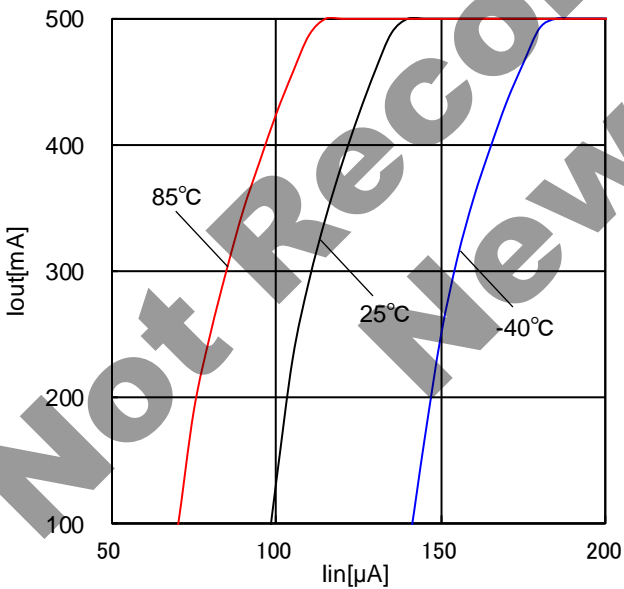


Figure 3 .  
Output Current vs Input Current

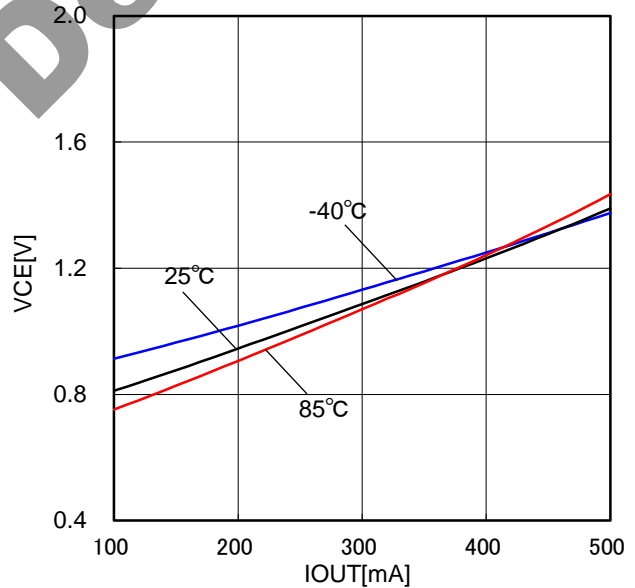


Figure 4 .  
Output Saturation Voltage1 vs Output Current

Typical Performance Curve (Reference Data) - continued

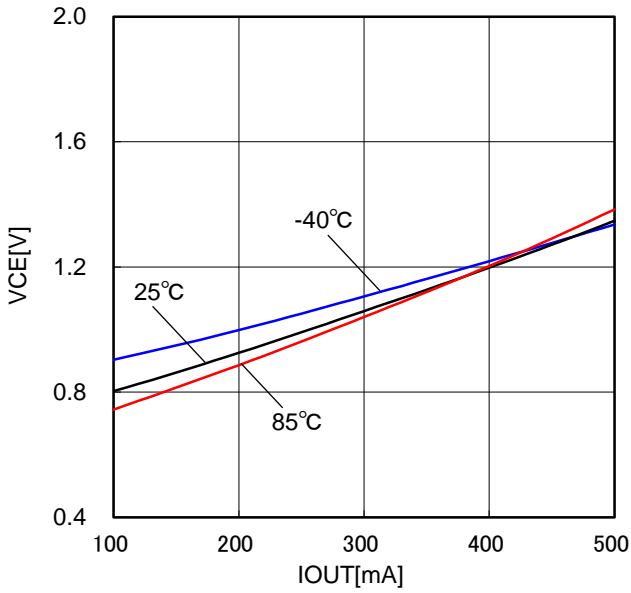


Figure 5 .  
Output Saturation Voltage2 vs Output Current

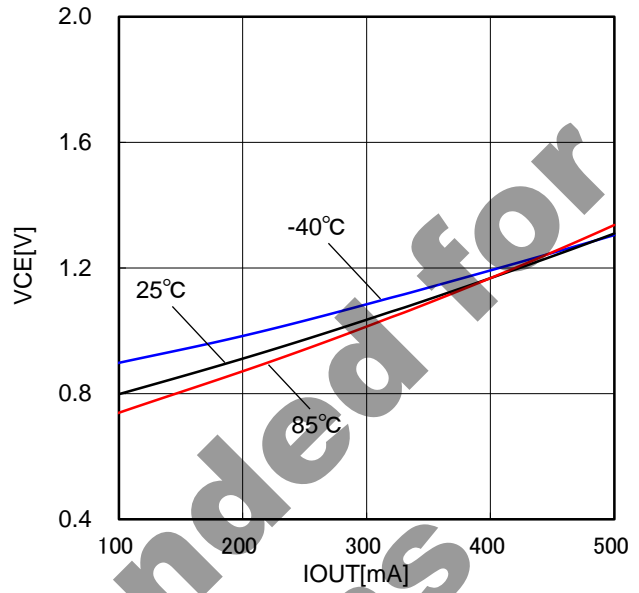


Figure 6 .  
Output Saturation Voltage3 vs Output Current

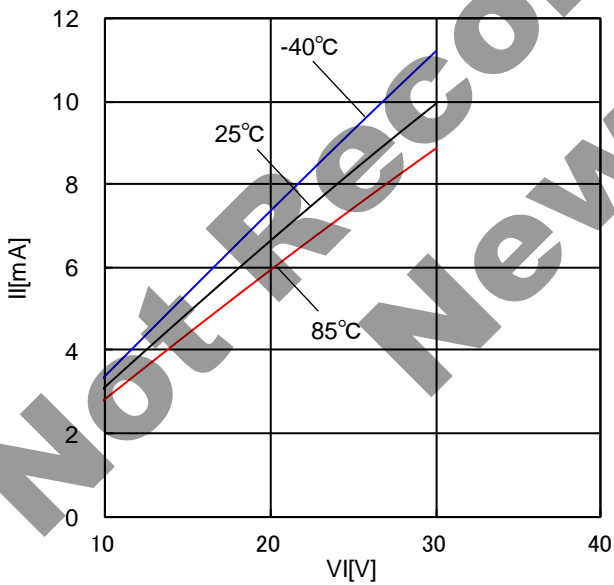


Figure 7 .  
Input Current vs Input Voltage  
(BA12003)

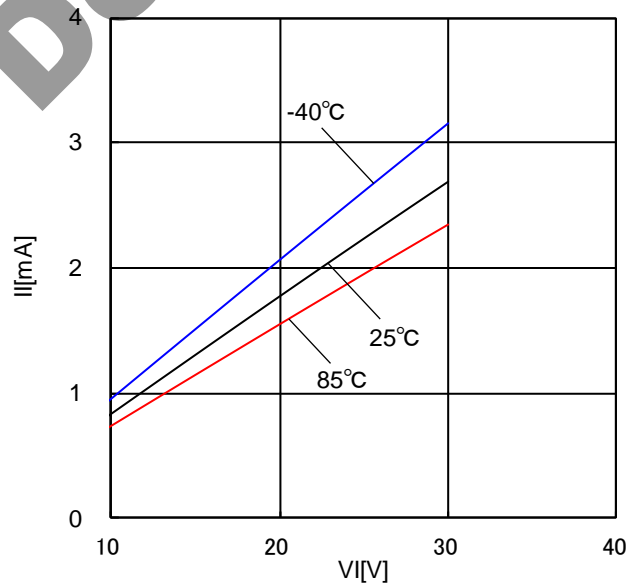


Figure 8 .  
Input Current vs Input Voltage  
(BA12004)

Typical Performance Curve (Reference Data) - continued

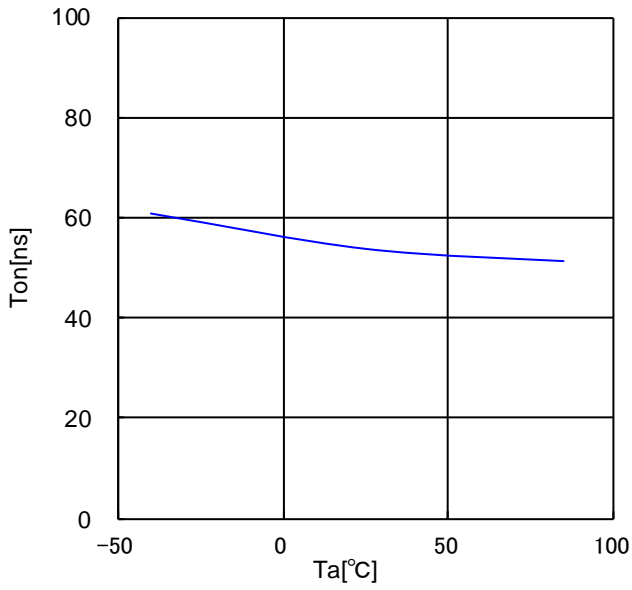


Figure 9 .  
Turn-ON Time vs Ambient Temperature

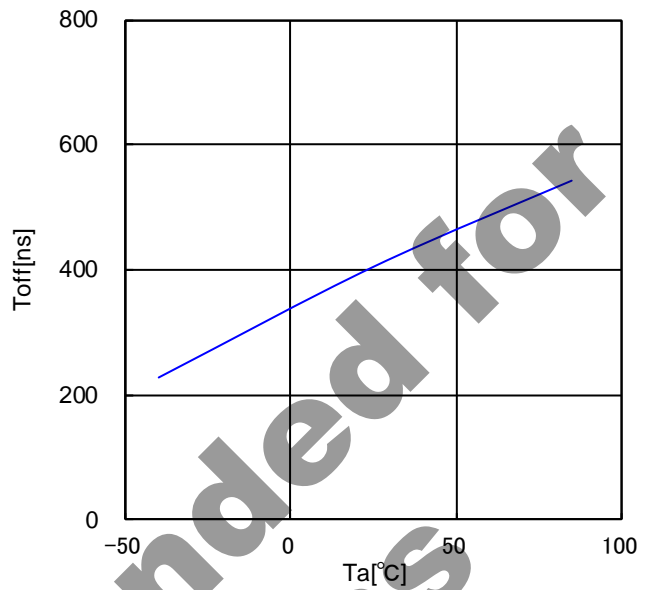


Figure 10 .  
Turn-OFF Time vs Ambient Temperature

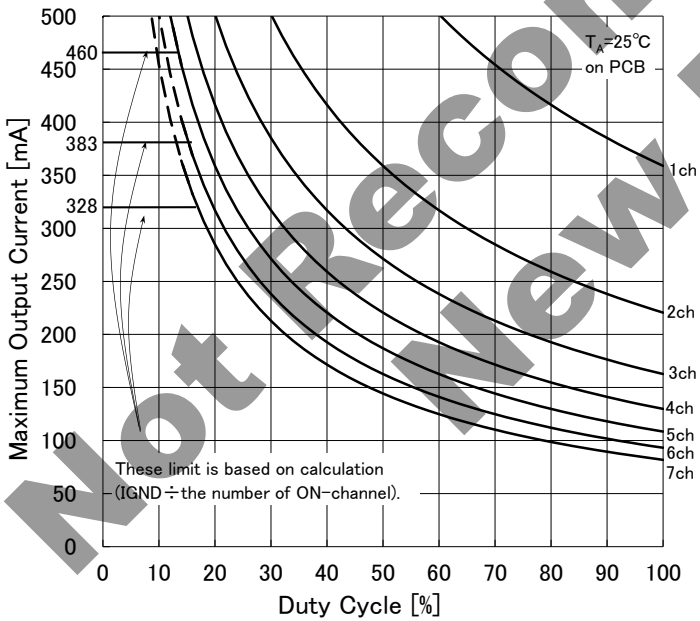


Figure 11.  
Output Current - Duty Cycle

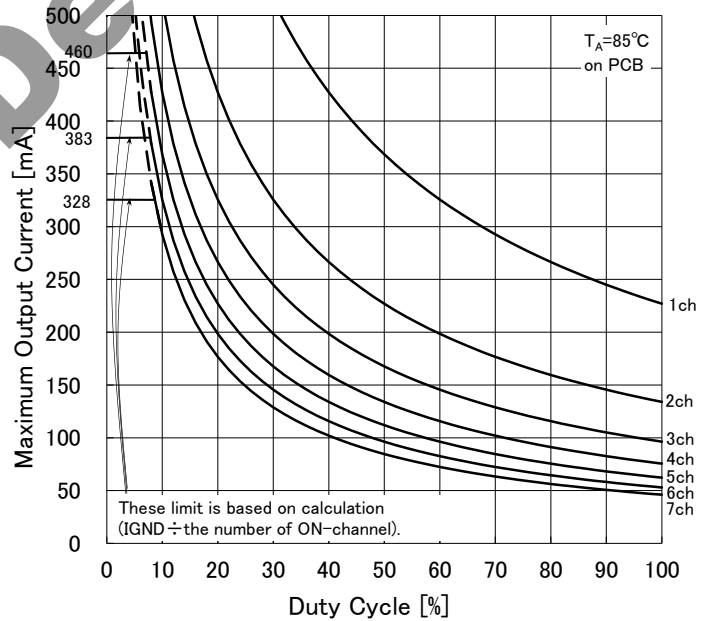


Figure 12.  
Output Current - Duty Cycle

**Power Dissipation**

Power dissipation(total loss) indicates the power that can be consumed by IC at  $T_A=25^{\circ}\text{C}$ (normal temperature). IC is heated when it consumed power, and the temperature of IC chip becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing process, and consumable power is limited. Power dissipation is determined by the temperature allowed in IC chip(maximum junction temperature) and thermal resistance of package(heat dissipation capability). The maximum junction temperature is typically equal to the maximum value in the storage temperature range. Heat generated by consumed power of IC radiates from the mold resin or lead frame of the package. The parameter which indicates this heat dissipation capability(hardness of heat release)is called thermal resistance, represented by the symbol  $\theta_{JA}$  ( $^{\circ}\text{C}/\text{W}$ ).The temperature of IC inside the package can be estimated by this thermal resistance. Figure 13(a) shows the model of thermal resistance of the package. Thermal resistance  $\theta_{JA}$ , ambient temperature  $T_A$ , maximum junction temperature  $T_{jmax}$ , and power dissipation  $P_d$  can be calculated by the equation below:

$$\theta_{JA} = (T_{JMAX} - T_A) / P_d \quad [^{\circ}\text{C}/\text{W}]$$

Derating curve in Figure 13(b) indicates power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient is determined by thermal resistance  $\theta_{JA}$ . Thermal resistance  $\theta_{JA}$  depends on chip size, power consumption, package, ambient temperature, package condition, wind velocity, etc even when the same of package is used. Thermal reduction curve indicates a reference value measured at a specified condition. Figure 14 show a derating curve for an example of BA12003DF-Z, BA12004DF-Z.

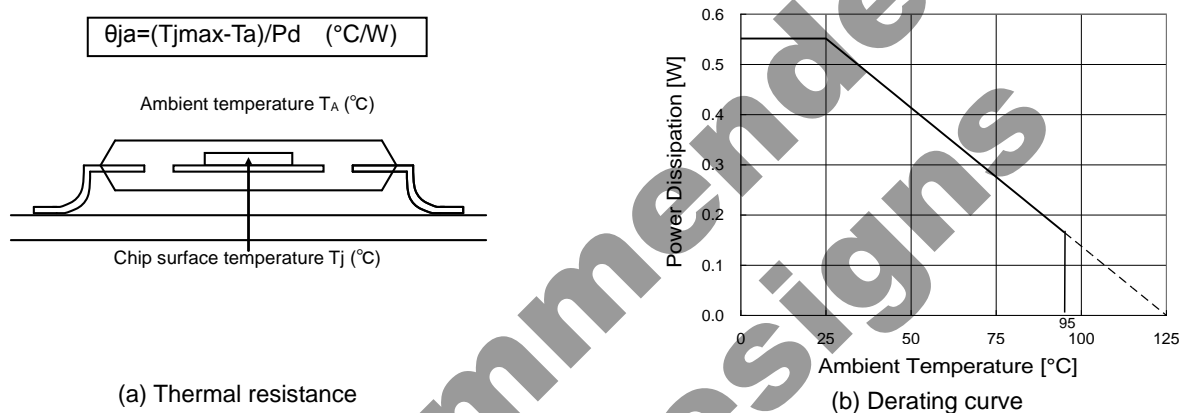


Figure 13. Thermal resistance and derating curve

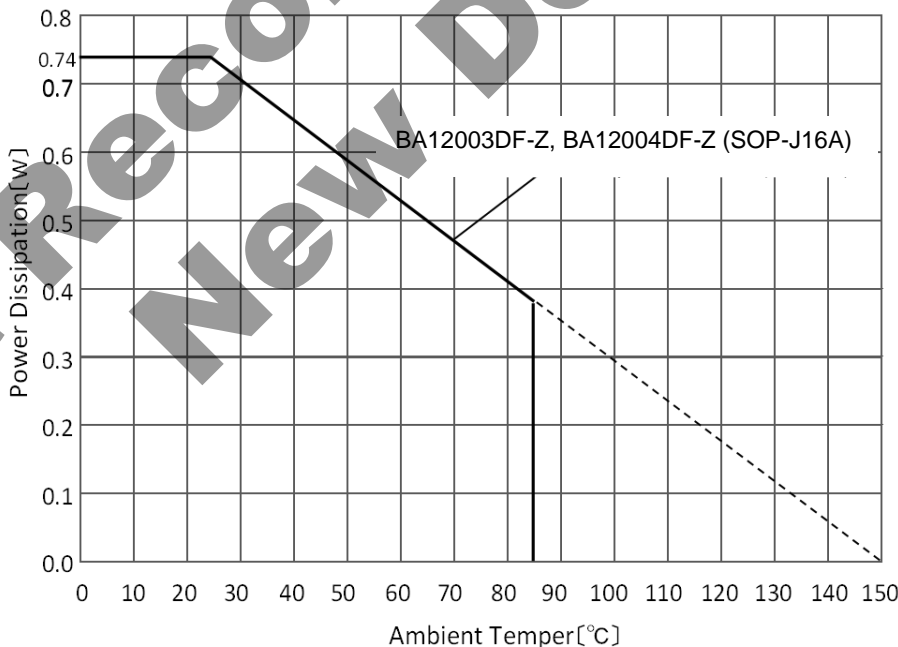


Figure 14. Derating curve

| Part Number              | Slope of Derating Curve | Unit                   |
|--------------------------|-------------------------|------------------------|
| BA12003DF-Z, BA12004DF-Z | 5.9                     | mW/ $^{\circ}\text{C}$ |



## Operational Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition. However, pins that drive inductive loads (e.g. motor driver outputs, DC-DC converter outputs) may inevitably go below ground due to back EMF or electromotive force. In such cases, the user should make sure that such voltages going below ground will not cause the IC and the system to malfunction by examining carefully all relevant factors and conditions such as motor characteristics, supply voltage, operating frequency and PCB wiring to name a few.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Thermal Consideration

Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the maximum junction temperature rating.

### 6. Recommended Operating Conditions

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

### 7. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 9. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

### 10. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

### 11. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

12. Regarding the 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 the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

- 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 inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

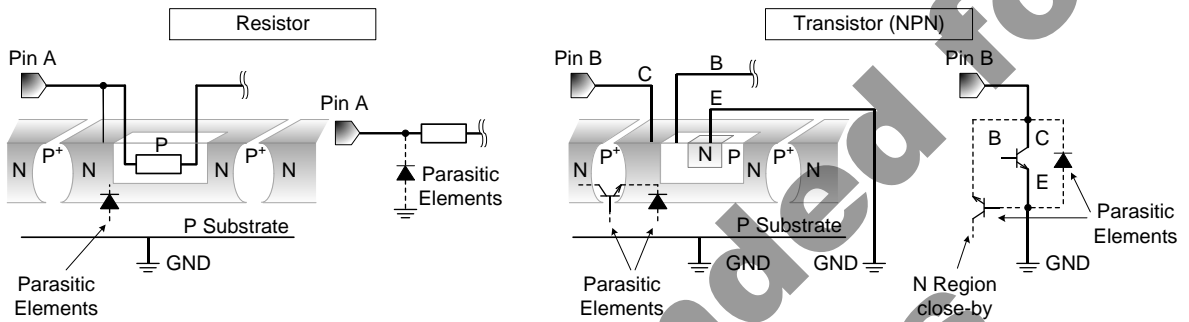


Figure 15. Example of monolithic IC structure

13. Ceramic Capacitor

When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

14. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

15. Output Pins

Connecting zener diode should be able to prevent degradation of current time. Please use zener diode satisfy with  $V_{CC} + V_Z \leq V_{CE(SUS)}$ .

16. Output clamp diode

Figure 16 is a construction of the clamp diode part in this IC. When the clamp diode works, PNP transistor works. Therefore, a consumption power increases. When a consecutive surge current (or backward current of motor) flows in this clamp diode, we recommend the diode with a low forward voltage etc. (schottky diode) connection between OUT and COM for bypass pathway of surge current.

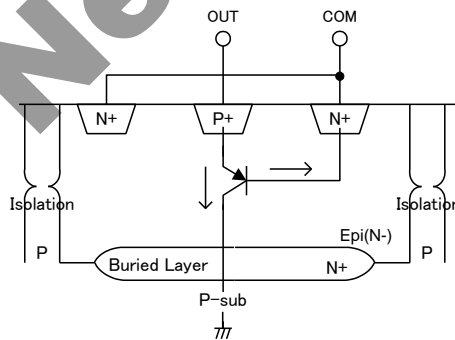
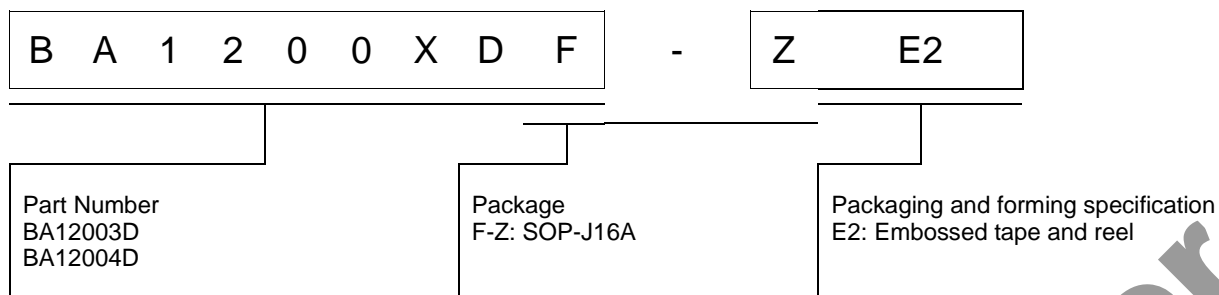


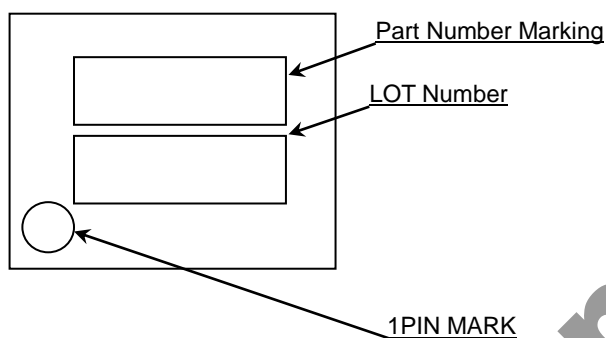
Figure 16. Construction of output clamp diode

Ordering Information



Marking Diagrams

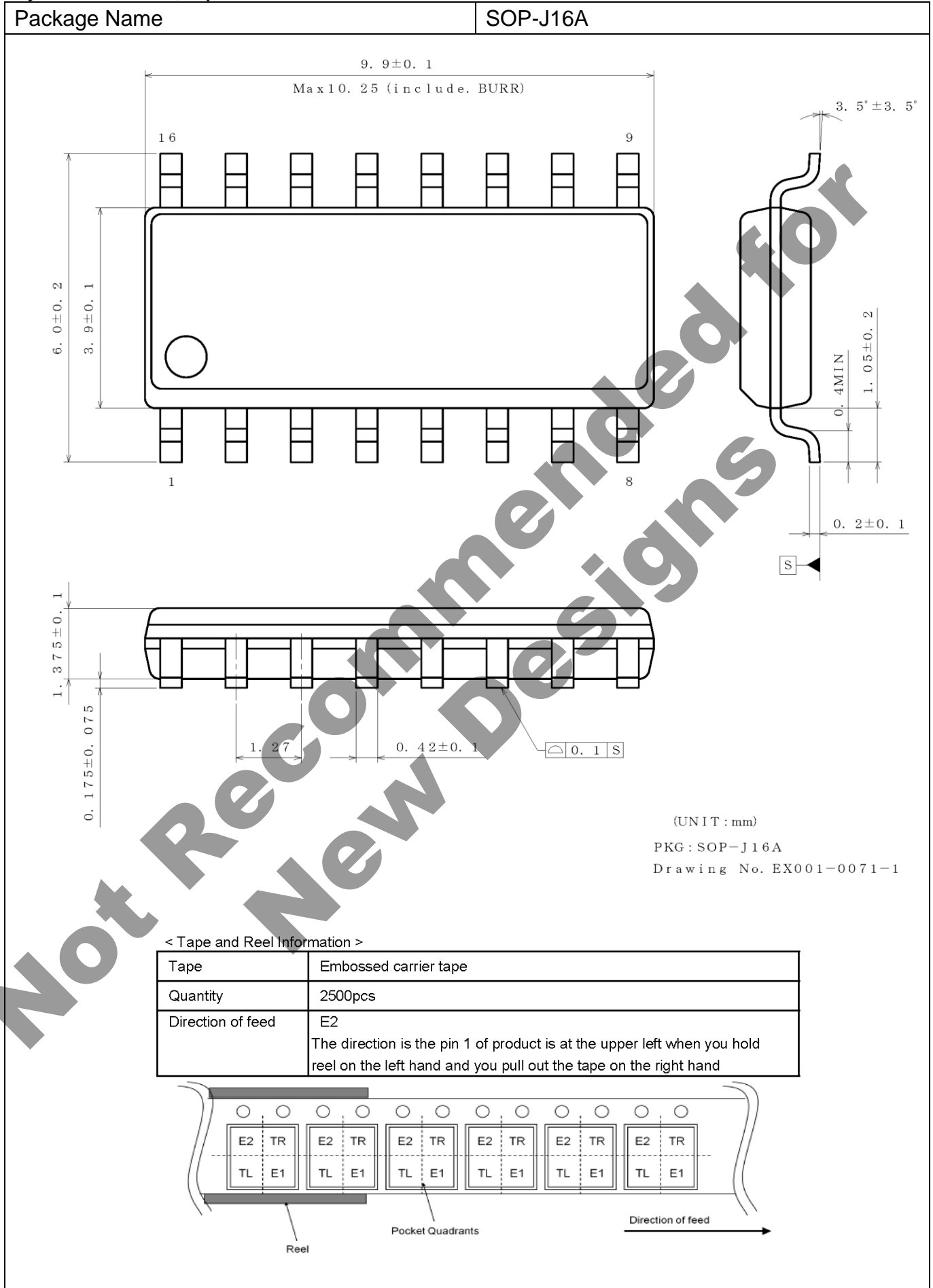
SOP-J16A (TOP VIEW)



Lineup

| Part Number Marking | Package  | Orderable Part Number |
|---------------------|----------|-----------------------|
| A12003DF            | SOP-J16A | BA12003DF-ZE2         |
| A12004DF            | SOP-J16A | BA12004DF-ZE2         |

Physical Dimension, Tape and Reel Information



## Revision History

| Date        | Revision | Changes  |
|-------------|----------|--|
| 13.Jun.2016 | 001      | New Release  |
| 6.Jul.2016  | 002      | Update Lineup  |
| 29.Nov.2016 | 003      | Update Physical Dimension and Package Name   |
| 20.Dec.2016 | 004      | Update Lineup  |
| 10.Feb.2017 | 005      | Update Lineup  |
| 02.Jun.2017 | 006      | Update Lineup  |
| 09.Aug.2017 | 007      | Update Marking Diagrams and Lineup   |
| 26.Sep.2017 | 008      | Update Lineup  |
| 24.Aug.2018 | 009      | Update Lineup  |
| 27.Aug.2020 | 010      | Physical Dimension, Tape and Reel Information (P.12)<br>Change dimension to JEDEC standard values. |

Not Recommended for  
New Designs

# Notice

## Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipment (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
  - Installation of protection circuits or other protective devices to improve system safety
  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
  - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

### Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

### Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

### Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

### Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

### Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

### Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

### Precaution Regarding Intellectual Property Rights

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