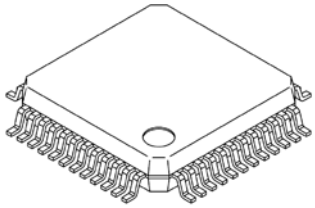
TOSHIBA Bi-CMOS Integrated Circuit Silicon Monorithic

TB9057FG

Automotive GATE-driver for DC brushed motor driver

TB9057FG is a Pre-Driver IC for DC Brushed Motor.
It controls motor speed by inputting PWM signal.
The IC has charge pump, motor current detection circuit, motor driving direction detection circuit and oscillator in it.
Also, it has various abnormality detection circuits, and the detection condition can be adjusted by external pin setting.



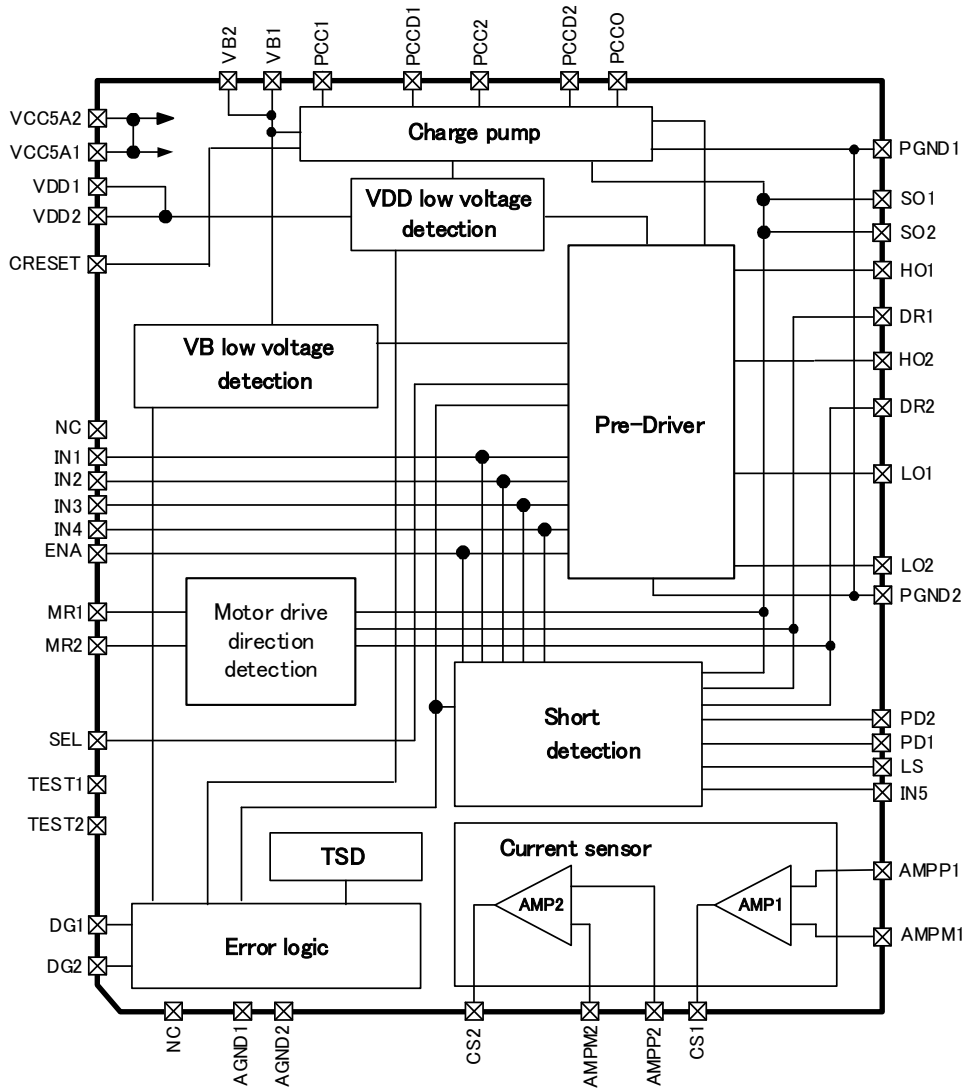
LQFP48-P-0707-0.50C

Weight: 0.186g (typ.)

1. Features

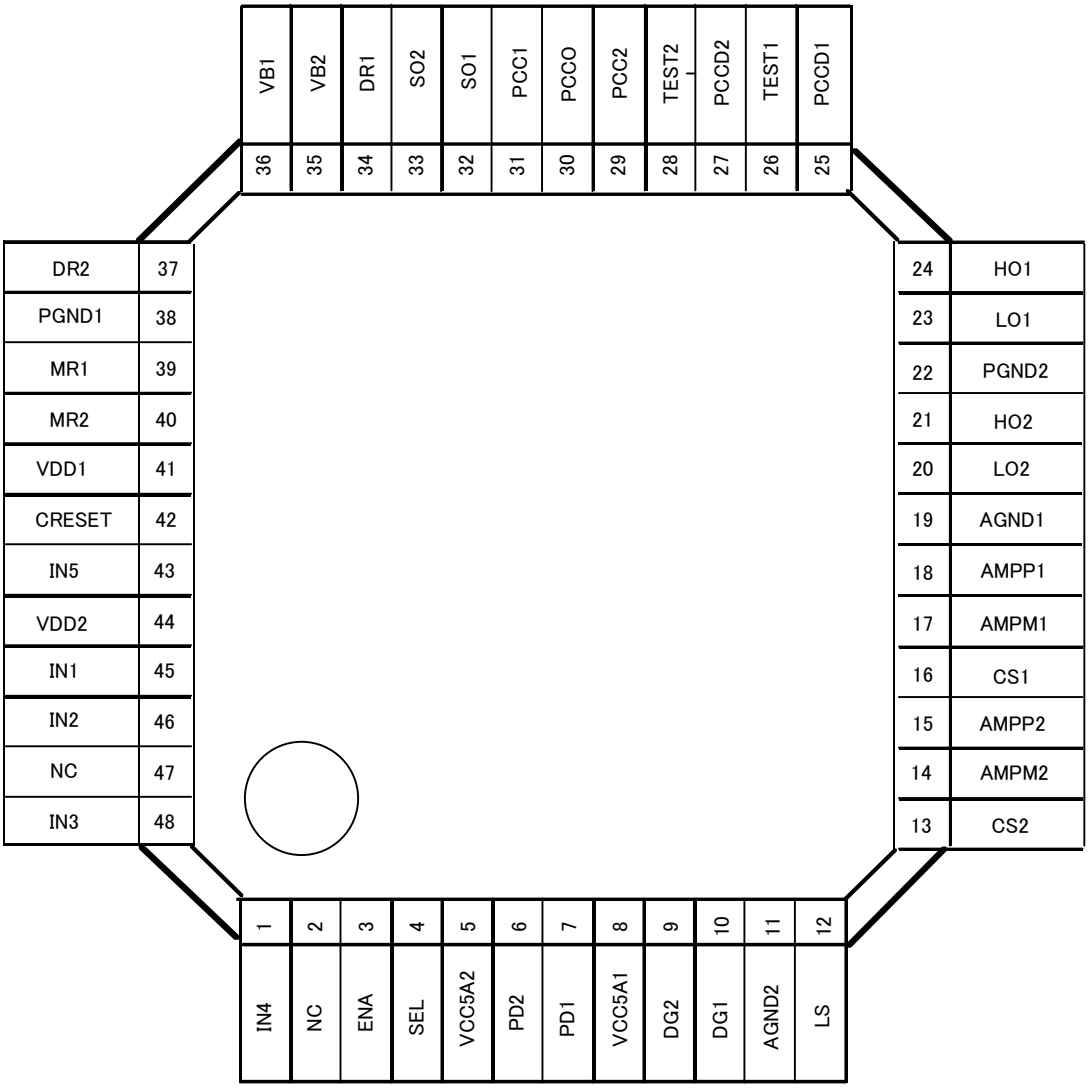
- Control motor speed by Inputting PWM signal
- Build-in charge pump
- Current detection circuit
- Detection circuit for Motor driving direction
- Various abnormality detection circuits (Over temperature / Low voltage / Short detection)
- Operating range of voltage : 5 to 21V
- Operating range of temperature : −40 to 125°C
- Small size flat package : LQFP48-P-0707-0.50C (0.5mm Pitch)
- The product(s) is/are compatible with RoHS regulations (EU directive 2011 / 65 / EU) as indicated, if any, on the packaging label ("[[G]]/RoHS COMPATIBLE", "[[G]]/RoHS [[Chemical symbol(s) of controlled substance(s)]]", "RoHS COMPATIBLE" or "RoHS COMPATIBLE, [[Chemical symbol(s) of controlled substance(s)]]>MCV").
- AEC-Q100 Qualified
- Developed according to ISO 26262 ASIL-D
- Safety Manual and Safety Analysis Report
- Over temperature dection is duplicated

2. BLOCK DIAGRAM



Note 1：Some of the functional blocks,circuit,or constants in the block diagram may be omitted or simplified for explanatory purpose.

3. PACKAGE PIN LAYOUT



4. PIN DESCRIPTION

PIN No.	Symbol	Description	IN/OUT	Internal IC	Notes
1	IN4	Pre-Driver Direct Control 4	I	Pull-up	
2	NC	Non Connection Pin	-	-	Please use OPEN (No B`g wire)
3	ENA	Pre-Driver Enable Signal	I	Pull-down	
4	SEL	Select control method for abnormality detection	I	Pull-up	
5	VCC5A2	Power Supply for Analog 2	-	-	
6	PD2	Set reference voltage for Short Detection 2	I	-	
7	PD1	Set reference voltage for Short Detection 1	I	-	
8	VCC5A1	Power Supply for Analog 1	-	-	
9	DG2	Output of error logic detection 2	O	-	
10	DG1	Output of error logic detection 1	O	-	
11	AGND2	Analog GND 2	-	-	
12	LS	Pre-Driver Low-side Source Input	I	-	
13	CS2	2nd AMP. Output for Current detection	O	-	
14	AMPM2	2nd AMP. - Input for Current detection	I	-	
15	AMPP2	2nd AMP. + Input for Current detection	I	-	
16	CS1	1st AMP. Output for Current detection	O	-	
17	AMPM1	1st AMP. - Input for Current detection	I	-	
18	AMPP1	1st AMP. + Input for Current detection	I	-	
19	AGND1	Analog GND 1	-	-	
20	LO2	Output of Pre-Driver L2	O	-	
21	HO2	Output of Pre-Driver H2	O	-	
22	PGND2	Power GND 2	-	-	
23	LO1	Output of Pre-Driver L1	O	-	
24	HO1	Output of Pre-Driver H1	O	-	
25	PCCD1	1st Charge Pump Drive Output	O	-	
26	TEST1	TEST PIN 1	I	Pull-down	Please use OPEN
27	PCCD2	2nd Charge Pump Drive Output	O	-	
28	TEST2	TEST PIN 2	I	Pull-down	Please use OPEN
29	PCC2	2nd Charge Pump Output	O	-	
30	PCCO	Final Charge Pump Output	O	-	
31	PCC1	1st Charge Pump Output	O	-	
32	SO1	Pre-Driver High-side Drain Input 1	I	-	
33	SO2	Pre-Driver High-side Drain Input 2	I	-	
34	DR1	Motor Connect PIN 1	I	Pull-down	
35	VB2	Power Supply(Battery 12V) 2	-	-	
36	VB1	Power Supply(Battery 12V) 1	-	-	
37	DR2	Motor Connect PIN 2	I	Pull-down	
38	PGND1	Power GND 1	-	-	
39	MR1	Motor driving direction detection signal 1	O	-	
40	MR2	Motor driving direction detection signal 2	O	-	
41	VDD1	Power supply for logic 1	-	-	
42	CRESET	Charge pump reset signal	I	Pull-up	
43	IN5	Set filter time for short detection	I	-	
44	VDD2	Power supply for logic 2	-	-	
45	IN1	Pre-Driver Direct Control 1	I	Pull-up	
46	IN2	Pre-Driver Direct Control 2	I	Pull-up	
47	NC	Non Connection Pin	-	-	Please use OPEN (No B`g wire)
48	IN3	Pre-Driver Direct Control 3	I	Pull-up	

Note 1 : If the soldering comes off, it may cause that motor does not rotate, motor rotation is unstable or motor protection is not operated.

Note 2 : In case of neighboring pin short, it may cause break down of IC or damage to the product.

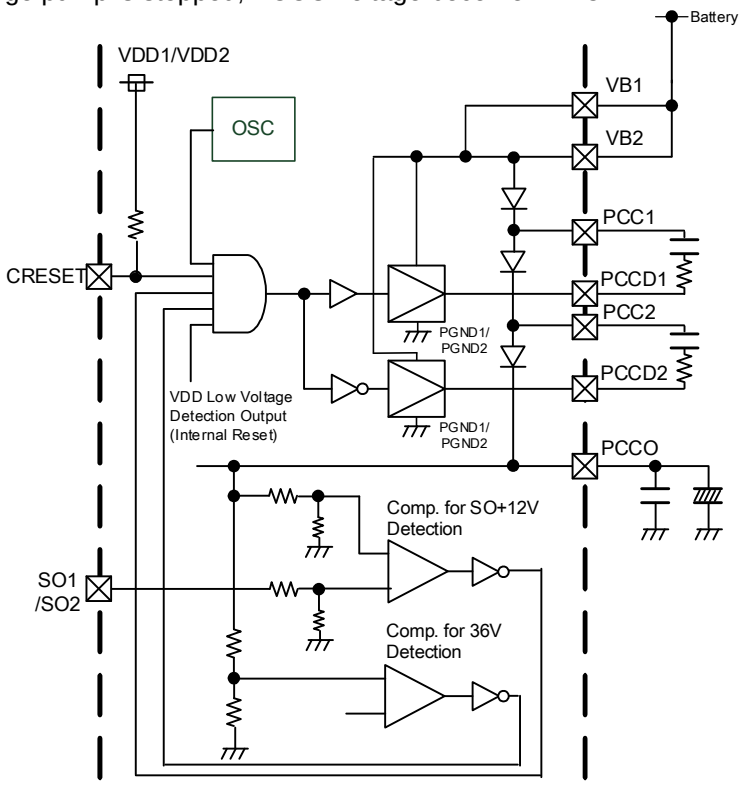
Note 3 : Install the product correctly. Otherwise, it may cause break down of IC or damage to the product.

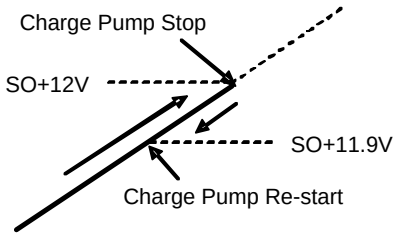
5. FUNCTIONAL DESCRIPTIONS

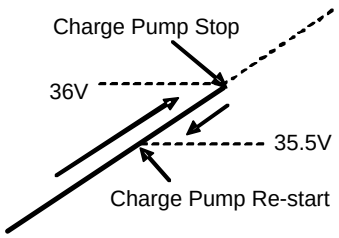
TB9057FG is a Pre-Driver IC for DC Brushed Motor.
TB9057FG has charge pump in it, so that it can control external Nch MOSFET directly. And the IC is able to detect the motor current from CS1 and CS2 pin by using the internal current detection circuit.
Also, it has various abnormality detection circuits, and the detection condition can be adjusted by external pin setting.

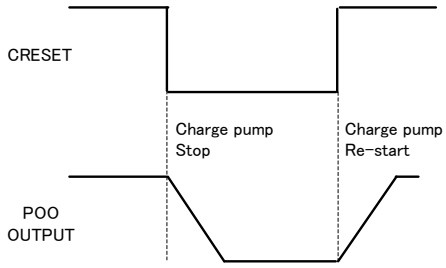
5.1. Charge Pump

In order to operate the external Nch MOSFET, TB9057FG has pre-driver. And the charge pump is built-in to operate the pre-driver. The charge pump voltage is monitored by internal circuit, and controlled as described below.
The charge pump voltage (PCCO pin) has 2 types of detection and clamp function. When the voltage rises up to SO+12V, the operation of charge pump would be stopped. And it re-starts the operation when the voltage falls down to SO+11.9V. To prevent the over voltage, if the voltage rises up to 36V, the operation of charge pump would be stopped until the voltage falls down to 35.5V.
Charge Pump Operation can be stopped by using external PIN “CRESET”.
CRESET = High : Normal operation. CRESET = Low : Stop the operation of charge pump.
When charge pump is stopped, PCCO voltage become “VB-3VF”.





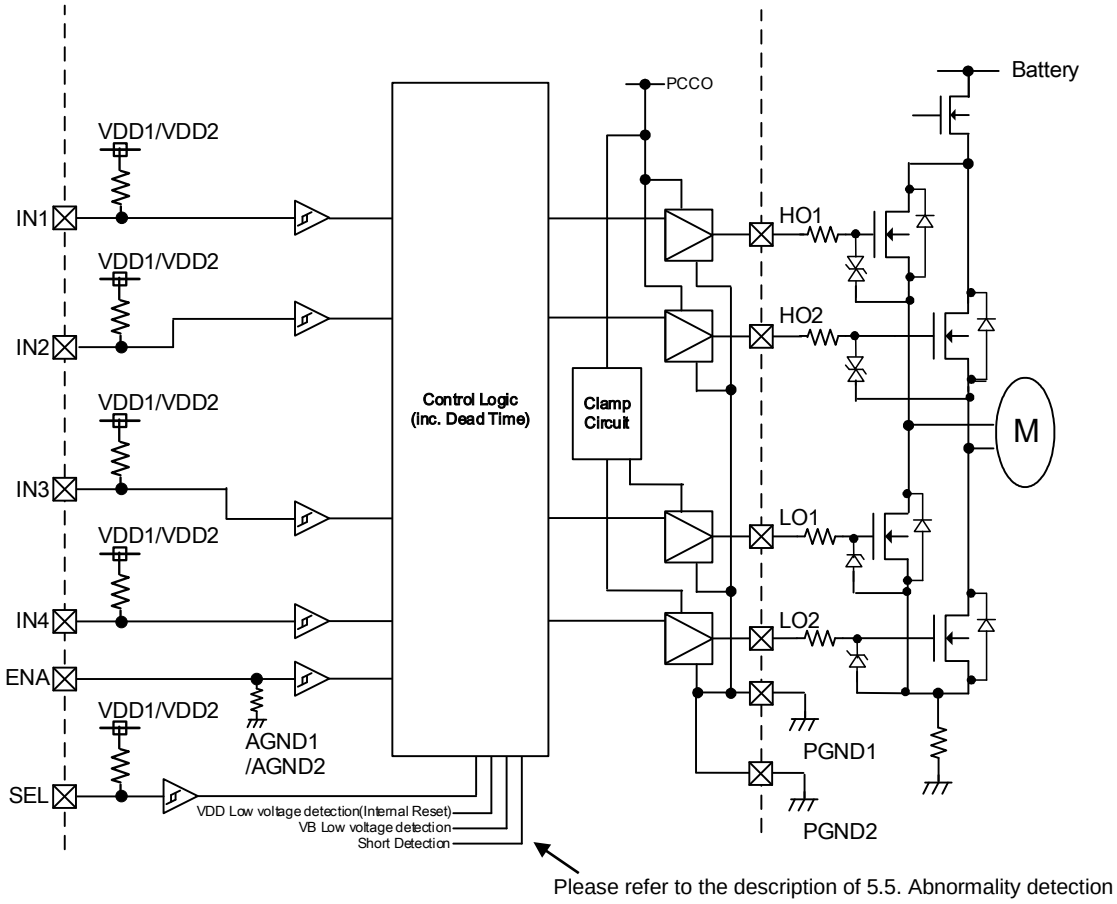




Note 1 : When VB is over 40V, it exceeds the absolute maximum rating of PCCO (40V), even if the charge pump is stopped as shown above. Please make sure not to exceed 40V at VB
Note 2 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.
Note 3 : The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

5.2. Pre-Driver Circuit

The pre-driver circuit is operated by IN1 to IN4 pin. And the output voltage of charge pump is used as the power supply. The operation of pre-driver would be stopped when the ENA pin = Low.



Note 1 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

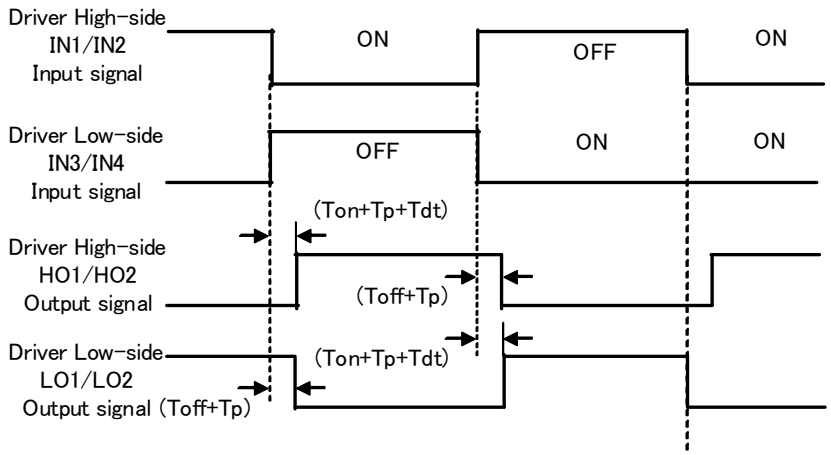
Truth Table

Input Signal					Output Signal			
IN1	IN2	IN3	IN4	ENA	HO1	HO2	LO1	LO2
L	*	L	*	H	L	L	L	L
*	L	*	L	H	L	L	L	L
L	L	H	H	H	H	H	L	L
L	H	H	L	H	H	L	L	H
H	L	L	H	H	L	H	H	L
H	H	L	L	H	L	L	H	H
L	H	H	H	H	H	L	L	L
H	L	H	H	H	L	H	L	L
H	H	L	H	H	L	L	H	L
H	H	H	L	H	L	L	L	H
H	H	H	H	H	L	L	L	L
*	*	*	*	L	L	L	L	L

* : Don't care.

∗ DEAD TIME generation

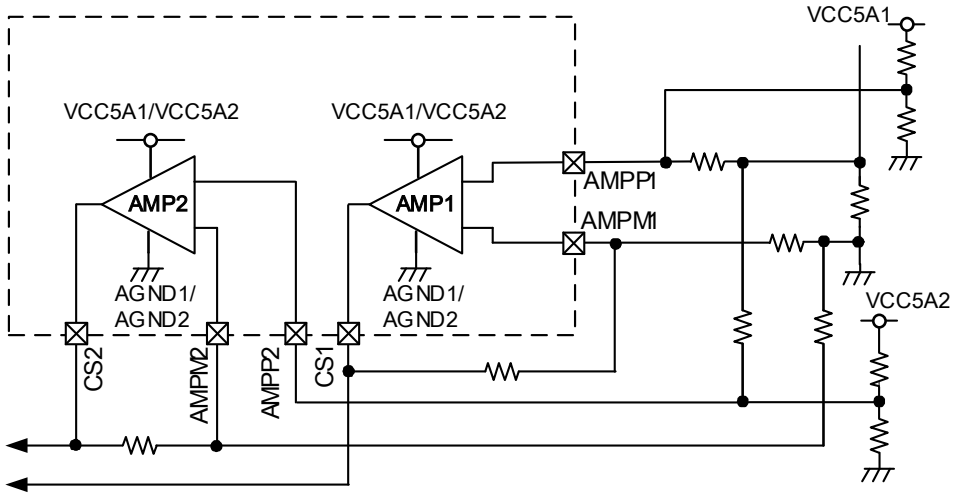
To prevent the short current by simultaneous turnning on both Low-side and High-side, which compose the each of half-bridge at the H-bridge circuit, the IC generates dead time at the timing of driver [OFF to ON] as shown below.



Note 1: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

5.3. Current detection circuit

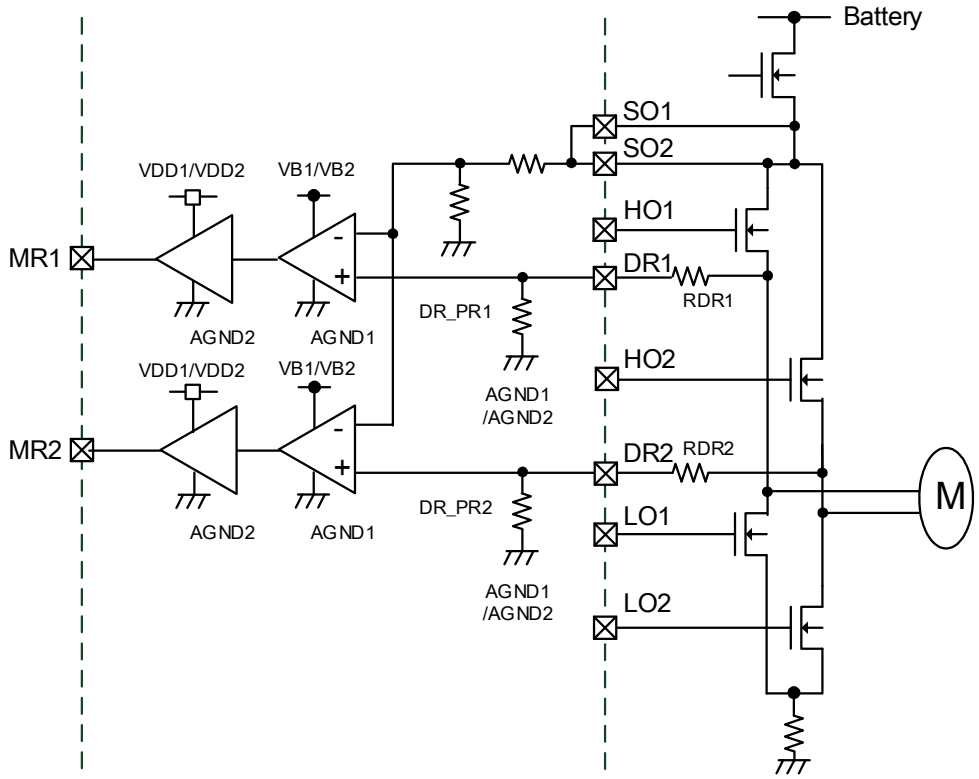
Current detection circuit could be used for detecting the motor current. By using external shunt resistor, it converts the motor current to voltage.
The amplification rate of differential circuit can be adjusted by changing the value of external resistor.



Note 1: Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

5.4. Motor driving direction detection

The IC has the motor driving direction detection circuit. To monitor the reverse assist, it can detect whether the external MOSFET turns on normally, as following the driver turnning on command.



Note 1：Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

Truth Table

Input Signal				Output Signal	
HO1	HO2	LO1	LO2	DR1	DR2
L	L	L	L	Hi-Z(Open)	Hi-Z(Open)
H	H	L	L	H	H
H	L	L	H	H	L
L	H	H	L	L	H
L	L	H	H	L	L
H	L	L	L	H	Hi-Z(Open)
L	H	L	L	Hi-Z(Open)	H
L	L	H	L	L	Hi-Z(Open)
L	L	L	H	Hi-Z(Open)	L

Input Signal		Output Signal	
DR1	DR2	MR1	MR2
Hi-Z(Open)	Hi-Z(Open)	L	L
H	H	H	H
H	L	H	L
L	H	L	H
L	L	L	L
H	Hi-Z(Open)	H	L
Hi-Z(Open)	H	L	H
L	Hi-Z(Open)	L	L
Hi-Z(Open)	L	L	L

5.5. Abnormality detection circuit

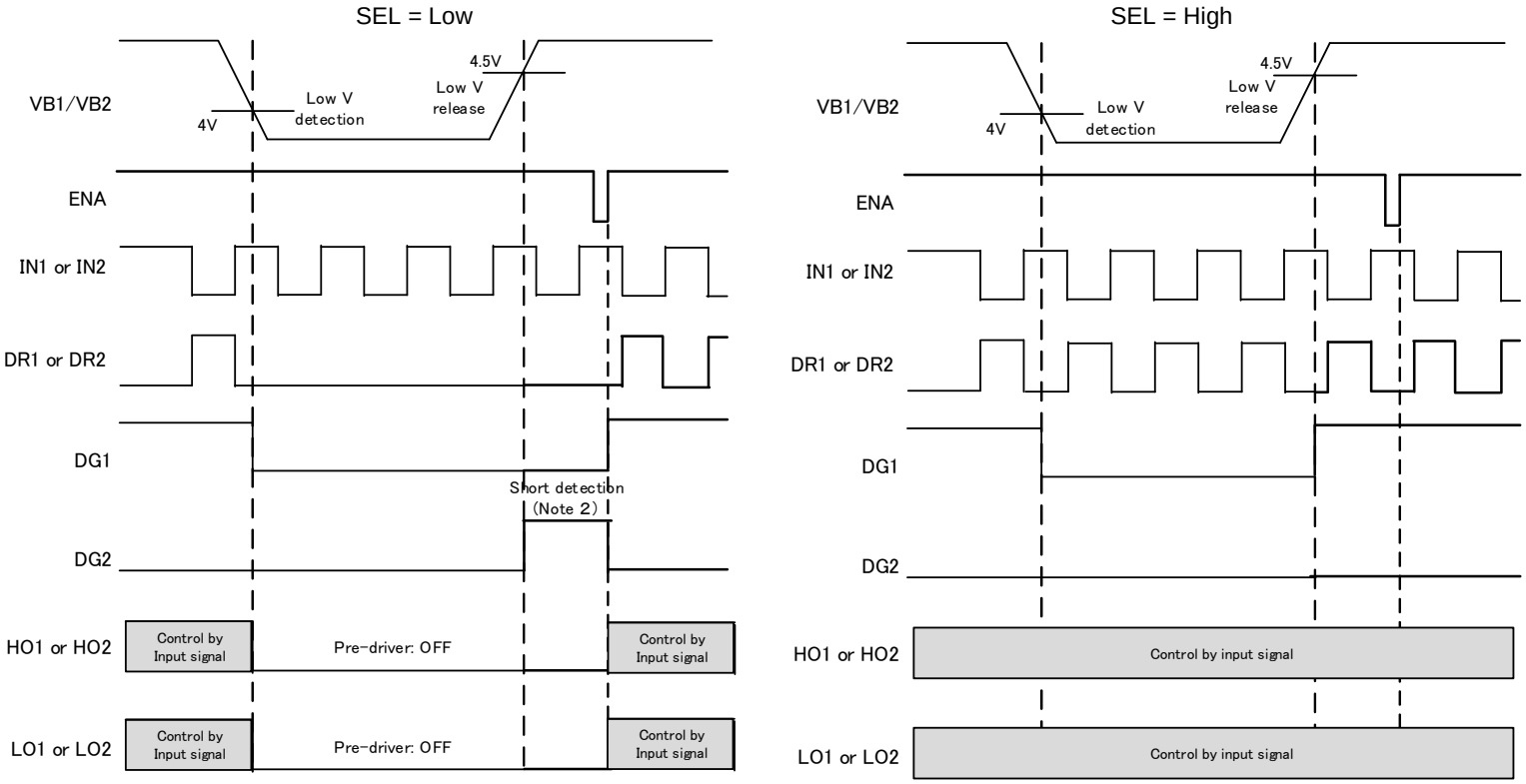
TB9057FG has various abnormality detection functions like low voltage detection, over temperature detection, external MOSFET short detection and motor short detection circuit.
In case of low voltage detection, DG1=Low,DG2=Low.
In case of over temperature detection, DG1=High, DG2=High.
In case of short detection, DG1=Low, DG2=High.
And if it returns to the normal operation, DG1=High, DG2=Low.

PIN"DG1"	PIN"DG2"	Description
H	L	Normal
L	L	VB low voltage or VDD low voltage detection
L	H	MOSFET or motor short detection
H	H	Over temperature detection

Priority of each detection is as follow.
Low voltage detection > over temperature detection > short detection

5.5.1. VB low voltage detection / VDD low voltage detection

5.5.1.1. VB low voltage detection
When VB is dropped to lower than 4.0V, DG1=Low and DG2=Low.
When VB is increased over 4.5V, it re-starts the low voltage detection and restore to the normal operation, as DG1=High and DG2=Low.
Also, in case of the low voltage detection, the pre-driver output could be controlled by the pin SEL.
When pin SEL=Low, HO1,HO2,LO1 and LO2 become Low, regardless of the input conditions.
When pin SEL=High, the pre-driver keeps normal operation.

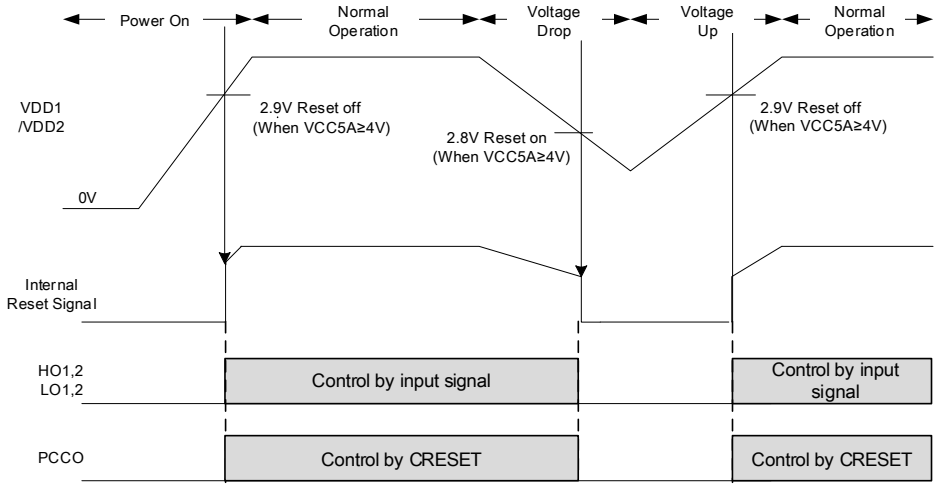


Note 1: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.
Note 2: Only when SEL=Low, it moves to the short detection atfer releasing the VB low voltage detection. (Regardless of the IN input, driver=Low (hold) and DG1/DG2=Low/High (hold))
Therefore in order to re-start the normal operation, please change the ENA signal from Low to High.

5.5.1.2. VDD low voltage detection (internal power-on reset function)

As comparing with the internal band gap voltage, it detects the low voltage by mornitoring the external supply voltage of VDD that is applied to VDD1/VDD2. When VDD is dropped to lower than the reset voltage, charge pump would be stopped and the pre-driver output becomes OFF. When it increases to higher than the release voltage, the internal reset would be released and it becomes normal operation. The reset detection voltage sets up the hysteresis width.

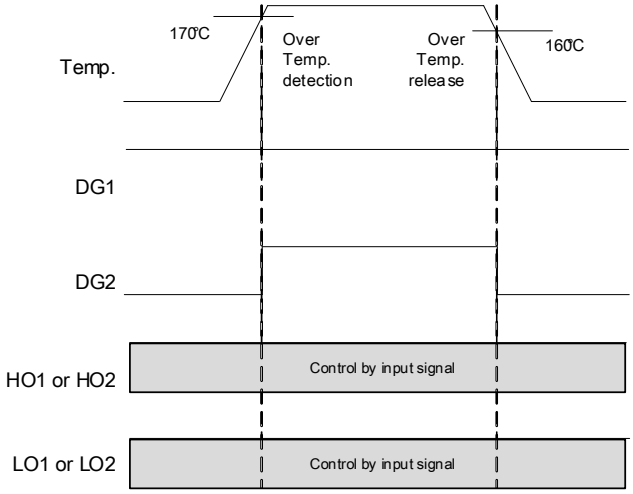
Also, both of internal reset detection signal and release signal have charttering prevention circuit, so that it can be designed with considering to prevent the operation error.



Note 1: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

5.5.2. Over temperature detection

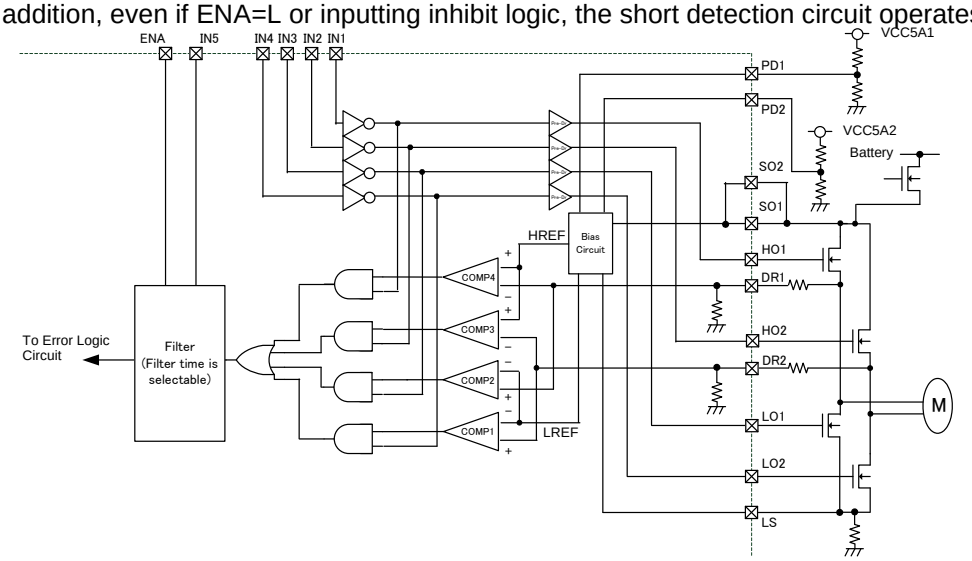
When the chip temperature is over 170°C, pin DG1=High and DG2=High. And when the chip temperature is dropped to lower than 160°C, it releases the over temperature detection and DG1=High, DG2=Low. As considering the functional safety, the over temperature is duplicated.



Note 1 : The guaranteed storage temperature from the absolute maximum rating is 150°C. If the IC is used or preserved under the over temperature, the normal operation is not guarantee, and also it may cause smoking and ignition. Be sure not to exceed the temperature in any case. The IC has the over temperature detection function but it does not intend to limit the IC temperature under 150°C and as it does not guarantee the operation, it regards as an additional function.

5.5.3. Short detection

The short detection of both MOSFET and motor would be implemented by monitoring the voltage between source pin and drain pin of external driver.
If it detects the short, than DG1=Low and DG2=High (latch). When the short detection is released by the ENA signal, it becomes DG1=High and DG2=Low. And then it restores to the normal operation. Also, pre-driver output can be controlled during the short detection by the SEL pin.
When SEL=Low, HO1,HO2,LO1 and LO2 become Low, regardless of the input conditions.
When SEL=High, the pre-driver keeps normal operation.
Short detection circuit has filter time to prevent the wrong detecion caused by the switching noise during driver ON. The filter time could be set by the resistor value connected to IN5.
The short detection voltage can be set by the supplied voltage at PD pin.
In addition, even if ENA=L or inputting inhibit logic, the short detection circuit operates normally.



Note 1 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.
Note 2 : In case 18<SO≤21V, due to the reverse output error of the comparator (COMP3/COMP4) at high-side, the error logic could have the reverse output error, too.

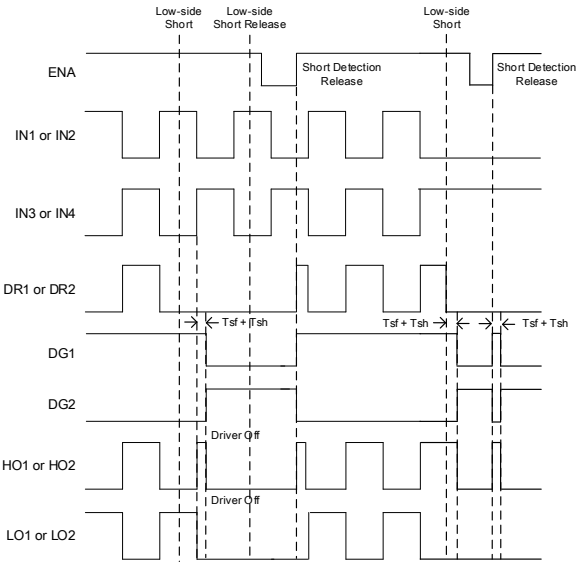
Comparator Input	Comparator output	PWM Input	Abnormal Phenomenon
DR1 > LREF	COMP2 = H	IN3 = L	HO1 external MOSFET Short or Motor Line Short
DR2 > LREF	COMP1 = H	IN4 = L	HO2 external MOSFET Short or Motor Line Short
DR1 < HREF	COMP4 = H	IN1 = L	LO1 external MOSFET Short or Motor Line Short
DR2 < HREF	COMP3 = H	IN2 = L	LO2 external MOSFET Short or Motor Line Short

*HREF = SO voltage - PD1 voltage, LREF = LS voltage + PD2 voltage

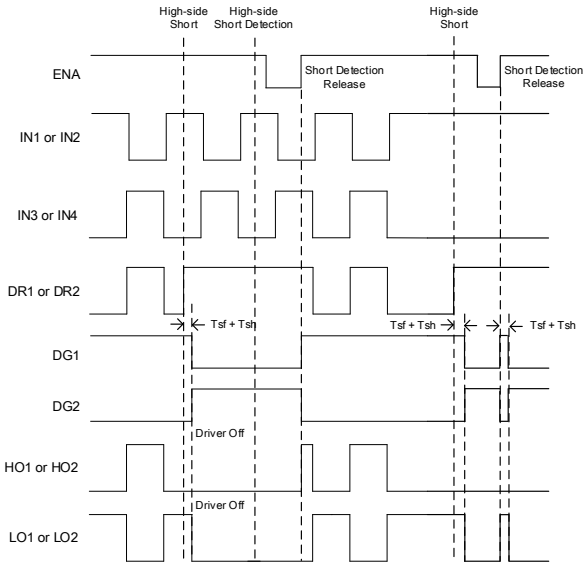
< MOSFET Short Detection >

・SEL = Low

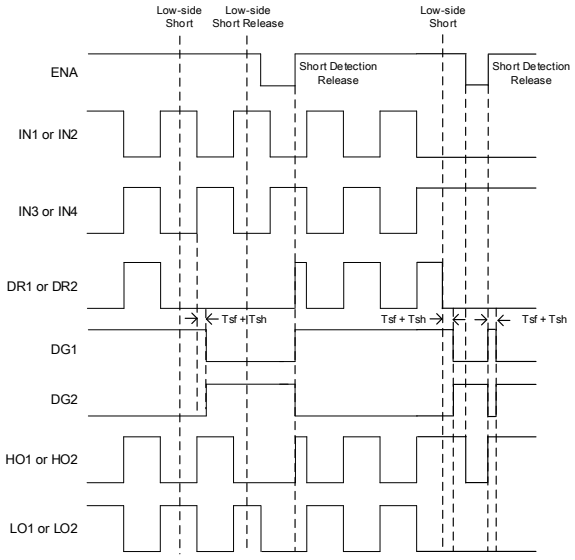
<Low-side MOSFET Short>



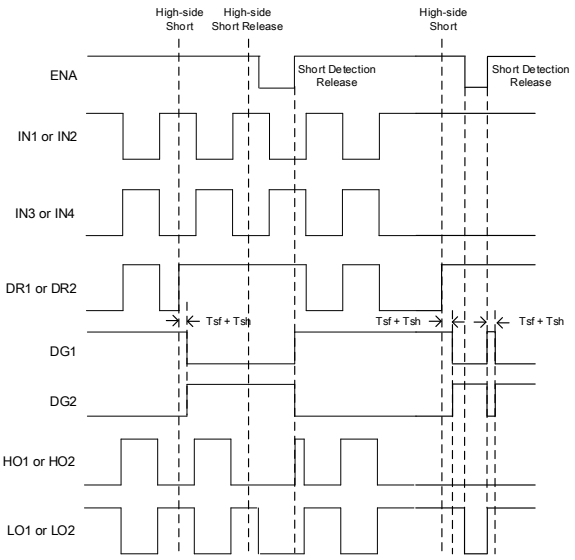
<High-side MOSFET Short>



・SEL = High <Low-side MOSFET Short>

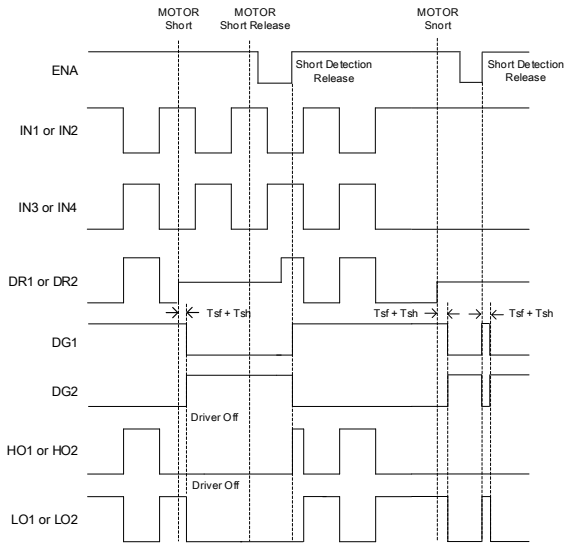


<High-side MOSFET Short>

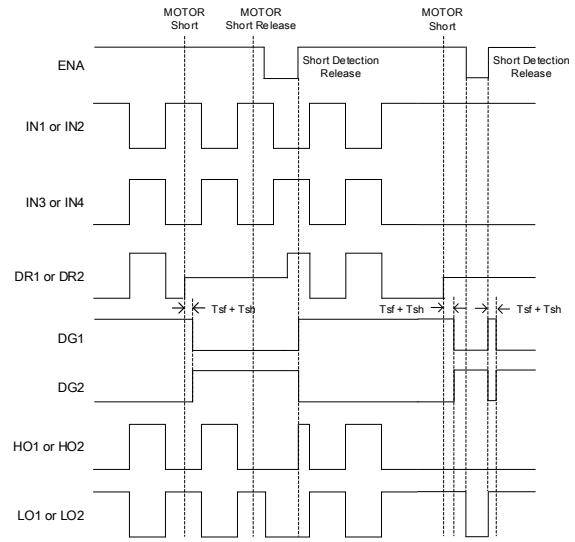


< Motor Short Detection >

SEL = Low



SEL = High



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6. ABSOLUTE MAXIMUM RATING (Ta = -40 to 125°C)

CHARACTERISTIC	SYMBOL	PIN	VALUE	UNIT
Input/Output Voltage	Vin, Vout	VB1, VB2, DR1, DR2, SO1,SO2	-0.3 to 21(DC)	V
			21 to 24(1ms)	
			24 to 40(1s)	
		PCC1, PCCD1, PCC2, PCCD2, PCCO, HO1, HO2, TEST1, TEST2	-0.3 to 40(1s)	V
		LO1, LO2	-0.3 to PCCO (PCCO≤14V)	V
		VCC5A1, VCC5A2, VDD1, VDD2	-0.3 to 6	V
		CS1, CS2,LS, IN5, PD1,PD2, AMPP1, AMPM1, AMPP2, AMPM2	-0.3 to VCC5A+0.3 (max: 6V)	V
		IN1, IN 2, IN 3, IN 4, ENA, SEL, DG1, DG2, CRESET, MR1, MR2	-0.3 to VDD+0.3 (max: 6V)	V
Input Current	Iin	DR1, DR2	-50	mA
Output Current	Iout	HO1, HO2, LO1, LO2, PCCD1, PCCD2	±1(1μs)	A
		CS1, CS2	±10	mA
		PCC1, PCC2, PCCO	±100	mA
		DG1, DG2	±10	mA
		MR1, MR2	±10	mA
Storage Temperature	Tstg	-	-55 to 150	°C
Power dissipation	PD	(In case of JEDEC 4layer board)	0.4(Ta=125°C)	W

Note 1: The absolute maximum ratings of a semiconductor device are a set of specified parameter values, which must not be exceeded during operation, even for an instant. If any of these rating would be exceeded during operation, the device electrical characteristics may be irreparably altered and the reliability and lifetime of the device can no longer be guaranteed. Moreover, these operations with exceeded ratings may cause break down, damage and/or degradation to any other equipment. Applications using the device should be designed such that each maximum rating will never be exceeded in any operating conditions. Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in these documents.
Note 2: About the current, it defines IC_Sink as (+) and IC_Source as (-).

7. STATIC ELECTRICAL CHARACTERISTICS

7.1. Operating Voltage Range (unless otherwise specified, operating range is as below)

CHARACTERISTIC	SYMBOL	PIN	VALUE	UNIT
Supply Voltage	Vin	VB1, VB2, SO1, SO2	5 to 21 *VB≥VCC5A,VDD* VB≥SO-1V	V
		VCC5A1, VCC5A2	4 to 5.5 *VCC5A≥VDD	V
		VDD1, VDD2	3 to 5.5	V
Operating Temperature	Topr	-	-40 to 125	°C

*VB: a voltage applied to VB1/VB2
*VCC5A: a voltage applied to VCC5A1/VCC5A2
*VDD: a voltage applied to VDD1/VDD2

7.2. IC Characteristics

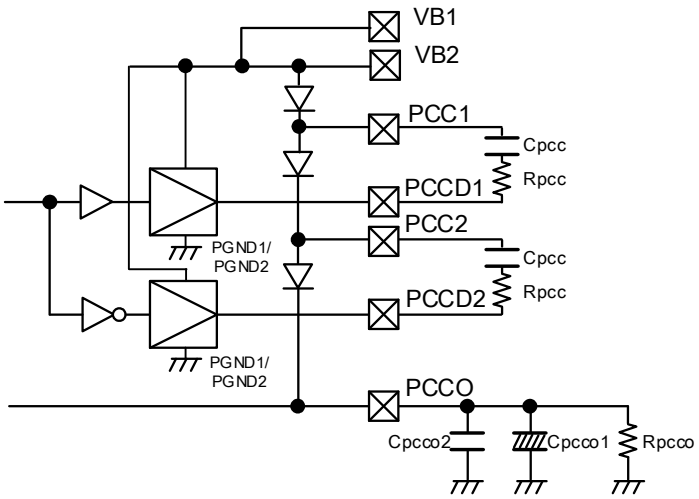
CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
Current Consumption(VB)	Ivb1	VB1, VB2	CRESET=Low	-	1.5	3	mA
	Ivb2	VB1, VB2	CRESET=High HO1,HO2=20kHz Cload=10nF Roh=100Ω	-	50	70	mA
Current Consumption(VCC5A)	Ivcc5a	VCC5A1, VCC5A2	-	-	4	5.5	mA
Output Voltage ”H”	Voh	DG1, DG2	Iload = -1mA	0.8x VDD	-	VDD	V
Output Voltage “L”	Vol		Iload = 1mA	-	-	0.2x VDD	V
Input Current ”L”	Iil	ENA	VDD = 5.0V Vin = 0V	-5	-	5	µA
Input Current ”H”	Iih	ENA	VDD = 5.0V Vin = 5.0V	25	50	100	µA
Input “L” detection Voltage	Vil	IN1, IN2, IN3, IN4, ENA, SEL, CRESET	VDD=3.0 to 5.5V	0	-	0.3× VDD	V
Input “H” detection Voltage	Vih			0.7× VDD	-	VDD	V
Hysteresis	Vh		VDD=4.5 to 5.5V	0.25	0.5	0.7	V
Input Current ”L”	Iil	IN1, IN2, IN3, IN4, SEL	VDD = 5.0V Vin = 0V	-100	-50	-25	µA
Input Current ”H”	Iih	IN1, IN2, IN3, IN4, SEL	VDD = 5.0V Vin = 5.0V	-5	-	5	µA

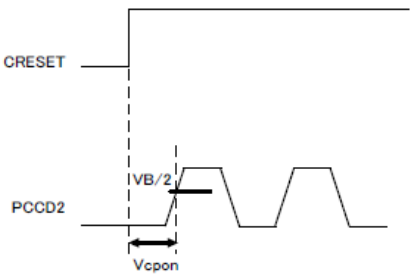
Note 1: About the current, it defines IC_Sink as (+) and IC_Source as (-).

7.3. Charge Pump

CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
Output Voltage	Vcp1	PCCO	VB=6V to 8V Cpcc=0.1μF Rpcc=10Ω Rpcco=2.5kΩ Cpcco1=10μF Cpcco2=1μF	SO+7.5	SO+8.8	SO+13	V
	Vcp2		VB=8V to 21V Cpcc=0.1μF Rpcc=10Ω Rpcco=2.5kΩ Cpcco1=10μF Cpcco2=1μF	SO+10	SO+12	SO +14.0 (Note 2)	V
	Vcp3		VB=5V to 6V Cpcc=0.1μF Rpcc=10Ω Rpcco=2.5kΩ Cpcco1=10μF Cpcco2=1μF	SO+5.8	SO+7.1	SO +10.1	V
	Vcp4		VB=4V to 5V Cpcc=0.1μF Rpcc=10Ω Rpcco=2.5kΩ Cpcco1=10μF Cpcco2=1μF	SO+4.0	-	-	V
Active Clamp Voltage	Vcpclh	PCCO	-	31	36	40	V
	Vcpcll			30.5	35.5	39.5	V

Note 1: About the current, it defines IC_Sink as (+) and IC_Source as (-).
Note 2: When VB=21V, SO=5V in Vcp2, the maximum specification becomes SO+15.4V.
Because the circuit configuration makes PCCO voltage = VB-3VF, in case VB-3VF > (SO+12V)





Note 3: Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

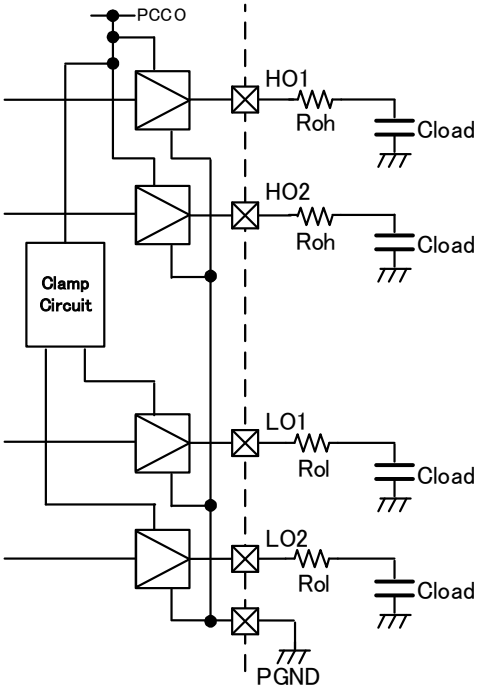
7.4. Pre-Driver

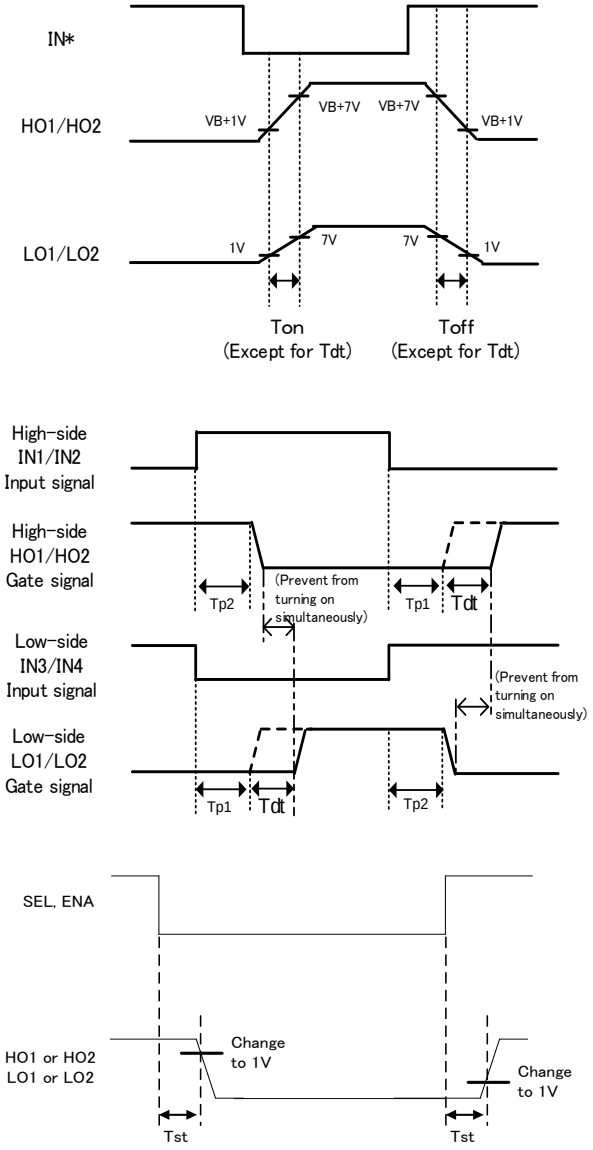
CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
Output Voltage	Voh1	HO1, HO2	Cload=10nF, Roh=100Ω	Vcp-1	-	Vcp*	V
	Vol1			-	-	0.5	V
	Voh2	LO1, LO2	Cload=10nF, Rol=20Ω	7	12	14	V
	Vol2			-	-	0.5	V
Output Resistance	Ronh1	HO1,HO2,	Pre-driver High Side Ron (Calculate the resistance from the voltage difference between in case Iload=10mA and 50mA)	-	4	10	Ω
	Ronh2	LO1, LO2	Pre-driver High Side Ron (Calculate the resistance from the voltage difference between in case Iload=10mA and 50mA)	-	10	20	Ω
	Ronl	HO1,HO2, LO1, LO2	Pre-driver Low Side Ron (Calculate the resistance from the voltage difference between in case Iload=10mA and 50mA)	-	4	10	Ω
Turn on time	Ton1A	HO1, HO2	VB=5 to 6V, Roh=100Ω Rol=20Ω, Cload=10nF, VB+1V→VB+6V	10	-	70	ns
	Ton1		VB=6 to 21V, Roh=100Ω Rol=20Ω, Cload=10nF, VB+1V→VB+7V				
Turn off time	Toff1A		VB=5 to 6V, Roh=100Ω Rol=20Ω, Cload=10nF, VB+6V→VB+1V	1	-	50	ns
	Toff1		VB=6 to 21V, Roh=100Ω Rol=20Ω, Cload=10nF, VB+7V→VB+1V				
Turn on time	Ton2	LO1, LO2	VB=5 to 21V, Roh=100Ω Rol=20Ω, Cload=10nF, 1V→7V	30	-	300	ns
Turn off time	Toff2		VB=5 to 21V, Roh=100Ω Rol=20Ω, Cload=10nF, 7V→1V	1	-	50	ns
Propagation Delay time of Input	Tp1	HO1,HO2, LO1, LO2	The time until driver output changes as much as 1V, in case IN falls. Roh=100Ω, Rol=20Ω Cload=10nF	100	-	500	ns
	Tp2		The time until driver output changes as much as 1V, in case IN raises. Roh=100Ω, Rol=20Ω Cload=10nF	50	-	350	ns
Time tolerant of Input propagation delay time	Tp_diff	HO1,HO2, LO1, LO2	Time difference between HO1 propagation delay (rising edge) and LO1 propagation delay (falling edge) Tp-on(HO1) – Tp-off(LO1)	20	120	220	ns
			Time difference between HO2 propagation delay (rising edge) and LO2 propagation delay (falling edge) Tp-on(HO2) – Tp-off(LO2)	20	120	220	ns
			Time difference between HO1 propagation delay (falling edge) and LO1 propagation delay (rising edge) Tp-off(HO1) – Tp-on(LO1)	20	120	220	ns
			Time difference between HO2 propagation delay (falling edge) and LO2 propagation delay (rising edge) Tp-off(HO2) – Tp-on(LO2)	20	120	220	ns

Dead time	Tdt	HO1, HO2, LO1, LO2	-	0.25	0.5	0.75	μs
Pre-Driver operation start time	Tst	SEL, ENA	The time interval from changing SEL, ENA=Low⇔ High to change 1V of the pre-driver output	50	250	500	ns

*Vcp: Charge pump voltage

Note 1: About the current, it defines IC_Sink as (+) and IC_Source as (-).



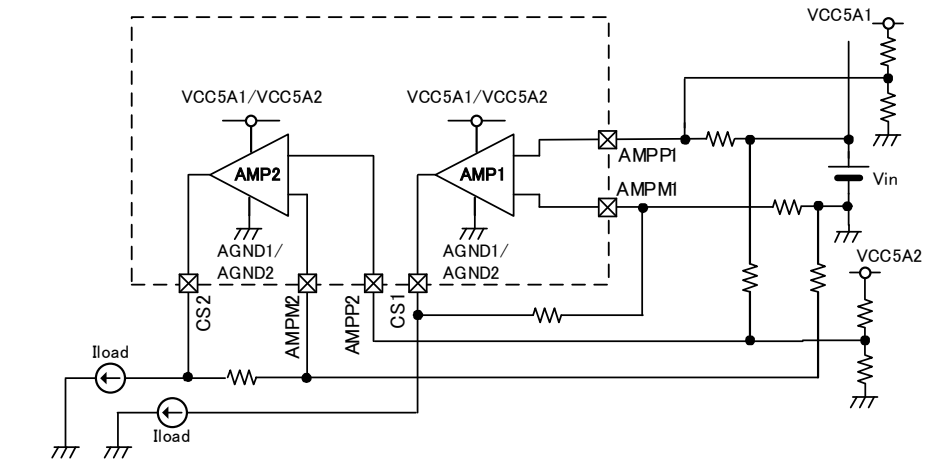


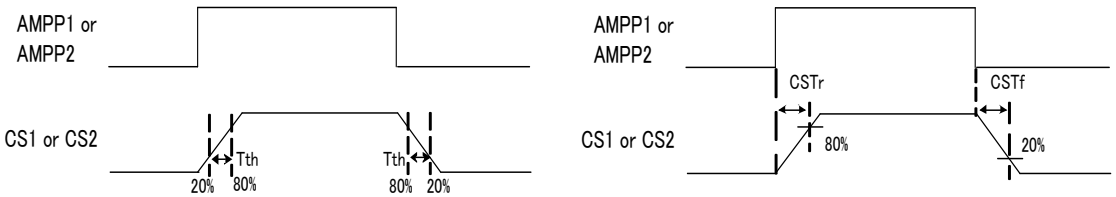
Note 1: Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.
Note 2: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

7.5. Current Detection Circuit

CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
Common mode Input Voltage Range	Vin	AMPM1, AMPP1 AMPM2, AMPP2	Voltage Follower, no-load, Input voltage range which can operate AMP	0.1	-	VCC5A – 0.1	V
Input Bias Current Difference	Iib	AMPM1, AMPP1 AMPM2, AMPP2	Voltage Follower, no-load, Vin=0.1V to VCC5A-0.1V *Current difference between AMPM1 and AMPP1. Current difference between AMPM2 and AMPP2.	-0.3	-	0.3	μA
Input Offset Voltage	Vio1	AMPM1, AMPP1 AMPM2, AMPP2	Voltage Follower, no-load Vin = 0.1V to VCC5A-0.1V	-8	-	8	mV
Slew rate	Tth1	CS1, CS2	Voltage Follower, no-load Vin = 0.3V to VCC5A-0.3V	3	6	10.5	V/μs
Maximum Output Voltage	Voh1	CS1, CS2	Voltage Follower Iload=±500μA	VCC5A -0.1	-	VCC5A	V
Minimum Output Voltage	Vol1	CS1, CS2	Voltage Follower Iload=±500μA	0	-	0.1	V

Note 1: About the current, it defines IC_Sink as (+) and IC_Source as (-).





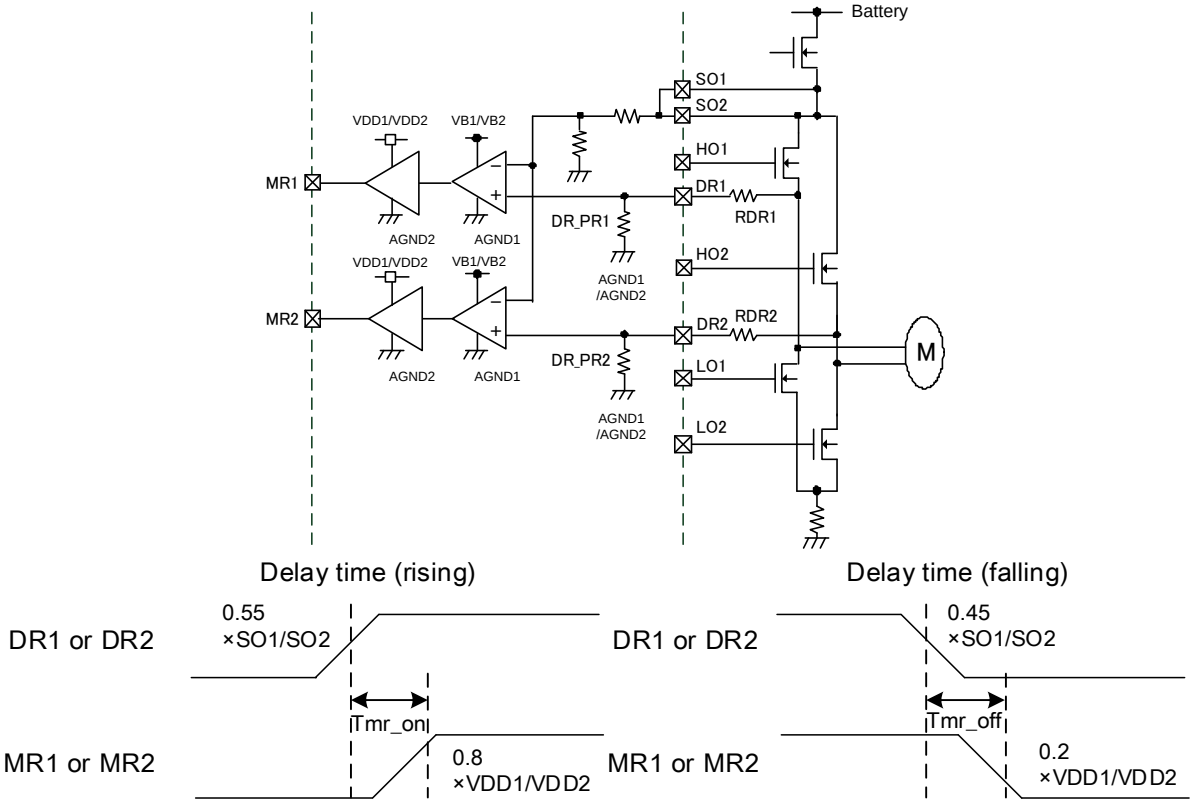
Note 1: Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.
Note 2: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

7.6. Motor Drive Direction Detection Circuit

CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
Input “H” detection Voltage	Vih	DR1, DR2	RDR=1kΩ	0.50x SO	0.55x SO	0.60x SO	V
Input “L” detection Voltage	Vil	DR1, DR2	RDR=1kΩ	0.40x SO	0.45x SO	0.50x SO	V
Hysteresis	Vhys	DR1, DR2	Vhys = Vih-Vil	-	0.1x SO	-	V
Output Voltage “H”	Voh	MR1, MR2	Iload = -1mA	0.8x VDD	-	VDD	V
Output Voltage “L”	Vol	MR1, MR2	Iload = 1mA	-	-	0.2x VDD	V
Detection delay time	Tmr_on	MR1, MR2	DR1,2=0.55xSO ⇒ MR1,2=0.8xVDD Iload = ±1mA RDR=1kΩ	0.1	0.6	2	μs
	Tmr_off	MR1, MR2	DR1,2=0.55xSO ⇒ MR1,2=0.2xVDD Iload = ±1mA RDR=1kΩ	0.1	0.6	2	μs
Common mode Input Voltage Range	Vin	DR1, DR2	Apply -2V by setting RDR1,2=1kΩ	-VF	-	SO	V
Internal Pull-down Resistance	DR_PR	DR1, DR2	-	1.4	2	2.6	MΩ

Note 1: Minimum voltage of Common mode Input Voltage Range is VF voltage of internal protection device.

Note 2: About the current, it defines IC_Sink as (+) and IC_Source as (-).



Note 3: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

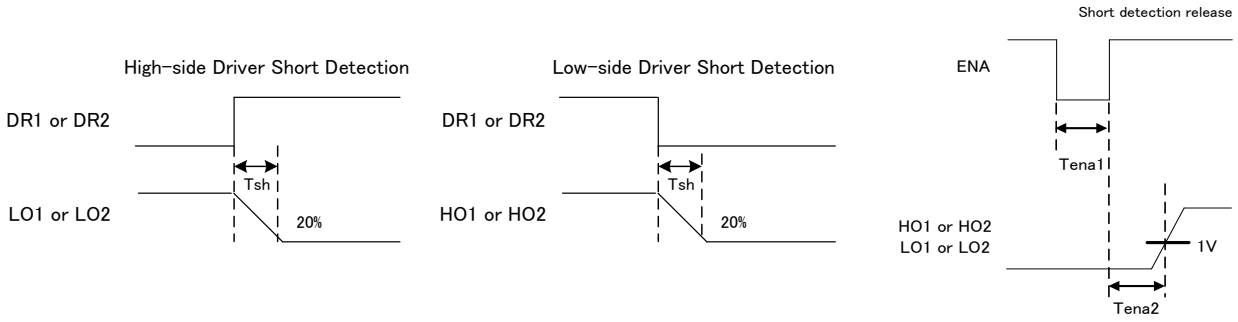
7.7. Abnormality Detection Circuit

CHARACTERISTIC	SYMBOL	PIN	CONDITION	MIN	TYP.	MAX	UNIT
VB low voltage detection	Vcpll	VB	-	3.6	4.0	4.4	V
VB low voltage release	Vcplh			4.1	4.5	4.9	V
Hysteresis voltage of VB low voltage detection	Vcphys	VB	Vcphys = Vcplh - Vcpll	-	0.5	-	V
VDD low voltage detection	Vrstl	VDD	VCC5A ≥ 4V	2.7	2.8	2.9	V
VDD low voltage release	Vrsth		VCC5A ≥ 4V	2.8	2.9	3.0	V
Hysteresis voltage of VDD low voltage detection	Vrsthys	VDD	VCC5A ≥ 4V Vrsthys = Vrsth-Vrstl	-	0.1	-	V
Over Temperature detection	Tsdh	-	-	150	170	190	°C
Over Temperature release	Tsdl	-	-	140	160	180	°C
Hysteresis temperature of over Temperature detection	Tsdhys	-	Tsdhys = Tsdh – Tsdl	-	10		°C
Short detection Filtering time	Tsf	IN5	IN5=300kΩ	2.5	4	5.5	µs
		IN5	IN5=430kΩ	3.75	6	8.25	µs
		IN5	IN5=560kΩ	4.5	7.5	11	µs
PD voltage range	Vpd	PD1,PD2	VB=5 to 18V	0.5	-	2	V
Short detection error	Vsh_diff	PD1,PD2	VB=5 to 18V,PD=0.5 to 2V, RDR=1kΩ	-50	-	50	mV
Short detection delay time	Tsh	HO1, HO2, LO1, LO2	VB=5 to 18V, Time interval from DR rising to Pre-Driver Off (20%) (Cload=10nF, Rload=100Ω) *Filtering time is not included	0.1	0.6	3	µs
	Tsh2	DG1, DG2	VB=5 to 18V, Time interval from DR rising to switching between DR1 and DR2. *Filtering time is not included	0.01	0.6	2	µs
Short detection release ENA Low width time	Tena1	ENA	VB=5 to 18V	10	-	-	µs
Short detection release Pre-Driver operation start time	Tena2	ENA	VB=5 to 18V The time interval from changing ENA=Low→ High to change 1V of the pre-driver output	-	-	1	µs

*Please use the resistance range of IN5 from 300kΩ to 2MΩ

Note 1 : In case 18<SO≤21V, due to the reverse output error of the comparator (COMP3/COMP4) at high-side, the error logic may have the reverse output error, too.

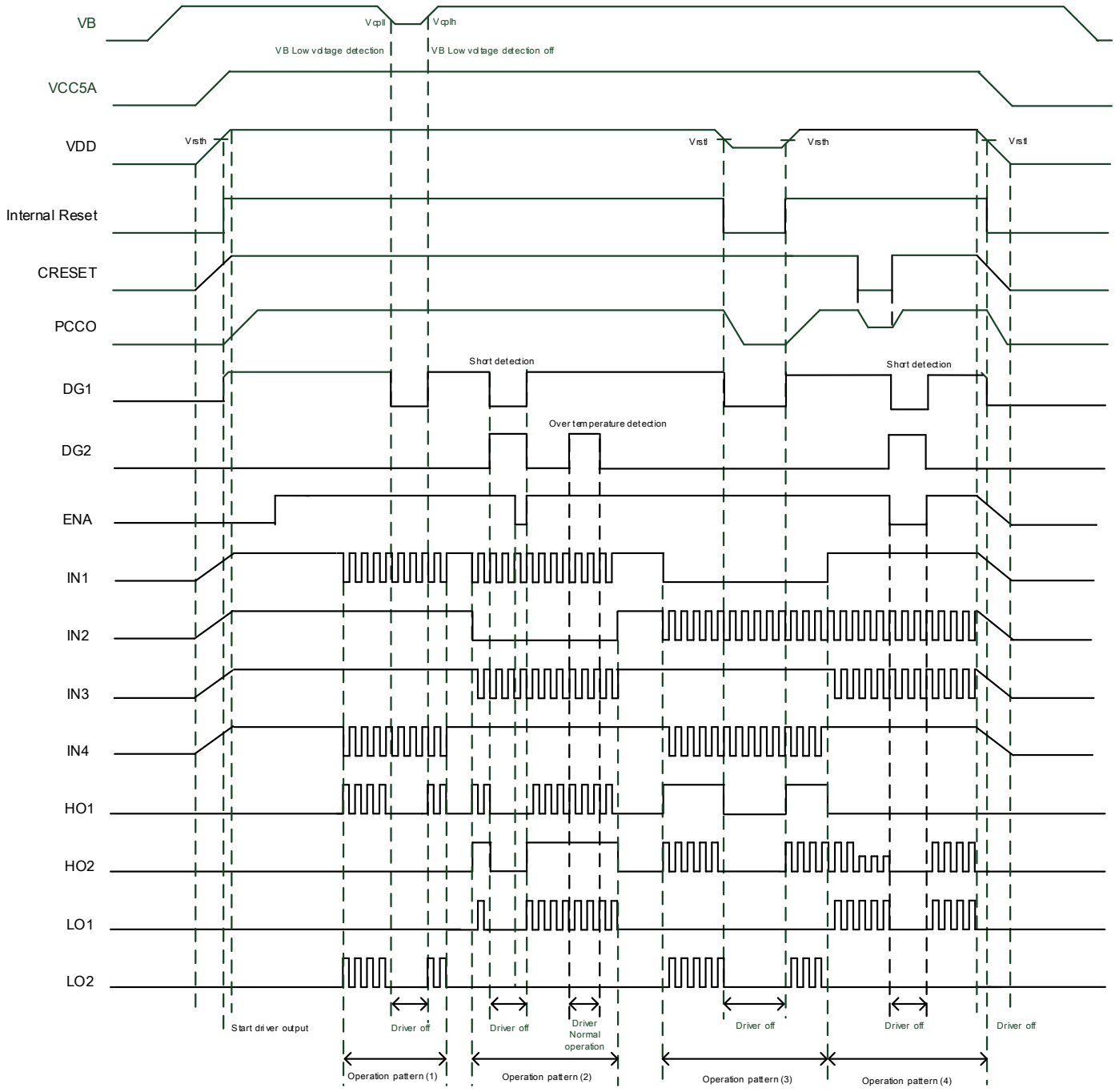
Note 2: About the current, it defines IC_Sink as (+) and IC_Source as (-).



Note 3: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

8. Timing Chart

・SEL = Low (When it detects Short Detection and VB Low voltage detection, Pre-Driver becomes OFF)

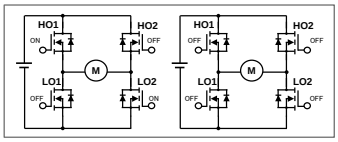


Note 1：Please turn on VCC5A before VDD, in case it uses without short between VCC5A and VDD.

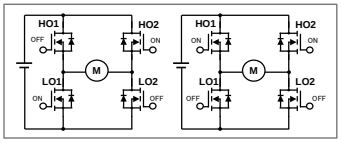
Note 2: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

*Driver operation pattern of above timing chart is as follow.

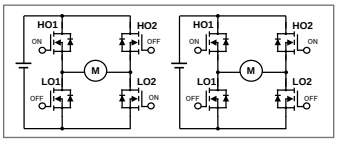
Driver operation pattern (1)



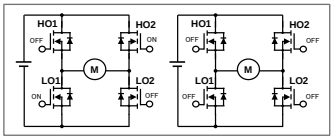
Driver operation pattern (2)



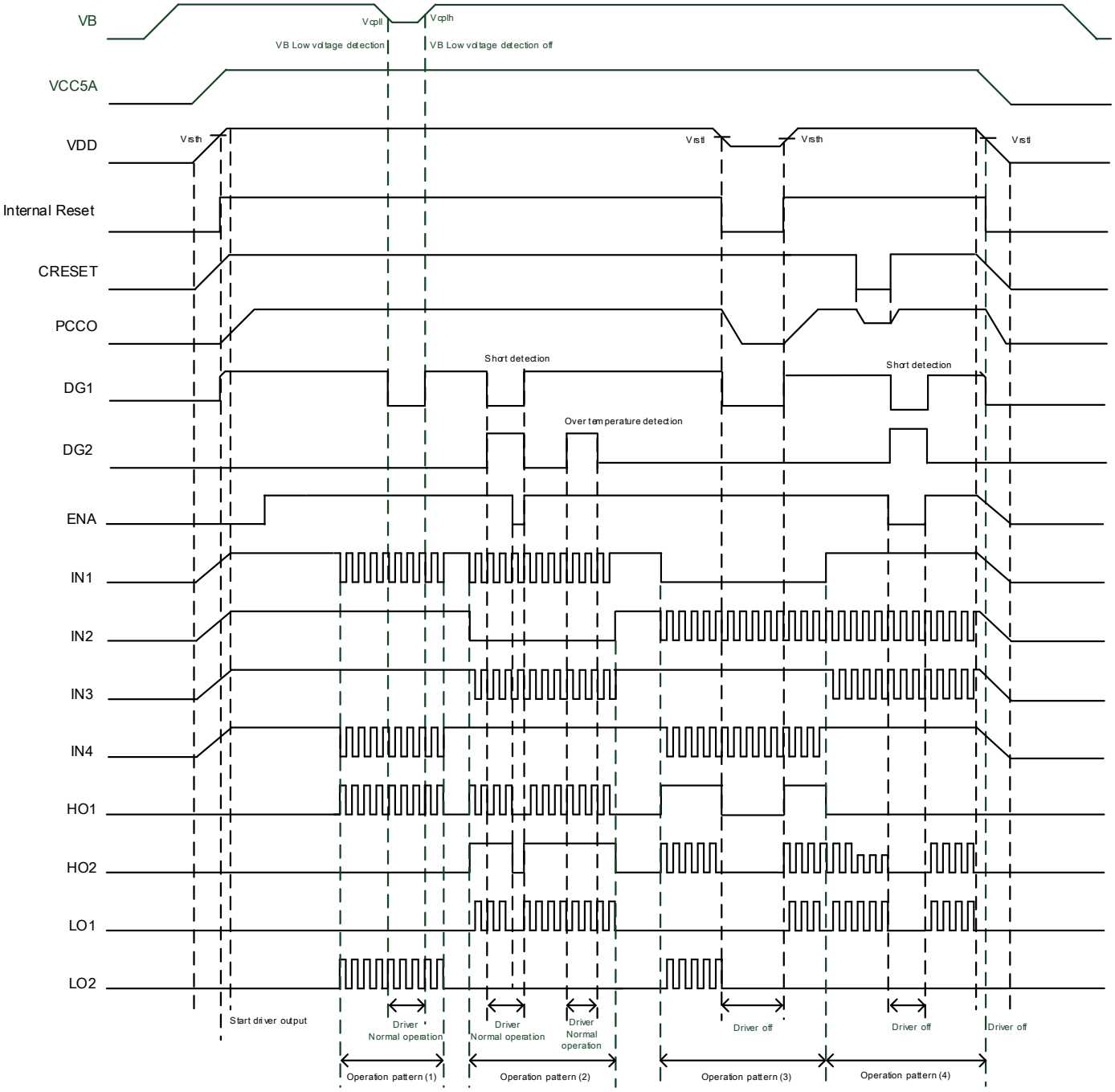
Driver operation pattern (3)



Driver operation pattern (4)



・SEL = High (When it detects Short Detection and VB Low voltage detection, Pre-Driver operates normally.)

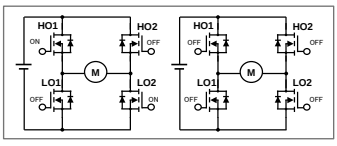


Note 1：Please turn on VCC5A before VDD, in case it uses without short between VCC5A and VDD.

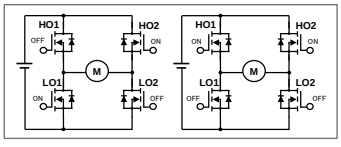
Note 2: The timing charts is to describe the function and operation of IC. Therefore it is different from the actual wave form of the IC.

*Driver operation pattern of above timing chart is as follow.

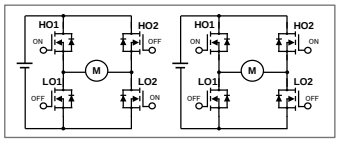
Driver operation pattern (1)



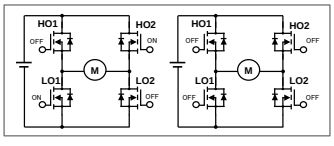
Driver operation pattern (2)



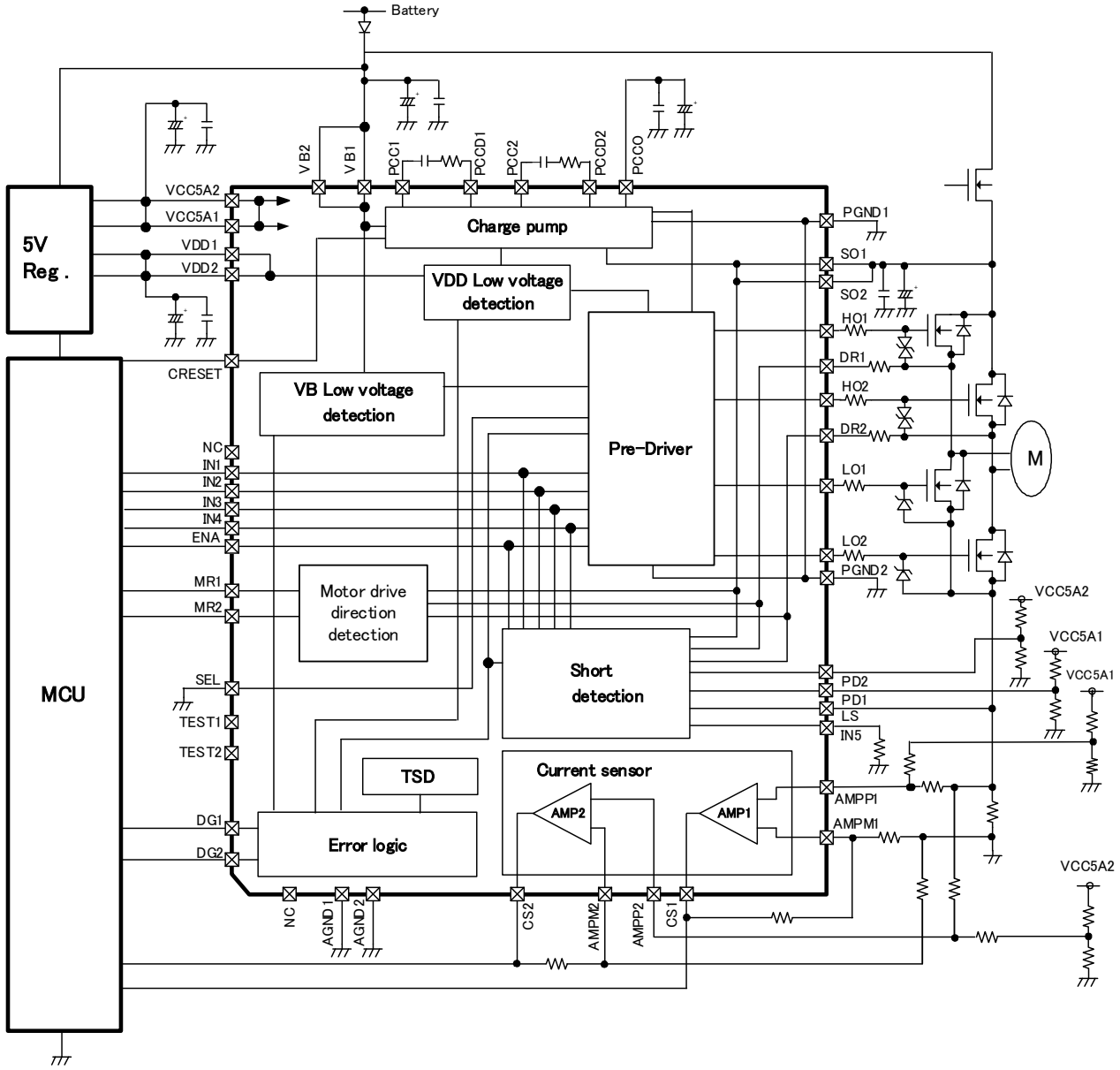
Driver operation pattern (3)



Driver operation pattern (4)



9. Reference Circuit Diagram

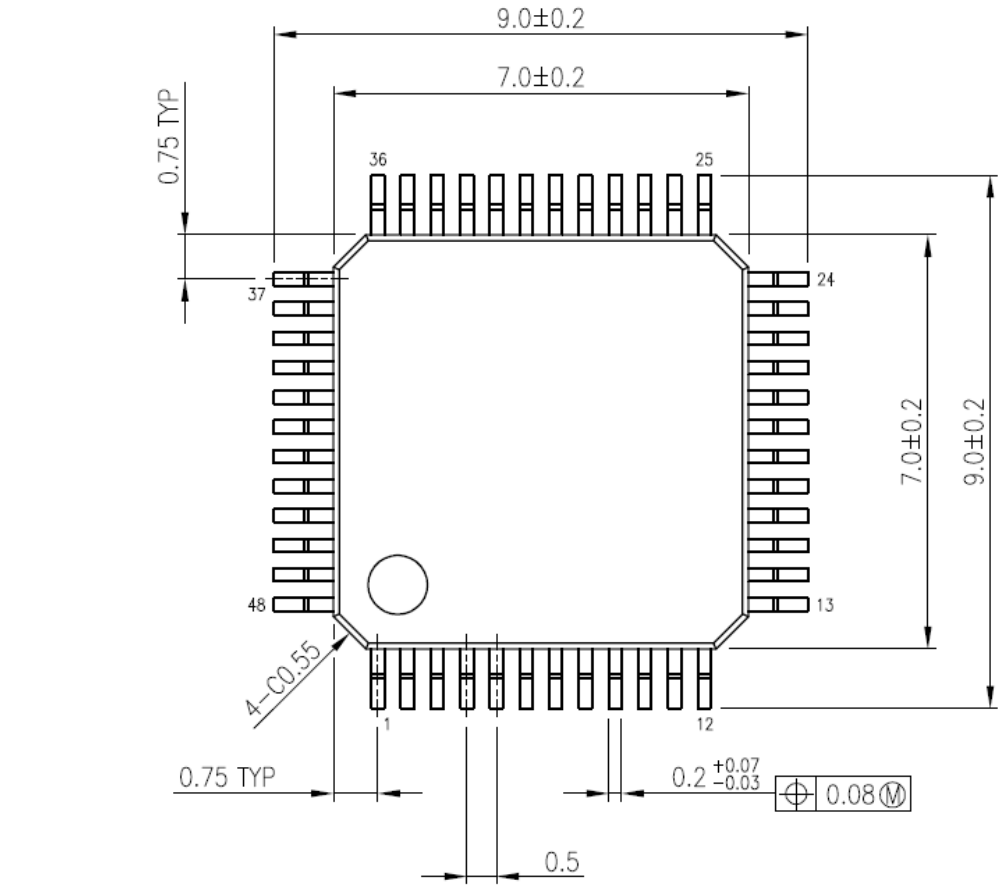


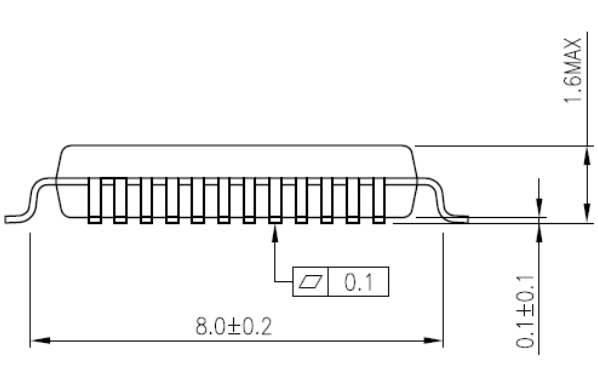
Note 1：Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.
Note 2：The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purpose.
Note 3：Timing charts may be simplified for explanatory purpose.
Note 4：Install the product correctly. Otherwise, it may result in break down, damage and/or deterioration to the product or equipment.
Note 5：The application circuits shown in this document are provided for reference purposes only. Especially, a thorough evaluation is required on the phase of mass production design. Providing these application circuit examples does not grant any license for industrial property rights.

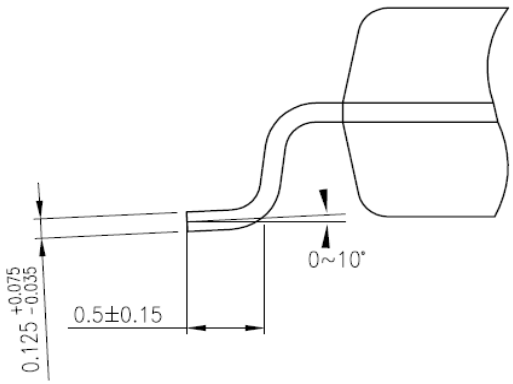
10. PACKAGE

LQFP48-P-0707-0.50C

Unit: mm







Weight: 0.186g (typ.)

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