M54687FP

Bi-Directional Motor Driver with Governor

REJ03F0048-0100Z
Rev.1.0
Sep.19.2003

Not recommend for new design

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 (IO(max) =700mA)
- Built-in clamp diode
- Flat package (16P2N)

Application

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

Function

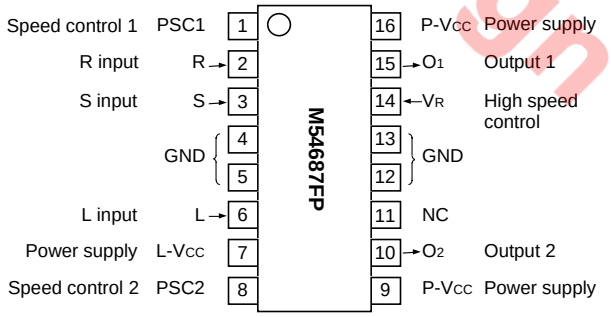
The M54687FP is an IC that can control the forward rotation, reverse rotation and speed of small DC brush motor.

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



Outline 16P2N-A

NC: no connection

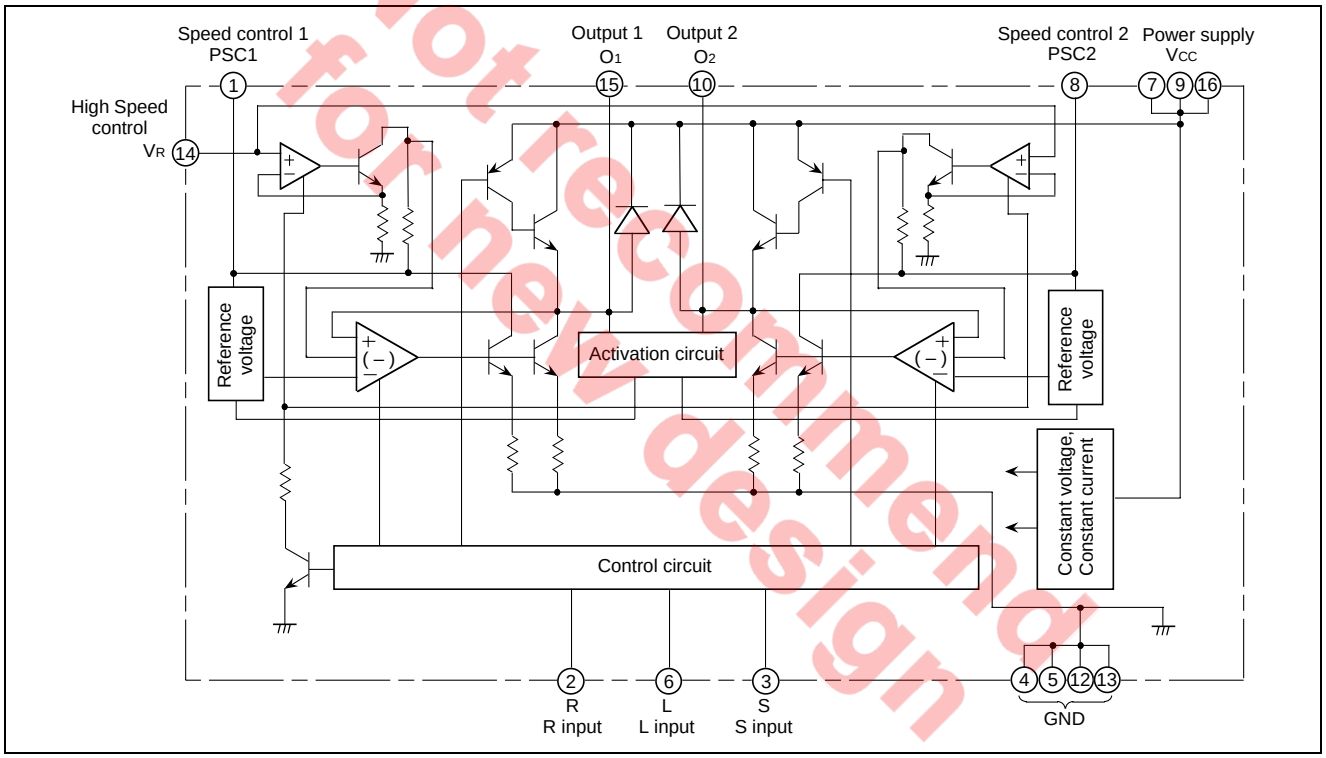
Logic Truth Table

Input			Output			
R	**L**	**S**	**O1**	**O2**	**Mode**	
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



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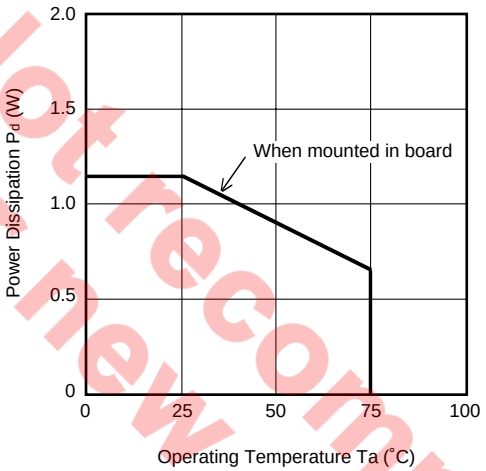
Absolute Maximum Ratings

(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} ≤ 100ms, 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	

Thermal Derating (Absolute Maximum Rating)



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Recommended Operational Conditions

(Ta = 25°C unless otherwise noted.)

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

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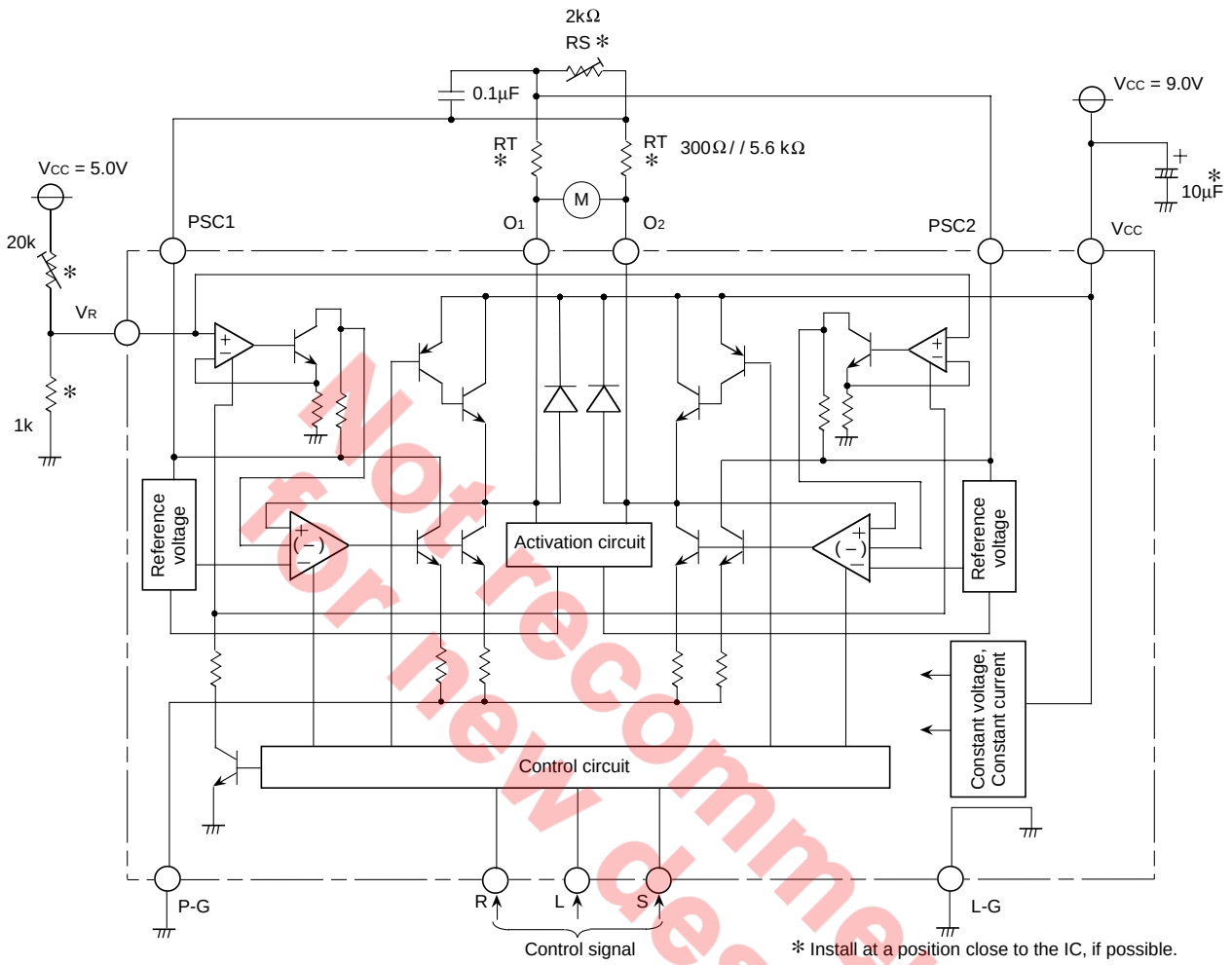
Application Example

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



Motor: Armature resistance R_a = 14Ω, Generation constant $K_a = \frac{2.57}{3000}$

RT: The resistance of 300Ω is used for temperature compensation to take measures against hunting at low temperature.

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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:

$$N=\frac{1}{Ka}\{IB \cdot RT+V_{ref}(1+\frac{RT}{RT+RS})+Ia(\frac{RT}{K}-Ra)\}\cdots\cdots(1)$$

Where:

Motor generation constant: Ka, Motor armature resistance: Ra, Rotation number: N

K: Current proportional constant, IB: PSC pin bias current,

Ia:motor current

RT, RS: External resistance

In addition, to set the rotation number with RS, external resistance RT is generally set as follows:

$RT \leq K \times Ra$

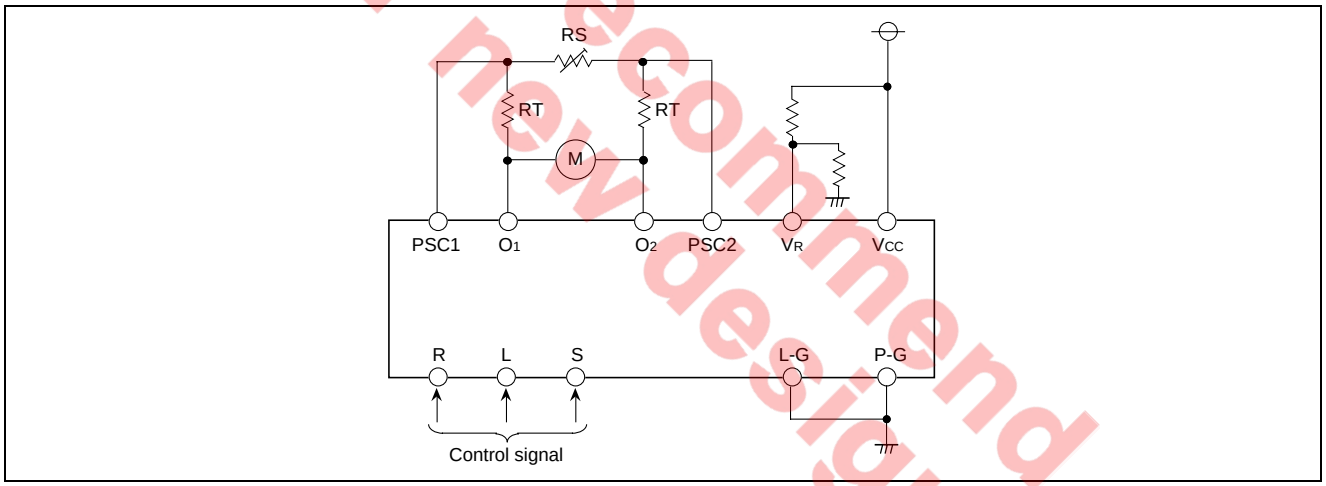
For FF/REW

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

Vref and different bias current IB are to be used.

However, Vref 5VR+0.5

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



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

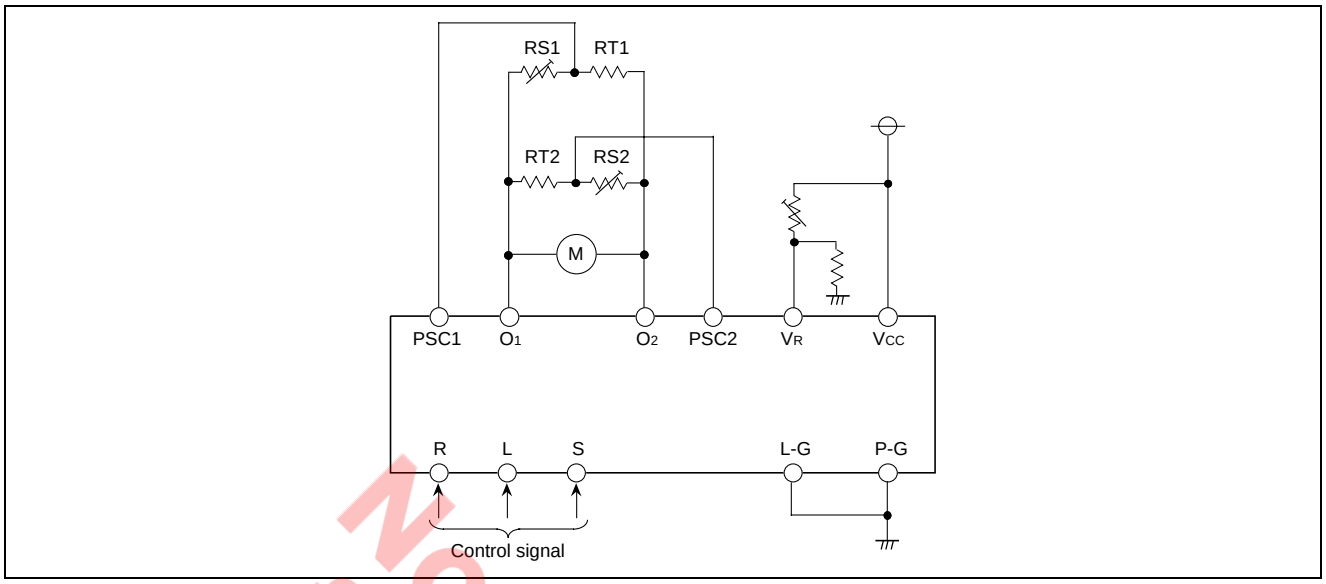
As method (1) of speed control I, the rotation number can be controlled.

However, the following relations must be satisfied:

RT→RT+RS

RS+RT→RT

(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→RS1 or RS2

RT→RT1 or RT2

CAUTIONS

(1) Oscillation may take place with the setting of RT>K•Ra. Set
R ≤ K•Ra.
(2) Add a capacitor of 0.1µF to the portion between PSCs to reduce brush noise of the motor.
(3) Add a capacitor of 10µF to the portion between VCC and GND to reduce brush noise and back electromotive noise of the motor.
(4) At a low temperature, RT>K•Ra is set due to temperature characteristics of resistance Ra 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.

$$2.0V \leq V_{CC} - (EC + Ia \cdot Ra)$$
$$= V_{CC} - \{RT \cdot IB + V_{ref}(1 + \frac{RT}{RS}) + \frac{RT}{K} \cdot Ia\}$$

When the back electromotive force is large with the brakes applied, for example, malfunction may occur in internal parasitic Di. If flyback current of 1A or more flows, add Schottky Di 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. 10µs.

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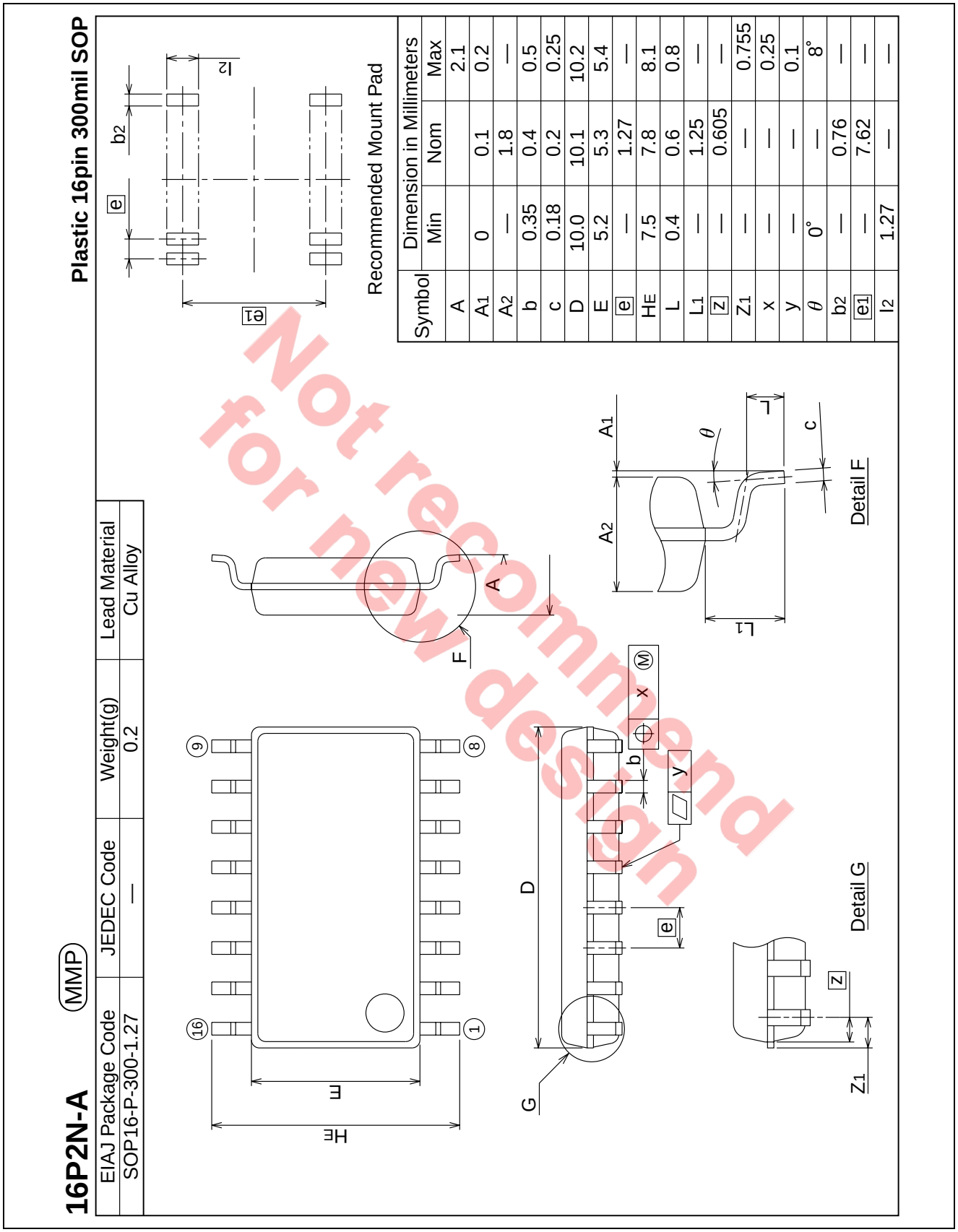
Package Dimensions



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