

## DC Brushless Motor Drivers for Fans

# 24V single-phase full wave DC Brushless fan motor driver


**BA6424AFS**

No.12010EAT02

**●Description**

This is the summary of application for BA6424AFS. BA6424AFS incorporates lock protection and automatic restart circuit.

**●Features**

- 1) Lock protection and automatic restart circuit
- 2) Rotating speed pulse signal (FG) output
- 3) Lock alarm signal (AL) output

**●Applications**

General consumer electronics, BD player, DVR, STB  
Office equipment, Copier, FAX Laser Printer etc.,.

**●Absolute maximum ratings**

Parameter	Symbol	Ratings	Unit
Supply voltage	Vcc	30	V
Power dissipation	Pd	812.5*	mW
Operation temperature	Topr	-40~+100	°C
Storage temperature	Tstg	-55~+150	°C
Output current	Iomax	1.0**	A
Output voltage	VOUT	30	V
AL signal output voltage	VAL	30	V
FG signal output voltage	VFG	30	V
Junction temperature	Tjmax	150	°C

\* Reduce by 6.5mW/°C over 25°C. (On 70.0mm×70.0mm×1.6mm glass epoxy board)

\*\* This value is not to exceed Pd.

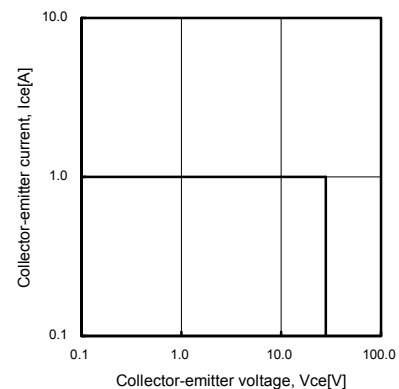
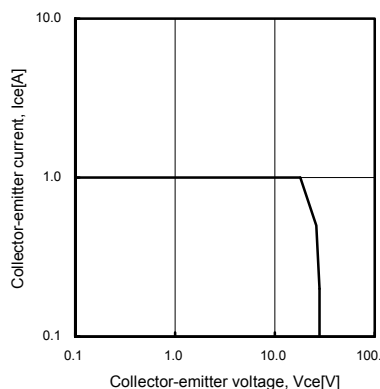
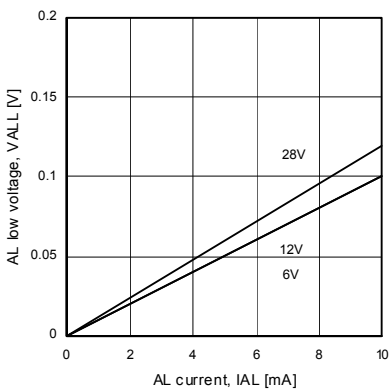
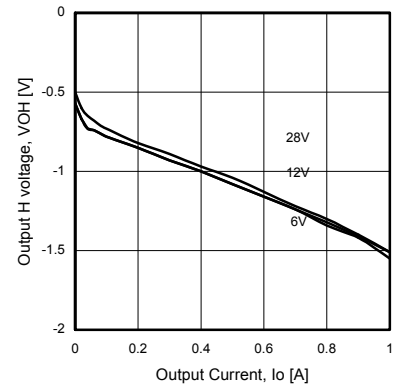
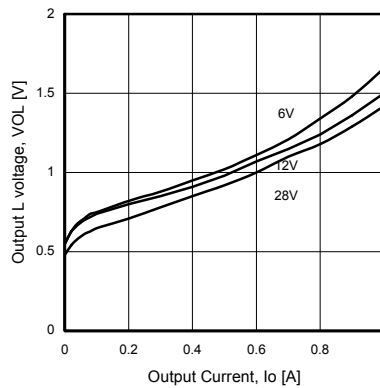
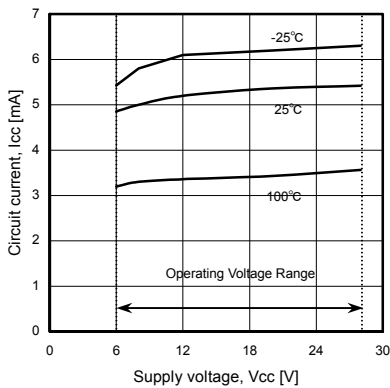
**●OPERATING CONDITIONS**

Parameter	Symbol	Ratings	Unit
Operating supply voltage range	Vcc	6.0~28.0	V
Hall input voltage range	VH	2.5~Vcc	V

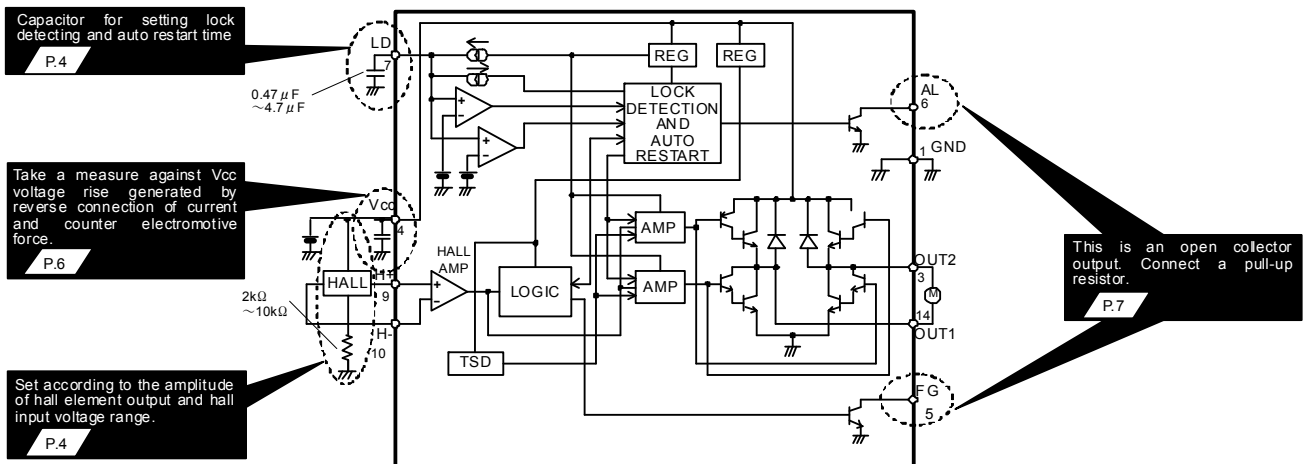
●Electrical characteristics (Unless otherwise specified Ta=25°C,Vcc=12V)

Parameter	Symbol	Limits			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	2.7	5.4	8.1	mA	At output OFF	Fig.1
Charge current of capacitor	ILDC	1.55	3.10	4.65	μA	VLD=1.8V	-
Discharge current of capacitor	ILDD	0.33	0.66	0.99	μA	VLD=1.8V	-
Charge-discharge current ratio of capacitor for lock detection	rCD	3.0	4.7	6.4	-	rCD=ILDC/ILDD	-
Clamp voltage of capacitor for lock detection	VLDCL	2.00	2.48	3.00	V		-
Comparison voltage of capacitor for lock detection	VLDPC	0.70	0.99	1.30	V		-
Output voltage L	VOL	-	0.8	1.2	V	Io=200mA	Fig.2
Output voltage H	VOH	-	0.9	1.4	V	Io=-200mA Voltage between output and Vcc	Fig.3
FG output voltage L	VFGL	-	0.1	0.3	V	IFG=10mA	Fig.4
FG output leak current	IFGL	-	0	10	μA	VFG=30V	-
AL output voltage L	VALL	-	0.1	0.3	V	IAL=10mA	Fig.4
AL output leak current	IALL	-	0	10	μA	VAL=30V	-
Hall input - output offset voltage	VOFS	-20	0	20	mV		-
Hall input - FG offset voltage	VFGOFS	-45	-25	-5	mV		-

●Reference Data



●Block diagram, application circuit, and pin assignment(Constant etc are for reference)



PIN No.	Terminal name	Function
1	GND	GND terminal
2	N.C.	
3	OUT2	Motor output terminal2
4	Vcc	Power supply terminal
5	FG	Rotating speed pulse signal output terminal
6	AL	Lock alarm signal output terminal
7	LD	Lock detection and auto restart capacitor connecting terminal
8	N.C.	
9	H+	Hall input terminal+
10	H-	Hall input terminal-
11	N.C.	
12	N.C.	
13	N.C.	
14	OUT1	Motor output terminal1
15	N.C.	
16	N.C.	

●Truth table

H+	H-	OUT1	OUT2	FG
H	L	H	L	H
L	H	L	H	L

AL normal operation  
:L(output is ON)  
lock detection  
:H(output is OFF)

●Description of operations

1) Lock protection and automatic restart

Lock detection ON time (TON) and lock detection OFF time (TOFF) is set by charging and discharging of external capacitor of LD terminal.

$$TON \text{ (Lock detection ON time)} = \frac{C \cdot (VLDCL - VLDCL)}{ILDC}$$

$$TOFF \text{ (Lock detection OFF time)} = \frac{C \cdot (VLDCL - VLDCL)}{ILDD}$$

C : Capacity of capacitor equipped externally on LD terminal  
 VLDCL : LD terminal clamping voltage  
 VLDCL : LD terminal comparator voltage  
 ILDC : LD terminal charging current  
 ILDD : LD terminal discharging current

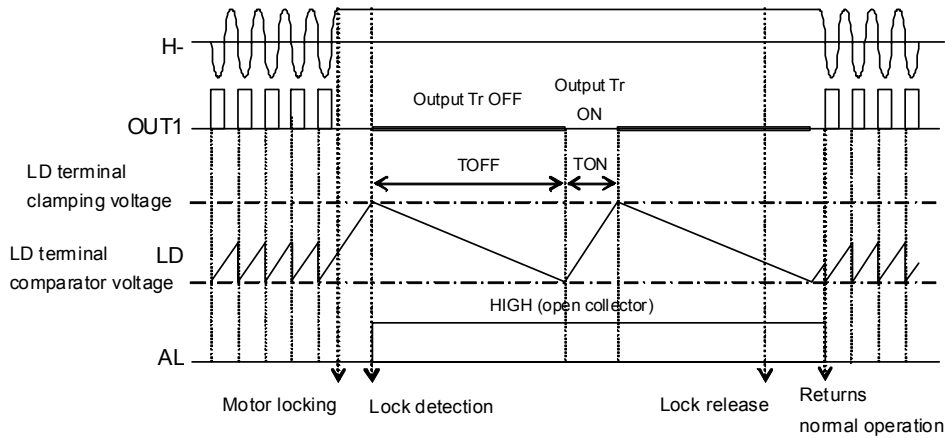


Fig.7 Lock protection timing chart

\* BA6424AFS returns normal operation by the input of hall signal during TOFF.

2) Hall input setting

Hall input voltage range is shown in operating conditions.

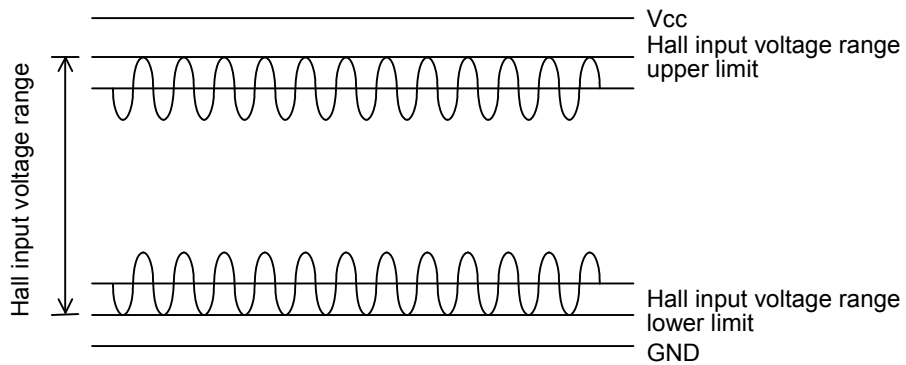


Fig.8 Hall input voltage range

Adjust the value of hall element bias resistor R1 in Fig.9 so that the input voltage of a hall amplifier is input in "hall input voltage range" including signal amplitude.

○Reducing the noise of hall signal

Hall element may be affected by Vcc noise or the like depending on the wiring pattern of board. In this case, place a capacitor like C1 in Fig.9. In addition, when wiring from the hall element output to IC hall input is long, noise may be loaded on wiring. In this case, place a capacitor like C2 in Fig.9.

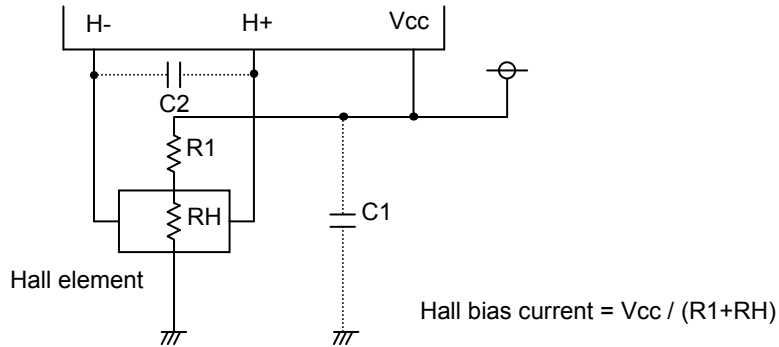


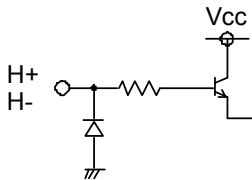
Fig.9 Application near hall signal

\* This IC doesn't have hall input hysteresis.

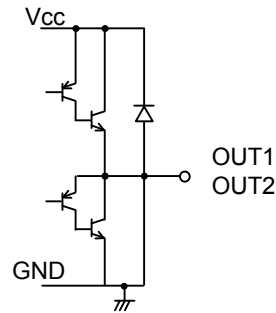
Note the hall input so that the FG signal do not chatter by the noise of the hall signal.

●Equivalent circuit

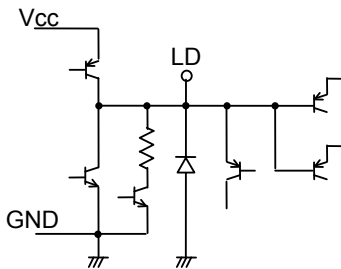
1) Hall input terminal



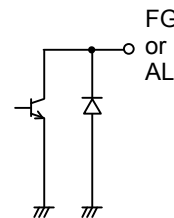
2) Motor output terminal



3) Lock detection and automatic restart capacitor connecting terminal



4) FG/AL signal output terminal



● Safety measure

1) Reverse connection protection diode

Reverse connection of power results in IC destruction as shown in Fig.10. When reverse connection is possible, reverse connection protection diode must be added between power supply and Vcc.

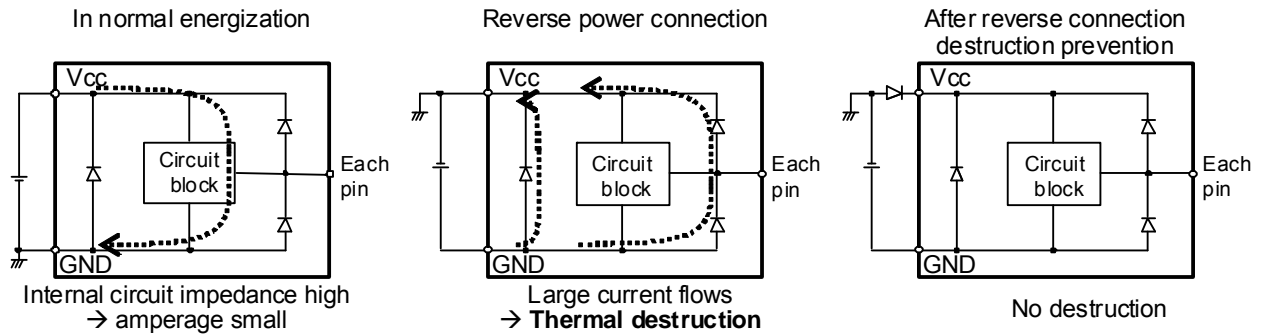


Fig.10 Flow of current when power is connected reversely

2) Measure against Vcc voltage rise by back electromotive force

Back electromotive force (Back EMF) generates regenerative current to power supply. However, when reverse connection protection diode is connected, Vcc voltage rises because the diode prevents current flow to power supply.

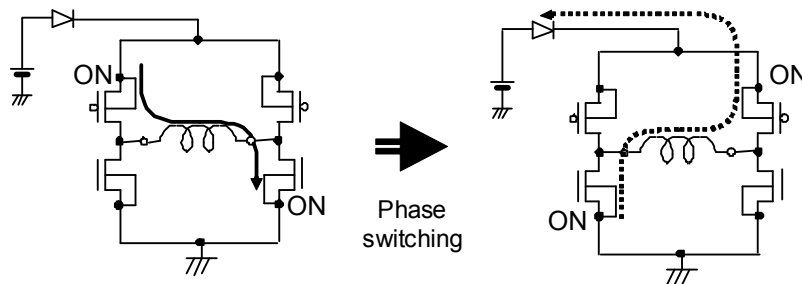


Fig.11 Vcc voltage rise by back electromotive force

When the absolute maximum rated voltage may be exceeded due to voltage rise by back electromotive force, place (A) Capacitor or (B) Zener diode between Vcc and GND. If necessary, add both (C).

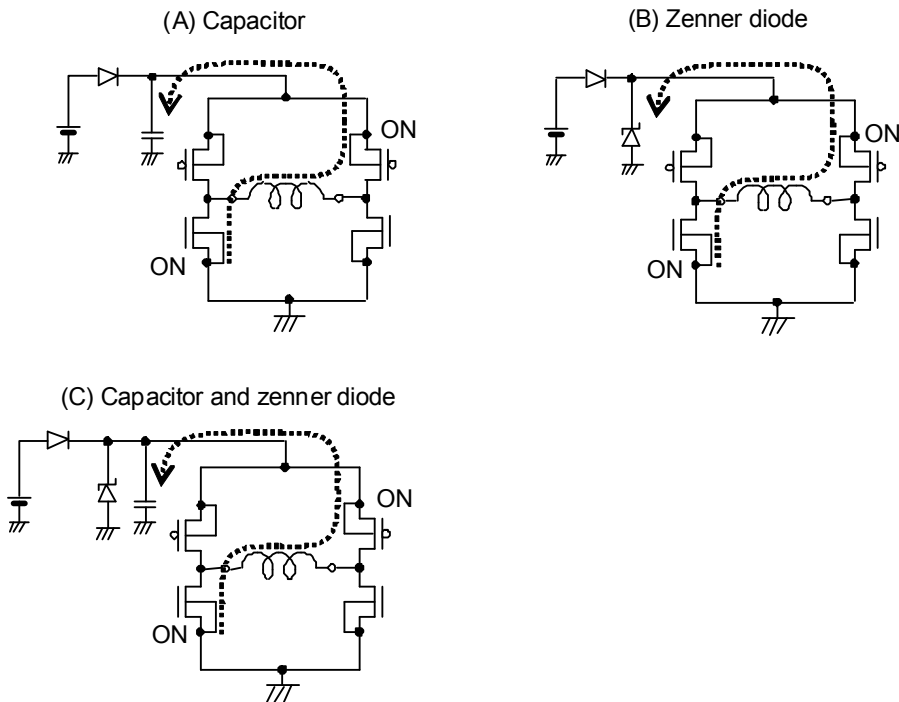


Fig.12 Measure against Vcc voltage rise

3) Problem of GND line PWM switching

Do not perform PWM switching of GND line because GND terminal potential cannot be kept to a minimum.

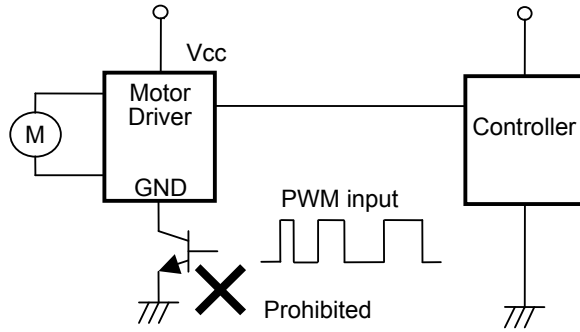


Fig.13 GND line PWM switching prohibited

4) FG and AL output

FG and AL output is an open collector and requires pull-up resistor.

The IC can be protected by adding resistor R1. An excess of absolute maximum rating, when FG or AL output terminal is directly connected to power supply, could damage the IC.

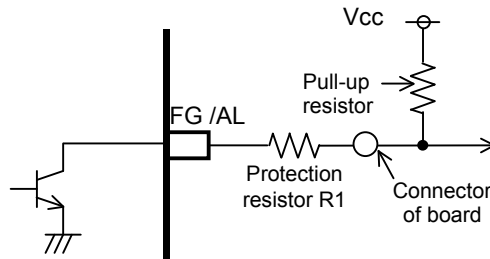


Fig.14 Protection of FG and AL terminal

●Calculation of power consumed by IC

Power consumed by this IC  $P_c$  is approximately calculated as follows:

$$P_c = P_{c1} + P_{c2} + P_{c3}$$

- $P_{c1}$  : Power consumption by circuit current  
 $P_{c1} = V_{cc} \times I_{cc}$
- $P_{c2}$  : Power consumption at output stage  
 $P_{c2} = V_{OL} \times I_o + V_{OH} \times I_o$   
 $V_{OL}$  is L voltage of output terminal 1 and 2.  
 $V_{OH}$  is H voltage of output terminal 1 and 2.  
 $I_o$  is the current flowing to output terminal 1 and 2.
- $P_{c3}$  : Power consumption at FG and AL  
 $P_{c3} = V_{FG} \times I_{FG} + V_{AL} \times I_{AL}$   
 $V_{FG}$  is L voltage of FG output.  
 $V_{AL}$  is L voltage of AL output.  
 $I_{FG}$  and  $I_{AL}$  are the current of FG and AL.

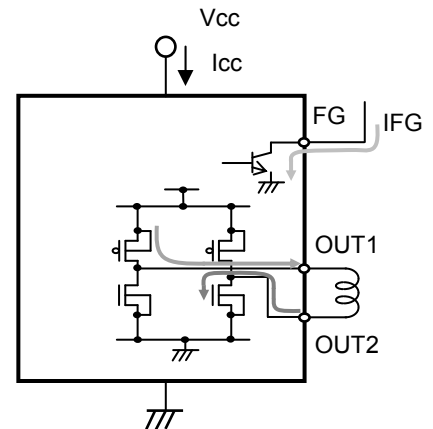


Fig.15 Calculation of power consumed by IC

Power consumption by IC greatly changes with use condition of IC such as power supply voltage and output current. Consider thermal design so that the maximum power dissipation on IC package is not exceeded.

●Thermal derating curve

Power dissipation (total loss) indicates the power that can be consumed by IC at Ta = 25°C (normal temperature). IC is heated when it consumes 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, etc, 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 in general equal to the maximum value in the storage temperature range.

Heat generated by consumed power of IC is radiated from the mold resin or lead frame of package. The parameter which indicates this heat dissipation capability (hardness of heat release) is called heat resistance, represented by the symbol  $\theta_{ja}$  [°C/W]. The temperature of IC inside the package can be estimated by this heat resistance. Fig.16 shows the model of heat resistance of the package.

Heat resistance  $\theta_{ja}$ , ambient temperature Ta, junction temperature Tj, and power consumption P can be calculated by the equation below:

$$\theta_{ja} = (T_j - T_a) / P \quad [^{\circ}\text{C}/\text{W}]$$

Thermal derating curve 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, packaging condition, wind velocity, etc., even when the same package is used. Thermal derating curve indicates a reference value measured at a specified condition. Fig.25 shows a thermal derating curve (Value when mounting FR4 glass epoxy board 70 [mm] x 70 [mm] x 1.6 [mm] (copper foil area below 3 [%]))

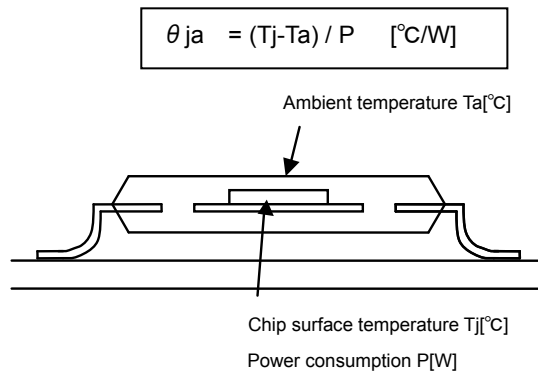
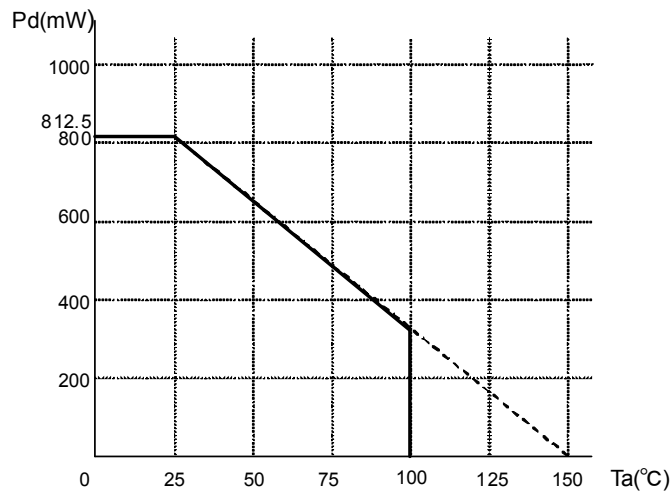


Fig.16 Thermal resistance



\* Reduce by 6.5 mW/°C over 25°C.  
 (On 70.0mm x 70.0mm x 1.6mm glass epoxy board)

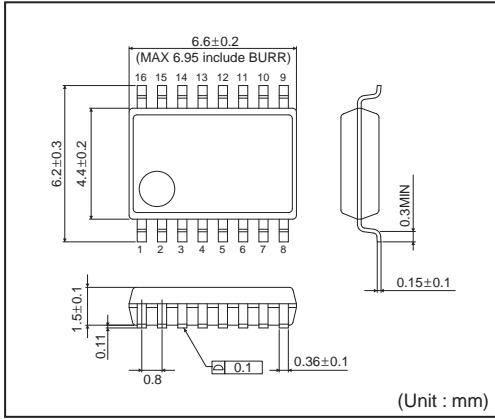
Fig.17 Thermal derating curve

**●Cautions on 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) Connecting the power supply connector backward  
Connecting of the power supply in reverse polarity can damage IC. Take precautions when connecting the power supply lines. An external direction diode can be added.
- 3) Power supply line  
Back electromotive force causes regenerated current to power supply line, therefore take a measure such as placing a capacitor between power supply and GND for routing regenerated current. And fully ensure that the capacitor characteristics have no problem before determine a capacitor value. (when applying electrolytic capacitors, capacitance characteristic values are reduced at low temperatures)
- 4) GND potential  
It is possible that the motor output terminal may deflect below GND terminal because of influence by back electromotive force of motor. The potential of GND terminal must be minimum potential in all operating conditions, except that the levels of the motor outputs terminals are under GND level by the back electromotive force of the motor coil. Also ensure that all terminals except GND and motor output terminals do not fall below GND voltage including transient characteristics. Malfunction may possibly occur depending on use condition, environment, and property of individual motor. Please make fully confirmation that no problem is found on operation of IC.
- 5) Thermal design  
Use a thermal design that allows for a sufficient margin in light of the power dissipation(Pd) in actual operating conditions.
- 6) 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.
- 7) 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.
- 8) ASO  
When using the IC, set the output transistor so that it does not exceed absolute maximum ratings or ASO.
- 9) Thermal shut down circuit  
The IC incorporates a built-in thermal shutdown circuit (TSD circuit). Operation temperature is 175°C(typ.) and has a hysteresis width of 25°C(typ.). When IC chip temperature rises and TSD circuit works, the output terminal becomes an open state. 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 operation this circuit or use the IC in an environment where the operation of this circuit is assumed.
- 10) 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.
- 11) GND 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.
- 12) Capacitor between output and GND  
When a large capacitor is connected between output and GND, if Vcc is shorted with 0V or GND for some cause, it is possible that the current charged in the capacitor may flow into the output resulting in destruction. Keep the capacitor between output and GND below 100uF.
- 13) IC terminal input  
When Vcc voltage is not applied to IC, do not apply voltage to each input terminal. When voltage above Vcc or below GND is applied to the input terminal, parasitic element is actuated due to the structure of IC. Operation of parasitic element causes mutual interference between circuits, resulting in malfunction as well as destruction in the last. Do not use in a manner where parasitic element is actuated.
- 14) In use  
We are sure that the example of application circuit is preferable, but please check the character further more in application to a part which requires high precision. In using the unit with external circuit constant changed, consider the variation of externally equipped parts and our IC including not only static character but also transient character and allow sufficient margin in determining

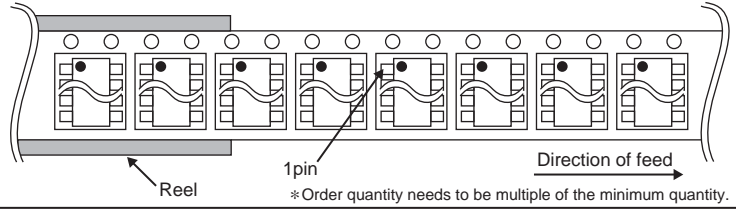
●Physical Dimension

SSOP-A16



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 ( The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand )



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