

# M54687FP

## Bi-Directional Motor Driver with Governor

REJ03F0048-0100Z

Rev.1.0

Sep.19.2003

### Description

The M54687FP is a semiconductor integrated circuit that is capable of directly controlling the rotating direction and rotating speed of a smallsize bi-directional motor rotating in both forward and reverse directions.

### Features

- Capable of controlling the speed in forward and reverse rotating directions
- Capable of controlling the speed in high speed mode
- Large output current drive ( $I_{O(max)} = 700mA$ )
- Built-in clamp diode
- Flat package (16P2N)

### Application

Micro-cassette for phone-answering machine, AV equipment, and other general consumption appliances

### Function

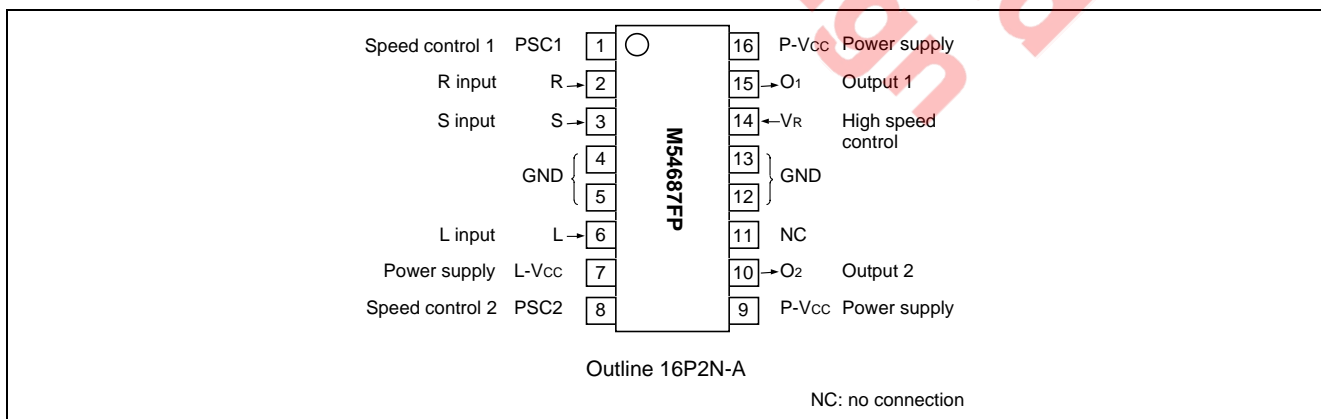
The M54687FP is an IC that can control the forward rotation, reverse rotation and speed of small DC brush motor.

For the basic operation of this IC, output modes are selected, as shown in the logic truth table, by entering appropriate H/L level into the R, L and S inputs.

Two resistances are put between the output pin and the PSC pin and the resistance ratios are appropriately adjusted to perform the speed control.

In addition to the above, speed control can be done by varying the voltage at  $V_R$  pin, in the high speed mode.

### Pin Configuration



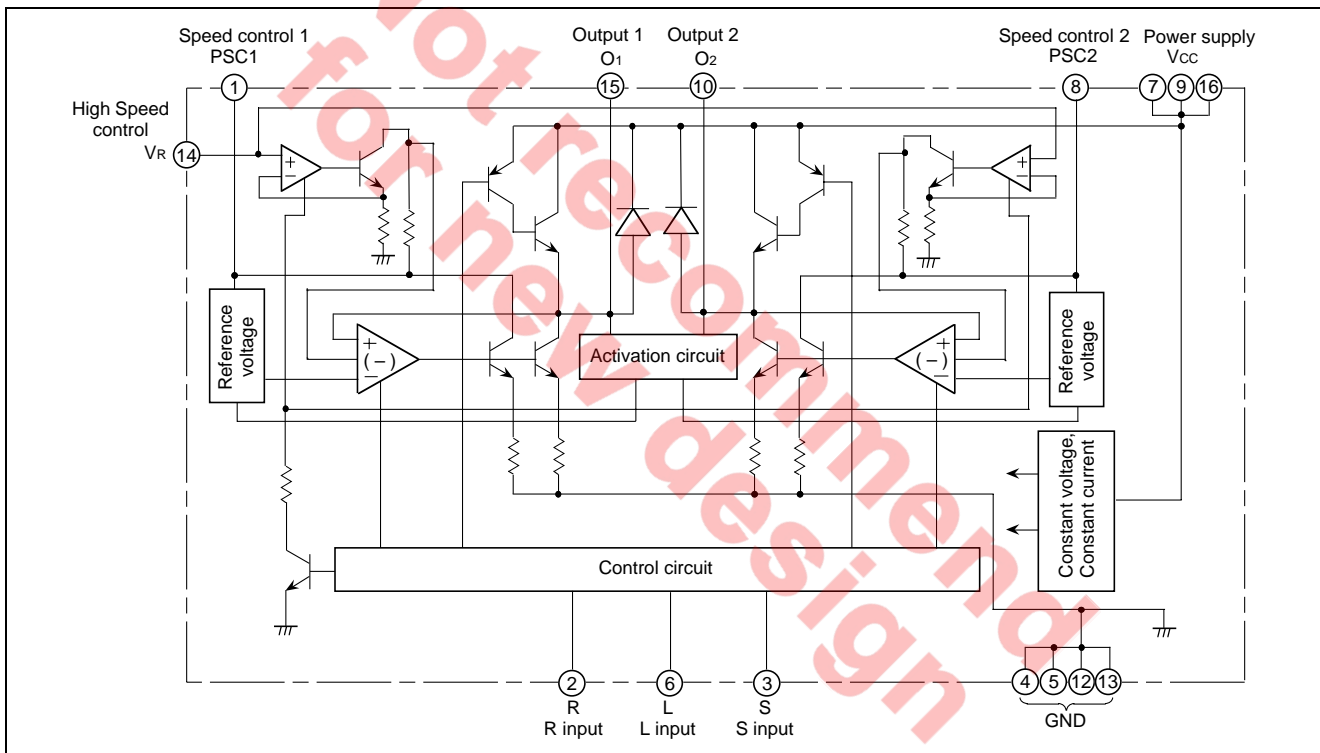
Logic Truth Table

Input			Output			Mode	
R	L	S	O1	O2			
H	H	H	H	FG	FF	Forward rotation high speed governor	
H	L	H	H	G	PLAY	Forward rotation governor	
L	H	H	FG	H	REW	Reverse rotation high speed governor	
L	L	H	G	H	REV	Reverse rotation governor	
H	H	L	L	L	BRAKE	Brake operation	
L	L	L	OFF	OFF	STB	Standby mode output high imp.	
H	L	L	—	—	—	Reserved	
L	H	L	—	—	—		

G: Governor control output mode

FG: Rotating speed controllable with the voltage at VR pin (However, the precision is worse than G.)

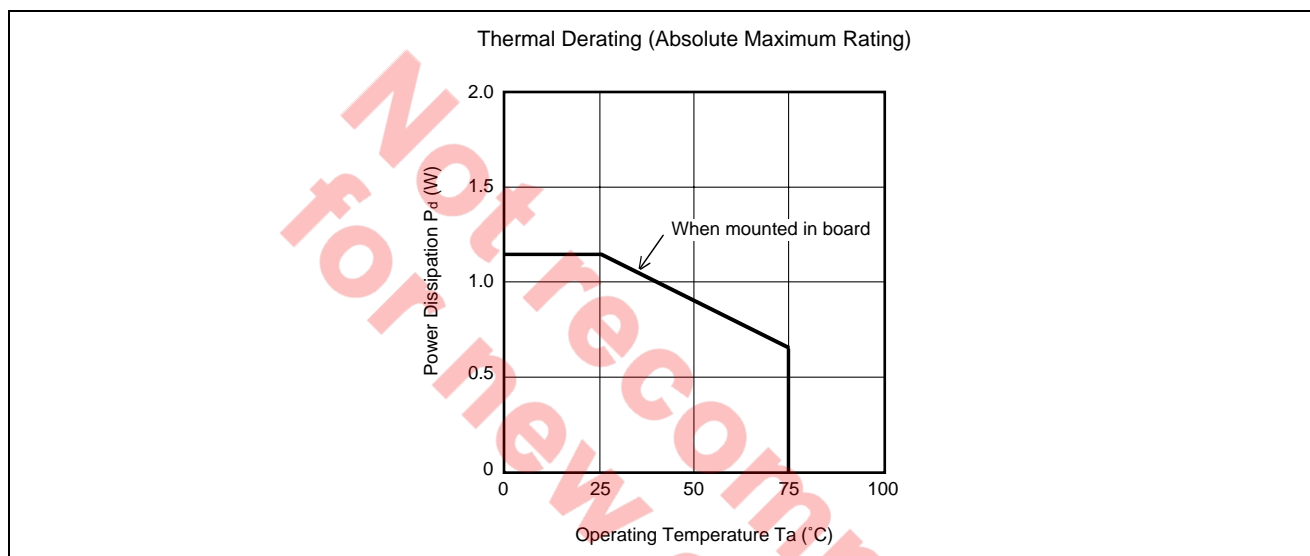
Block Diagram



## Absolute Maximum Ratings

(Ta = 25°C unless otherwise noted.)

Parameter	Symbol	Ratings	Unit	Condition
Power supply	VCC	-0.5 – +14	V	
Input voltage	VI	-0.5 – VCC	V	
Output voltage	VO	-0.5 – VCC+2	V	
Allowable motor rush current	IOP	±700	mA	$t_{ON} \leq 100\text{ms}$ , duty of 1% or less.
Continuous output current	IO	±200	mA	However, Pd must not exceed the maximum rating.
Power dissipation	Pd	1.14	W	When mounted in board
Operating temperature	Topr	-20 – 75	°C	
Storage temperature	Tstg	-40 – 125	°C	



## Recommended Operational Conditions

(Ta = 25°C unless otherwise noted.)

Parameter	Symbol	Limits			Unit
		Min.	Typ.	Max.	
Supply voltage	Vcc	6.0	9.0	13.0	V
"H" input voltage	VIH	2.0		Vcc	V
"L" input voltage	VIL	0		0.4	V
VR control voltage range*	VR	0		Vcc	V

\* : IO ≤ 200mA when FF/REW speed is controlled.

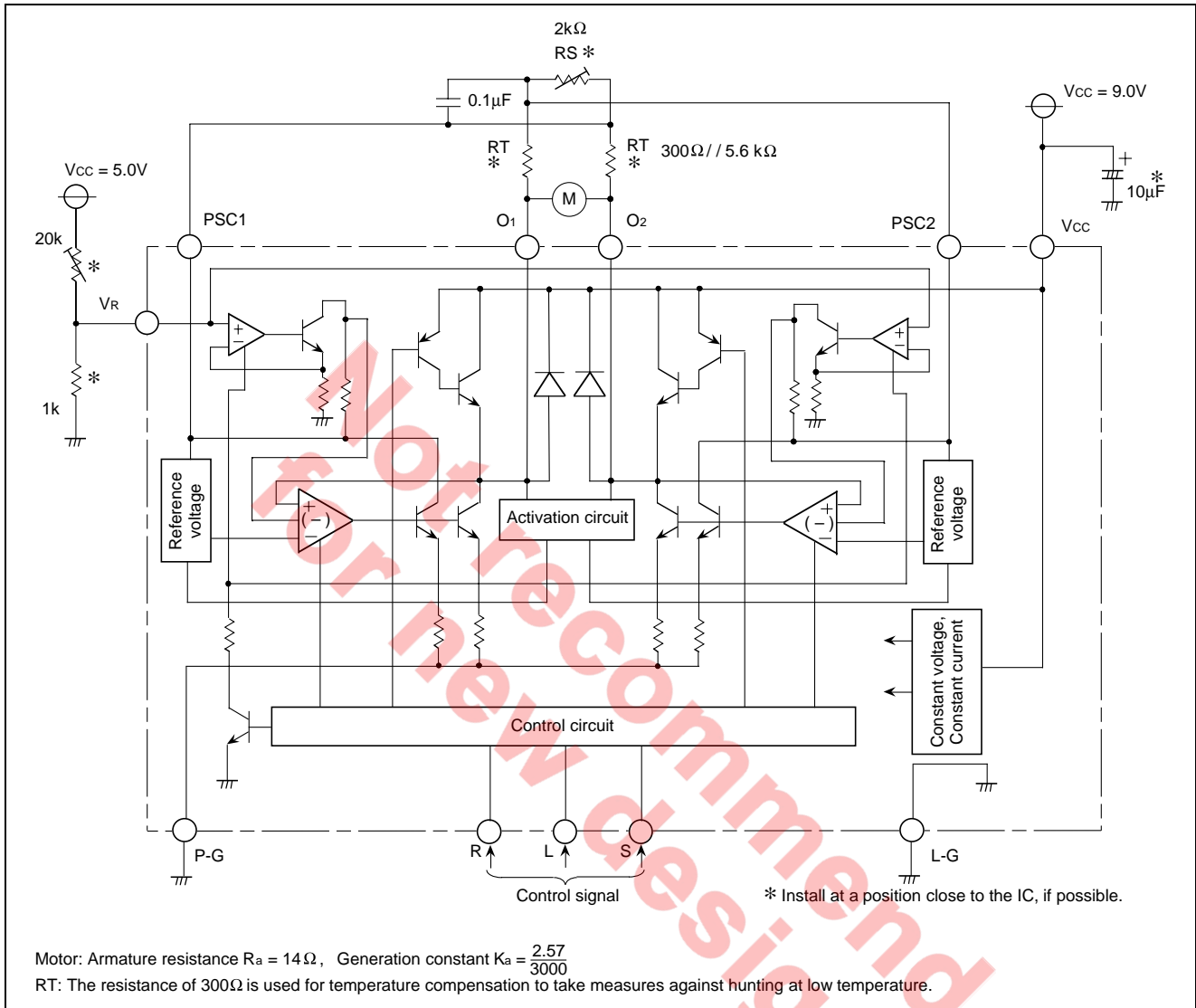
## Electrical characteristics

(Ta = 25°C, unless otherwise noted.)

Symbol	Parameter	Test conditions	Limits			Unit	
			Min.	Typ.	Max.		
I <sub>o(leak)</sub>	Output leak current	V <sub>CC</sub> = 14V, V <sub>o</sub> = 14V Standby mode		0	100	μA	
I <sub>i</sub>	Input current	V <sub>i</sub> = 5.0V	0	0.4	1.0	mA	
V <sub>OH</sub>	"H" output voltage	I <sub>o</sub> = -200mA, V <sub>R</sub> = 5.0V	V <sub>CC</sub> -1.2	V <sub>CC</sub> -0.9	–	V	
V <sub>OL</sub>	"L" output voltage	I <sub>o</sub> = 200mA, V <sub>R</sub> = 0V, V <sub>pSC</sub> = 2.5V FF / REW / BRAKE mode	–	0.22	0.5	V	
I <sub>CC1</sub>	Supply current	FF/REW	Output open	–	5.0	8.0	mA
I <sub>CC2</sub>		PLAY/REV	Output open	–	5.0	8.0	mA
I <sub>CC3</sub>		BRAKE	Output open	–	35	48	mA
I <sub>CC4</sub>		STAND BY		–	0	10.0	μA
V <sub>ref</sub>	Governor characteristics (I) PLAY/REV mode	Reference voltage		0.95	1.0	1.05	V
I <sub>B</sub>		Bias current		0.7	1.2	1.7	mA
K		Current proportional constant	ΔI <sub>o</sub> = 40mA	18	20	22	–
$\frac{\Delta V_{ref}}{V_{ref}} / V_{CC}$		Voltage characteristics	V <sub>ref</sub> V <sub>CC</sub> = 6.0 – 13V		0.1		%/V
$\frac{\Delta K}{K} / V_{CC}$		Voltage characteristics	K V <sub>CC</sub> = 6.0 – 13V ΔI <sub>o</sub> = 40mA		0.2		%/V
$\frac{\Delta V_{ref}}{V_{ref}} / I_o$		Current characteristics	V <sub>ref</sub> I <sub>o</sub> = 50 – 200mA		0.02		%/mA
$\frac{\Delta K}{K} / I_o$		Current characteristics	K I <sub>o</sub> = 50 – 200mA		0.01		%/mA
$\frac{\Delta V_{ref}}{V_{ref}} / T_a$		Temperature characteristics	V <sub>ref</sub> T <sub>a</sub> = -20 – 75°C		0.01		%/°C
$\frac{\Delta K}{K} / T_a$	Temperature characteristics	K T <sub>a</sub> = -20 – 75°C		0.01		%/°C	
V <sub>ref II</sub>	Governor characteristics (II) FF-REW	Reference voltage	V <sub>R</sub> = 0.3V		2.0	V	
$\frac{\Delta V_{ref}}{V_{ref}} / V_{CC}$			Voltage characteristics	V <sub>R</sub> = 0.3V V <sub>CC</sub> = 6.0 – 13V		3.0	%/V
$\frac{\Delta V_{ref}}{V_{ref}} / I_o$			Current characteristics	V <sub>R</sub> = 0.3V I <sub>o</sub> = 50 – 200mA		0.2	%/mA
$\frac{\Delta V_{ref}}{V_{ref}} / T_a$			Temperature characteristics	V <sub>R</sub> = 0.3V T <sub>a</sub> = -20 – 75°C		0.1	%/°C
I <sub>B</sub>	Bias current	V <sub>R</sub> = 0.3V	0.7	1.3	1.8	mA	
I <sub>R</sub>	V <sub>R</sub> input current	V <sub>R</sub> = 0V	0	-5.0	-20	μA	

### Application Example

When the normal speed is set to 2000rpm, and the high speed is set to 3500rpm



## Speed Control Method

(1) Speed Control Method I (See the application circuit drawing.)

For PLAY/REV

Rotation number can be expressed by the following formula:

$$N = \frac{1}{K_a} \{ I_B \cdot R_T + V_{ref} (1 + \frac{R_T}{R_T + R_S}) + I_a (\frac{R_T}{K} - R_a) \} \dots \dots (1)$$

Where:

Motor generation constant:  $K_a$ , Motor armature resistance:  $R_a$ , Rotation number:  $N$

$K$ : Current proportional constant,  $I_B$ : PSC pin bias current,

$I_a$ : motor current

$R_T$ ,  $R_S$ : External resistance

In addition, to set the rotation number with  $R_S$ , external resistance  $R_T$  is generally set as follows:

$$R_T \leq K \times R_a$$

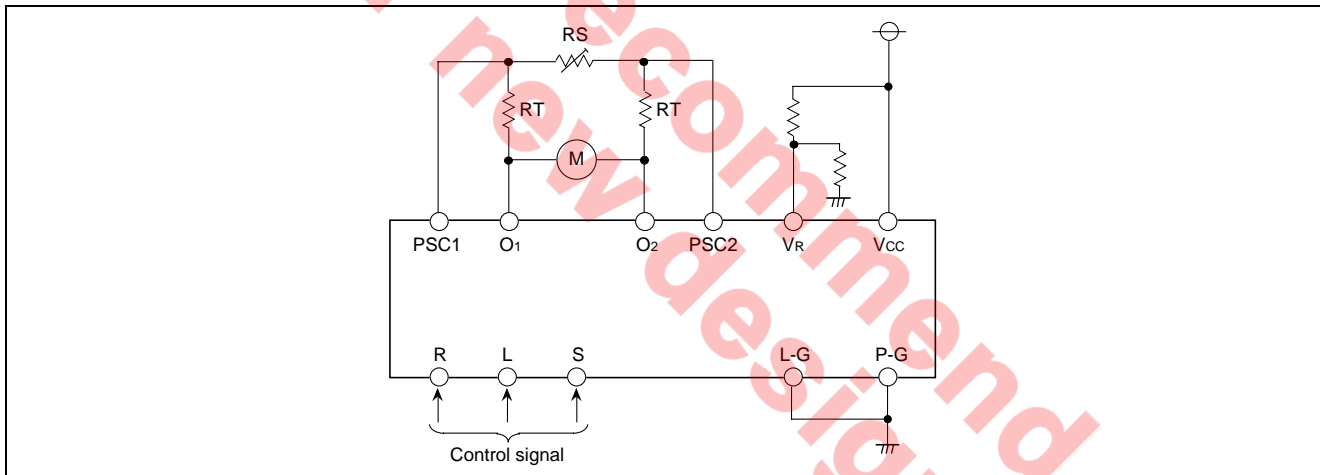
For FF/REW

Note that the rotation number is basically controlled with the same expression as formula (1) but different reference voltage

$V_{ref}$  and different bias current  $I_B$  are to be used.

However,  $V_{ref} = 5V_R + 0.5$

(2) Speed Control Method II (to increase the motor rotation number)



In the external circuit above, the voltage across motors is almost determined by the ratio of ' $R_S + R_T$ ' to ' $R_T$ ' and, therefore, a value set for the voltage across motors is not so large.

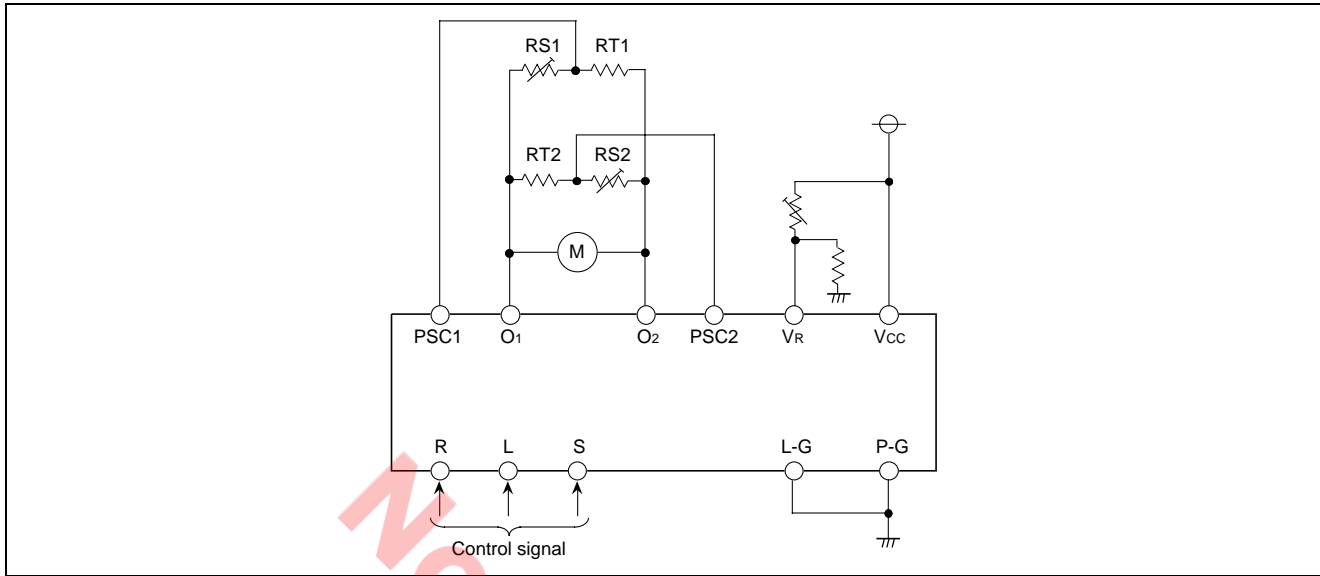
As method (1) of speed control I, the rotation number can be controlled.

However, the following relations must be satisfied:

$$R_T \rightarrow R_T + R_S$$

$$R_S + R_T \rightarrow R_T$$

## (3) Speed Control Method III (to increase the precision of forward rotation and reverse rotation)



The above two applications cannot make fine adjustments in forward rotation and reverse rotation (because the external resistance is shared with the forward rotation and reverse rotation).

Fine adjustments can be made for each of forward rotation and reverse rotation if the external circuit is set as shown in the drawing above.

This external circuit is also available to change the speed of forward and reverse rotation.

The control method adopts the same formula as formula (1).

However, the following relations must be satisfied:

$$RT + RS \rightarrow RS1 \text{ or } RS2$$

$$RT \rightarrow RT1 \text{ or } RT2$$

## CAUTIONS

- (1) Oscillation may take place with the setting of  $RT > K \cdot Ra$ . Set  $R \leq K \cdot Ra$ .
- (2) Add a capacitor of  $0.1 \mu\text{F}$  to the portion between PSCs to reduce brush noise of the motor.
- (3) Add a capacitor of  $10 \mu\text{F}$  to the portion between  $v_{cc}$  and GND to reduce brush noise and back electromotive noise of the motor.
- (4) At a low temperature,  $RT > K \cdot Ra$  is set due to temperature characteristics of resistance  $R_a$  of the motor. When oscillation takes place, use resistance with a temperature coefficient for  $RT$ .
- (5) When the supply voltage is low, note that saturation of the output transistor of the IC may prevent the rotating speed for control. Taking into account motor noise etc., set constants in the following range.

$$2.0V \leq V_{cc} - (EC + I_a \cdot Ra) \\ = V_{cc} - \left\{ RT \cdot I_B + V_{ref} \left( 1 + \frac{RT}{RS} \right) + \frac{RT}{K} \cdot I_a \right\}$$

When the back electromotive force is large with the brakes applied, for example, malfunction may occur in internal parasitic  $D_i$ . If flyback current of 1A or more flows, add Schottky  $D_i$  to the portion between the output and the GND.

When the IC is used at a high speed for PWM etc., note that switching of output results in delay of approx.  $10 \mu\text{s}$ .

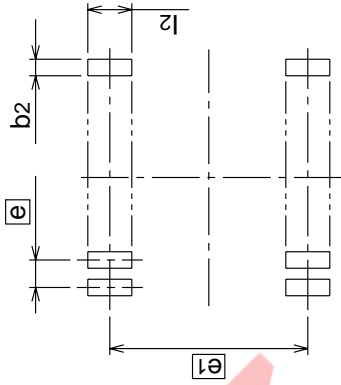
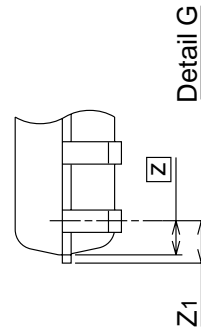
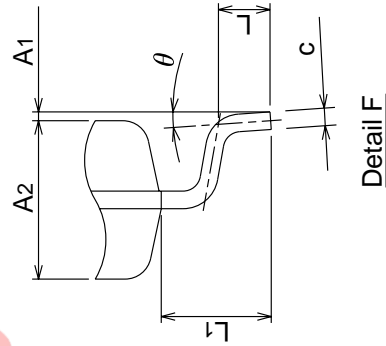
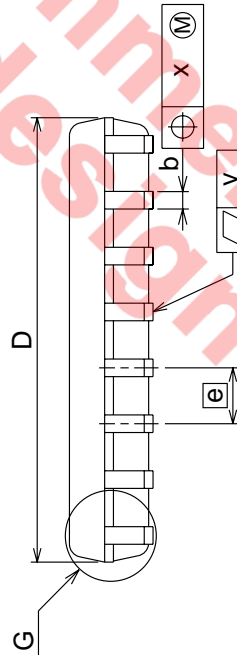
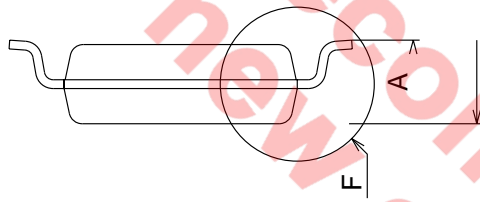
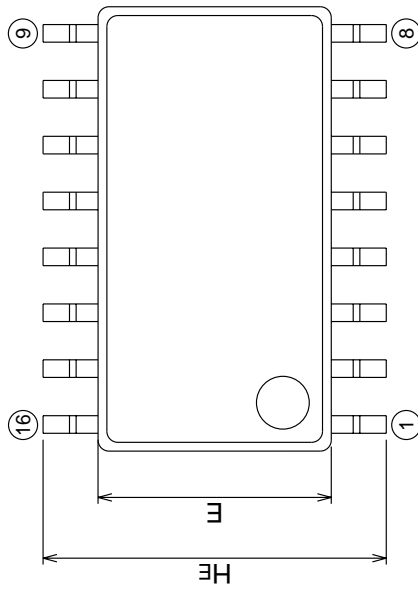
Package Dimensions

Plastic 16pin 300mil SOP

(MMP)

16P2N-A

EIAJ Package Code SOP16-P-300-1.27	JEDEC Code —	Weight(g) 0.2	Lead Material Cu Alloy
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Recommended Mount Pad

Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	0	0.1	0.2
A1	—	1.8	—
A2	0.35	0.4	0.5
b	0.18	0.2	0.25
D	10.0	10.1	10.2
E	5.2	5.3	5.4
e	—	1.27	—
HE	7.5	7.8	8.1
L	0.4	0.6	0.8
L1	—	1.25	—
Z	—	0.605	—
Z1	—	—	0.755
x	—	—	0.25
y	—	—	0.1
$\theta$	0°	—	8°
b2	—	0.76	—
e1	—	7.62	—
l2	1.27	—	—



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