Preliminary

TOSHIBA Bi-CD Integrated Circuit Silicon Monolithic

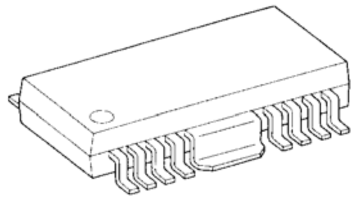
TB6569FG

Full-Bridge DC Motor Driver IC

The TB6569FG is a full-bridge DC motor driver with DMOS output transistors.

It uses P-channel MOSFETs on the high side and N-channel MOSFETs on the low side, eliminating the need for a charge pump. The TB6569FG achieves high thermal efficiency.

Four operating modes are selectable via IN1 and IN2: clockwise (CW), counterclockwise (CCW), short brake and stop.

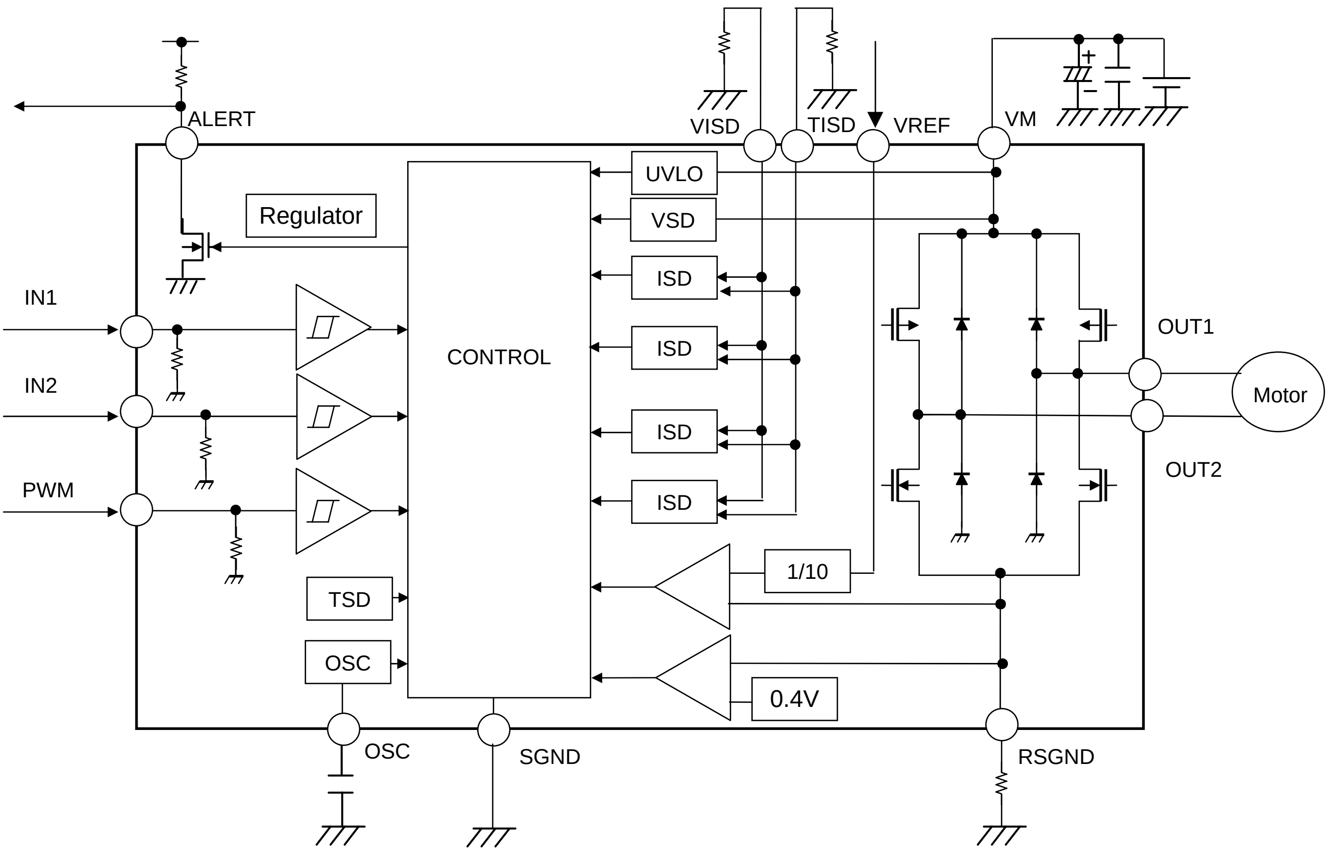


Weight: 0.50 g (typ.)

Features

- Power supply voltage: 50 V (max)
- Output current: (4.5 to 5A)(max)
- Low-ON resistance (upper and lower sum): (1.0 Ω) (typ.)
- Constant-current
- PWM control
- Clockwise (CW), counterclockwise (CCW), short brake and stop
- Overcurrent shutdown
- Undervoltage Lockout
- Overvoltage shutdown
- Thermal shutdown

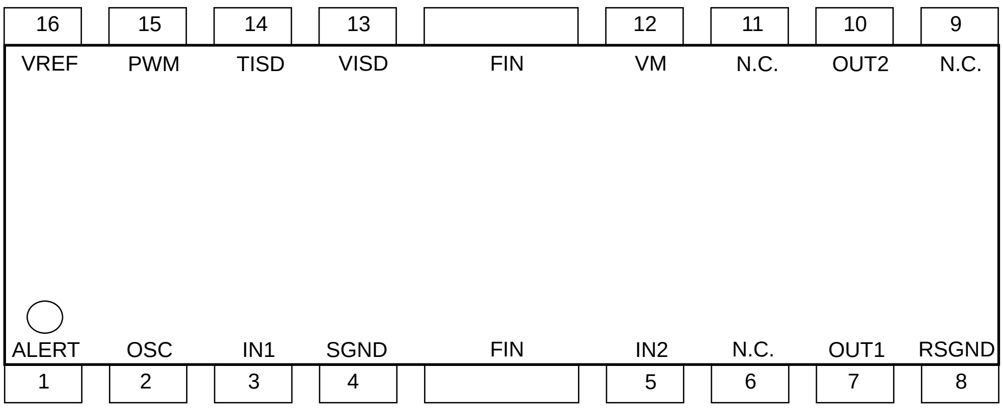
Block Diagram/ Typical Application Examples (preliminary)



Pin Functions (preliminary)

端 子 番 号	名 称	端 子 説 明
1	ALERT	Protective operation alert output
2	OSC	Connection pin for an external capacitor
3	IN1	Control signal input 1
4	SGND	Ground
5	IN2	Control signal input 2
6	N.C.	No connection
7	OUT1	Output pin 1
8	RSGND	Power ground/ Connection pin for an output current detection resistor
9	N.C.	No connection
10	OUT2	Output pin 2
11	N.C.	No connection
12	VM	Power supply pin
13	VISD	Connection pin for an external resistor to set current value for ISD
14	TISD	Connection pin for an external resistor to set the current time
15	PWM	PWM signal input
16	VREF	Supply voltage pin for current control
-	FIN	FIN

Pin Assignment (Top View)



Absolute Maximum Ratings (Ta = 25°C) (preliminary)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	50	V
Output current	I_O (Peak)	(4.5 to 5)	A
Power dissipation	P_D	1.4 (Note 1)	W
Operating temperature	T_{opr}	(−40 to 85)	°C
Storage temperature	T_{stg}	−55 to 150	°C

Note 1: Measured on a 60 × 30 × 1.6 mm PCB with a 50% dissipating copper surface.

Operating Ranges (Ta = 25°C) (preliminary)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	10 to 42	V
PWM frequency	f_{CLK}	up to 100	kHz
OSC frequency	fosc	up to 500	kHz

Electrical Characteristics (VM = 24 V, Ta = 25°C, unless otherwise specified) (preliminary)

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current		I_{CC1}	Stop mode	—	4	8	mA
		I_{CC2}	CW and CCW modes	—	4	8	
		I_{CC3}	Short brake mode	—	4	8	
Control circuit (IN1,IN2,PWM)	Input voltage	V_{INH}		2	—	5	V
		V_{INL}		–0.2	—	0.8	
	Hysteresis voltage	$V_{IN\ (HYS)}$	(Design target only. Not tested in production.)	—	0.1	—	
	Input current	I_{INH}	V_{IN} = 5 V	—	50	75	μA
		I_{INL}	V_{IN} = 0 V	—	—	2	
Vref input circuit	Input current	I_{ref}		—	1	3	μA
Output ON-resistance		$R_{on\ (U + L)}$	I_o =3A	—	(1.0)	(1.3)	Ω
Output leakage current		$I_{L\ (U)}$	V_{CC} = 50 V	—	0.1	10	μA
		$I_{L\ (L)}$	V_{CC} = 50 V	—	0.1	10	
Diode forward voltage		$V_{F\ (U)}$	I_o =3A	—	1.3	1.7	V
		$V_{F\ (L)}$	I_o =3A	—	1.3	1.7	
Thermal shutdown temperature		T_{SD}	(Design target only. Not tested in production.)	—	170	—	°C
Charge/ Discharge current for OSC		Iosc		—	0.51	—	mA
ALERT voltage		V_{ALERT}(L)	I_{ALERT} = 1 mA	—	—	0.4	V

Functional Descriptions (preliminary)

Input/Output Functions

Input			Output		
IN1	IN2	PWM	OUT1	OUT2	Mode
H	H	H	L	L	Short brake
		L			
L	H	H	L	H	CW/CCW
		L	L	L	Short brake
H	L	H	H	L	CCW/CW
		L	L	L	Short brake
L	L	H	OFF (Hi-Z)		Stop
		L			

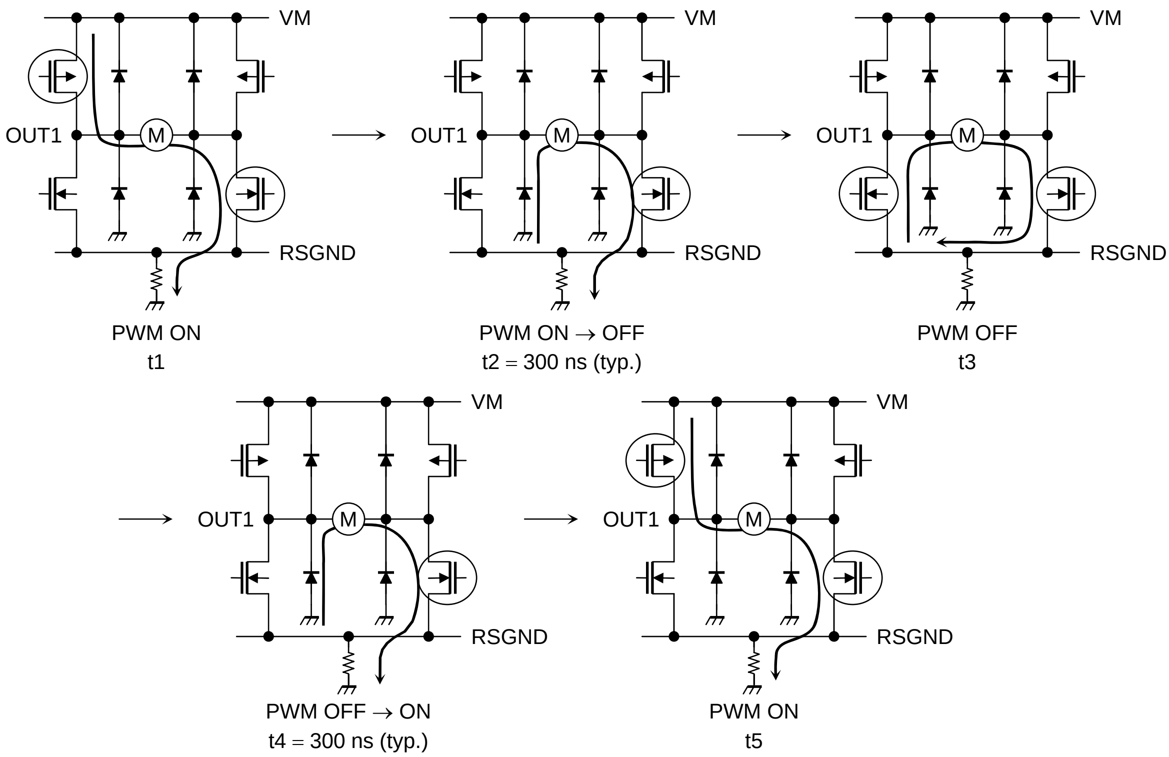
Output Operation

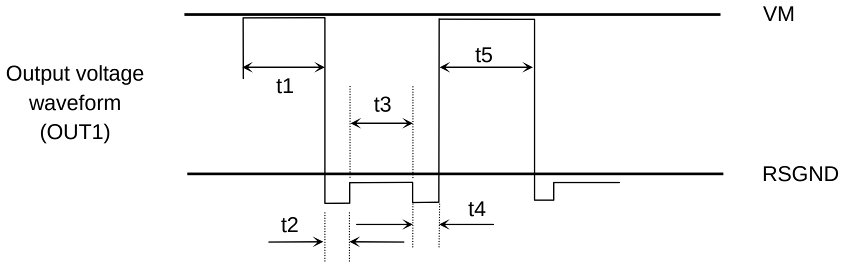
PWM control at PWM, IN1,IN2 pin.

The motor operating mode changes between CW/CCW and short brake alternately.

To eliminate shoot-through current that flows from supply to ground due to the simultaneous conduction of high-side and low-side transistors in the bridge output, a dead time of 300 ns (design target value) is generated in the IC when transistors switch from on to off, or vice versa.

The shoot-through protection permits a synchronous rectification PWM operation without controlling the dead time externally. A dead time is also provided internally when the motor operation mode switches between CW and CCW, and between CW (CCW) and short brake, thereby eliminating the need for external dead time insertion.

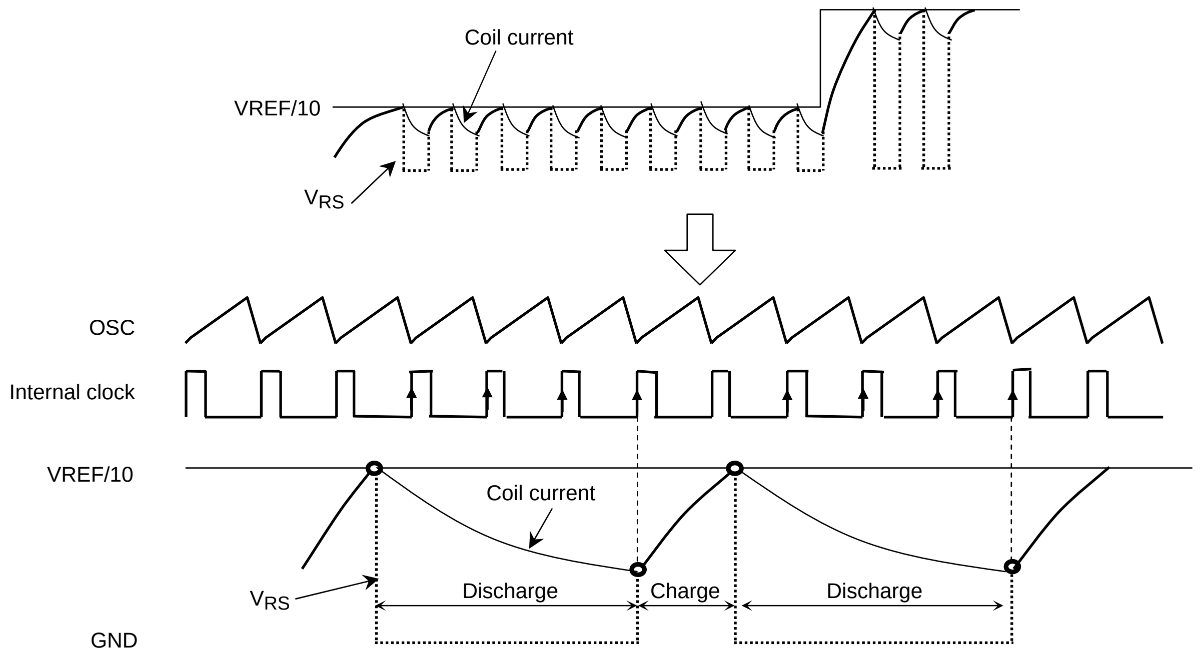




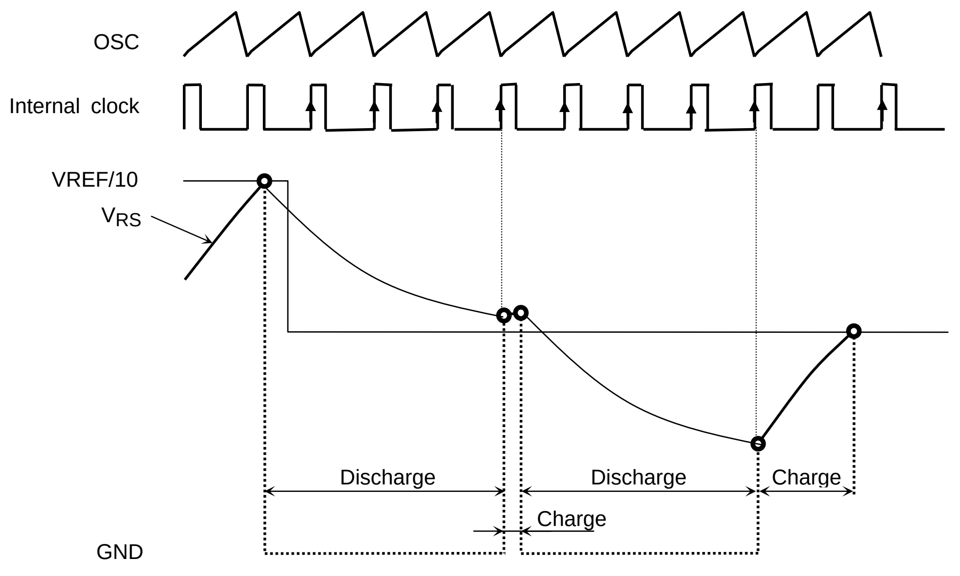
Constant-Current Regulation

When the VREF voltage is kept constant, the constant current regulator keeps the output current constant by using a peak current detection technique.

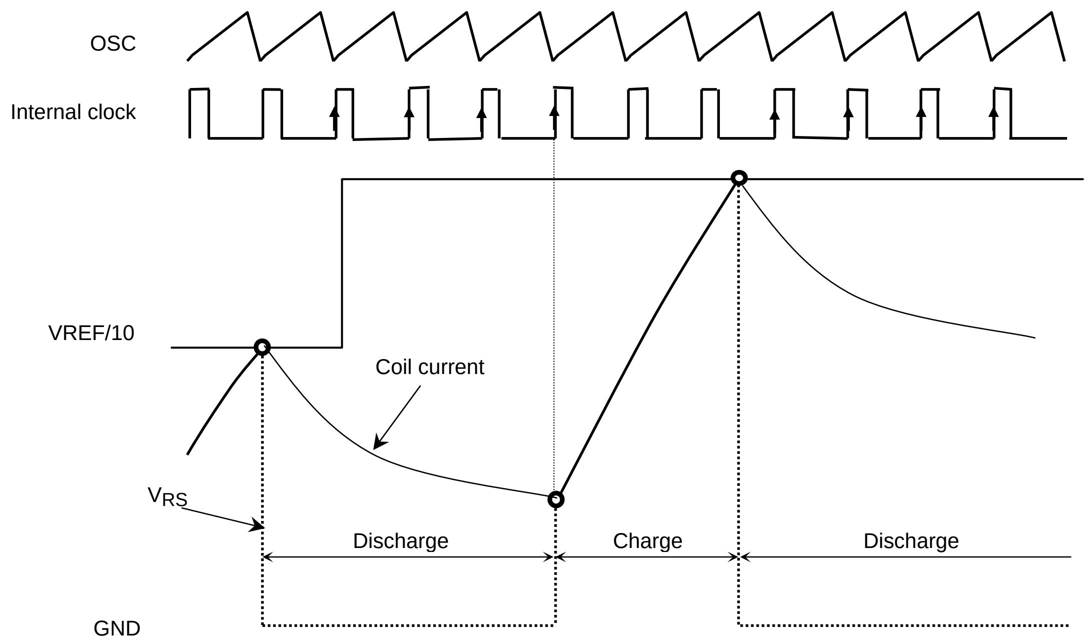
(1) Constant-current chopping
When V_{RS} reaches the reference voltage (VREF), the regulator enters Discharge mode.
After four cycles of CK, an internal clock generated by OSC, the regulator moves from Discharge mode to Charge mode.



(2) Changing the predefined current (during deceleration)
When VRS reaches the reference voltage (VREF/10), the regulator enters Discharge mode. Four CK cycles later, the regulator exits Discharge mode and enters Charge mode. If VRS > VREF/10 when it enters Charge mode, however, it then reenters Discharge mode. Four CK cycles later, VRS is again compared against VREF/10. If VRS < VREF/10, the regulator enters and remains in Charge mode until VRS reaches VREF/10.



(3) Changing the predefined current (during acceleration)
Even when the reference voltage is increased, the regulator remains in Discharge mode for four CK cycles and then it enters Charge mode.



The average current value becomes lower than the set current value because of the peak current detection method. It should be noted that the average current value changes, depending on the motor characteristics.

Calculation of the Internal Oscillation Frequency

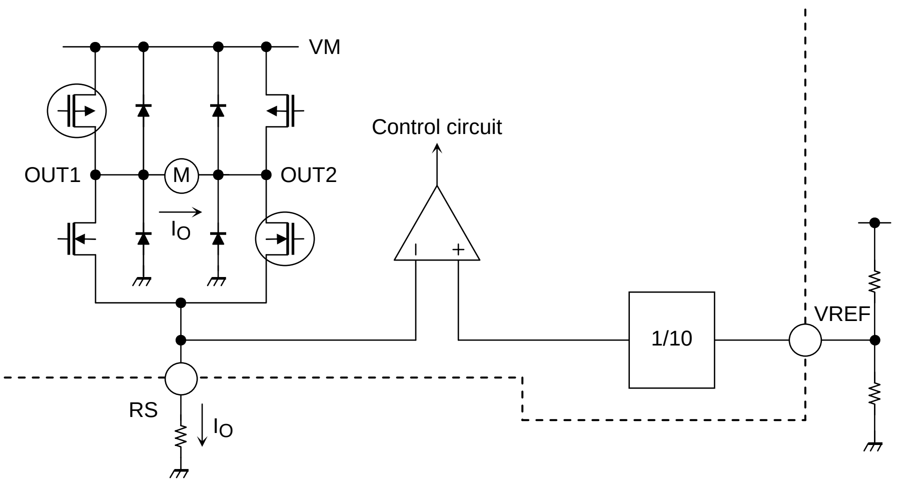
The OSC oscillation frequency can be calculated by the following equation:

$f_{osc} = 0.42 \times 10^6 / C_{osc}$ [F] [Hz](typ.)

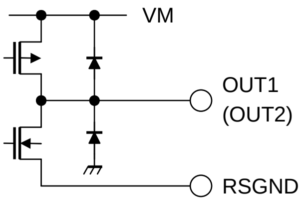
Reference Voltage Generator

In constant-current mode, the peak current is determined by the VREF voltage, as follows:

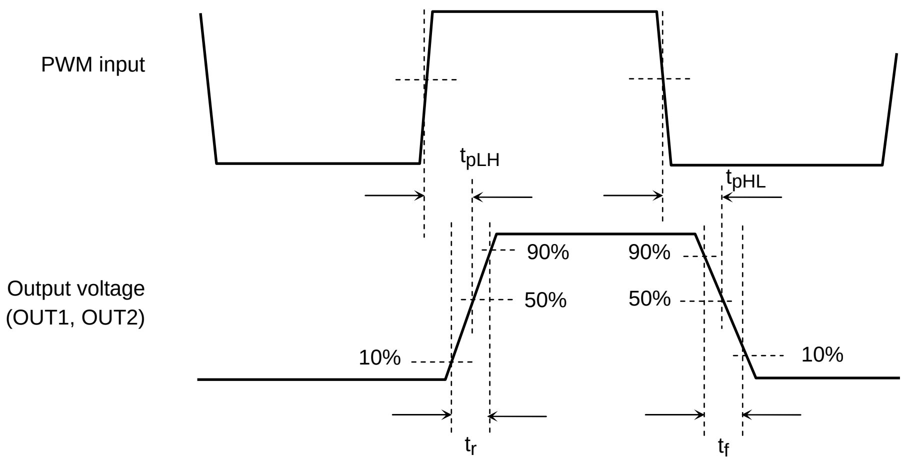
$I_O = VREF/RS \times 1/10$ [A]



Output Circuit



- The TB6569FG uses P-channel MOS transistors on the high side and N-channel MOS transistors on the low side.
- The output ON-resistance (R_{on}) is (1.0 Ω) (high-side and low-side sum)
- The switching characteristics of the output transistors are shown below.



Switching Characteristics

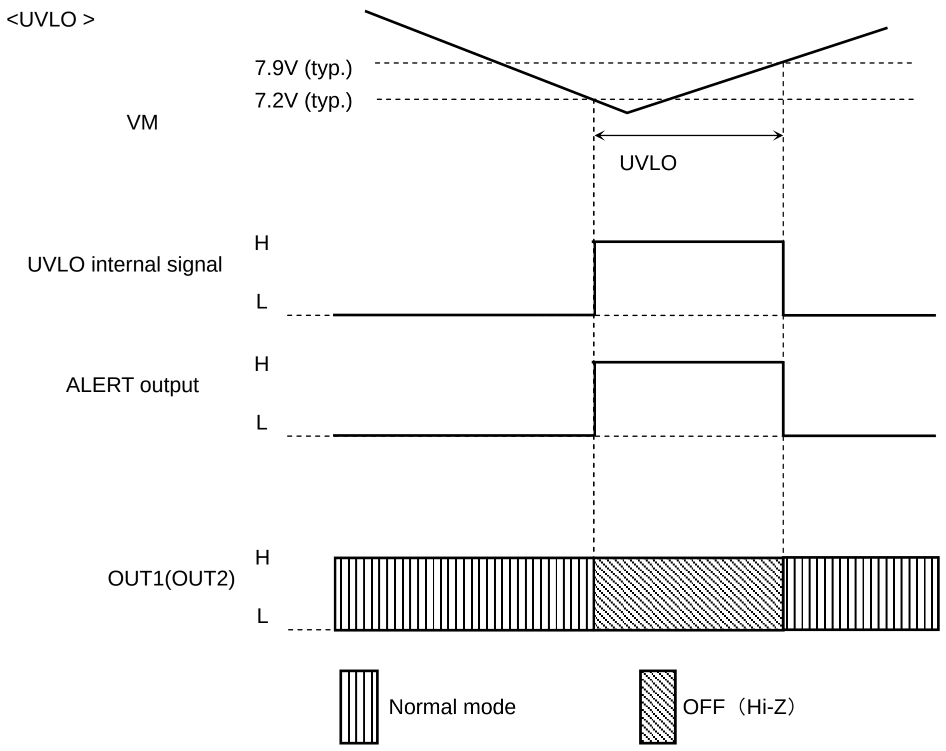
Item	Typical Value	Unit
t_{pLH}	400	ns
t_{pHL}	400	
t_r	200	
t_f	200	
Dead time	300	

ALERT circuit

ALERT output connect the pull-up external resistance for open drain.
When TSD,ISD,VSD,UVLO is activated, ALERT output goes Low.
Normal mode is ALERT output=High.

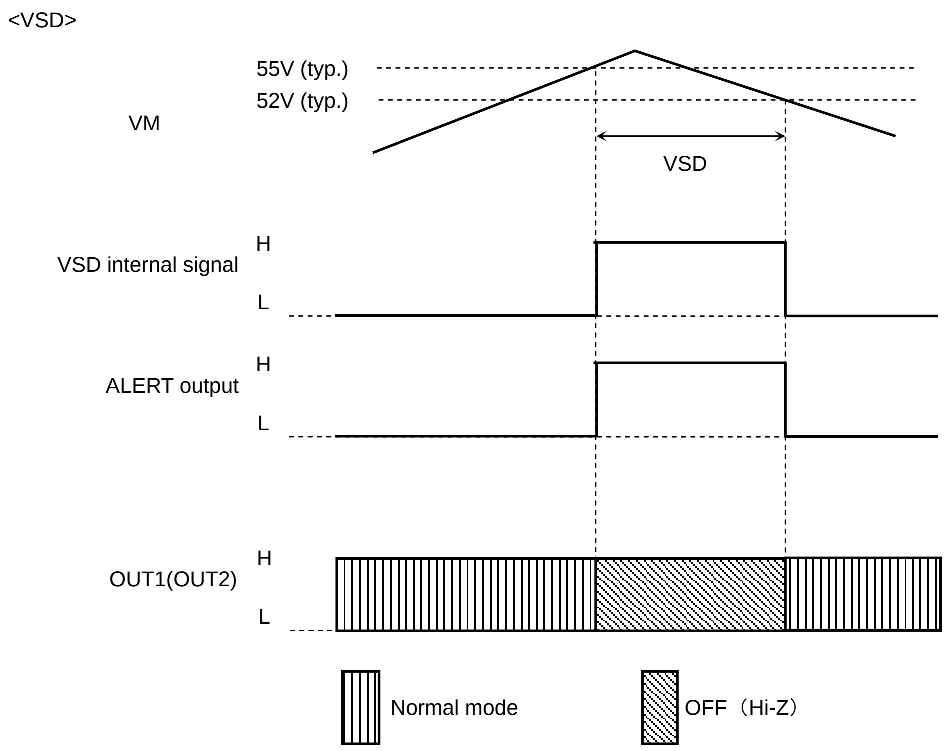
Under voltage Lockout（UVLO）

In UVLO, all circuits are turned off at VM<7.9V(target spec).
UVLO has 0.7V(target spec.) hysteresis.



Over voltage shutdown（VSD）

In VSD, all circuits are turned off at VM>55V(target spec).
VSD has 3V (target spec.) hysteresis.



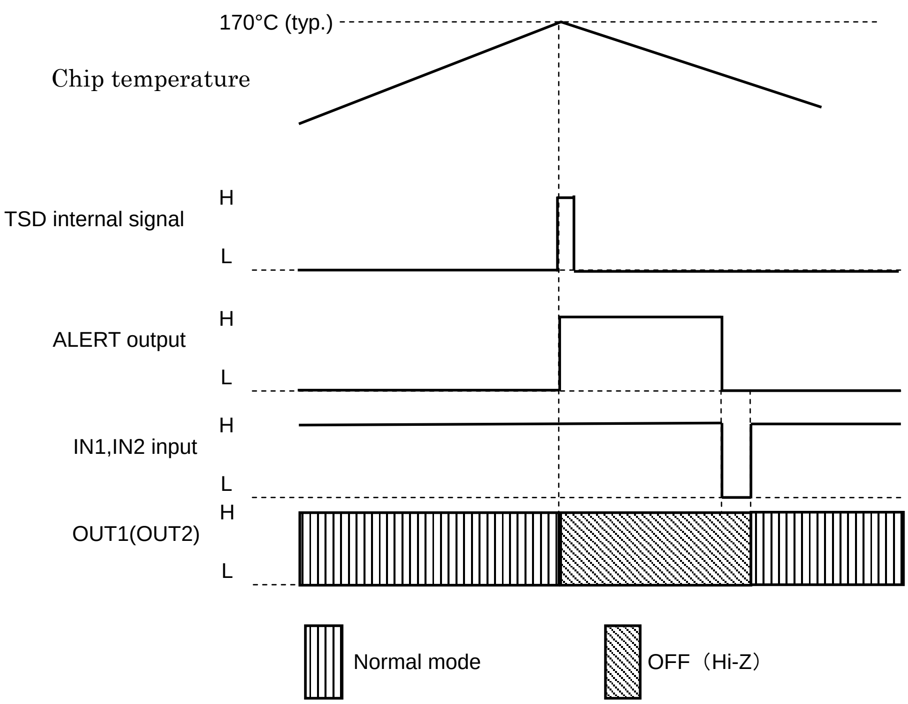
Thermal Shutdown Circuit(TSD)

The TB6569FG incorporates a thermal shutdown circuit. When the junction temperature (T_j) exceeds 170°C (typ.), the output transistors are turned off.

The output transistors are turned on by IN1=low and IN2=low.

TSD = 170°C (target spec)

<TSD >

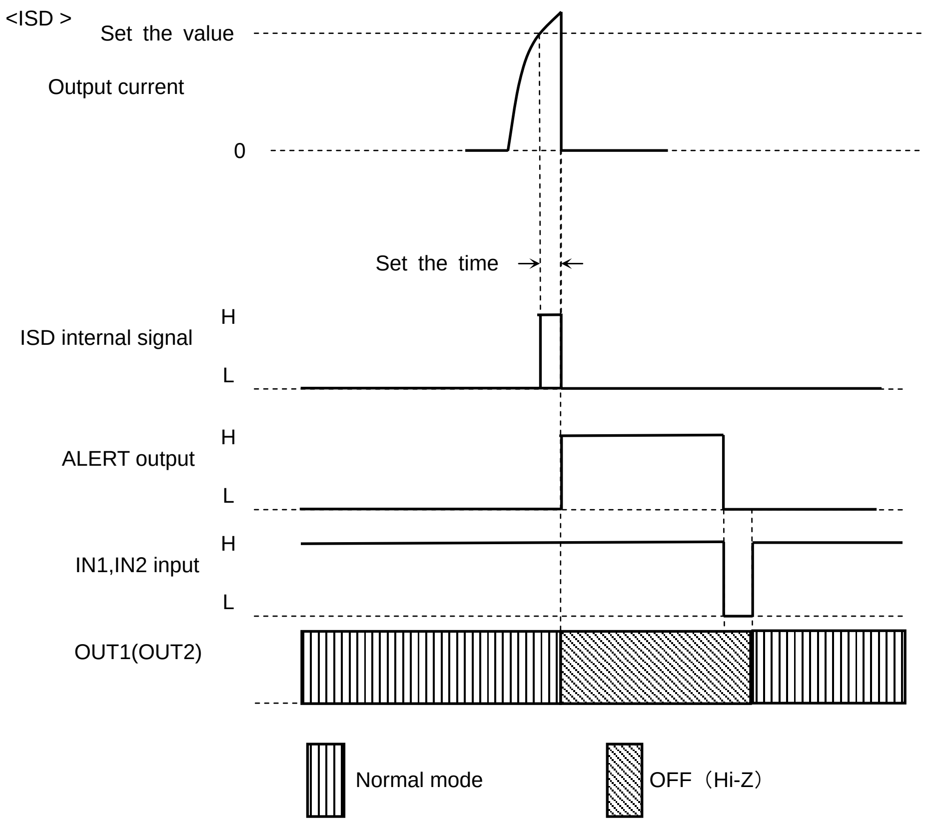


Overcurrent Shutdown Circuit(ISD)

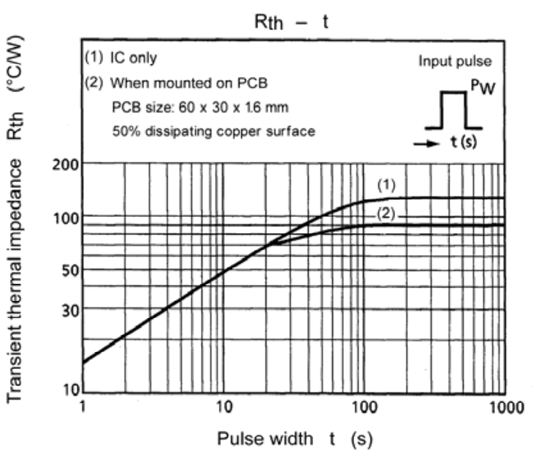
The TB6569FG allows for the sensing of the current that flows through each output transistor.
The currents through each of the output transistors are continually monitored. In the event of an overcurrent in at least one of the transistors, the overcurrent protection circuitry turns all transistors off.
The output transistors are turned on by IN1=low and IN2=low.
It is possible to set the current value by the external resistance at VISD terminal.
And it is possible to set the time by the external resistance at TISD terminal.

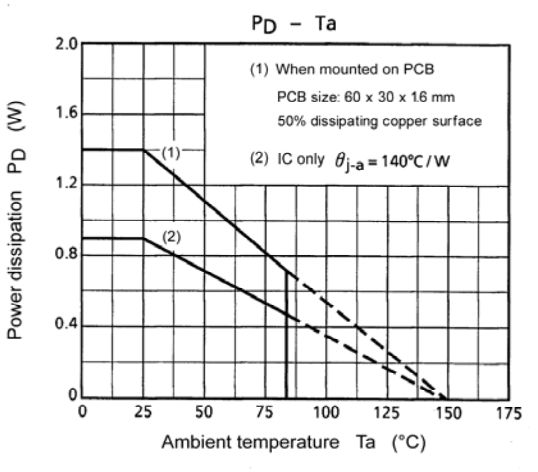
The external resistance example at VISD terminal
10kohm: between 4.1A and 9.4A (target spec)
20kohm: between 3.4A and 5.4A (target spec)
30kohm: between 2.5A and 3.9A (target spec)
40kohm: between 1.9A and 3.1A (target spec)
50kohm: between 1.5A and 2.6A (target spec)

The external resistance example at TISD terminal
5kohm: between 0.3 μs and 0.55 μs (target spec)
20kohm: between 1.2 μs and 2.1 μs (target spec)
50kohm: between 2.9 μs and 5.3 μs (target spec)
100kohm: between 5.8 μs and 10.4 μs (target spec)
200kohm: between 11 μs and 21 μs (target spec)



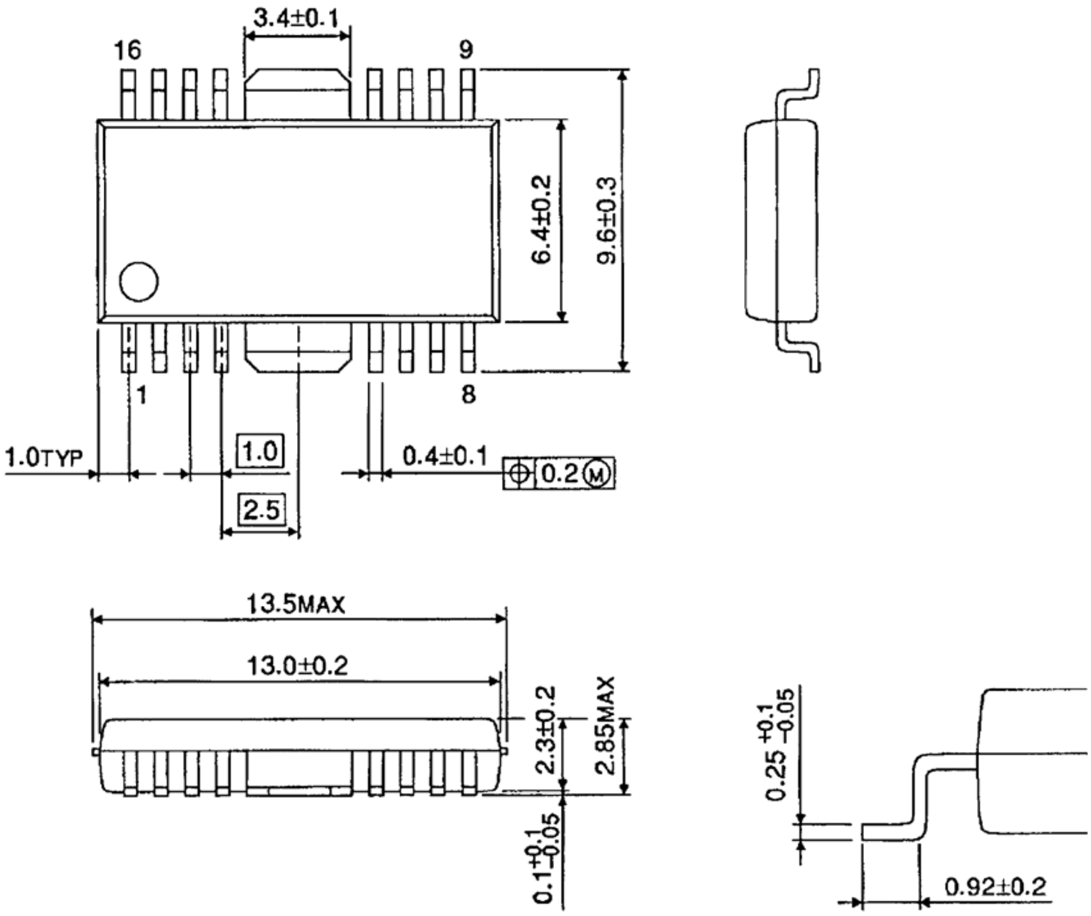
Typical Characteristics Graphs





Package Dimensions

HSOP16-P-300-1.00 Unit : mm



Weight: 0.50 g (typ.)

Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.
Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on Handling of ICs

(1) The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

(2) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

(3) If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

(4) Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

Points to Remember on Handling of ICs

(1) Over Current Protection Circuit
Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately.
Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

(2) Thermal Shutdown Circuit
Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.
Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(3) Heat Radiation Design
In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (T_j) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(4) Back-EMF
When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

RESTRICTIONS ON PRODUCT USE

070122EBA_R6

- The information contained herein is subject to change without notice. 021023_D
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc. 021023_A
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk. 021023_B
- The products described in this document shall not be used or embedded to any downstream products of which manufacture, use and/or sale are prohibited under any applicable laws and regulations. 060106_Q
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patents or other rights of TOSHIBA or the third parties. 070122_C
- Please use this product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances.
  Toshiba assumes no liability for damage or losses occurring as a result of noncompliance with applicable laws and regulations. 060819_AF
- The products described in this document are subject to foreign exchange and foreign trade control laws. 060925_E