Datasheet

DC Brushless Motor Drivers for FANs

Single-phase Full-wave FAN Motor Driver for Automotive

BD6985FVM-M

General Description

BD6985FVM-M is single-phase full-wave FAN motor driver IC that can drive FAN motor silently by the BTL soft switching. It has capacitor-free lock protection function.

Key Specifications

- Power Supply Voltage Range: 3 V to 16 V
- Operating Temperature Range: -40 °C to +105 °C

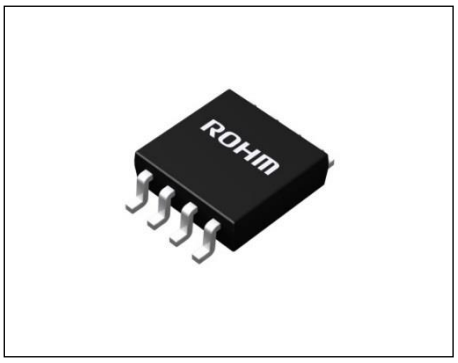
Features

- AEC-Q100 Qualified(Note 1)
- Small Package (MSOP8)
- BTL Soft Switching Drive
- Voltage Regulator for Hall Element
- Lock Protection and Automatic Restart
- Rotation Speed Pulse Signal (FG) Output
- Under Voltage Locked Out (UVLO)
- Thermal Shutdown (TSD)
- Over Current Protection (OCP)

(Note 1) Grade 2

Package

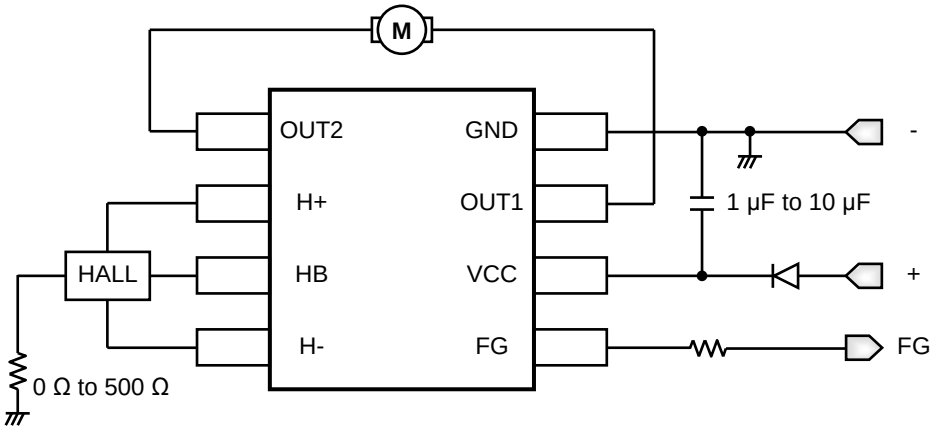
W (Typ) x D (Typ) x H (Max)
MSOP8	2.9 mm x 4.0 mm x 0.9 mm



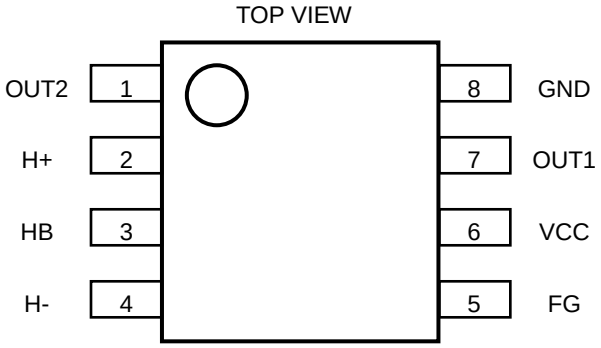
Applications

- Cooling FAN Motor for Automotive Navigation / Audio System
- FAN Motor for the Electric Equipment such as Seat FAN
- Cooling FAN Motor for LED Headlamp

Typical Application Circuit



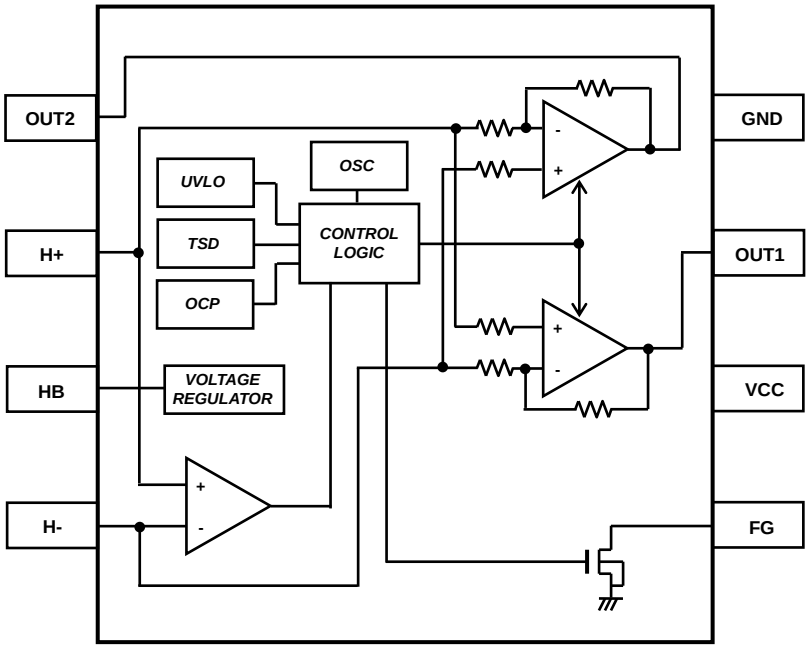
Pin Configuation



Pin Description

Pin No.	Pin Name	Function
1	OUT2	Motor output 2
2	H+	Hall input +
3	HB	Constant voltage output for hall element
4	H-	Hall input -
5	FG	FG output
6	VCC	Power supply
7	OUT1	Motor output 1
8	GND	Ground

Block Diagram



Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	18	V
Storage Temperature Range	Tstg	-55 to +150	°C
Junction Temperature	Tj	+150	°C
Output Voltage	V_O	18	V
Output Current	I_O	800	mA
HB Output Current	I_{HB}	10	mA
FG Output Voltage	V_{FG}	18	V
FG Output Current	I_{FG}	10	mA
Input Voltage (H+, H-)	V_{IN}	7	V

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

Thermal Resistance*(Note 1)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s*(Note 3)*	2s2p*(Note 4)*	
MSOP8				
Junction to Ambient	θ_{JA}	240.7	137.4	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	34	27	°C/W

(Note 1) Based on JESD51-2A(Still-Air), using a BD6985 Chip.
(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 3) Using a PCB board based on JESD51-3.
(Note 4) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 µm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 µm	74.2 mm x 74.2 mm	35 µm	74.2 mm x 74.2 mm	70 µm

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V_{CC}	3	12	16	V
Operating Temperature	Topr	-40	-	+105	°C
Hall Input Voltage	V_H	0	-	1/3×V_{CC}	V

Electrical Characteristics (Unless otherwise specified V_{CC} = 12 V Ta = -40 °C to +105 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Circuit Current	I_{CC}	1	3	5	mA	
Hall Bias Voltage	V_{HB}	1.1	1.25	1.3	V	I_{HB} = -3 mA
Hall Amp Gain	G_{IO}	49	51	53	dB	
Hall Amp Input Offset Voltage	V_{OFS}	0	-	±6	mV	
Output Voltage	V_O	0.2	0.45	0.7	V	I_O = 200 mA Upper and Lower total
FG Hysteresis Voltage 1	V_{HYS1}	±7	±12	±17	mV	Ta = +25 °C
FG Hysteresis Voltage 2	V_{HYS2}	±7	-	±21	mV	+25 °C < Ta ≤ +105 °C
FG Hysteresis Voltage 3	V_{HYS3}	±4	-	±17	mV	-40 °C ≤ Ta < +25 °C
FG Low Voltage	V_{FGL}	-	0.2	0.4	V	I_{FG} = 5 mA
FG Leak Current	I_{FGL}	0	-	5	µA	V_{FG} = 18 V
Lock Protection Detection Time	t_{ON}	0.28	0.47	0.72	s	
Lock Protection Restart Time	t_{OFF}	2.8	4.7	7.2	s	
Lock Protection ON/OFF Time Ratio	r_{LP}	-	10	-	-	$r_{LP} = t_{OFF}/t_{ON}$
UVLO Threshold Voltage High	V_{ON}	-	2.75	2.9	V	V_{CC} Rise
UVLO Threshold Voltage Low	V_{OFF}	2.3	2.45	-	V	V_{CC} Fall
TSD Detection Temperature*(Note 1)*	T_{DET}	150	160	170	°C	
TSD Restore Temperature*(Note 1)*	T_{RES}	130	140	150	°C	
OCP Detection Current*(Note 1)*	I_{OCP}	1.05	1.6	2.5	A	

About current items, define the inflow current to the IC as a positive notation.
(Note 1) It is the design value on which evaluation confirmation was carried out, and shipment inspection is not carried out.

I/O Truth Table

H+	H-	OUT1	OUT2	FG
H	L	H	L	Hi-Z
L	H	L	H	L

H; High, L; Low, Hi-Z; High impedance
FG output is open-drain type.

Typical Performance Curves
(Reference Data)

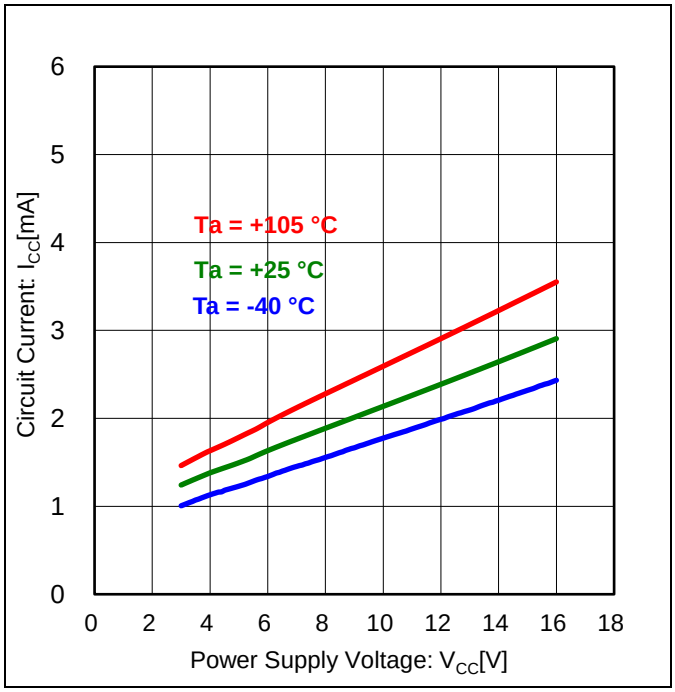


Figure 1. Circuit Current vs Power Supply Voltage

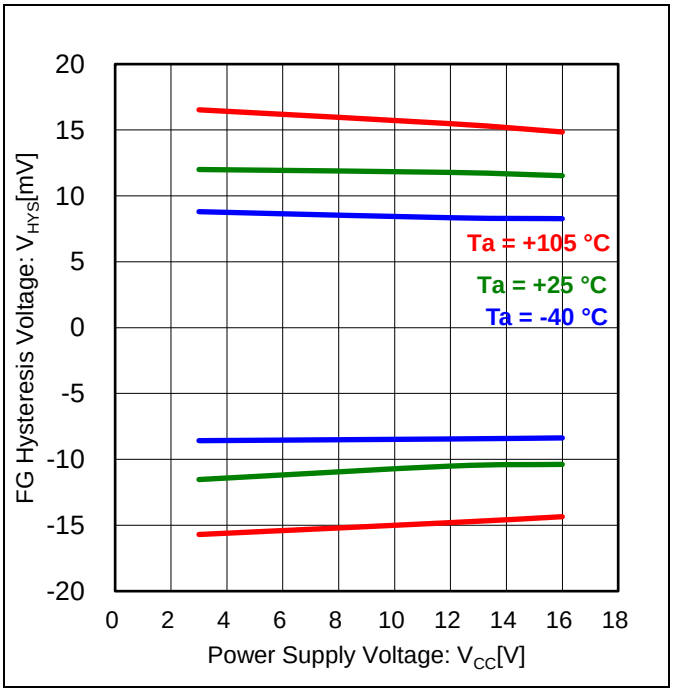


Figure 2. FG Hysteresis Voltage vs Power Supply Voltage

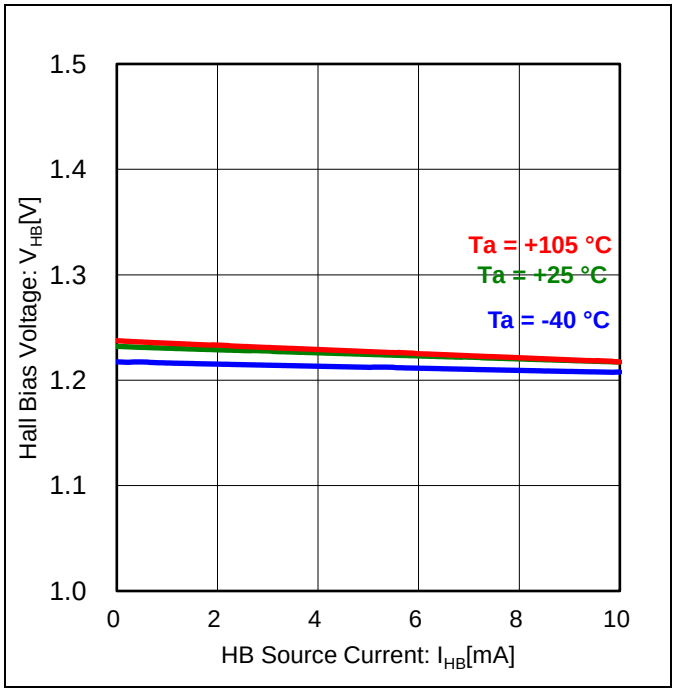


Figure 3. Hall Bias Voltage vs HB Source Current
(V_{CC} = 12 V)

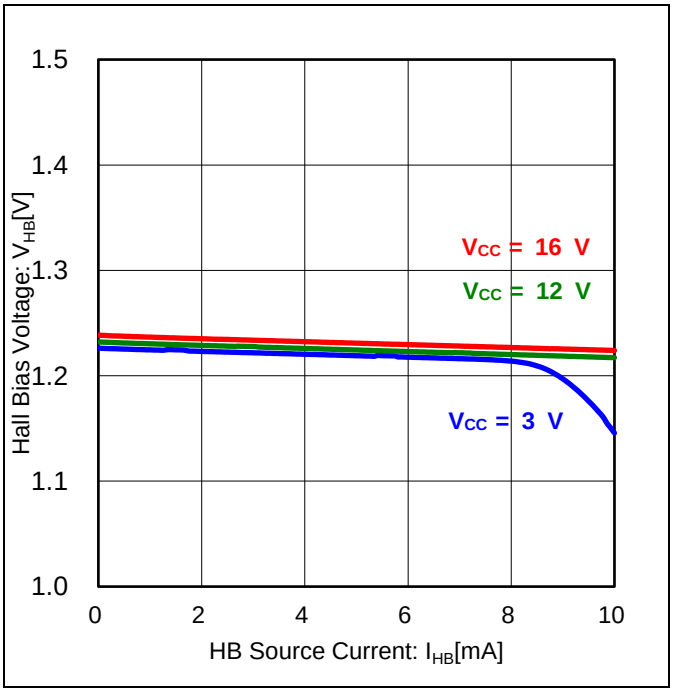


Figure 4. Hall Bias Voltage vs HB Source Current
(Ta = 25 °C)

Typical Performance Curves - continued
(Reference Data)

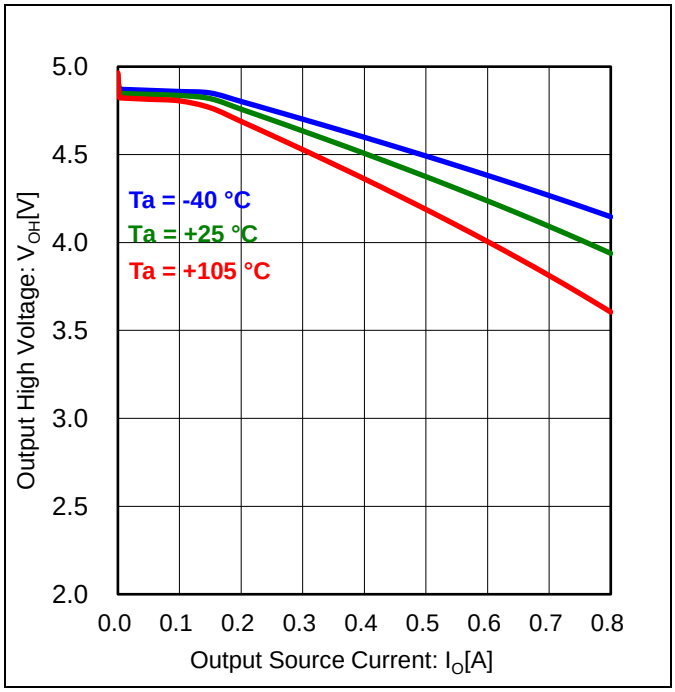


Figure 5. Output High Voltage vs Output Source Current
(V_{CC} = 5 V)

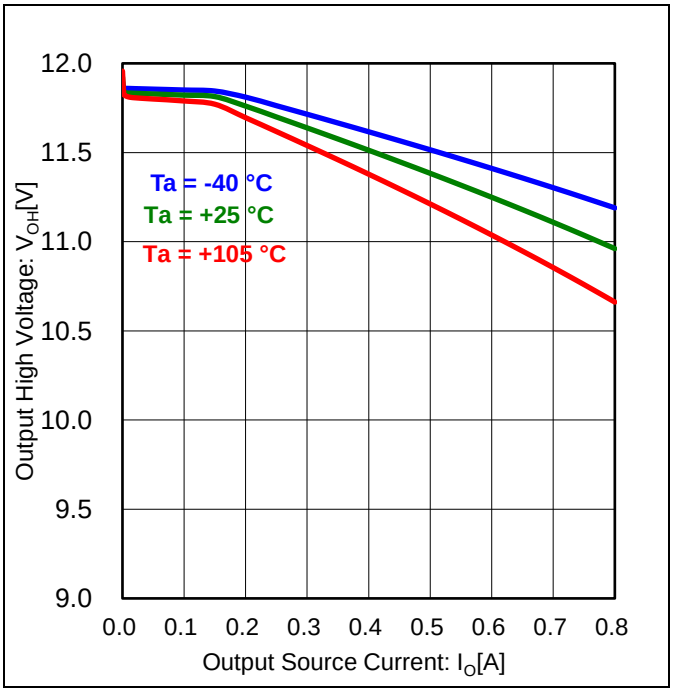


Figure 6. Output High Voltage vs Output Source Current
(V_{CC} = 12 V)

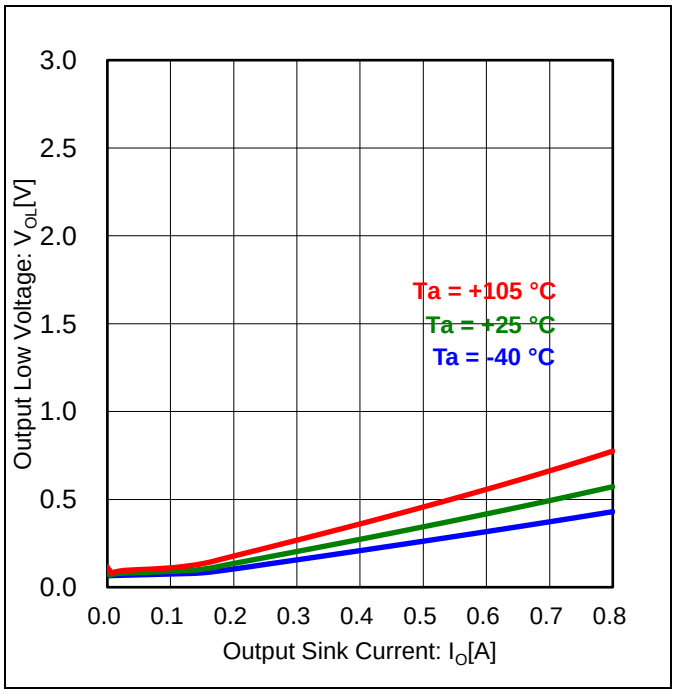


Figure 7. Output Low Voltage vs Output Sink Current
(V_{CC} = 5 V)

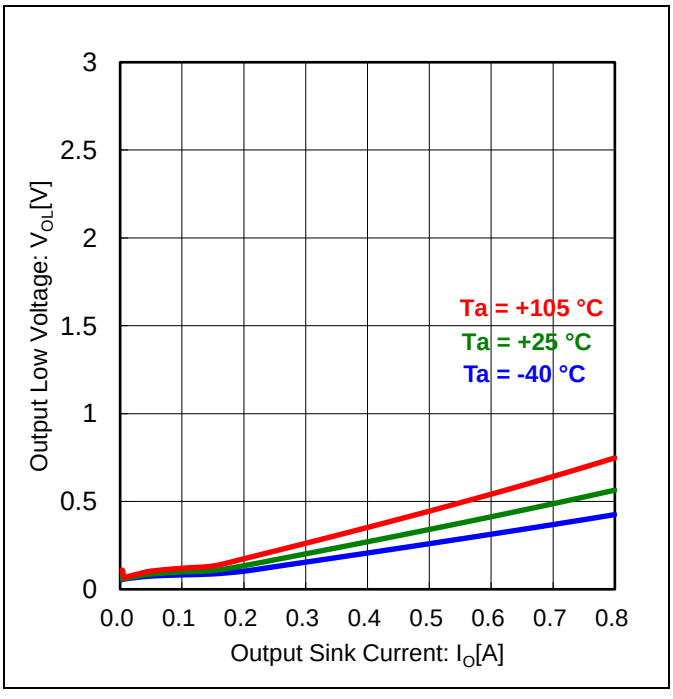


Figure 8. Output Low Voltage vs Output Sink Current
(V_{CC} = 12 V)

Typical Performance Curves - continued
(Reference Data)

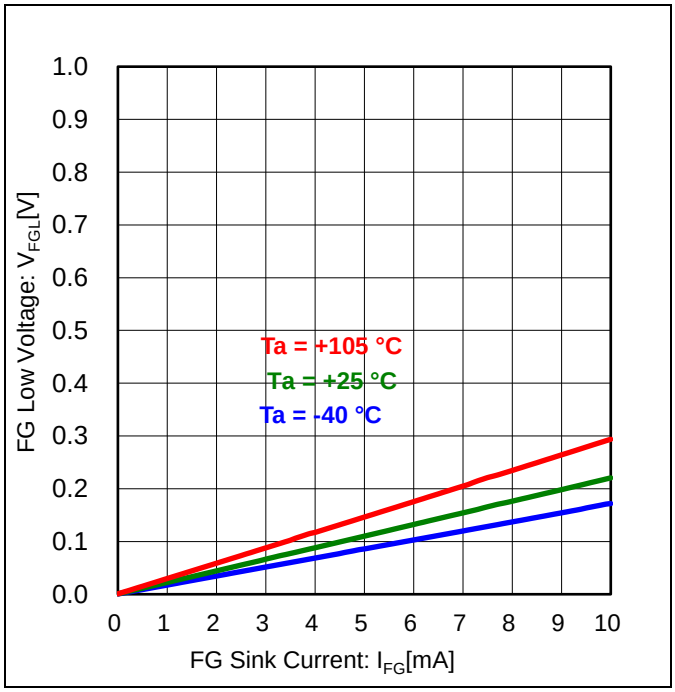


Figure 9. FG Low Voltage vs FG Sink Current
(V_{CC} = 12 V)

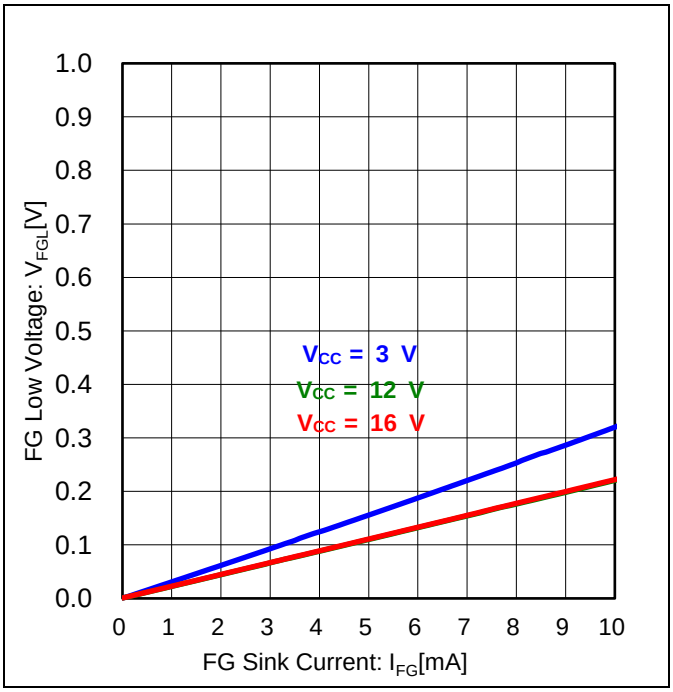


Figure 10. FG Low Voltage vs FG Sink Current
(Ta = 25 °C)

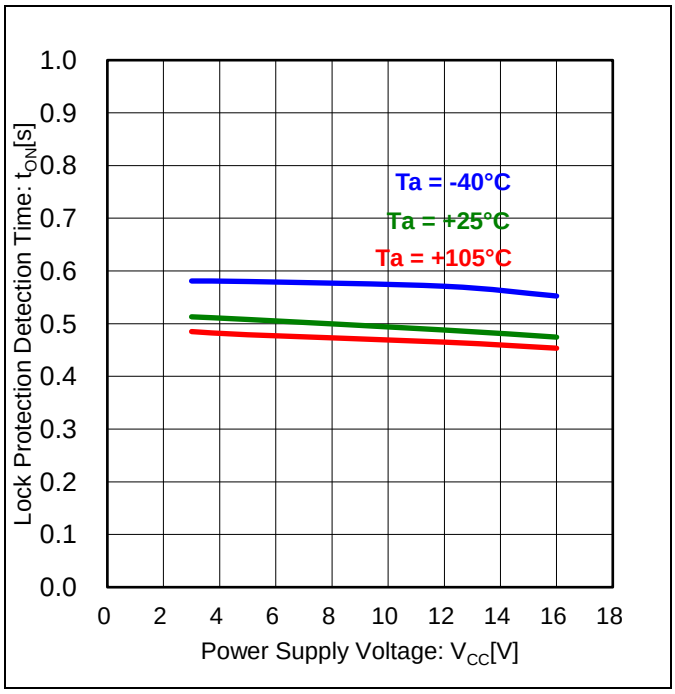


Figure 11. Lock Protection Detection Time
vs Power Supply Voltage

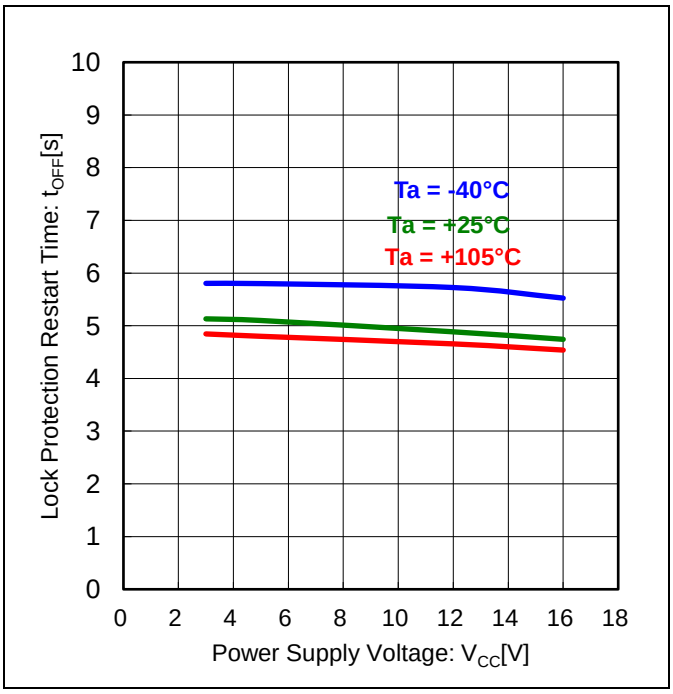


Figure 12. Lock Protection Restart Time
vs Power Supply Voltage

Functional Description

1. Hall Input Voltage Setting

Figure 13 shows hall input voltage range, Figure 14 shows the application of hall element.
Adjust the value of R_1 in Figure 13 so that the input voltage of a hall signal is in "Hall Input Voltage Range" including signal amplitude.
In order to detect rotation of a motor, the amplitude of hall signal more than “FG Hysteresis Voltage” is required. Input the hall signal of at least 50 mV.

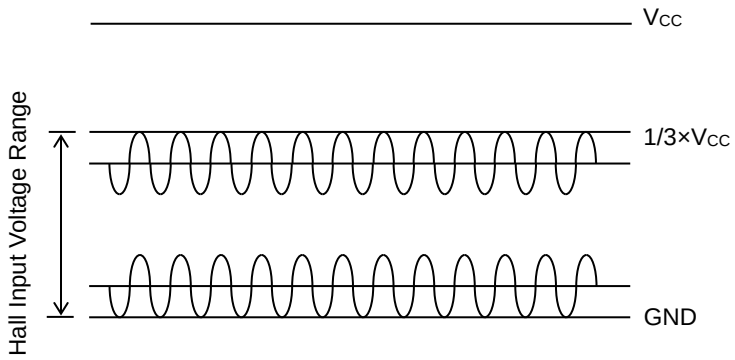


Figure 13. Hall Input Voltage Range

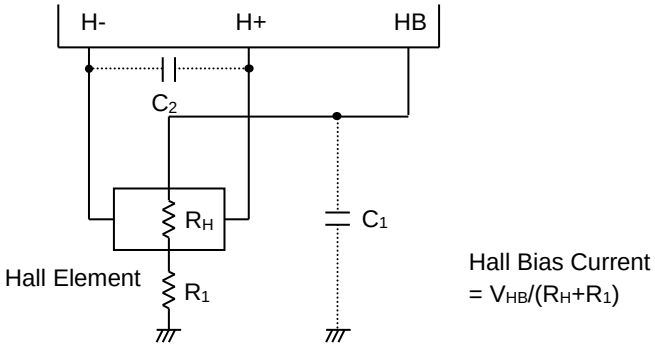


Figure 14. Application near of Hall Element

●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 C_1 in Figure 14. 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 C_2 in Figure 14.

Functional Description - continued

2. Soft Switching Drive

Hall amplifier amplifies input signal to produce the output signal.
When input 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 hall amplifier is 51 dB (360 times). Input an appropriate hall element output to IC where output waveform swings sufficiently.

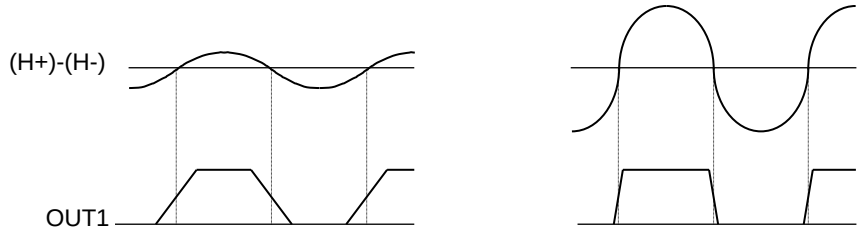


Figure 15. Relation between Hall Element Output Amplitude and Output Waveform

3. Lock Protection and Automatic Restart

The IC detects motor rotation by hall signal. The digital counter based on internal oscillator sets lock detection ON time (t_{ON}) and lock detection OFF time (t_{OFF}). Therefore, the ratio of ON/OFF time is always constant. Timing chart is shown in Figure 16.

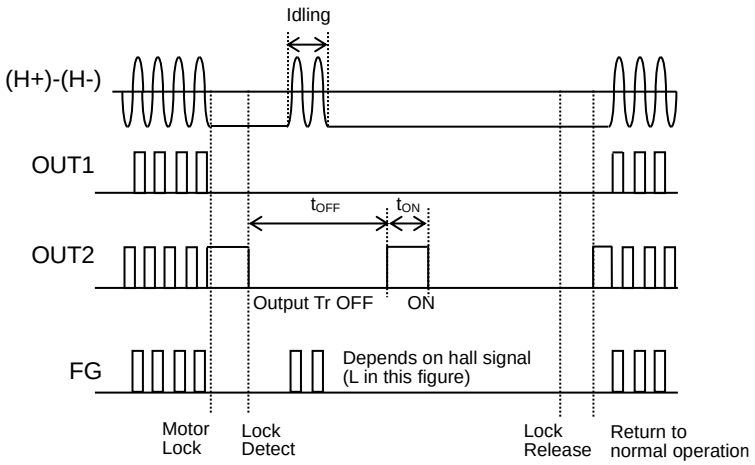


Figure 16. Timing Chart of Lock Protection and Automatic Restart

Functional Description - continued

4. Under Voltage Lock Out (UVLO)

When the voltage applied to the VCC pin becomes 2.45 V (Typ) or lower, the driver output and HB output become OFF. It returns when the voltage applied to the VCC pin becomes 2.75 V (Typ) or higher.

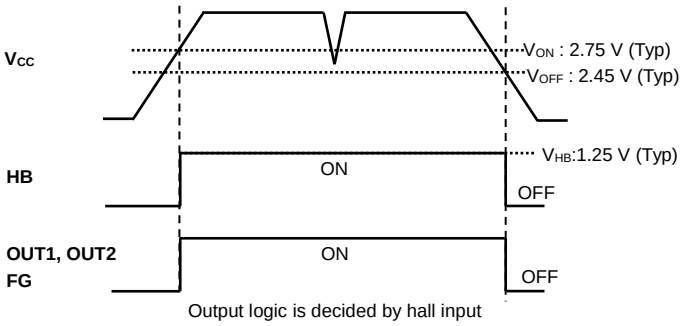


Figure 17. UVLO Timing Chart

5. Thermal Shutdown (TSD)

TSD is the protection circuit that prevent IC from heat destruction. When junction temperature rises to 160 degrees Celsius (Typ), TSD circuit turns off driver output. When junction temperature drops to 140 degrees Celsius (Typ), output turns on. When TSD function works, junction temperature is beyond the maximum rating. Perform thermal design so that TSD function does not work.

6. Over Current Protection (OCP)

When output current more than 1.6 A (Typ) flows, OCP turns output off. OCP detects for the OUT1, OUT2 pin and each upper and lower transistor independently. When OCP activates, it turns all output off. After having turned output off, output becomes ON when OFF time passes 57 µs (Typ). Timing chart is shown in Figure 18.

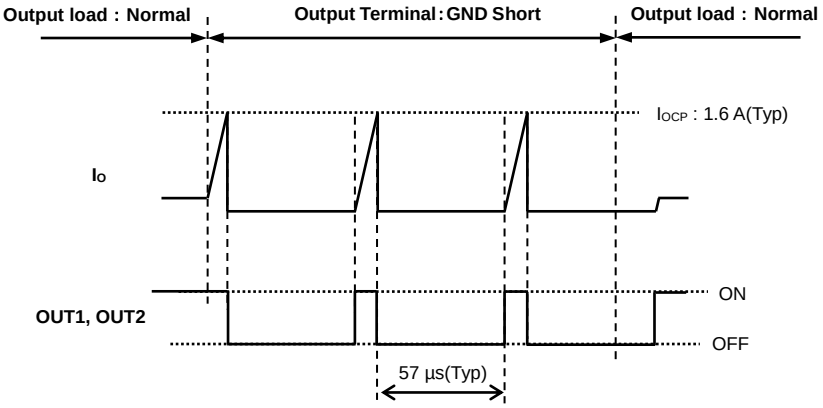


Figure 18. OCP Timing Chart

OCP is the function to prevent IC from excess current destruction in the load short by the sudden accident. At the normal operation of the motor, perform a motor design not to exceed absolute maximum rating of output current of 0.8 A.

Thermal Resistance

Heat generated by consumed power of IC is radiated from the mold resin or lead frame of package. The parameter that indicates this heat dissipation capability (hardness of heat release) is called thermal resistance. Thermal resistance from the chip junction to the ambient is represented in θ_{JA} [°C/W], and thermal characterization parameter from junction to the top center of the outside surface of the component package is represented in Ψ_{JT} [°C/W]. Thermal resistance is divide into the package part and the substrate part. Thermal resistance in the package part depends on the composition materials such as the mold resins and the lead frames. On the other hand, thermal resistance in the substrate part depends on the substrate heat dissipation capability of the material, the size, and the copper foil area etc. Therefore, thermal resistance can be decreased by the heat radiation measures like installing a heat sink etc. in the mounting substrate.
Figure 19 shows the thermal resistance model, and equation is shown below.

$$\theta_{JA} = \frac{Tj-Ta}{P} \text{ [°C/W]}$$
$$\psi_{JT} = \frac{Tj-Tt}{P} \text{ [°C/W]}$$

θ_{JA}: Thermal resistance from junction to ambient [°C/W]
ψ_{JT}: Thermal characterization parameter from junction to the top center of the outside surface of the component package [°C/W]
Tj: Junction temperature [°C]
Ta: Ambient temperature [°C]
Tt: Package outside surface temperature (top center) [°C]
P: Power consumption [W]

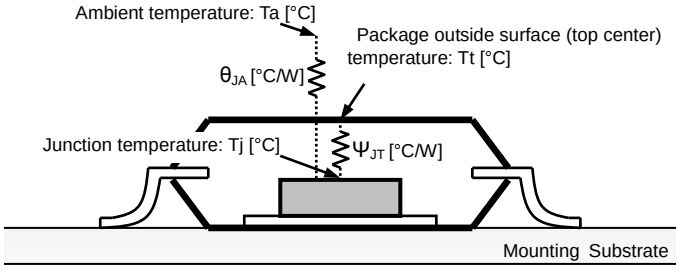
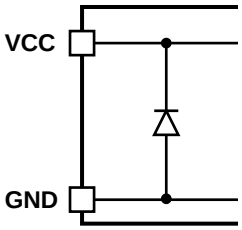


Figure 19. Thermal Resistance Model of Surface Mount Package

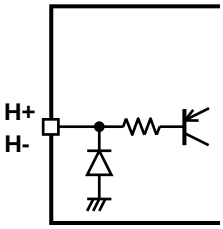
Even if it uses the same package, θ_{JA} and Ψ_{JT} varies depending on the chip size, power consumption, and the measurement environments of the ambient temperature, the mounting condition, and the wind velocity, etc.

I/O Equivalence Circuits

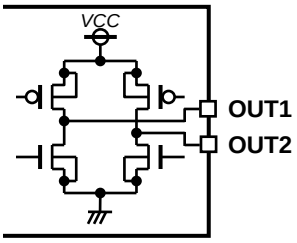
1. VCC, GND



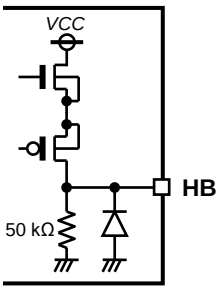
2. Hall Input



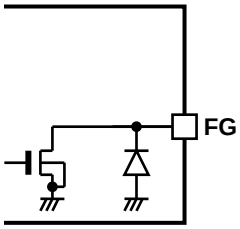
3. Motor Output



4. HB



5. FG



Safety Measure

1. Reverse Connection Protection Diode

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

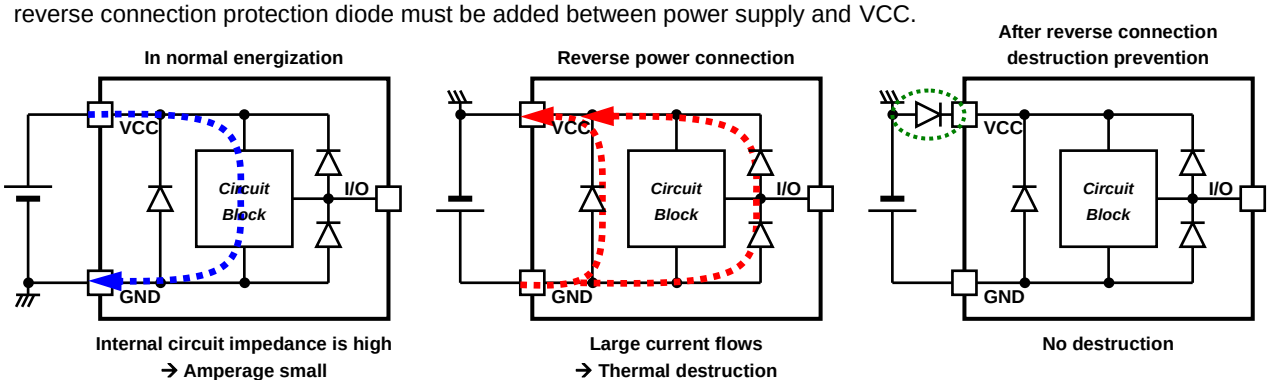


Figure 20. Flow of Current When Power is Connected Reversely

2. Problem of GND Line PWM Switching

Do not perform PWM switching of GND line because GND pin potential cannot be kept to a minimum.

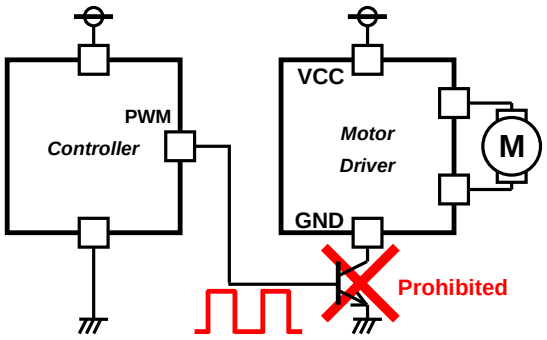


Figure 21. GND Line PWM Switching Prohibited

3. External Connecting Pin

Missconnecting of external connector from motor PCB, or hotplug of the connector, it may cause damage to IC by rush current or over voltage surge. About the input/output pin except VCC/GND line, take measures such as protection resistor so that IC is not affected by over voltage or excess current.
FG output is an open drain and requires pull-up resistor.

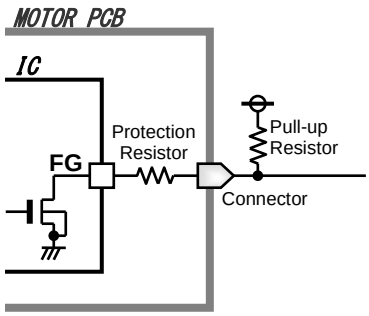


Figure 22. Protection of FG pin

Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition. However, pins that drive inductive loads (e.g. motor driver outputs, DC-DC converter outputs) may inevitably go below ground due to back EMF or electromotive force. In such cases, the user should make sure that such voltages going below ground will not cause the IC and the system to malfunction by examining carefully all relevant factors and conditions such as motor characteristics, supply voltage, operating frequency and PCB wiring to name a few.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

10. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

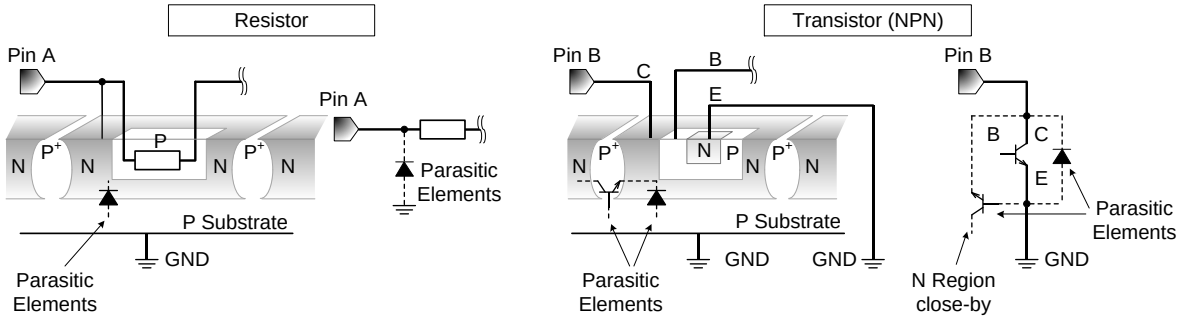


Figure 23. Example of Monolithic IC Structure

11. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

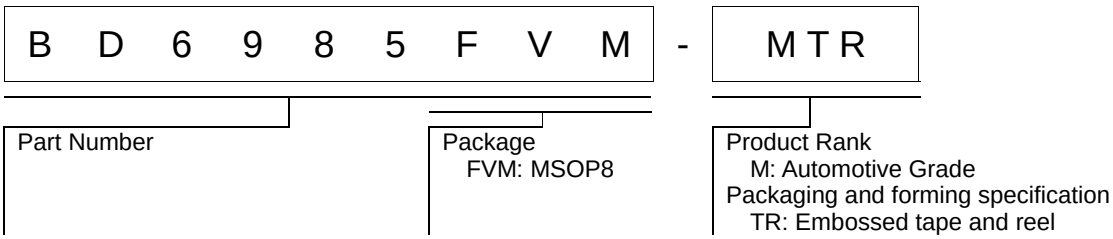
12. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF power output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

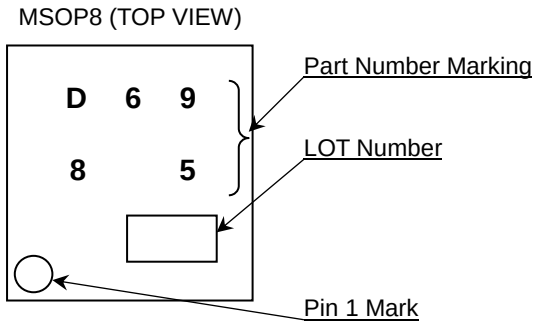
13. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

Ordering Information

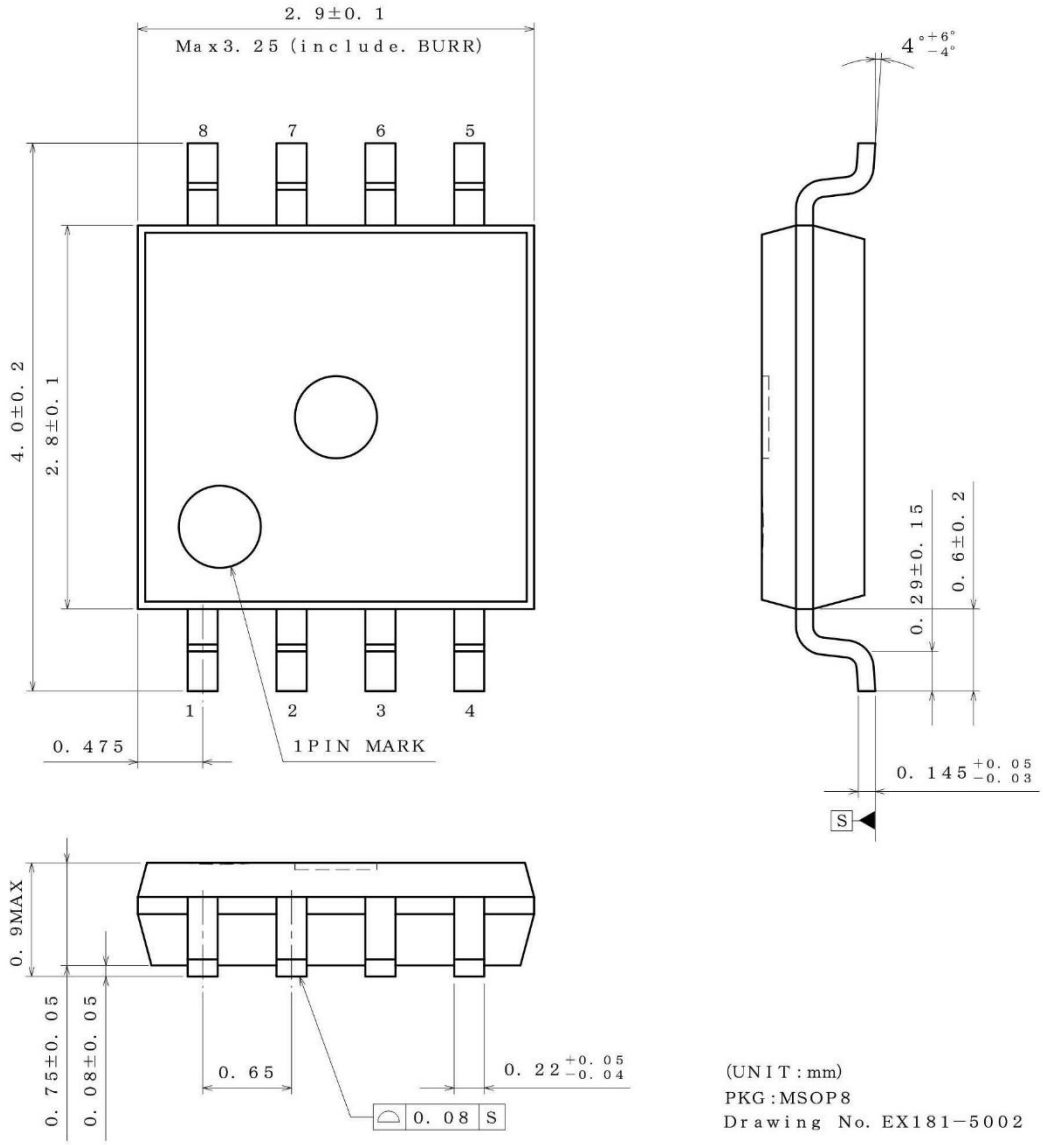


Marking Diagram



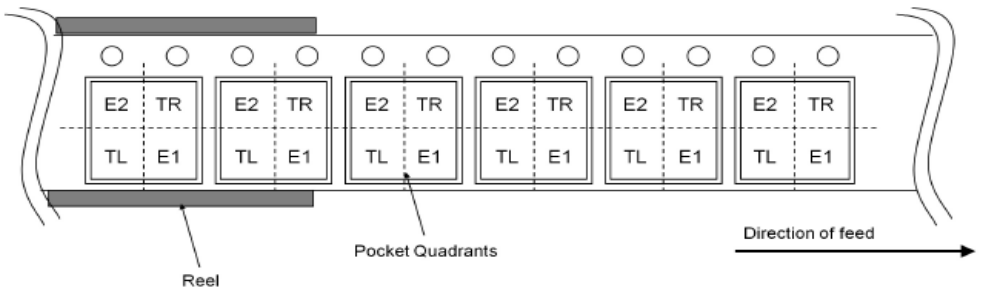
Physical Dimension and Packing Information

Package Name	MSOP8



< 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)



Revision History

Date	Revision	Changes
14.Jan.2020	001	Initial Release

Notice

Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), aircraft/spacecraft, nuclear power controllers, 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 not designed 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 (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); 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 depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction 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 on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

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 Cl_2, H_2S, NH_3, SO_2, and NO_2
   [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

A two-dimensional barcode 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.

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Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

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