3-phase motor driver

BA6446FP / BA6446FM

The BA6446FP and BA6446FM are 3-phase, full-wave, pseudo-linear motor drivers suited for VCR capstan motors. The IC has a torque ripple cancellation circuit to reduce wow and flutter, a forced brake circuit that allows abrupt change of operational mode, and an output transistor saturation prevention circuit that provides superb motor control over a wide range of currents. The IC also contains FG and hysteresis amplifiers.

●Applications

VCR and DAT capstan motors

●Features

1) 3-phase, full-wave, pseudo-linear drive system.
2) Torque ripple cancellation circuit. (cancellation ratio adjustable)
3) Forced brake circuit.
4) High- and low-side output transistor saturation prevention circuit.
5) FG and hysteresis amplifiers.
6) Thermal shutdown circuit.

●Absolute maximum ratings (Ta = 25°C)

Parameter		Symbol	Limits	Unit
Applied voltage		V_{CC}	7	V
Applied voltage		V_M	36	V
Power dissipation	BA6446FP	Pd	1700*1*3	mW
	BA6446FM		2200*2*3	
Operating temperature		T_{opr}	−25～+75	℃
Storage temperature		T_{stg}	−40～+150	℃
Allowable output current		$I_{o\ peak}$	1500*4	mA

*1 Reduced by 13.6 mW for each increase in Ta of 1℃ over 25℃.

*2 Reduced by 17.6 mW for each increase in Ta of 1℃ over 25℃.

*3 When mounted on a glass epoxy board (70×70×1.6 mm).

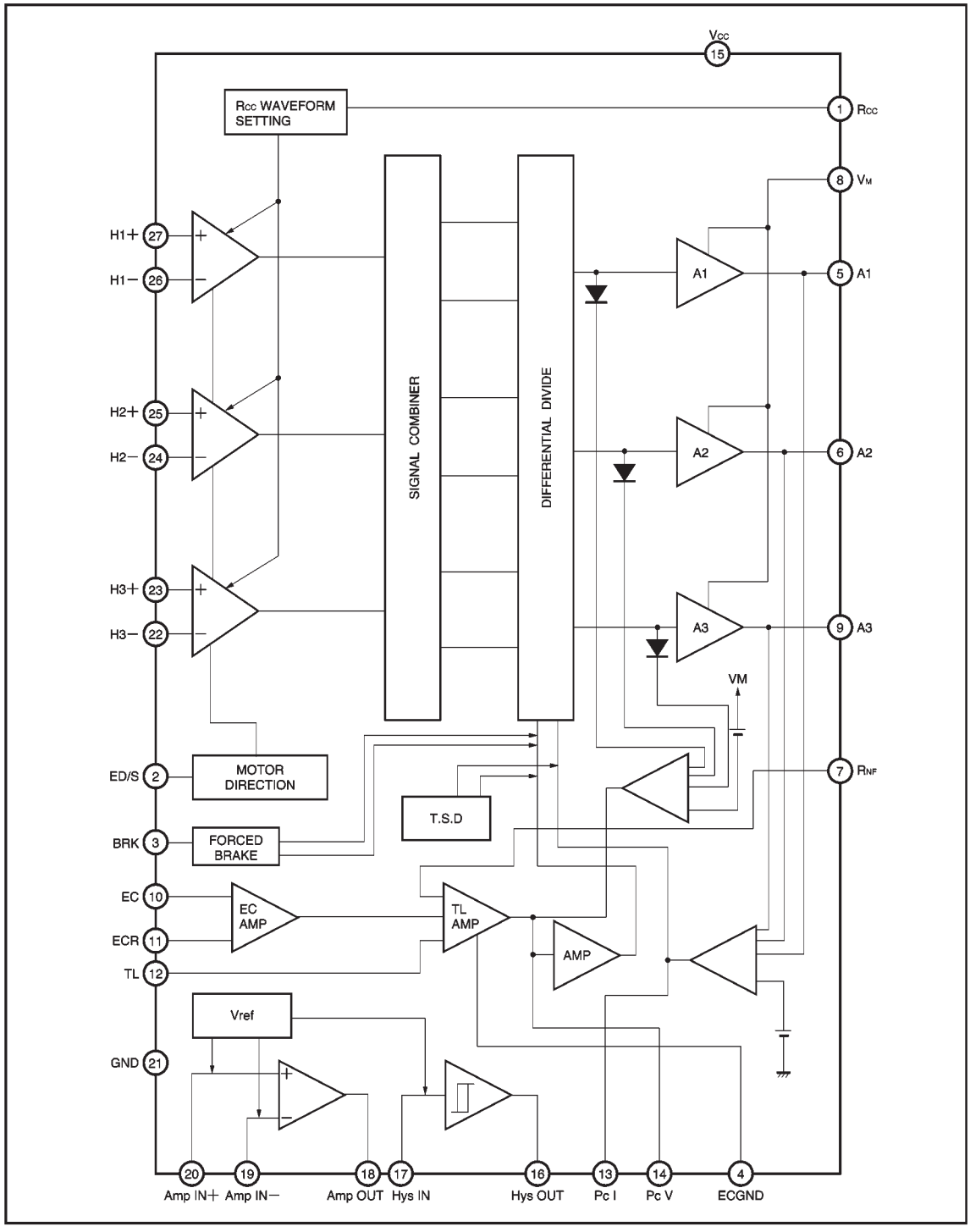
*4 Should not exceed Pd or ASO values.

●Recommended operating conditions (Ta = 25°C)

Parameter	Symbol	Limits	Unit
Operating power supply voltage	V_{CC}	4～6	V
	V_M	3～32*5	V
Hall signal input voltage	$H_n\pm$	1.5～ (V_{CC}−1.8)	V

*5 Should not exceed ASO value.

●Block diagram

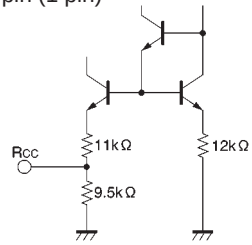


●Pin descriptions

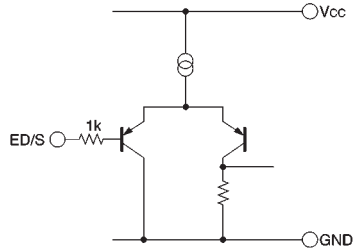
Pin No.	Pin name	Function
1	R_{CC}	Resistor connection pin for changing the ripple cancellation ratio
2	ED / S	Forward when LOW, reverse when HIGH
3	BRK	Forced brake pin; brake mode when LOW
4	ECGND	Torque amplifier ground
5	A1	Motor output
6	A2	Motor output
7	R_{NF}	Motor ground pin; connect a resistor (0.5Ω recommended) for current sensing
8	V_M	Motor power supply
9	A3	Motor output
10	E_C	Torque control voltage input
11	E_{CR}	Torque control reference voltage input
12	TL	Torque limit
13	P_{CI}	Capacitor connection pin for phase compensation of the low-side saturation prevention circuit
14	P_{CV}	Capacitor connection pin for phase compensation of the high-side saturation prevention circuit
15	V_{CC}	Power supply
16	Hys OUT	Schmitt trigger amplifier output
17	Hys IN	Schmitt trigger amplifier input
18	Amp OUT	Amplifier output
19	Amp IN−	Amplifier input, inverted
20	Amp IN+	Amplifier input, non-inverted
21	GND	Ground
22	H_3−	Hall signal input
23	H_3+	Hall signal input
24	H_2−	Hall signal input
25	H_2+	Hall signal input
26	H_1−	Hall signal input
27	H_1+	Hall signal input
28	N.C.	−

●Input / output circuits

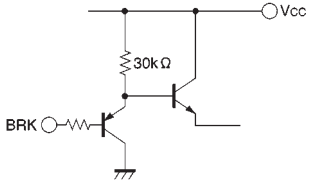
(1) R_{CC} pin (1 pin)



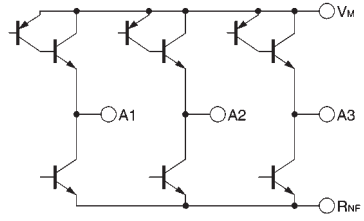
(2) ED / S pin (2 pin)



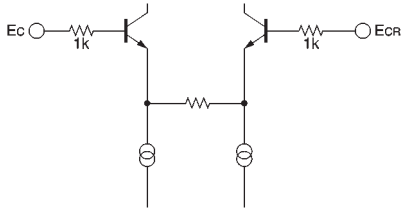
(3) BRK pin (3 pin)



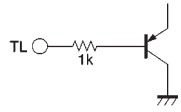
(4) Motor output (A1, 5 pin; A2, 6 pin; A3, 9 pin)



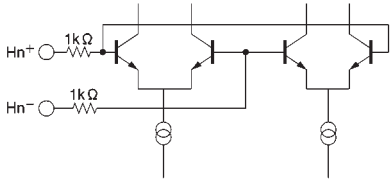
(5) E_C and E_{CR} pins (10 pin, 11 pin)



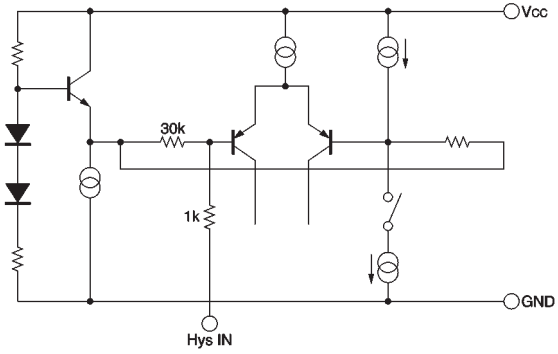
(6) TL pin (12 pin)

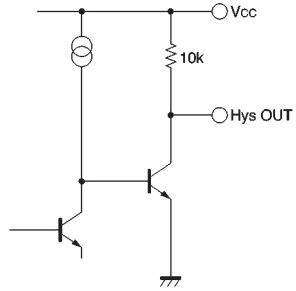


(7) Hall signal input pins
(H_1+ : 27 pin, H_1- : 26 pin, H_2+ : 25 pin,
H_2- : 24 pin, H_3+ : 23 pin, H_3- : 22 pin)

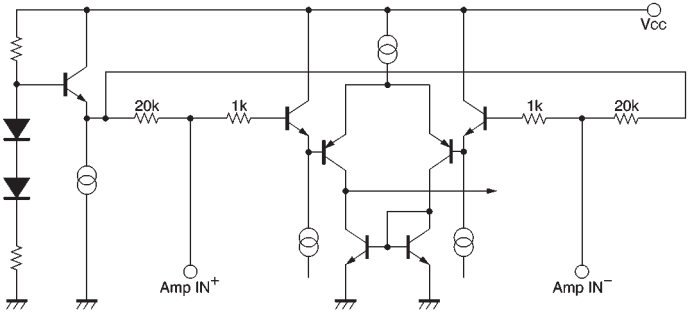


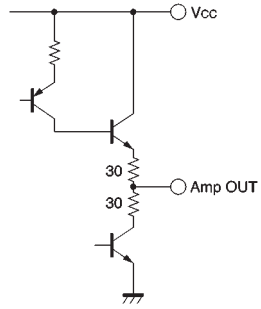
(8) Schmitt trigger amplifier I / O pins (17 pin, 16 pin)





(9) Amplifier I / O pins (20 pin, 19 pin, 18 pin)





●Electrical characteristics (unless otherwise noted, Ta = 25°C, V_{CC} = 5V, V_M = 12V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Supply current	Icc	—	9	14	mA	E_C=E_{CR}−0.1, ED / S=L Input = (L, L, H)
Hall element input conversion offset	H_{Eofs}	−10	0	+10	mV	
Torque control offset	E_{Cofs}	−120	—	+120	mV	
Output idle voltage	E_{Cidle}	—	0	10	mV	
Torque control input gain	G_{io}	0.52	0.58	0.64	A / V	E_C = 2.7→2.8, input = (L, L, H) R_{NF}=0.5Ω
Brake ON voltage	BR ON	—	—	0.7	V	
Brake OFF voltage	BR OFF	2.0	—	—	V	
Forward ON voltage	ED / F	—	—	2.2	V	
Reverse ON voltage	ED / R	2.8	—	—	V	
TL-R_{NF} offset	TL-R_{NOfs}	38	60	88	mV	TL=0.35V
Output high level voltage	V_{OH}	1.0	1.35	1.7	V	I_O=0.8A
Output low level voltage	V_{OL}	1.15	1.6	2.05	V	I_O=0.8A
Output current capacity	I_{OMAX}	1.4	—	—	A	V_{CC} = 4.5 V, input = (H, L, M)
〈FGAMP〉						
Input impedance	R_{BA}	14	20	26	KΩ	
Open gain 1	G_{A1}	65	70	—	dB	f=500Hz
Open gain 2	G_{A2}	33	38	—	dB	f=20kHz
DC bias voltage	V_{BA}	2.25	2.5	2.75	V	
Output high level voltage	V_{OH}A	3.6	4	—	V	I_{OA}=0.5mA
Output low level voltage	V_{OL}A	—	0.9	1.3	V	I_{OA}=0.5mA
Input voltage	V_{AB}	1.5	—	3.8	V	
〈Schmitt trigger amplifier〉						
Hysteresis width	V_{hys}	±115	±155	±195	mV	
DC bias voltage	V_{Bhys}	2.25	2.5	2.75	V	
Output low level voltage	V_{OLhys}	—	100	320	mV	I_{OLhys}=2mA

✻ Specifications are subject to change without notice.

◎Not designed for radiation resistance.

●Circuit operation

(1) Pseudo-linear output and torque ripple cancellation

The IC generates a trapezoidal (pseudo-linear) output current, whose waveform phase is 30 degrees ahead of that of the hall input voltage (Fig. 1).

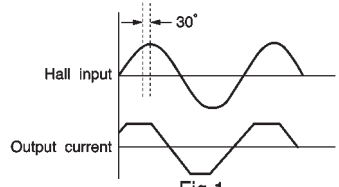


Fig.1

(2) Torque control

The output current can be controlled by adjusting the voltage applied to the torque control pins.

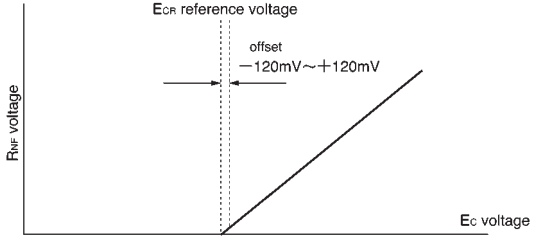


Fig. 2

The pins are the inputs to a differential amplifier. A reference voltage between 2. 3-3. 0V (2.5 V recommended) is applied to pin 11.

A brake is applied to the motor when the brake pin (3 pin) is put to LOW. The brake mode is activated when the brake pin voltage is 0.7V or less and deactivated when the voltage is 2.0V or more.

(3) Output current sensing and torque limitation

The R_{NF} pin (7 pin) is the ground pin for the output stage. To sense the output current, a resistor (0.5Ω recommended) is connected between pin 7 and the ground. The output current is sensed by applying the voltage developed across this resistor to the TL amplifier input as a feedback.

The output current can be limited by adjusting the voltage applied to pin 12. The current is limited when pin 12 reaches the same potential as pin 7. The output current ($I_{MAX.}$) under this condition is given by :

$$I_{MAX.} = \frac{V_{TL} - (TL - R_{NF}\ \text{offset})}{R_{RNF}}$$

where R_{RNF} is the value of the resistor connected between the R_{NF} pin and the ground, and V_{TL} is the voltage applied to the TL pin.

(4) Motor direction control (ED / S pin)

The motor mode is :

Forward when the ED / S-pin voltage is less than 2.2V,

Reverse when the voltage is above 2.8V.

(5) Output transistor saturation prevention circuit

This circuit monitors the output voltage and maintains the operation of the output transistors below their saturation levels. Operating the transistors in the linear characteristic range provides good control over a wide range of current and good torque characteristics even during overloading.

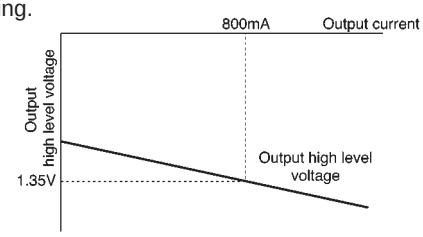


Fig. 3

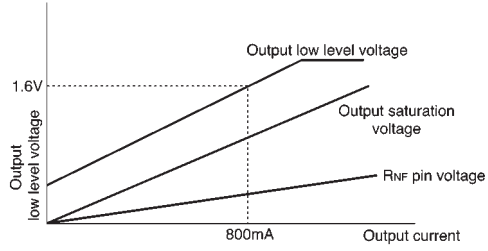


Fig. 4

(6) Ripple cancellation circuit

The torque ripple cancellation ratio can be adjusted by an external resistor connected to pin 1. Select a suitable value by taking wow and flutter into consideration.

(7) Brake pin

The brake pin threshold depends on the chip temperature as shown in Fig. 5. Make sure that your application will work properly when using the IC at low or high temperatures.

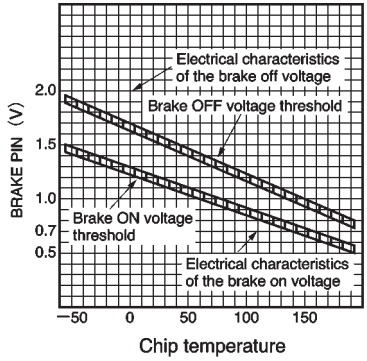


Fig.5 Brake pin threshold vs. chip temperature

●Application example

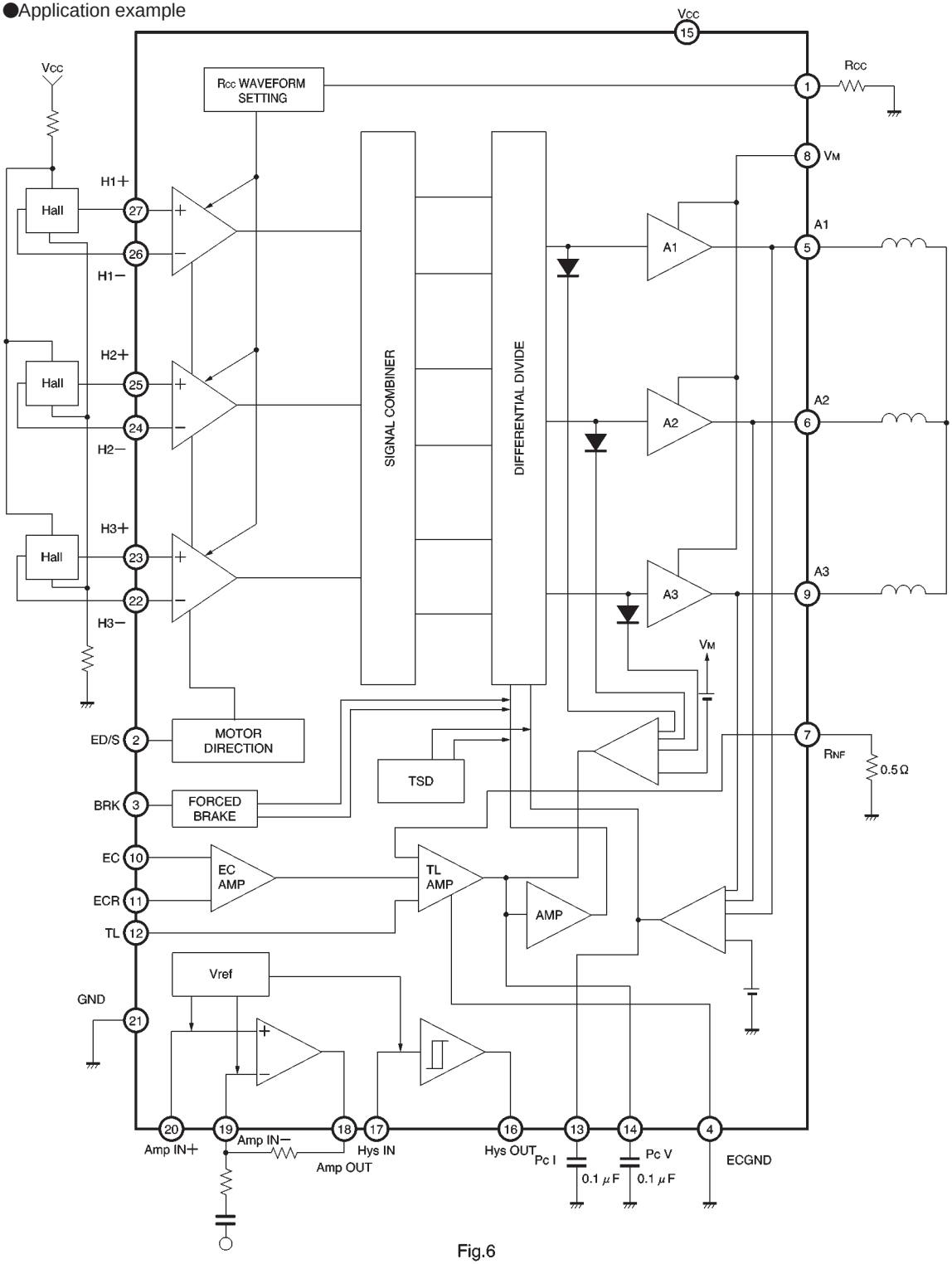


Fig.6

●Operation notes

(1) Thermal shutdown circuit

The BA6446FP / FM has a thermal shutdown circuit to protect the IC. The shutdown temperatures is 175°C (typical) with a hysteresis width of 45°C (typical).

When the circuit is activated due to an increase in the chip temperature, the output pins (pins 5, 6, and 9) are set to the open state. The circuit is functional against excessive power dissipation, output short-circuiting, and other irregularities in the output current, but does not work against overheating caused by high internal currents due to externally caused IC damage or pin-to-pin short-circuiting.

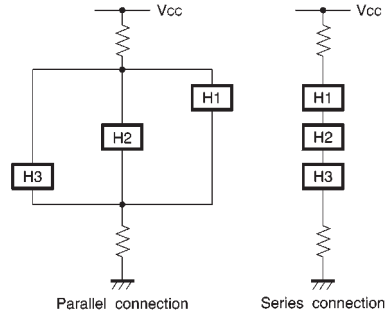
(2) Brake circuit

The brake circuit has temperature-dependent thresholds as shown in Fig. 5. Make sure that your application will work properly when using the IC at low or high temperatures.

(3) Be sure to connect the radiation fins to the ground.

(4) Hall input

The Hall input circuit is described in (7) of "I / O equivalent circuits." Hall devices can be connected in either series or parallel. Be sure to keep the Hall input within the range of 1.5V to (V_{CC} – 1.8V).



(5) FG amplifier

Note that unpredictable outputs may occur when the FG amplifier input is outside the recommended range.

(6) ECGND pin (4 pin)

Pin 4, a torque amplifier ground pin, should be connected to the ground. By connecting this pin to a point close to the motor ground, you can prevent the effect of GND common impedance on the current-sensing resistor (0.5Ω recommended) connected between R_{NF} (pin 7) and the motor ground pin.

●Electrical characteristic curves

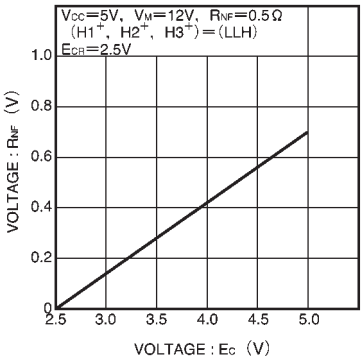


Fig.7 R_{NF}-pin voltage vs. E_C-pin voltage

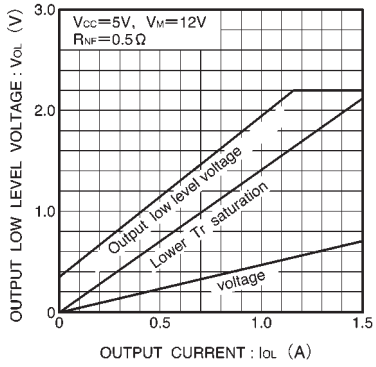


Fig.8 Output low level voltage vs. output current

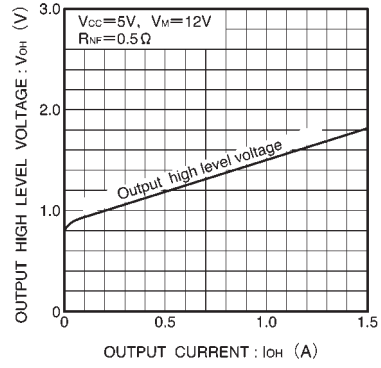


Fig.9 Output high level voltage vs. output current

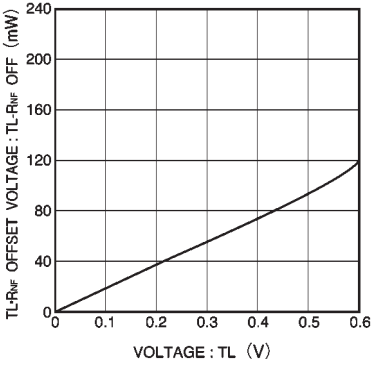


Fig.10 TL-R_{NF} offset voltage vs. TL voltage

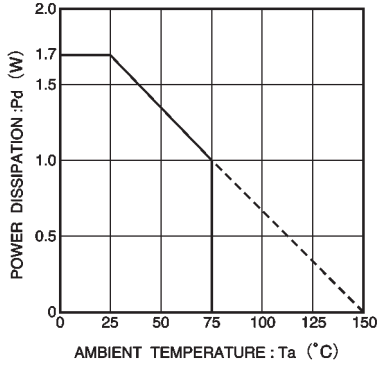


Fig.11 Temperature dependence of power dissipation (BA6446FP)

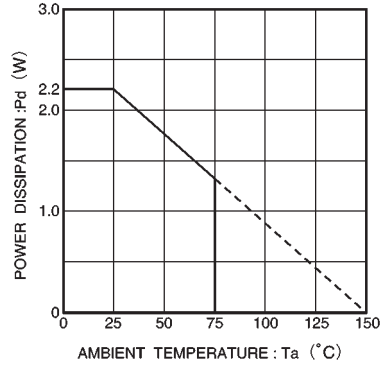
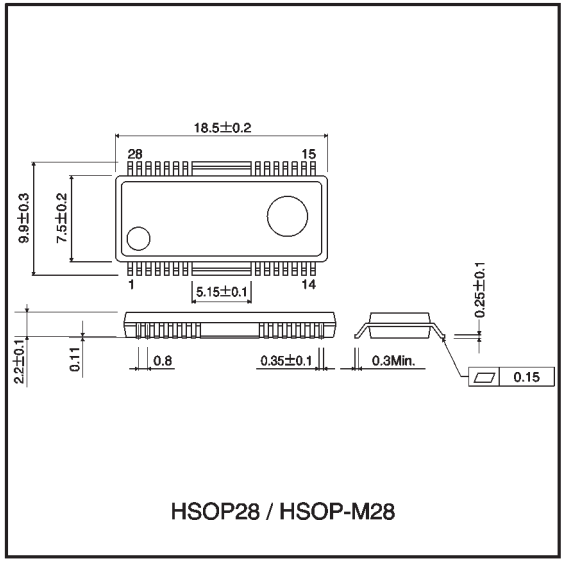


Fig.12 Temperature dependence of power dissipation (BA6446FM)

●External dimensions (Units: mm)



HSOP28 / HSOP-M28