M54687FP

Bi-DIRECTIONAL MOTOR DRIVER WITH GOVERNOR

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)

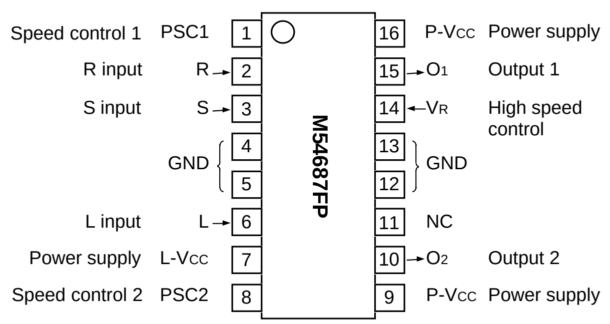
APPLICATION

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 (TOP VIEW)



Outline 16P2N-A

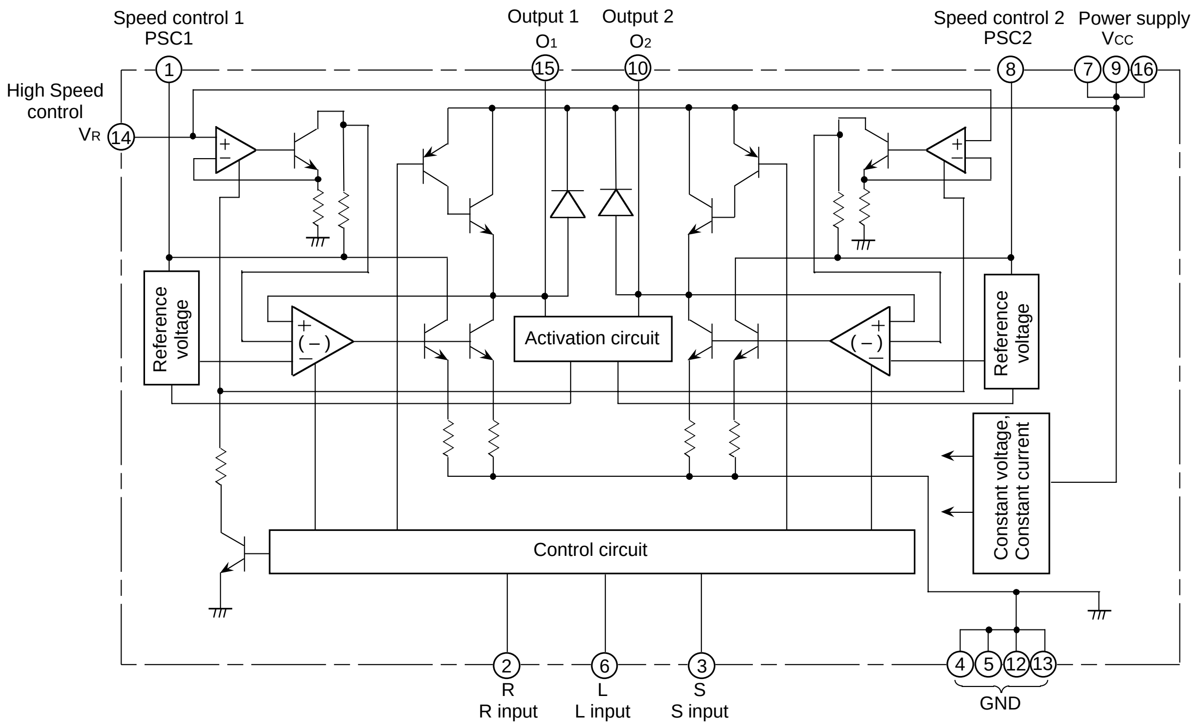
NC: no connection

LOGIC TRUTH TABLE

Input			Output		Mode	
R	L	S	O_1	O_2		
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 V_R pin (However, the precision is worse than G.)

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS (Ta=25°C, unless otherwise noted)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Supply voltage		-0.5 – +14	V
V_I	Input voltage		-0.5 – V_{CC}	V
V_O	Output voltage		-0.5 – V_{CC}+2	V
I_{OP}	Allowable motor rush current	t_{ON}≤100ms, duty of 1% or less.	±700	mA
I_O	Continuous output current	However, P_d must not exceed the maximum rating.	±200	mA
P_d	Power dissipation	When mounted in board	1.14	W
T_{opr}	Operating temperature		-20 – 75	˚C
T_{stg}	Storage temperature		-40 – 125	˚C

RECOMMENDED OPERATING CONDITION (Ta=25˚C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		Min.	Typ.	Max.	
V_{CC}	Supply voltage	6.0	9.0	13.0	V
V_{IH}	“H” input voltage	2.0		V_{CC}	V
V_{IL}	“L” input voltage	0		0.4	V
V_R	V_R control voltage range*	0		V_{CC}	V

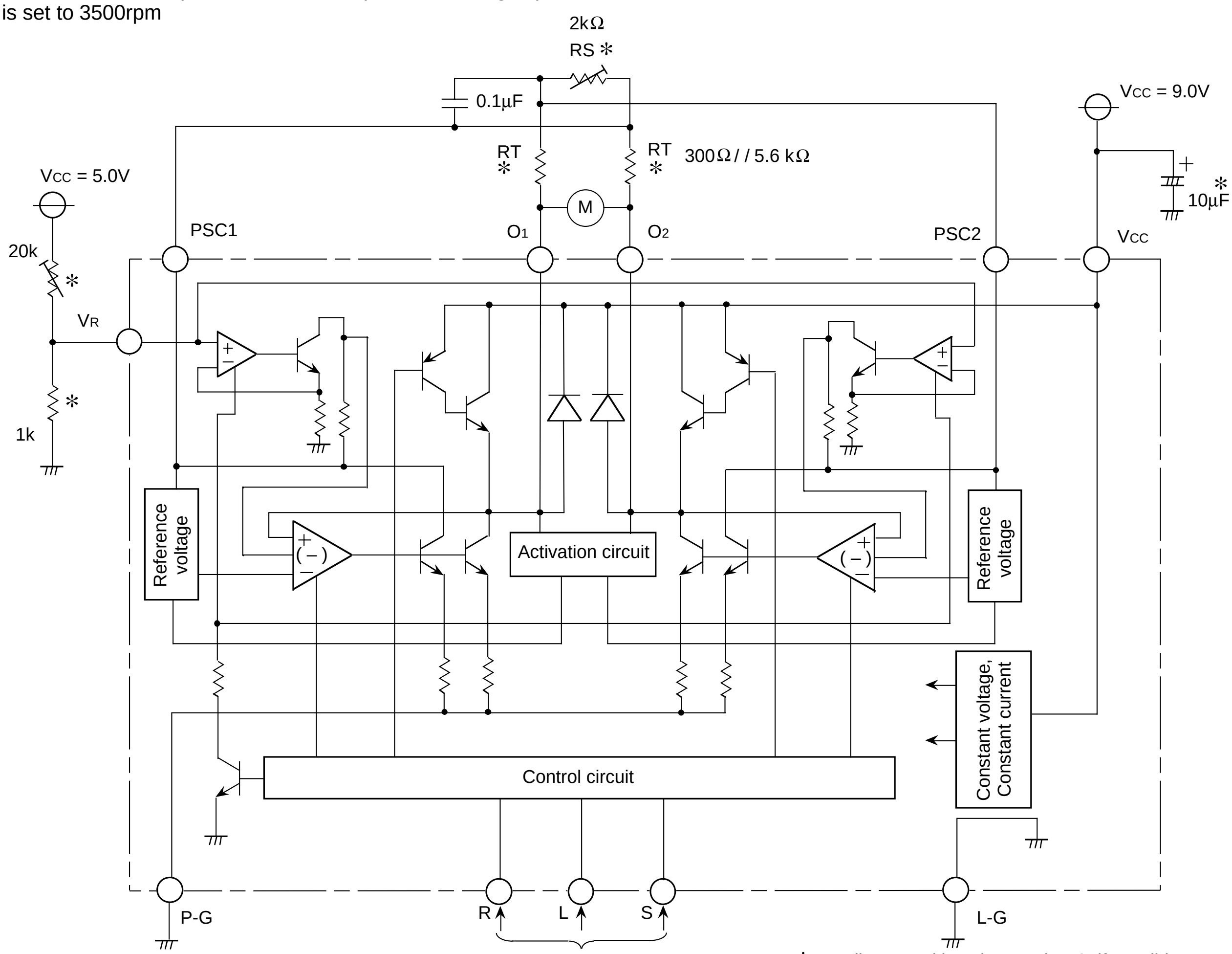
* I_O ≤ 200mA when FF/REW speed is controlled.

ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
$I_{O(leak)}$	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}	Supply current: PLAY/REV	Output open	–	5.0	8.0	mA
I_{CC3}	Supply current: BRAKE	Output open	–	35	48	mA
I_{CC4}	Supply current: 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	Governor characteristics (I) PLAY•REV mode: Bias current		0.7	1.2	1.7	mA
K	Governor characteristics (I) PLAY•REV mode: Current proportional constant	ΔI_O = 40mA	18	20	22	–
$\frac{\Delta V_{ref}}{V_{ref}} / V_{CC}$	Governor characteristics (I) PLAY•REV mode: Voltage characteristics, V_{ref}	V_{CC} = 6.0 – 13V		0.1		%/V
$\frac{\Delta K}{K} / V_{CC}$	Governor characteristics (I) PLAY•REV mode: Voltage characteristics, K	V_{CC} = 6.0 – 13V ΔI_O = 40mA		0.2		%/V
$\frac{\Delta V_{ref}}{V_{ref}} / I_O$	Governor characteristics (I) PLAY•REV mode: Current characteristics, V_{ref}	I_O = 50 – 200mA		0.02		%/mA
$\frac{\Delta K}{K} / I_O$	Governor characteristics (I) PLAY•REV mode: Current characteristics, K	I_O = 50 – 200mA		0.01		%/mA
$\frac{\Delta V_{ref}}{V_{ref}} / T_a$	Governor characteristics (I) PLAY•REV mode: Temperature characteristics, V_{ref}	T_a = -20 – 75°C		0.01		%/°C
$\frac{\Delta K}{K} / T_a$	Governor characteristics (I) PLAY•REV mode: Temperature characteristics, 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
$\frac{\Delta V_{ref}}{V_{ref}} / V_{CC}$	Governor characteristics (II) FF•REW: Reference voltage, Voltage characteristics	V_R = 0.3V V_{CC} = 6.0 – 13V		3.0		%/V
$\frac{\Delta V_{ref}}{V_{ref}} / I_O$	Governor characteristics (II) FF•REW: Reference voltage, Current characteristics	V_R = 0.3V I_O = 50 – 200mA		0.2		%/mA
$\frac{\Delta V_{ref}}{V_{ref}} / T_a$	Governor characteristics (II) FF•REW: Reference voltage, Temperature characteristics	V_R = 0.3V T_a = -20 – 75°C		0.1		%/°C
I_B	Governor characteristics (II) FF•REW: 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

APPLICATION EXAMPLE

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



✻ Install at a position close to the IC, if possible.

Motor: Armature resistance $R_a = 14\Omega$, 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.

Speed Control Method

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

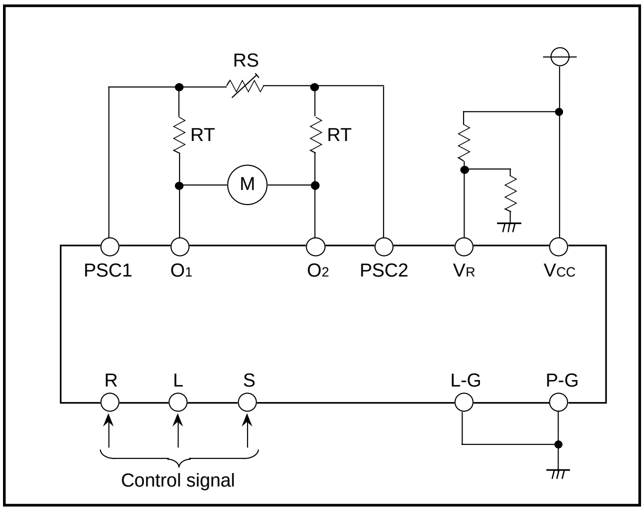
For PLAY/REV
Rotation number can be expressed by the following formula:

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

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:
$RT \leq K \times Ra$

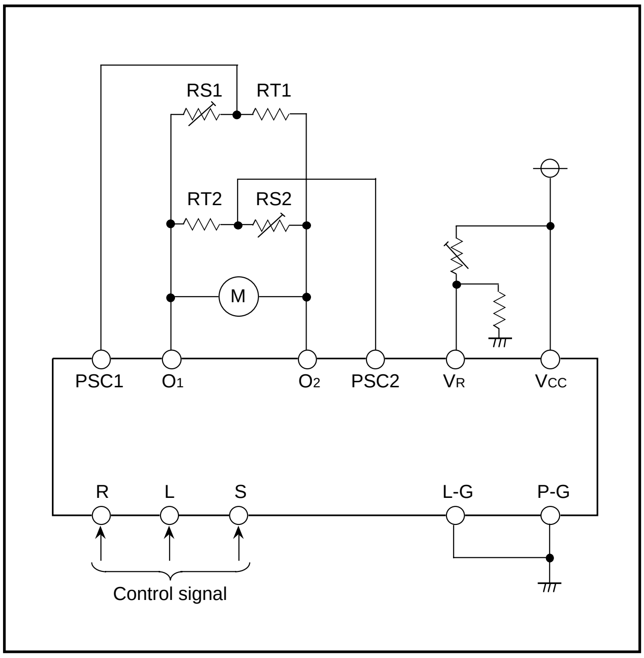
For FF/REW
Note that the rotation number is basically controlled with the same expression as formula (1) but different reference voltage V_{ref} and different bias current IB are to be used.
However, $V_{ref} \fallingdotseq 5VR+0.5$

(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 ‘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 V_{CC} 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.

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

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.

TYPICAL CHARACTERISTICS

Thermal Derating (Absolute Maximum Rating)