DC Brushless Fan Motor Driver

Standard Single-phase Full wave Fan Motor Driver

BD6967FVM

●General Description

This is the summary of application for BD6967FVM. BD6967FVM can drive FAN motor silently by BTL soft switching, and it can control rotational speed by direct PWM and DC voltage speed control.

●Features

- Small package (MSOP10)
- BTL soft switching drive
- PWM speed control
  Direct PWM and DC voltage control available
- Low duty start up function
- Quick start function
- Constant voltage output for hall element
- Lock protection and auto restart
  (without external capacitor)
- Rotating speed pulse signal (FG) output

●Applications

- PC, PC peripheral component
  (Power supply, VGA card, case FAN etc.)
- BD player, Projector etc.

●Package(s)

	W(Typ.) x D(Typ.) x H(Max.)
MSOP10	2.90mm x 4.00mm x 0.90mm



MSOP10

●Absolute maximum ratings

Parameter	Symbol	Limit	Unit
Supply voltage	Vcc	15	V
Power dissipation	Pd	585*	mW
Operating temperature	Topr	-40 to +105	℃
Storage temperature	Tstg	-55 to +150	℃
Output voltage	Vomax	15	V
Output current	Iomax	800**	mA
Hall input terminal voltage	Vhall	7	V
PWM terminal voltage	Vpwm	7	V
FG signal output voltage	Vfg	15	V
FG signal output current	Ifg	10	mA
HB output current	Ihb	10	mA
REF output current	Iref	10	mA
Junction temperature	Tjmax	150	℃

* Reduce by 4.68mW/℃ over Ta=25℃(On 70mm×70mm×1.6mm glass epoxy board)
** This value is not to exceed Pd

●Operating conditions

Parameter	Symbol	Limit	Unit
Operating supply voltage range	Vcc	3.3 to 14	V
Hall input voltage range	Vh	0.4 to Vcc/3	V

○Product structure：Silicon monolithic integrated circuit ○This product is not designed protection against radioactive rays

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●**Electrical characteristics**(Unless otherwise specified Ta=25℃,Vcc=12V)

Parameter	Symbol	Limit			Unit	Conditions	Characteristics
		Min.	Typ.	Max.			
Circuit current	Icc	3	5	7	mA		Fig.1
REF voltage	Vref	2.6	2.8	3.0	V	Iref=-3mA	Fig.2
Hall bias voltage	Vhb	1.1	1.2	1.3	V	Ihb=-3mA	Fig.2
Hall input offset	Vofs	0	-	±6	mV		-
Input-output Gain	Gio	53	55	57	dB		-
Output voltage	Vo	0.20	0.45	0.70	V	Io=200mA Upper and Lower total	Fig.3 to 6
PWM input H level	Vpwmh	2.7	-	7.0	V	direct PWM input condition	-
PWM input L level	Vpwml	-0.3	-	0.4	V	direct PWM input condition	-
PWM input frequency	Fpwm	2	-	88	kHz	direct PWM input condition	-
PWM terminal bias current	Ipwm	-5.0	-0.1	-	μA		-
OSC H voltage	Vosch	2.3	2.5	2.7	V	*	Fig.7
OSC L voltage	Voscl	0.4	0.5	0.6	V	*	Fig.7
OSC frequency	Fosc	44	66	88	kHz	PWM drive frequency at DC voltage input mode	Fig.8
Output PWM Duty 1	Duty1	50	60	70	%	Vpwm=1.9V	-
Output PWM Duty 2	Duty2	20	30	40	%	Vpwm=1.3V	-
FG hysteresis voltage	Vhys	±5	±10	±15	mV		Fig.9
FG L voltage	Vfgl	-	0.2	0.4	V	Ifg=5mA	Fig.10,11
FG leak current	Ifgl	0	-	5	μA	Vfg=15V	-
Lock detection ON time	Ton	0.35	0.5	0.65	s		Fig.12
Lock detection OFF time	Toff	3..5	5.0	6.5	s		Fig.12

* Peak voltage of triangular wave (OSC) inside IC

●**Terminal name**

PIN No.	Terminal name	Function
1	GND	GND
2	OUT2	Motor output 2
3	H+	Hall input +
4	HB	Constant voltage output for hall element
5	H-	Hall input -
6	FG	Rotational speed pulse output
7	PWM	Control signal input (PWM or DC voltage)
8	REF	Reference voltage output
9	Vcc	Power supply
10	OUT1	Motor output 1

●Truth table

H+	H-	PWM	OUT1	OUT2	FG
H	L	H	H	L	L（Output Tr : ON）
L	H	H	L	H	H（Output Tr : OFF）
H	L	L	L	L	L（Output Tr : ON）
L	H	L	L	L	H（Output Tr : OFF）

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●Reference data

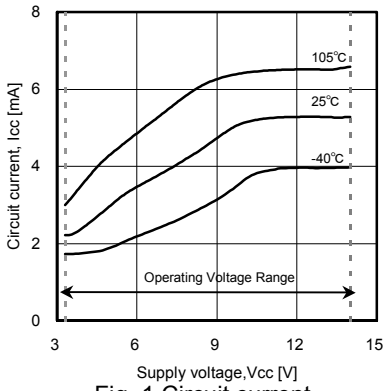


Fig. 1 Circuit current

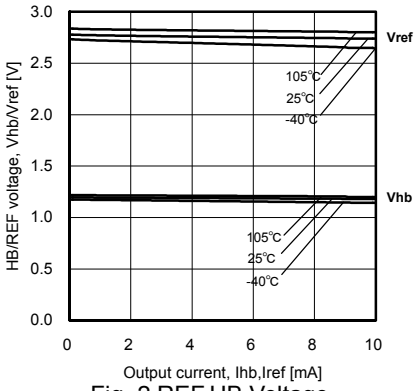


Fig. 2 REF,HB Voltage

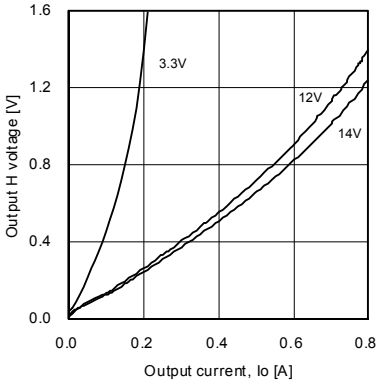


Fig.3 Output H voltage
(Voltage characteristics)

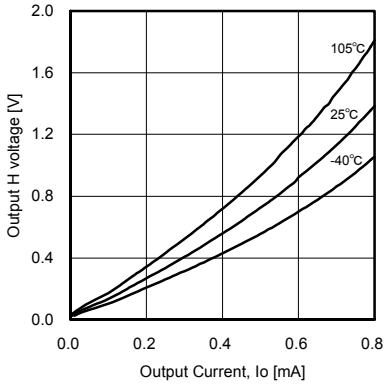


Fig.4 Output H voltage
(Temperature characteristics)

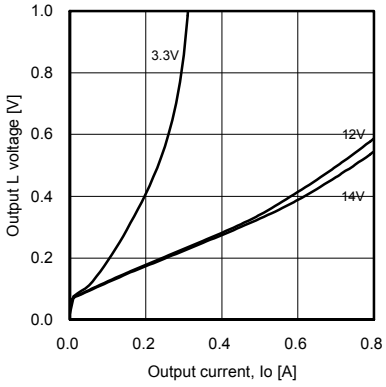


Fig.5 Output L voltage
(Voltage characteristics)

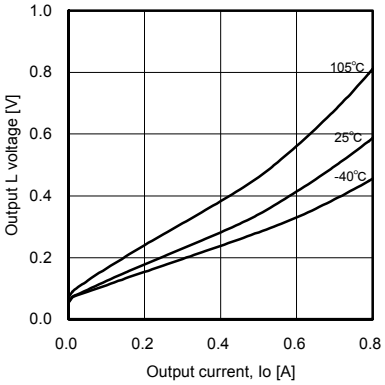


Fig.6 Output L voltage
(Temperature characteristics)

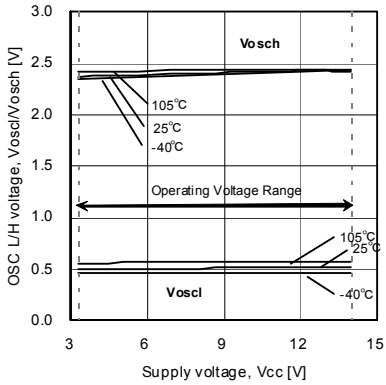


Fig. 7 OSC H/L voltage

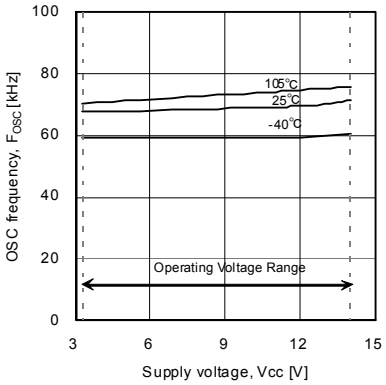


Fig. 8 OSC frequency

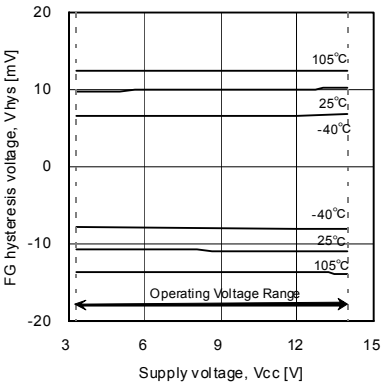


Fig. 9 FG hysteresis voltage

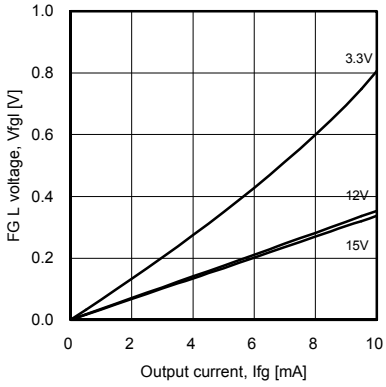


Fig.10 FG L voltage
(Voltage characteristics)

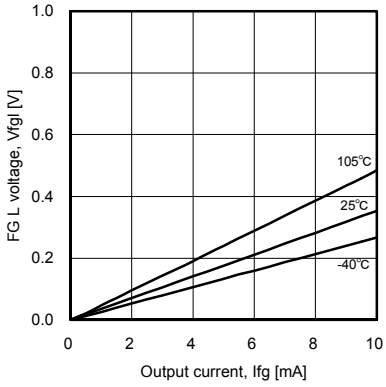


Fig.11 FG L voltage
(Temperature characteristics)

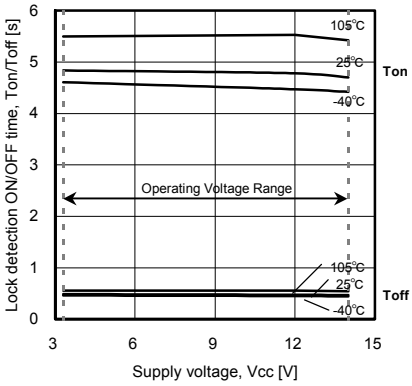


Fig. 12 Lock detection time

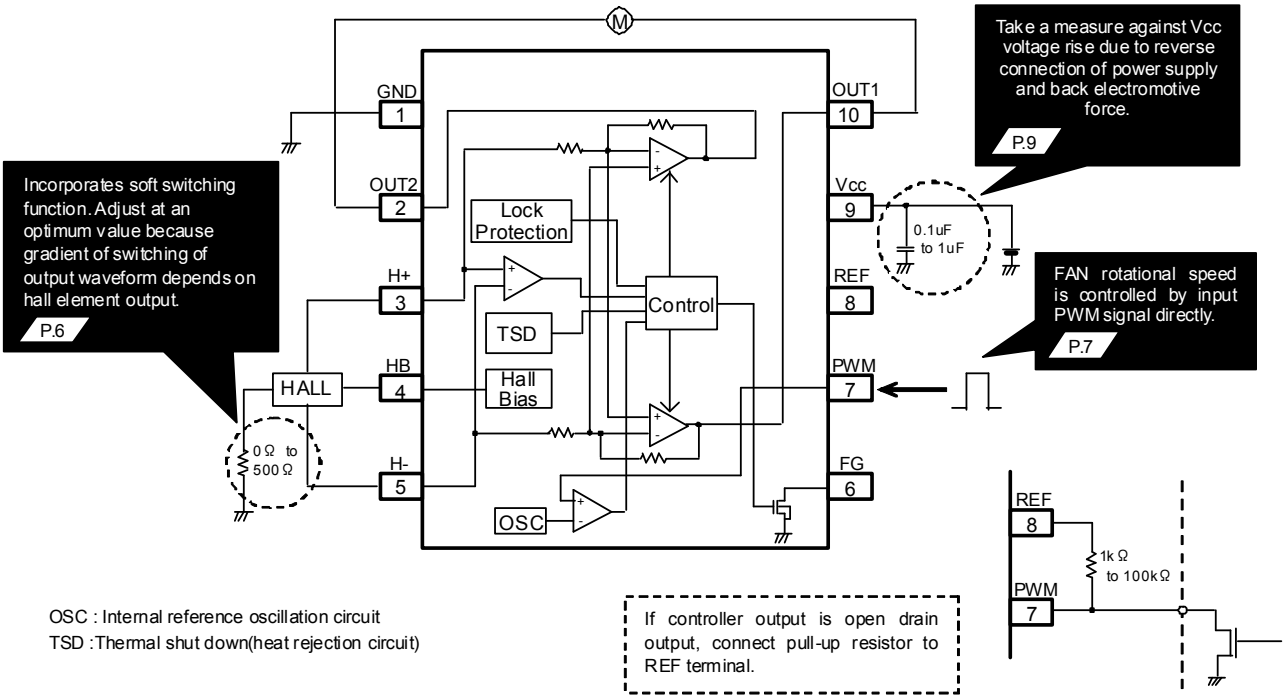
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●Block diagram, application circuit, and pin assignment (Constant etc are for reference)

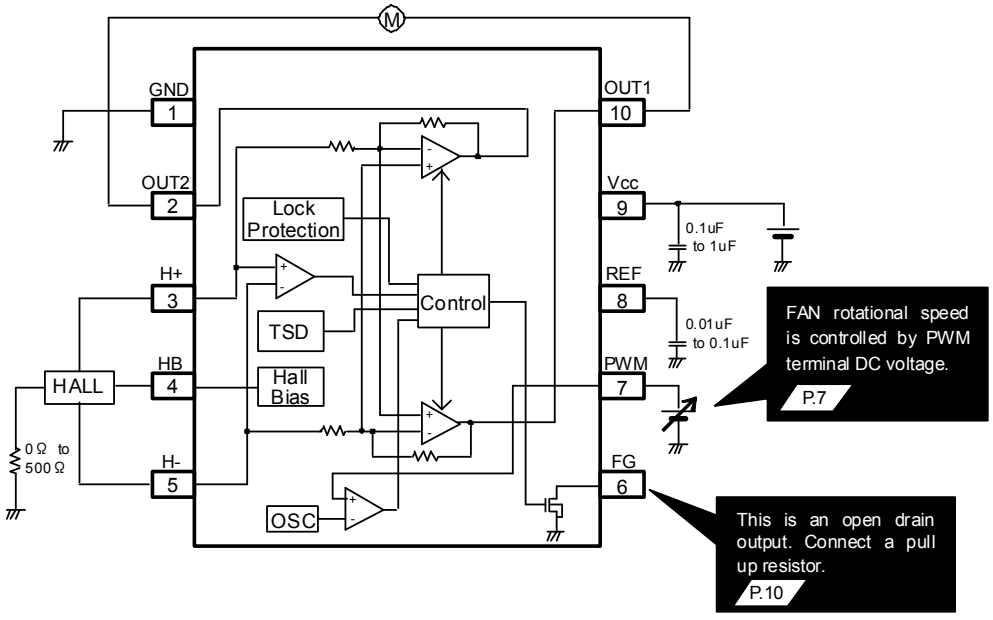
1)Direct PWM speed control

FAN speed is controlled by FAN controller PWM output. IC output PWM duty is changed directly by input PWM signal. H level input is motor active, L level input is motor stop.



2)DC voltage speed control

Output PWM duty is varied by input voltage. When input voltage level is low, output PWM duty is low. The voltage range of output duty changes is between OSC L voltage and OSC H voltage. When the input voltage is around OSC L (about 0.5V), rotational speed of the motor may fluctuate because of the low duty start-up function operates repeatedly. The recommend voltage is higher than 0.7V.

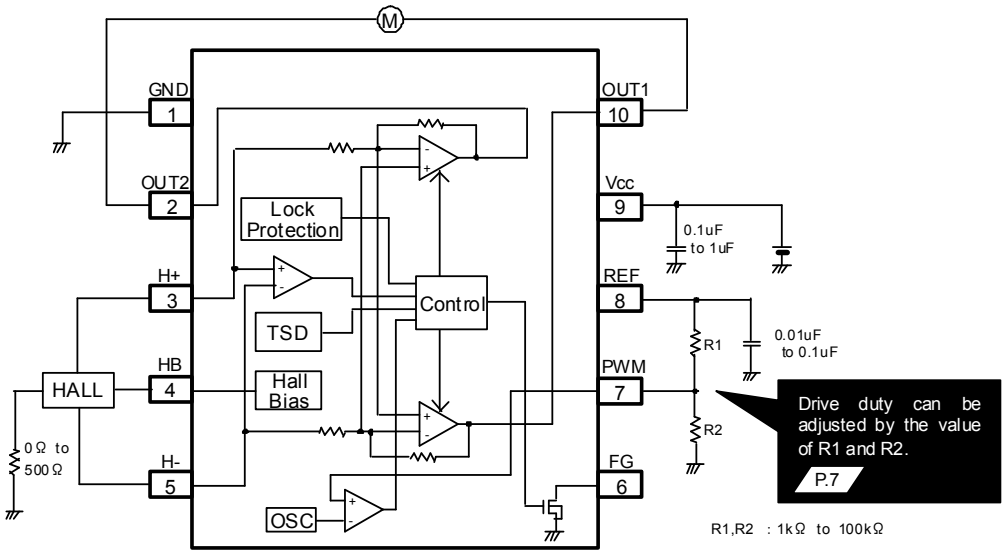


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3) Rotational speed adjusting application

This application circuit can set the FAN rotational speed without the change of motor coil by changing resistor value of PCB. The adjusting range of rotational speed is slower than full speed of the motor.



*If you use only full speed, connect the PWM terminal to REF terminal.

●Description of operations

1) Lock protection and automatic restart circuit

Motor rotation is detected by hall signal, and lock detection ON time (Ton) and lock detection OFF time (Toff) are set by IC internal counter. External part (C or R) is not required. Timing chart is shown in Fig.13.

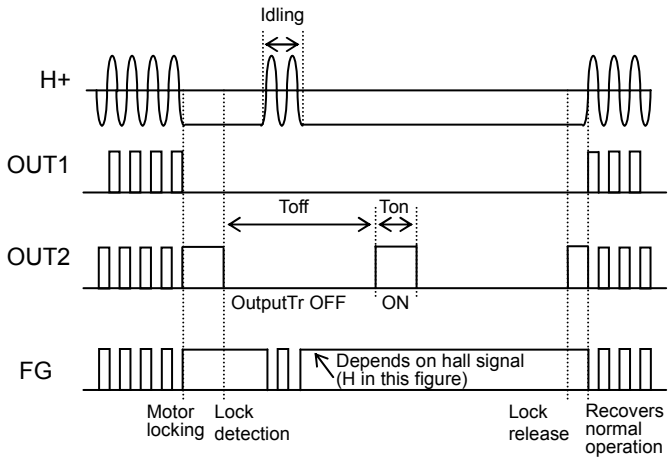


Fig.13 Lock protection timing chart

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2) Soft switching function (silent drive setting)

Input signal to hall amplifier is amplified to produce an output signal.

When the hall element output signal is small, the gradient of switching of output waveform is gentle. When it is large, the gradient of switching of output waveform is steep. Gain of 55dB (560 times) is provided between input and output, therefore enter an appropriate hall element output to IC where output waveform swings sufficiently.

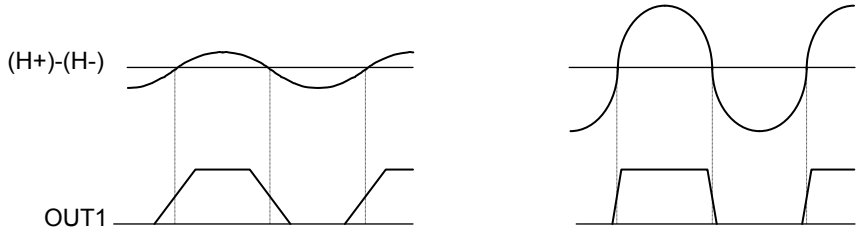


Fig.14 Relation between hall element output amplitude and output waveform

3) Hall input setting

Hall input voltage range is shown in operating conditions.

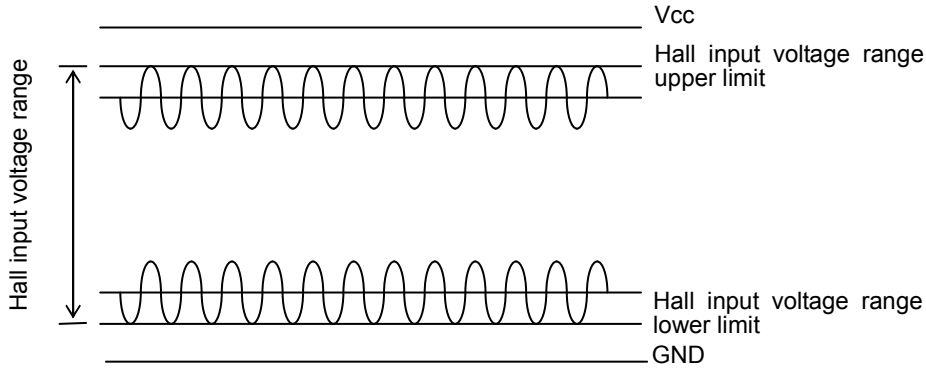


Fig.15 Hall input voltage range

Adjust the value of hall element bias resistor R1 in Fig.16 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.16. 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.16.

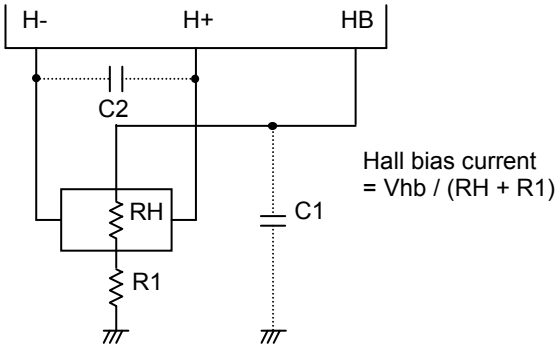


Fig.16 Application near of hall signal

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4) Speed control

4-1) Direct PWM control

Rotation speed of motor can be changed by controlling ON/OFF of the upper output depending on duty of the signal input to PWM terminal.

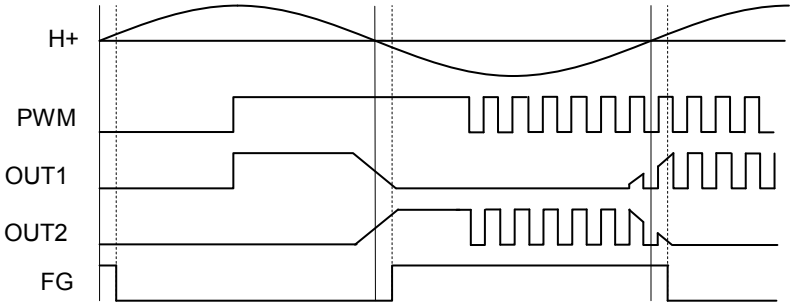


Fig.17 Timing chart in PWM control

When the voltage input to PWM terminal applies H logic : normal operation
L logic : H side output is off

4-2) DC voltage speed control

Output ON duty is controlled by the input voltage to PWM terminal, comparing with internal triangular wave (OSC). PWM terminal voltage become higher, output ON duty become wide. Timing chart is shown in Fig.18.

PWM voltage > OSC voltage : High side output ON
PWM voltage < OSC voltage : High side output OFF

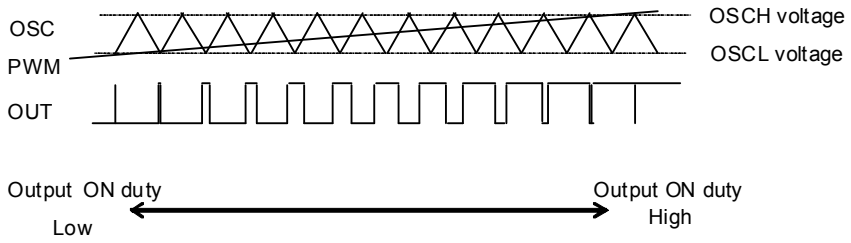


Fig.18 DC input speed control mode

Setting example 1. Output ON duty 60% on Vcc=5V.
PWM setting voltage equation:
Setting voltage = Voscl + { (Vosch - Voscl) × (Target Duty) / 100 } + 0.2(*1)
= 0.5 + { (2.5 - 0.5) × 60 / 100 } + 0.2 = 1.9 [V]
(*1 The constant of delay inside IC)

4-3) Rotational speed adjusting application

OSC H and OSC L voltage is generated by dividing resistance of internal power supply (REF terminal), and the ratio of those voltage are designed to be hard to fluctuate.
When the input voltage at PWM terminal is constant, the affection to change output ON duty by fluctuation of OSC H and OSC L voltage is large. However, by setting that voltage input via PWM terminal is generated by dividing resistance of REF terminal voltage, application can be made hard to be affected by voltage fluctuation of triangle wave. For an application which requires strict precision, determine a value with sufficient margin after full consideration of external constant is taken.

Notice : If the resistors value is too large, output ON duty is affected with a bias current to PWM. The recommend value is less than 100kohm.

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5) Quick start, stand-by function

When the PWM signal is input, the motor start up at once regardless of the detection time of the lock protection function.

When H level duty of PWM input signal is close to 0%, lock protection function does not work at input frequency is slower than 1kHz , therefore enter a frequency faster than 2kHz .

6) Low duty start up function

When motor start-up from stop condition, the output is driven in output duty 50%(33kHz, max.250ms). The output duty doesn't depend on the PWM terminal input. Even if input duty is low, the motor can be started. Timing chart at the Power ON is shown in Fig.19.

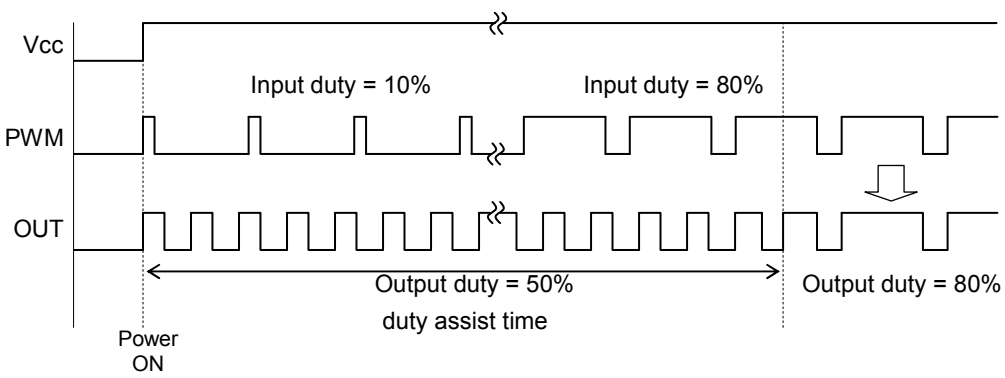
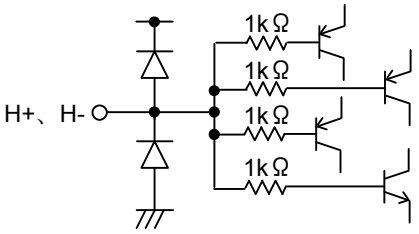


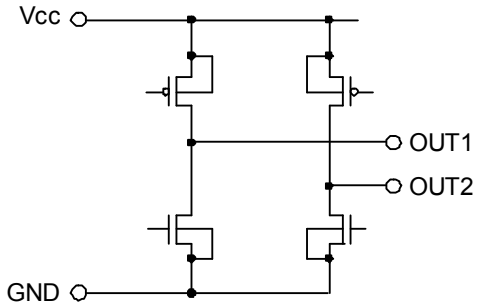
Fig.19 Low duty start up function

●Equivalent circuit

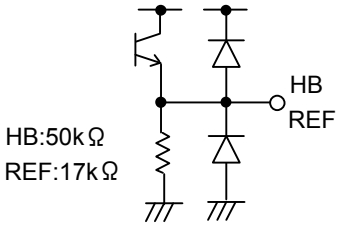
1) Hall input terminal



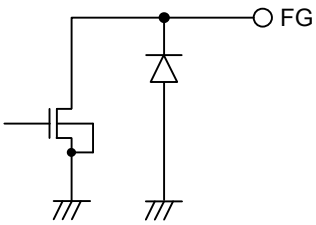
2) Motor output terminal



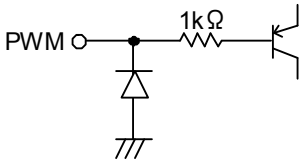
3) HB terminal, REF terminal



4) FG terminal



5) PWM terminal



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●**Safety measure**

1) Reverse connection protection diode

Reverse connection of power results in IC destruction as shown in Fig.20. When reverse connection is possible, reverse connection destruction preventive diode must be added between power supply and Vcc.

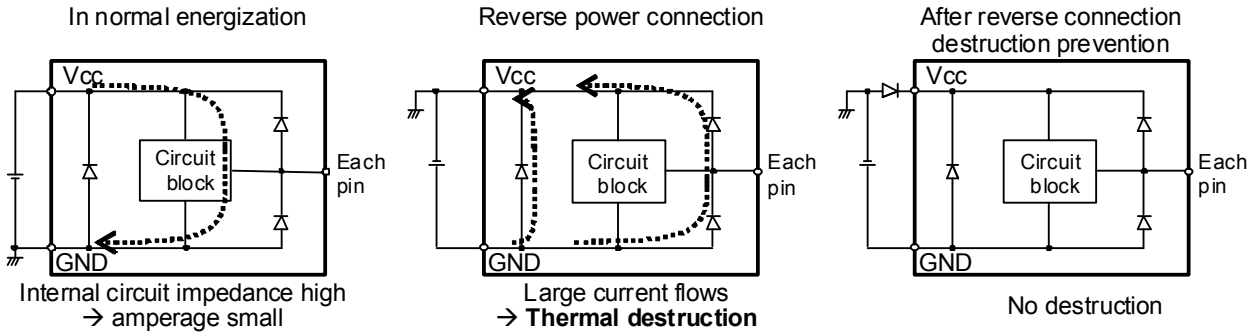


Fig.20 Flow of current when power is connected reversely

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 no route is available for regenerating to power.

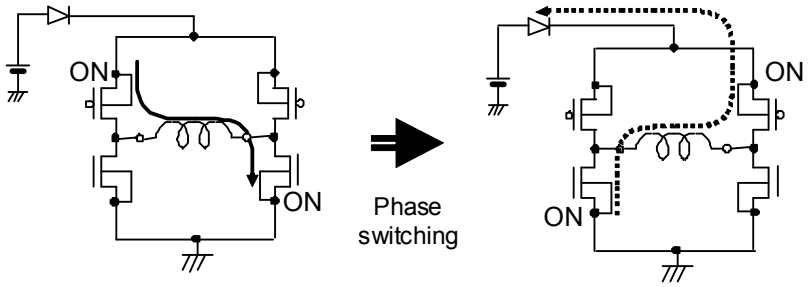
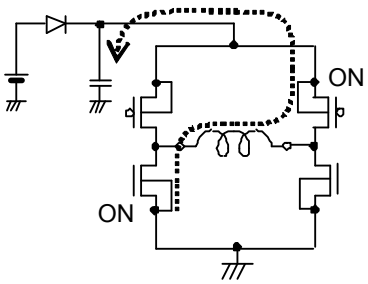


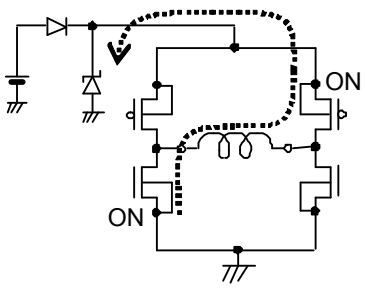
Fig.21 Vcc voltage rise by back electromotive force

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. In addition, also take the measure (A) and (B) as shown in (C) if required.

(A) Capacitor



(B) Zener diode



(C) Capacitor and zener diode

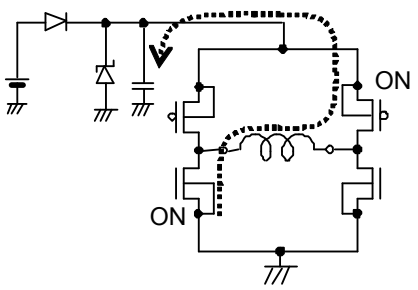


Fig.22 Measure against Vcc voltage rise

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3) Problem of GND line PWM switching

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

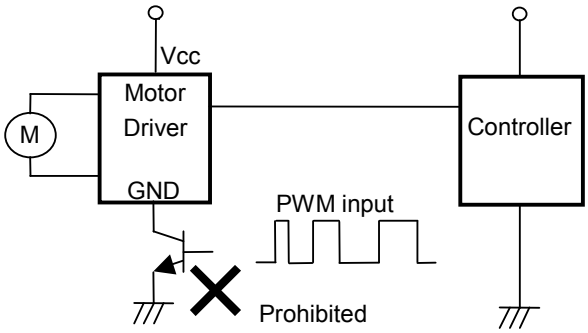


Fig.23 GND Line PWM switching prohibited

4) FG output

FG output is an open drain and requires pull-up resistor. The IC can be protected by adding resistor R1. An excess of absolute maximum rating, when FG output terminal is directly connected to power supply, could damage the IC.

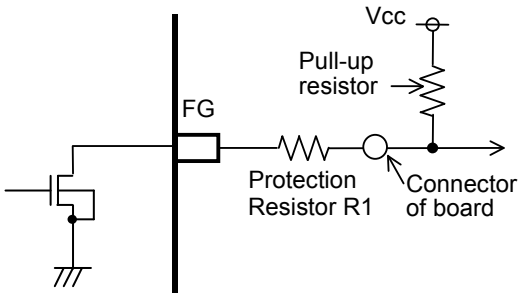
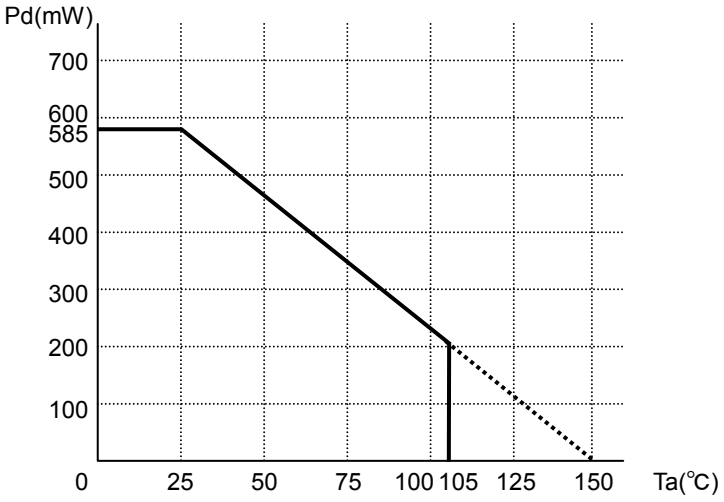


Fig.24 Protection of FG terminal

●Thermal derating curve

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 θja.

Thermal resistance θja 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.



＊ Reduce by 4.68 mW/°C over 25°C.
(70.0mm x 70.0mm x 1.6mm glass epoxy board)

Fig.25 Thermal derating curve

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●Notes for use

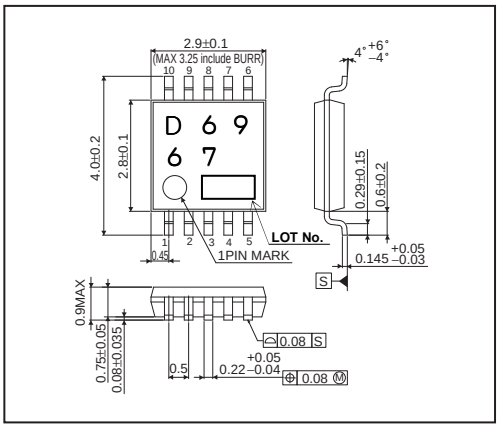
1) Absolute maximum ratings
An excess in the absolute maximum rations, such as supply voltage, temperature range of operating conditions, etc., can break down the devices, thus making impossible to identify breaking mode, such as a short circuit or an open circuit. If any over rated values will expect 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 rations or ASO.
9) Thermal shut down circuit
The IC incorporates a built-in thermal shutdown circuit (TSD circuit). Operation temperature is 175ºC (typ.) and has a hysteresis width of 25ºC (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.

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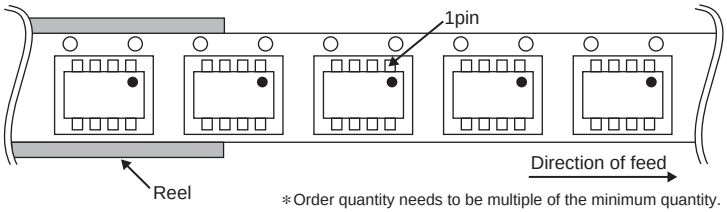
●Physical Dimension

MSOP10



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

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Notice

Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

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Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   - [b] the temperature or humidity exceeds those recommended by ROHM
   - [c] the Products are exposed to direct sunshine or condensation
   - [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

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