

TOSHIBA Bi-CMOS Integrated Circuit Silicon Monolithic

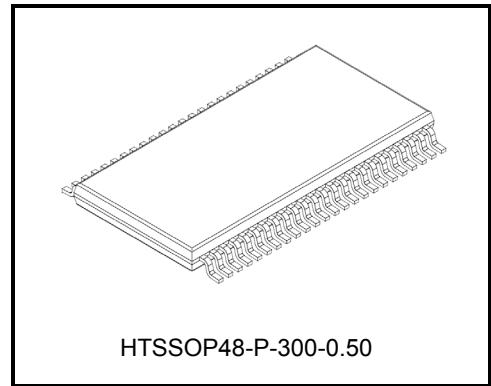
TB9052FNG

Automotive GATE-driver for DC brushed motor driver

TB9052FNG is Pre-Driver IC for DC Brushed Motor. Motor Speed is controlled by Input PWM signal Duty. Sequence control Logic, Charge Pump, Motor Current Detection circuit and Oscillator is built in. And also, TB9052FNG has Miscellaneous Abnormal Detection circuit which can be set up with external elements.

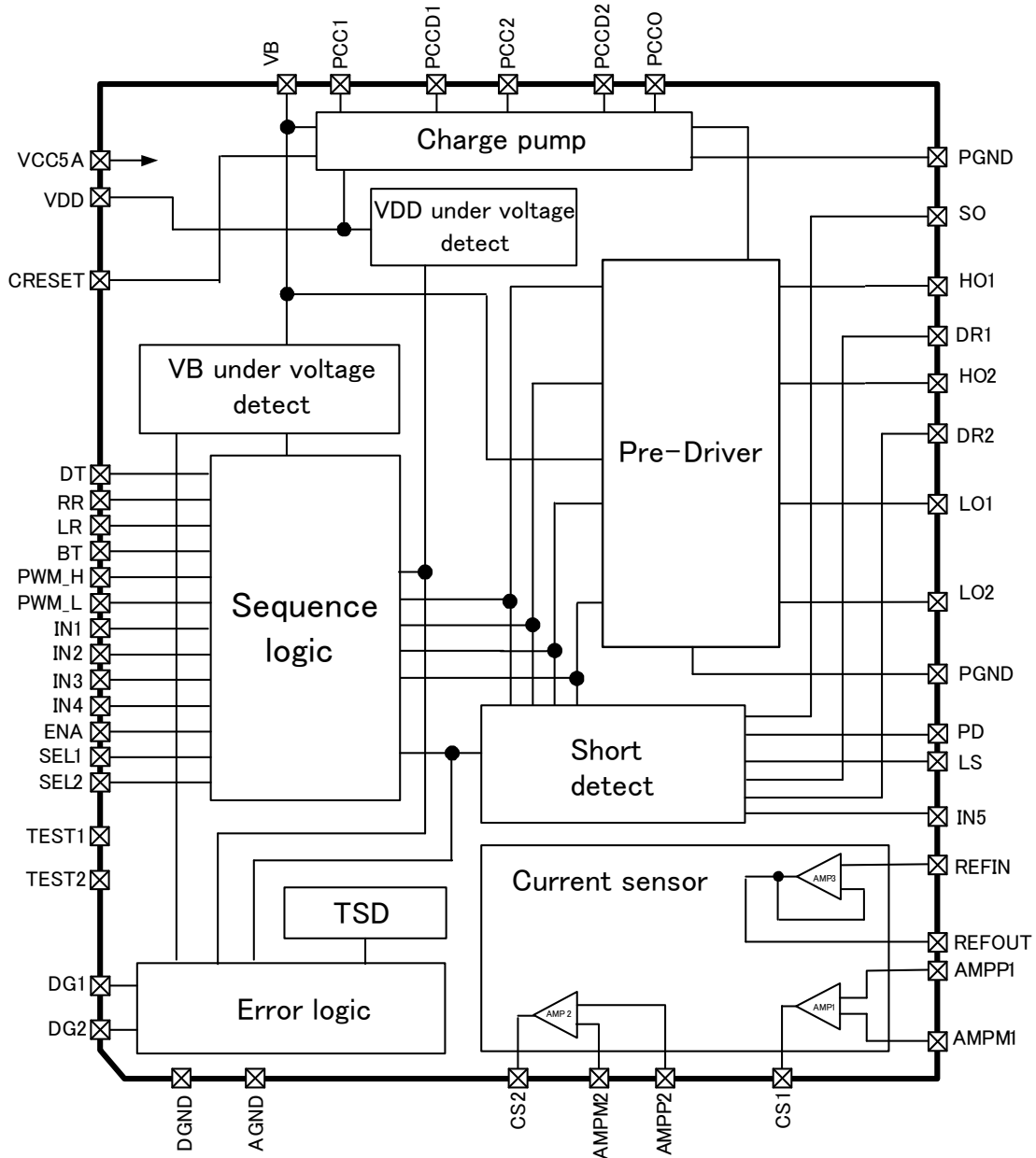
Features

- Motor Speed control by Input PWM signal Duty
- Build-in Charge Pump
- High response Current Detection circuit
Miscellaneous Abnormal Detection circuit (Over Temp / Low Voltage / Short Detection))
- Operating Voltage : 6 to 18V
- Operating Temperature : -40 to 125°C
- Package : HTSSOP-48pin (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



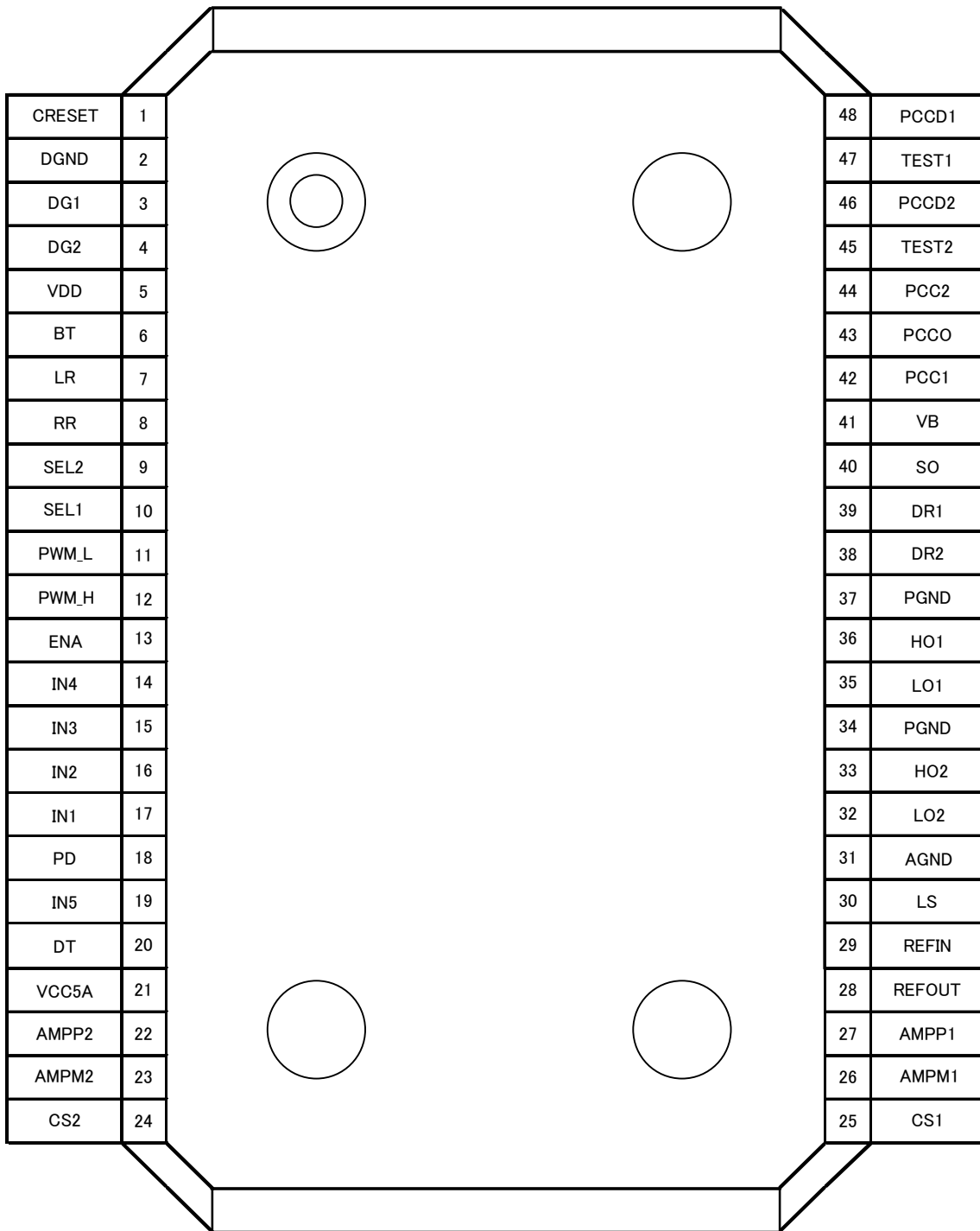
Weight: 0.24g(typ.)

INTERNAL BLOCK DIAGRAM



- * 1 : Some of the functional blocks,circuit,or constants in the block diagram may be omitted or simplified for explanatory purpose.
- * 2 : Install the product correctly. Otherwise, it may result in break down, damage and/or deterioration to the product or equipment.

PACKAGE PIN LAYOUT (Top View)



PIN DESCRIPTION

| PIN No. | Symbol | Definition | IN/OUT | Notes |
|---------|--------|-----------------------------------------------|--------|-----------------|
| 1 | CRESET | Charge pump reset signal | I | Pull-down |
| 2 | DGND | Digital GND | - | - |
| 3 | DG1 | Abnormal Detection Information Output 1 | O | - |
| 4 | DG2 | Abnormal Detection Information Output 2 | O | - |
| 5 | VDD | Power Supply for Logic | - | - |
| 6 | BT | Sequence Logic control signal | I | Pull-down |
| 7 | LR | Sequence Logic control signal. Left Rotation | I | Pull-up |
| 8 | RR | Sequence Logic control signal. Right Rotation | I | Pull-up |
| 9 | SEL2 | Pre-Driver Select Signal2 | I | Pull-down |
| 10 | SEL1 | Pre-Driver Select Signal1 | I | Pull-down |
| 11 | PWM_L | Low-side PWM Input | I | Pull-up |
| 12 | PWM_H | High-side PWM Input | I | Pull-up |
| 13 | ENA | Pre-Driver Enable Signal | I | Pull-down |
| 14 | IN4 | Pre-Driver Direct Control 4 | I | Pull-down |
| 15 | IN3 | Pre-Driver Direct Control 3 | I | Pull-down |
| 16 | IN2 | Pre-Driver Direct Control 2 | I | Pull-down |
| 17 | IN1 | Pre-Driver Direct Control 1 | I | Pull-down |
| 18 | PD | Short Detection Ref. | I | - |
| 19 | IN5 | Setting Filtering time for Short Detection | I | - |
| 20 | DT | Dead time setting | I | - |
| 21 | VCC5A | Power Supply for Analog | - | - |
| 22 | AMPP2 | 2nd AMP. + Input for Current Sensor | I | - |
| 23 | AMPM2 | 2nd AMP. - Input for Current Sensor | I | - |
| 24 | CS2 | 2nd AMP. Output for Current Sensor | O | - |
| 25 | CS1 | 1st AMP. Output for Current Sensor | O | - |
| 26 | AMPM1 | 1st AMP. - Input for Current Sensor | I | - |
| 27 | AMPP1 | 1st AMP. + Input for Current Sensor | I | - |
| 28 | REFOUT | Ref. Voltage Output for Current Sensor | O | - |
| 29 | REFIN | Ref. Voltage Input for Current Sensor | I | - |
| 30 | LS | Pre-Driver Low-side Source Input | I | - |
| 31 | AGND | Analog GND | - | - |
| 32 | LO2 | Pre-Driver Output LO2 | O | - |
| 33 | HO2 | Pre-Driver Output HO2 | O | - |
| 34 | PGND | Power GND | - | - |
| 35 | LO1 | Pre-Driver Output LO1 | O | - |
| 36 | HO1 | Pre-Driver Output HO1 | O | - |
| 37 | PGND | Power GND | I | - |
| 38 | DR2 | Motor Connect PIN 2 | I | - |
| 39 | DR1 | Motor Connect PIN 1 | I | - |
| 40 | SO | Pre-Driver High-side Drain Input | I | - |
| 41 | VB | Power Supply(Battery 12V) | - | - |
| 42 | PCC1 | 1st Charge Pump Output | O | - |
| 43 | PCCO | Final Charge Pump Output | O | - |
| 44 | PCC2 | 2nd Charge Pump Output | O | - |
| 45 | TEST2 | TEST PIN | I | Please use OPEN |
| 46 | PCCD2 | 2ndCharge Pump Drive Output | O | - |
| 47 | TEST1 | TEST PIN | I | Please use OPEN |
| 48 | PCCD1 | 1st Charge Pump Drive Output | O | - |

* 1 : Install the product correctly. Otherwise, it may result in break down, damage and/or deterioration to the product or equipment.

FUNCTIONAL DESCRIPTIONS

TB9052FNG is Pre-Driver IC for DC Brushed Motor. Pre-Driver is controlled by PWM signals which are inputted from PIN "PWM_H and PWM_L ". And the PWN signals are outputted from the PIN "HO1, HO2, LO1, LO2" to control the motor. The control mode is selectable either a sequence control or a direct control by PIN "SEL1".

TB9052FNG has Charge pump for Pre-Driver and it can control external Nch MOSFET directly.

TB9052FNG has Motor Current Detection circuit which can detect motor current from PIN"CS1, CS2".

(1) Charge Pump

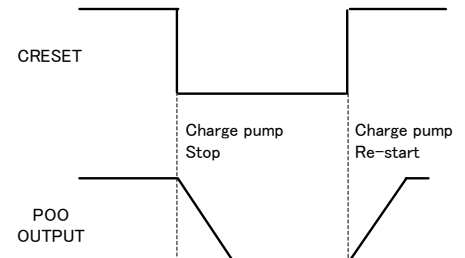
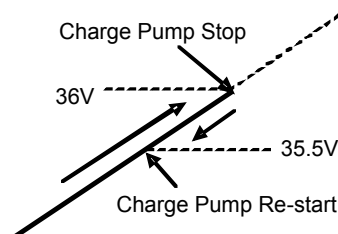
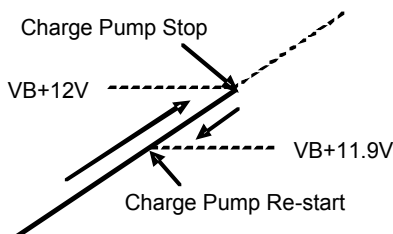
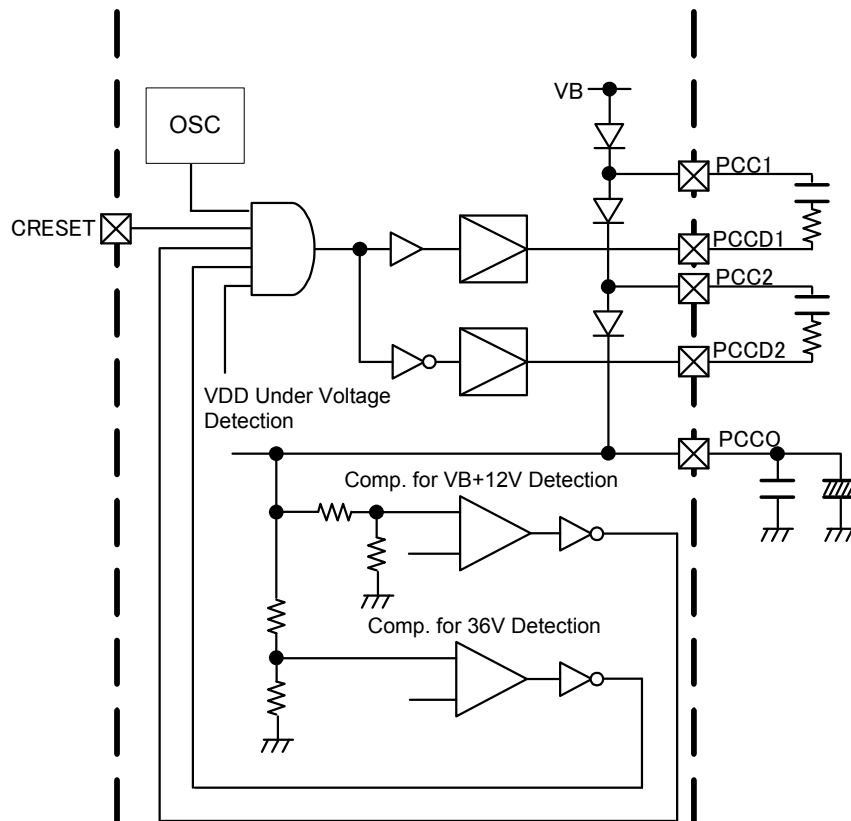
TB9052FNG has Charge pump for Pre-Driver and it can control external Nch MOSFET directly. Also Charge Pump Output Voltage Detection circuit is built-in. When Output voltage of Charge Pump (PCCO) is over V_B+12V or $36V$ (typ.), Charge Pump is stopped.

When this voltage is dropped to $V_B+11.9V$ or $35.5V$, Charge Pump re-start the operation.

And Charge Pump Operation can be stopped by using external PIN "CRESET".

- CRESET is "High": Normal operation.
- CRESET is "Low": Charge Pump operation is stopped.

When charge pump is stopped, PCCO voltage become " V_B-3VF ".



* 1 : Charge Pump is clamped by $36V$ (typ.). But when V_B is over $40V$, even Charge Pump is stopped the operation, the voltage of PCCO is over $40V$. V_B need to keep max. $40V$.

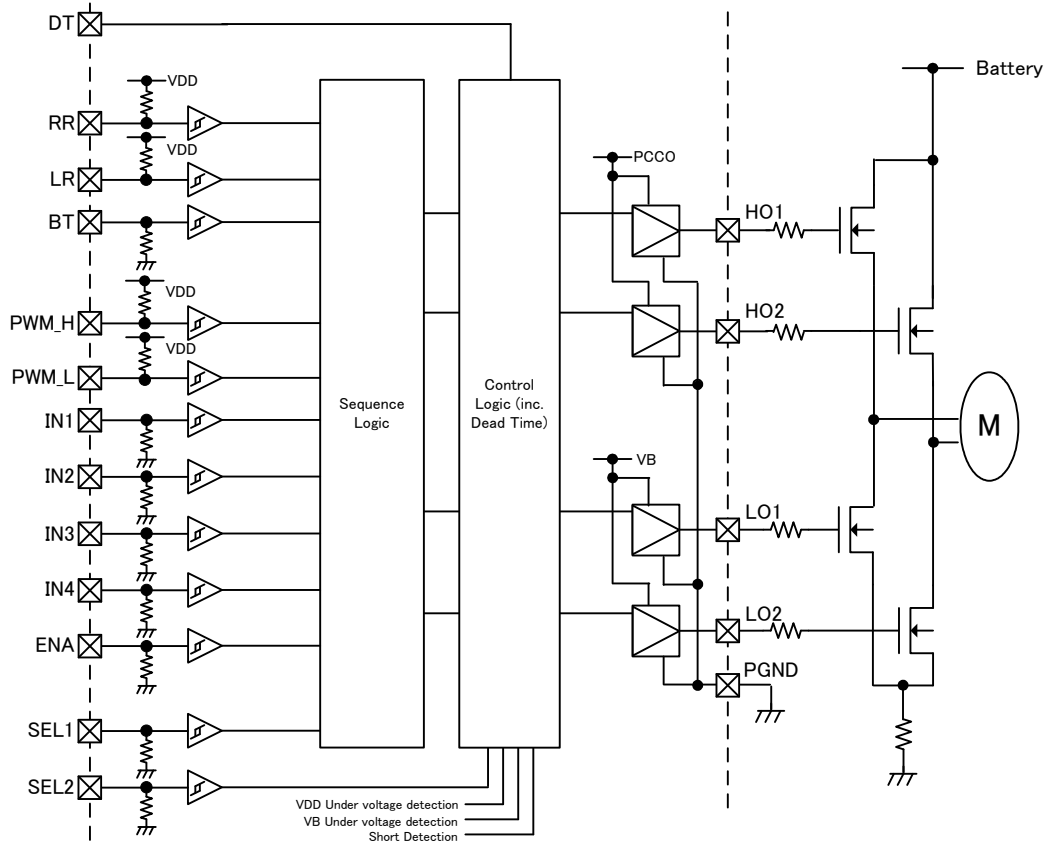
* 2 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

2) Pre-Driver Circuit / Sequence Logic Circuit

The Outputs of Pre-Driver (HO1,HO2,LO1,LO2) are controlled by external MCU through built-in Motor Sequence Control Logic Circuit. PIN"PWM_H" is PWM signal for High-side Pre-Driver and PIN"PWM_L" is for Low-side Pre-Driver.

Pre-Driver operation is selectable either sequence control or direct control by using PIN"SEL1".

- SEL1 = "Low" is Sequence Control.
- SEL1 = "High" is Direct Control.



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

- SEL1 = Low (Sequence Control)

Truth Table

| Input Signal | | | | | | Output Signal | | | |
|--------------|-------|----|----|----|-----|---------------|-----|-----|-----|
| PWM_H | PWM_L | RR | LR | BT | ENA | HO1 | HO2 | LO1 | LO2 |
| L | L | L | H | * | H | H | L | L | H |
| H | L | L | H | L | H | L | L | L | H |
| H | L | L | H | H | H | L | L | H | H |
| L | L | H | L | * | H | L | H | H | L |
| H | L | H | L | L | H | L | L | H | L |
| H | L | H | L | H | H | L | L | H | H |
| L | H | L | H | L | H | H | L | L | L |
| L | H | L | H | H | H | H | H | L | L |
| L | H | H | L | L | H | L | H | L | L |
| L | H | H | L | H | H | H | H | L | L |
| H | H | * | * | * | * | L | L | L | L |
| * | * | H | H | * | * | L | L | L | L |
| * | * | L | L | * | * | L | L | L | L |
| * | * | * | * | * | L | L | L | L | L |

* : Don't care.

• SEL1 = High (Direct Control)

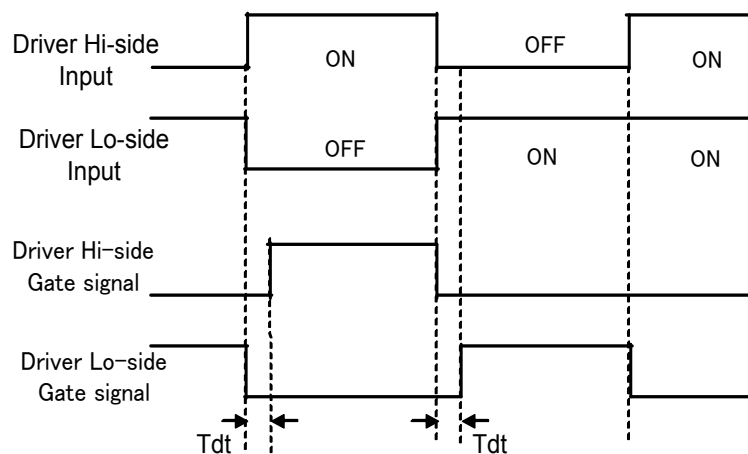
Truth Table

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

* : Don't care.

* DEAD TIME Operation

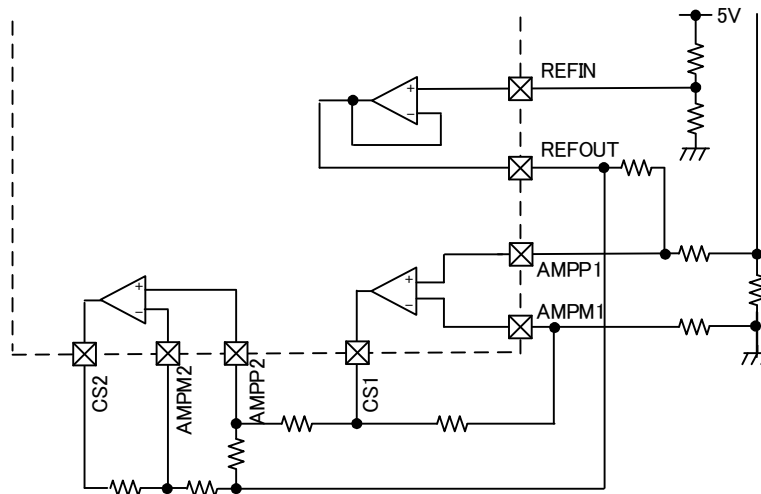
TB9052FNG automatically generates DEAD TIME(T_{dt}) to protect the short circuit of Hi-side/Lo-side on the same Half-Bridge as the follows. DEAD TIME can be set by external resistor which is connected to PIN"DT".



* 1 : Timing charts may be simplified for explanatory purpose.

(3) Motor Current Sensor Circuit

TB9052FNG has Motor Current Sensor Circuit which consists of Differential Amplifier and Offset Generation circuit. Motor Current sensing is done by external Shunt Resistor. Gains of Differential Amplifiers are set by external Resistor as shown below.



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

(4) Miscellaneous Abnormal Detection Circuit

TB9052FNG has Miscellaneous Abnormal Detection Circuits i.e. Low Voltage Detection of VB and VDD, Over Temperature Detection, external MOSFET Short Detection and Motor Line Short Detection.

In case of under voltage detection, DG1=Low, DG2=Low.

In case of under over temperature detection, DG1=High, DG2=High.

In case of short detection, DG1=Low, DG2=High.

And if return to normal operation, DG1=High, DG2=Low.

| PIN"DG1" | PIN"DG2" | Abnormal Phenomenon |
|----------|----------|---------------------------------------------|
| H | L | Normal (No Abnormal Detection) |
| L | L | VB Low Voltage or VDD Low Voltage Detection |
| L | H | Short Detection |
| H | H | Over Temp. Detection |

Priority of each detection is as follow.

- * When both Short Detection and Over Temp. Detection are occur, DG1=High, DG2=High.
- * When both Short Detection and Low Voltage Detection are occur, DG1=Low, DG2=Low.
- * When both Low Voltage Detection and Over Temp. Detection are occur, DG1= Low, DG2= Low.

(4-1) VB Low Voltage Detection / VDD Low Voltage Detection

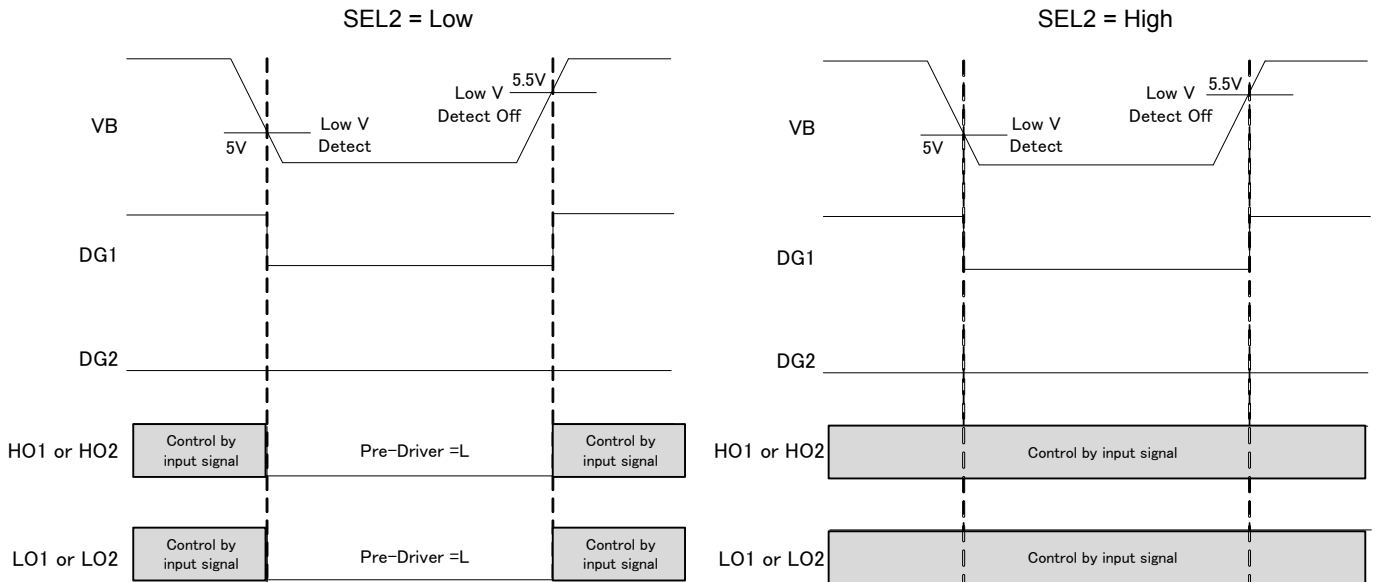
(4-1-1) VB Low Voltage Detection

When VB is dropped to lower than 5V(typ.), PIN"DG1" and "DG2" are changed to "L" by low voltage detection.

When VB is increased over 5.5V, these Diagnosis Information signal change to PIN"DG1"="H", "DG2"="L". The Output of Pre-driver at the abnormal detection can be selectable by PIN"SEL2".

When PIN"SEL2"="L", all of Pre-driver are changed to "L" at the abnormal detection.

When PIN"SEL2"="H", all of Pre-driver Output keeps normal operation even at abnormal detection.

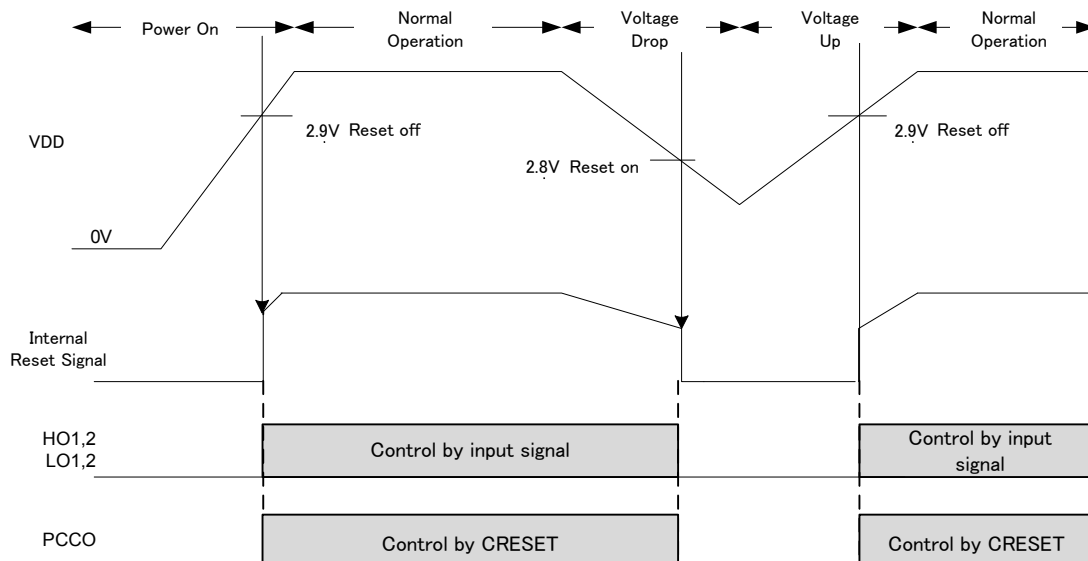


* 1 : Timing charts may be simplified for explanatory purpose.

(4-1-2)VDD Low Voltage Detection

TB9052FNG monitors the voltage of Logic Power Supply(VDD) and detects Low Voltage by internal Band Gap circuit. When VDD is dropped to 2.8V(typ.),TB9052FNG reset internal Logic circuit and Pre-Driver Output(PIN"HO1","HO2","LO1","LO2") are changed to "L" and Charge pump operation is stopped. When VDD increase to be over 2.9V(typ), internal reset is off and return to normal operation. There is hysteresis in both detection voltage and release voltage.

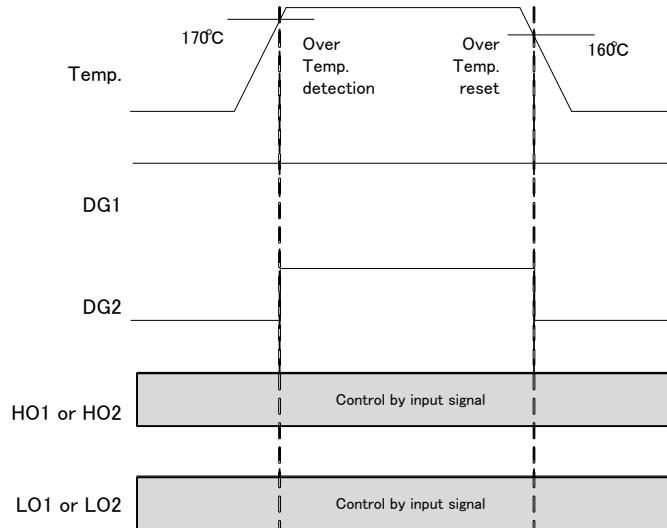
This internal Reset signal has the protection circuit for Chataring to prevent miss-reset.



* 1 : Timing charts may be simplified for explanatory purpose.

(4-2) Over Temperature Detection

TB9052FNG has CHIP Temperature Detection circuit. When CHIP Temperature is over 170°C, Diagnosis signals change to PIN"DG1"="H", "DG2"="H". But, Pre-Driver Output keeps normal operation signal. When CHIP Temperature is dropped to lower than 160°C, Diagnosis signals return to PIN"DG1"="H", "DG2"="L".



- * 1 : The absolute maximum rating of Storage Temperature of TB9052FNG is 150°C. This Over Temperature Detection function does not intend to limit the CHIP temperature. Thus, TB9052FNG should never exceed absolute maximum rating of Storage Temperature. If it 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 this documents.

This Over Temperature Detection is worded over the Max. Rating Temperature and shipping test does not perform at the Max. Rating Temp.

(4-3) Short Detection

TB9052FNG has MOSFET Short Detection and MOTOR Short detection by monitoring voltage of Source PIN and Drain PIN of external Driver.

If Short is detected, Diagnosis signals change to PIN"DG1"="L", "DG2"="H".

And when Short detection is released, Diagnosis signals return to PIN"DG1"="H", "DG2"="L".

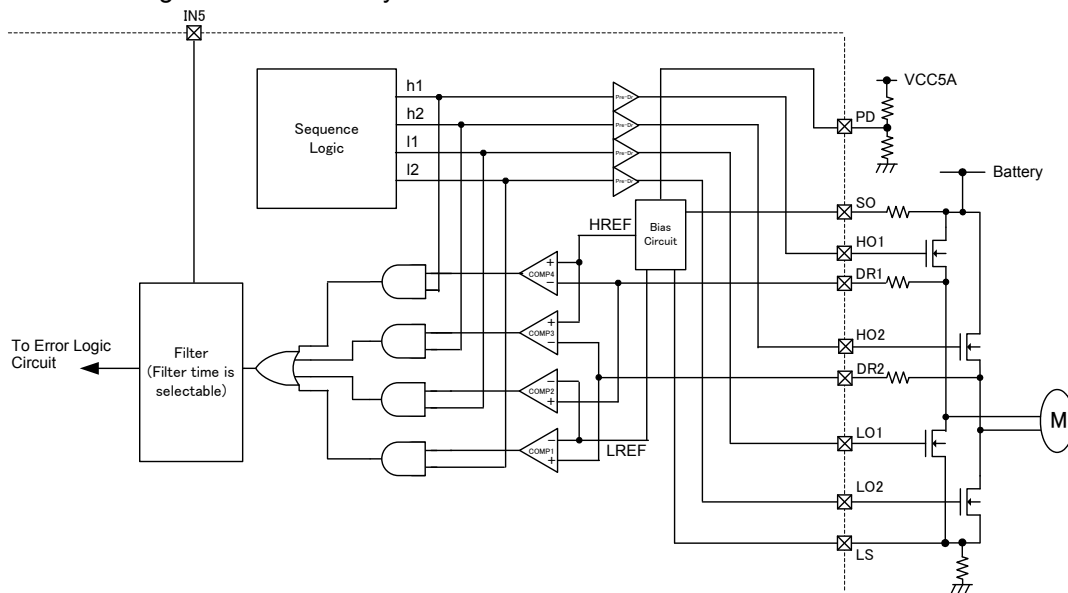
During Short Detection("DG1"="L" and "DG2"=H), the Output of Pre-Driver (PIN"HO1", "HO2" "LO1", "LO2") are decided by PIN"SEL2" setting.

When PIN"SEL2"="L", all of Pre-Drivers are "L" during Short Detection.

When PIN"SEL2"="H", Pre-Drivers keep normal operation during Short Detection.

Short Detection circuit has Filter to prevent miss-detection by noise.

This Filtering time is decided by external connection of PIN"IN5".



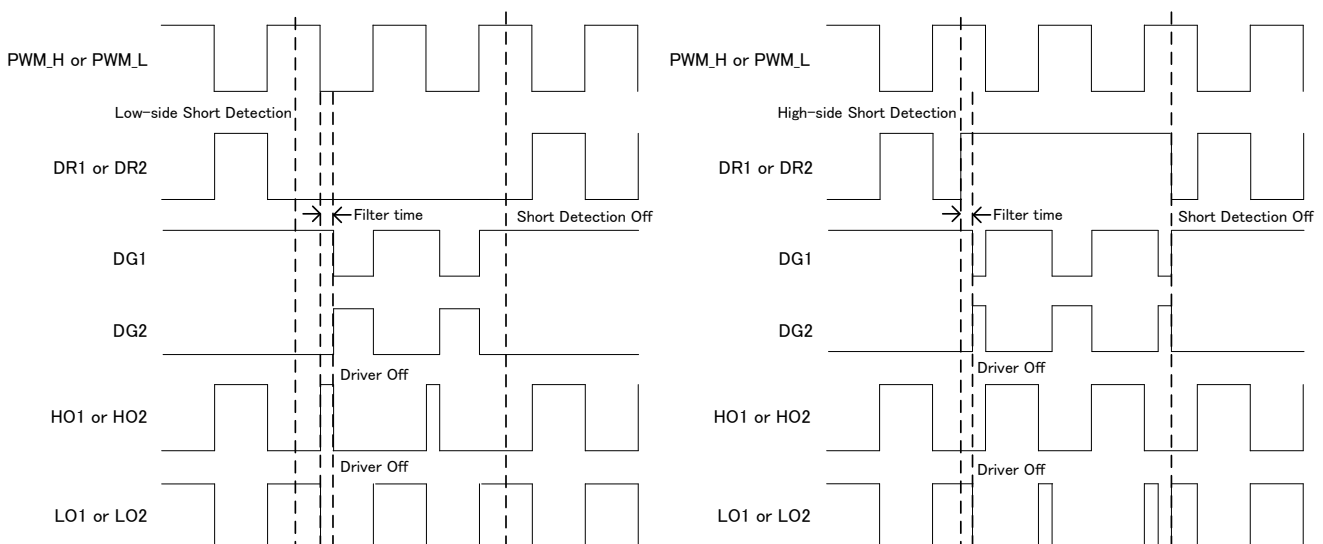
* 1 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

| Comparator Input | Comparator output | PWM Input | Abnormal Phenomenon |
|------------------|-------------------|-----------|-----------------------------------------------|
| DR1 > LREF | COMP2 = H | I1 = H | HO1 external MOSFET Short or Motor Line Short |
| DR2 > LREF | COMP1 = H | I2 = H | HO2 external MOSFET Short or Motor Line Short |
| DR1 < HREF | COMP4 = H | h1 = H | LO1 external MOSFET Short or Motor Line Short |
| DR2 < HREF | COMP3 = H | h2 = H | LO2 external MOSFET Short or Motor Line Short |

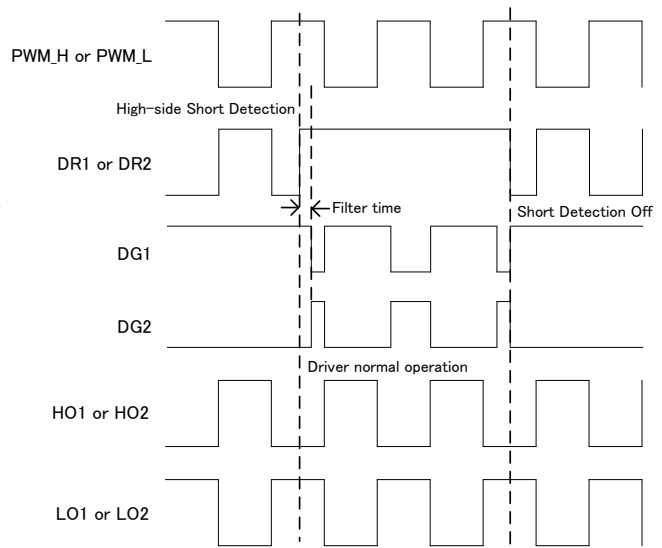
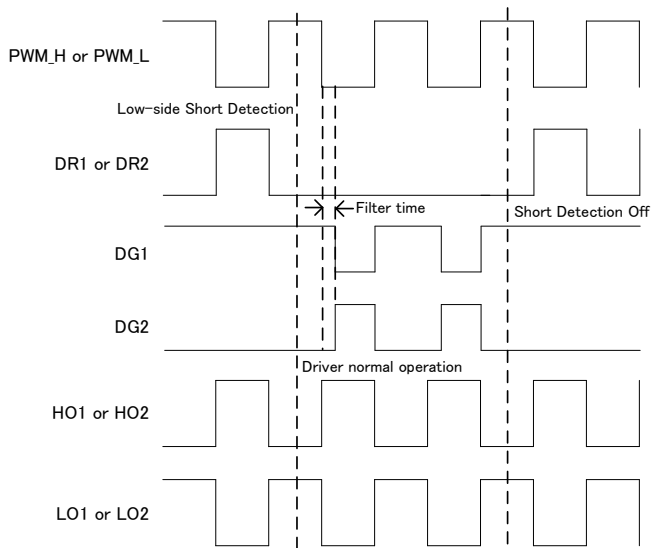
※HREF = (SO voltage) – (PD voltage), LREF = (LS voltage)+(PD voltage)

< MOSFET Short Detection >

• SEL2 = Low



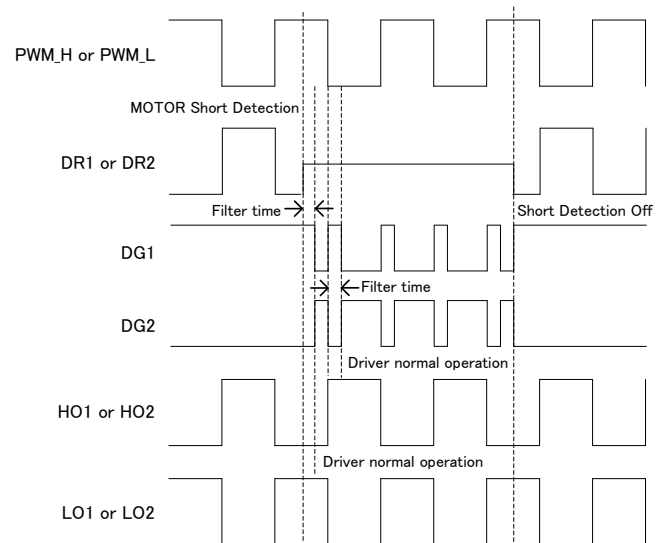
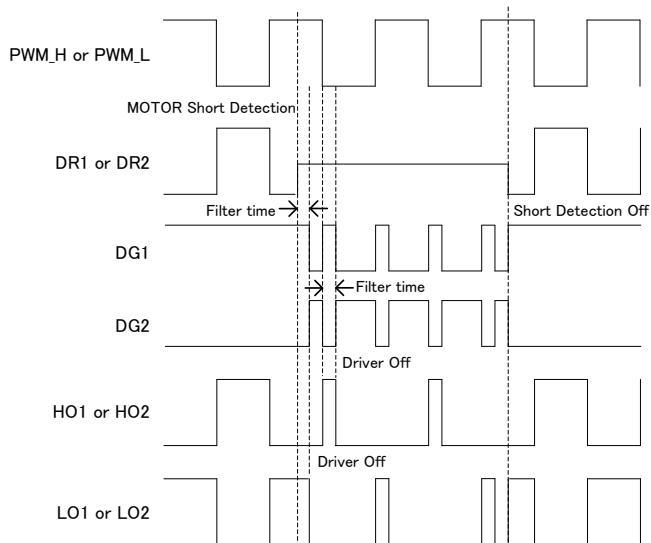
• SEL2 = High



< MOTOR Short Detection >

SEL2 = Low

SEL2 = High



* 1 : Timing charts may be simplified for explanatory purpose.

ABSOLUTE MAXIMUM RATING (Ta = 25°C)

| CHARACTERISTIC | SYMBOL | PIN | VALUE | UNIT | |
|------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------|----------------|-----------------------------|---|
| Input/Output Voltage | Vin, Vout | VB | -0.3 to 18(DC) | V | |
| | | | 18 to 24(1min) | | |
| | | | 24 to 40(1s) | | |
| | | PCC1, PCCD1, PCC2, PCCD2, PCCO, HO1, HO2, TEST1, TEST2 | | -0.3 to 40(1s) | V |
| | | DR1, DR2, SO, LO1, LO2, | | -0.3 to VB | V |
| | | VCC5A, VDD | | -0.3 to 6 | V |
| | | REFOUT, CS1, CS2, LS, REFIN, IN5, PD, AMPP1, AMPM1, AMPP2, AMPM2, DT | | -0.3 to VCC5A+0.3 (max: 6V) | V |
| BT, PWM_H, PWM_L, RR, LR, IN1, IN 2, IN 3, IN 4, ENA, SEL1, SEL2, DG1, DG2, CRESET | | -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 | |
| | | REFOUT, CS1, CS2 | 10 | mA | |
| | | PCC1, PCC2, PCCO | 100 | mA | |
| | | DG1, DG2 | 10 | mA | |
| Storage Temperature | Tstg | - | -40 to 150 | °C | |
| Power dissipation | PD | JEDEC 4layer | 0.76(Ta=125°C) | W | |
| | | | 3.8(Ta=25°C) | W | |

* 1: Timing charts may be simplified for explanatory purpose.

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.

STATIC ELECTRICAL CHARACTERISTICS

(The follows are under condition VB=6 to 18V, VCC5A=4.0 to 5.5V, VDD=3.0 to 5.5V, Ta=-40 to 125°C unless otherwise the follows)

Operating Range

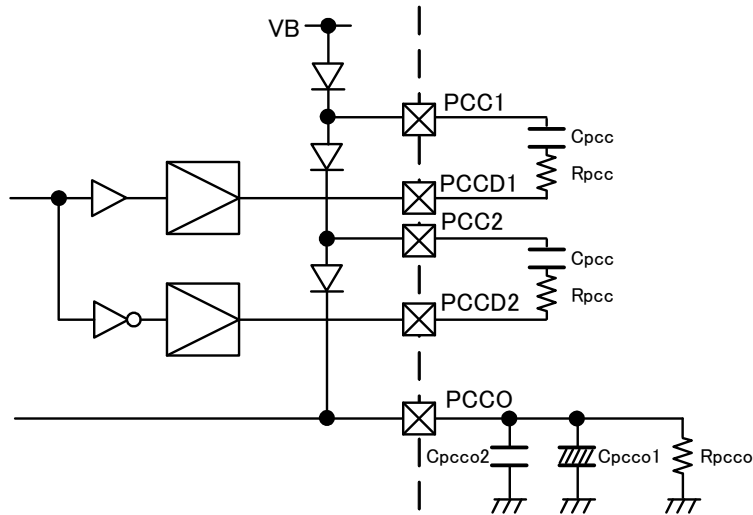
| CHARACTERISTIC | SYMBOL | PIN | VALUE | UNIT |
|-----------------------|--------|-------|----------------------------|------|
| Supply Voltage | Vin | VB | 6 to 18 | V |
| | | VCC5A | 4.0 to 5.5 ※VCC5A ≥ VDD | V |
| | | VDD | 3.0 to 5.5 | V |
| Operating Temperature | Topr | - | -40 to 125 | °C |

IC Characteristics

| CHARACTERISTIC | SYMBOL | PIN | CONDITION | MIN. | TYP. | MAX. | UNIT |
|-----------------------------|--------|-----------------------------------------------|---------------------------------------------------------|-------------|-----------|-------------|------|
| Current Consumption(VB) | lvb1 | VB | CRESET=Low | - | 1.5 | 3 | mA |
| | lvb2 | VB | CRESET=Hi HO1,HO2=20kHz Cload=10000pF Roh=100Ω | - | 50 | 70 | mA |
| Current Consumption(VCC5A) | lvcc5a | VCC5A | - | - | 4 | 5.5 | mA |
| Output Current "H" | Ih | DG1, DG2 | VDD = 5.0V DG*=VDD | - | - | -2.5 | mA |
| Output Current "L" | Il | | VDD = 5.0V DG* = 0V | 2.5 | - | - | mA |
| Input Current "L" | Iil | PWM_H, PWM_L, RR, LR | VDD = 5.0V Vin = 0V | -100 | -50 | -25 | μA |
| Input Current "H" | Iih | PWM_H, PWM_L, RR, LR | VDD = 5.0V Vin = 5.0V | -5 | - | 5 | μA |
| Input Current "L" | Iil | BT, IN1, IN2, IN3, IN4, ENA, SEL1, SEL2 | VDD = 5.0V Vin = 0V | -5 | - | 5 | μA |
| Input Current "H" | Iih | BT, IN1, IN2, IN3, IN4, ENA, SEL1, SEL2 | VDD = 5.0V Vin = 5.0V | 25 | 50 | 100 | μA |
| Input "L" detection Voltage | Vil | RR, LR, BT, PWM_H, | - | 0 | - | 0.3× VDD | V |
| Input "H" detection Voltage | Vih | PWM_L, IN1, IN2, IN3, IN4, ENA, SEL1, | | 0.7× VDD | - | VDD | V |
| Hysteresis | Vh | SEL2, CRESET | | - | 0.5 | - | V |
| Minimum Output voltage | VOH | DG1, DG2 | IOL = 2.5mA | - | 0.05 | 0.4 | V |
| Maximum Output voltage | VOL | DG1, DG2 | IOH = -2.5mA | VDD-0.6V | VDD-0.05V | - | V |

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 | VB+8 | - | - | V |
| | Vcp2 | | VB=8V to 18V Cpcc=0.1μF Rpcc=10Ω Rpcco=2.5kΩ Cpcco1=10μF Cpcco2=1μF | VB+10 | VB+12 | VB+14 | V |
| Active Clamp Detection Voltage | Vcpclh | PCCO | - | 31 | 36 | 40 | V |
| Active Clamp Release Voltage | Vcpcll | PCCO | - | 30.5 | 35.5 | 39.5 | V |



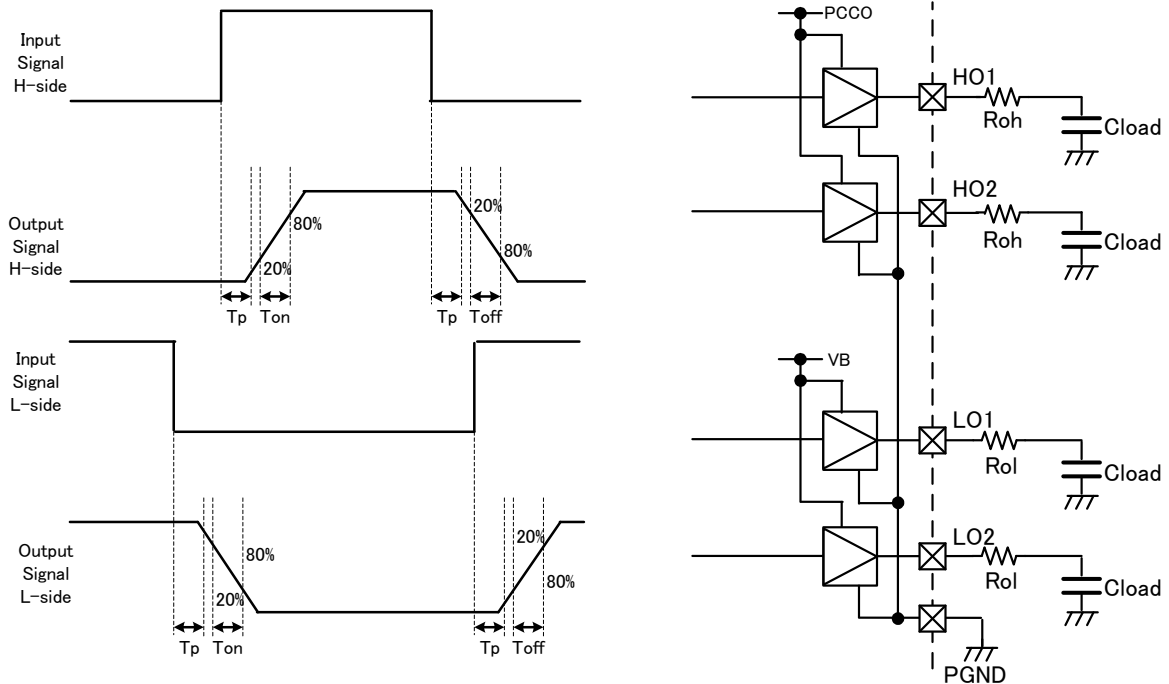
* 1 : Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purpose.

Pre-Driver

| CHARACTERISTIC | SYMBOL | PIN | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---------------------------------------------------------------------------------------------------|---------|-----------------------|-----------------------------------------------|--------|------|------|------|
| Output Voltage | Voh1 | HO1, HO2 | Coad=10nF, Roh=100Ω | Vcp-1 | - | Vcp | V |
| | Voh2 | | | - | - | 0.5 | V |
| | Vol1 | LO1, LO2 | Cload=10nF, Rol=20Ω | VB-0.3 | - | VB | V |
| | Vol2 | | | - | - | 0.5 | V |
| Output Resistance | Ronh | HO1, HO2 | - | - | 4 | - | Ω |
| | Ronl | LO1, LO2 | - | - | 4 | - | Ω |
| Turn on time | Ton | HO1, HO2, LO1, LO2 | Roh=100Ω Rol=20Ω Cload=10nF, 20%→80% | - | 150 | 300 | ns |
| Turn off time | Toff | | Roh=100Ω Rol=20Ω Cload=10nF, 80%→20% | - | 150 | 300 | ns |
| Propagation Delay time of Input (The time that both rising and falling PWM Output reach to 1V) | Tp | HO1, HO2, LO1, LO2 | Roh=100Ω Rol=20Ω Cload=10nF, | - | 250 | 500 | ns |
| Time tolerant of Input propagation delay time | Tp_diff | HO1, HO2, LO1, LO2 | - | - | 100 | 150 | ns |
| Dead time | Tdt | HO1, HO2, LO1, LO2 | Rdead=36kΩ | - | 0.1 | - | μs |
| | | | Rdead=200kΩ | - | 0.53 | - | μs |
| | | | Rdead=390kΩ | - | 1.02 | - | μs |
| | | | Rdead=1.2MΩ | - | 3.18 | - | μs |

*Vcp: Charge pump voltage

*Please use that Rdead resistance range is from 1kΩ to 2MΩ.



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

* 2 : Timing charts may be simplified for explanatory purpose.

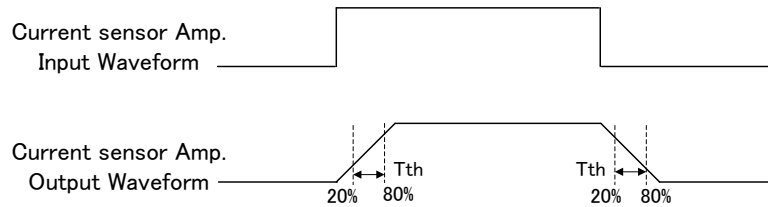
Current Sensor Circuit

Off set Generator

| CHARACTERISTIC | SYMBOL | PIN | CONDITION | MIN. | TYP. | MAX. | UNIT |
|-----------------------|---------|--------|-----------------------------------|-------|------|-------|------|
| Output Voltage | Vrefout | REFOUT | Vrefin=1.65V | 1.635 | 1.65 | 1.665 | V |
| Input Bias Current | libr | REFIN | Vrefin=1.65V | -5 | - | 5 | μA |
| Input Off set Voltage | Vio | REFIN | Vrefin=1.65V Output is no load | -15 | - | 15 | mV |

Differential Amplifier Circuit

| CHARACTERISTIC | SYMBOL | PIN | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---------------------------------|--------|------------------------------|----------------------------------------------------------------------|-----------|------|-----------|------|
| Common mode Input Voltage Range | Vin | AMPM1, AMPP1 AMPM2, AMPP2 | Voltage Follower Output is no load | -0.3 | - | VCC5A-0.3 | V |
| Input Bias Current | lib | AMPM1, AMPP1 AMPM2, AMPP2 | Voltage Follower Output is no load | -5 | - | 5 | μA |
| Input Off set Voltage | Vio | AMPM1, AMPP1 AMPM2, AMPP2 | Voltage Follower Output is no load Vin = 0.3V to VCC5A-0.3V | -15 | - | 15 | mV |
| Slew rate | Tth | CS1, CS2 | Voltage Follower 20% ⇄ 80% CL=100nF, RL=1kΩ | 3 | - | - | V/μs |
| Maximum Output Voltage | Voh | CS1, CS2 | Voltage Follower Output is no load | VCC5A-0.3 | - | VCC5A | V |
| Minimum Output Voltage | Vol | CS1, CS2 | Voltage Follower Output is no load | 0 | - | 0.3 | V |

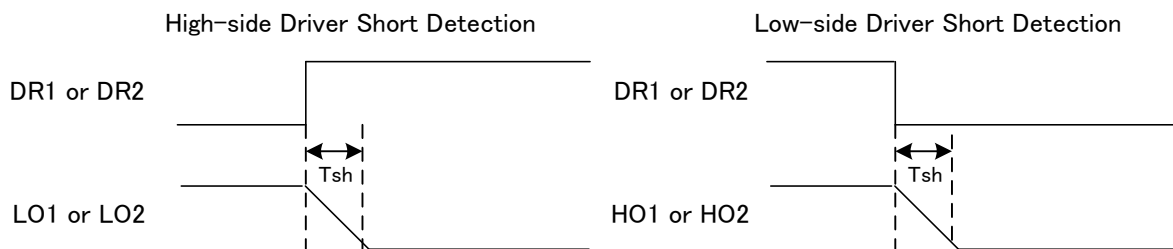


* 1 : Timing charts may be simplified for explanatory purpose.

Abnormal Detection Circuit

| CHARACTERISTIC | SYMBOL | PIN | CONDITION | MIN. | TYP. | MAX. | UNIT |
|------------------------------------------|----------|-----------------------|--------------------------------------------------------------------------------------------------|------|------|------|------|
| Low Voltage Detection (VB) | Vcpll | VB | - | 4.5 | 5 | 5.5 | V |
| Low Voltage Release (VB) | Vcplh | VB | - | 5 | 5.5 | 6 | V |
| Low Voltage Detection (VDD) | VRSTL | VDD | - | 2.7 | 2.8 | 2.9 | V |
| Low Voltage Release (VDD) | VRSTH | VDD | - | 2.8 | 2.9 | 3.0 | V |
| Hysteresis of Low Voltage Detection(VDD) | VRSTHYS | | VRSTHYS= VRSTH-VRSTL | - | 0.1 | - | V |
| Over Temperature Detection | Tsdh | - | - | - | 170 | - | °C |
| Over Temperature Release | Tsdl | - | - | - | 160 | - | °C |
| Short detection Filtering time | Tsf | IN5 | IN5=68kΩ | - | 1 | - | μs |
| | | | IN5=220kΩ | - | 3 | - | μs |
| | | | IN5=430kΩ | - | 6 | - | μs |
| PD voltage range | Vpd | PD | — | 0.5 | - | 4 | V |
| Short detection error | Vsh_diff | PD | — | -120 | - | 120 | mV |
| Short detection delay time | Tsh | HO1, HO2, LO1, LO2 | From Detected Short to Pre-Driver Off (Cload=10nF, Roh=100Ω) ※Filtering time is not included. | - | - | 3 | μs |

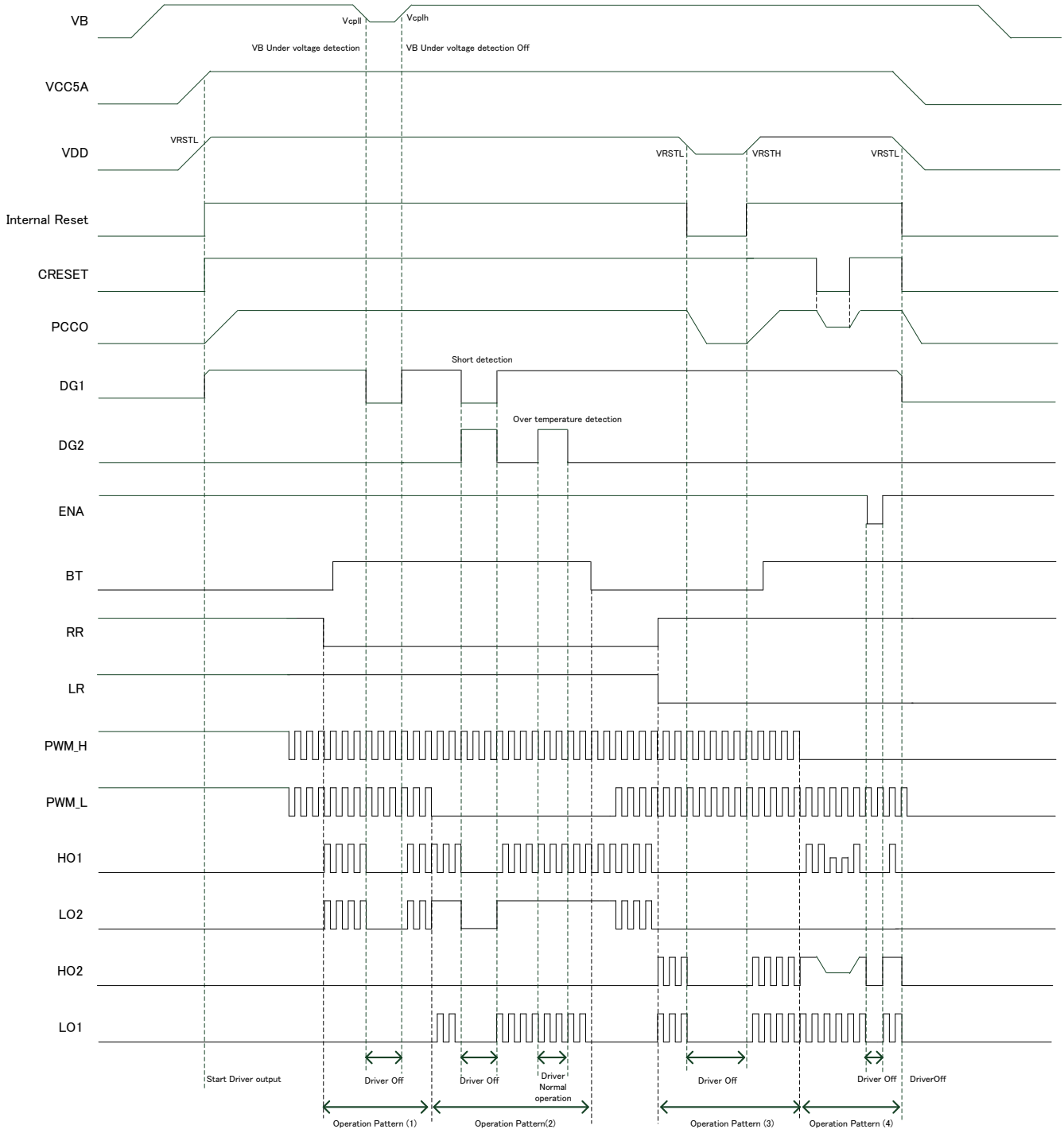
*Please use that IN5 resistance range is from 1kΩ to 2MΩ



* 1 : Timing charts may be simplified for explanatory purpose.

Timing Chart Image

- SEL1 = "Low" (Sequence Control)
- SEL2 = "Low" (When detected Short Detection and VB Under voltage detection, Pre-Driver is OFF)



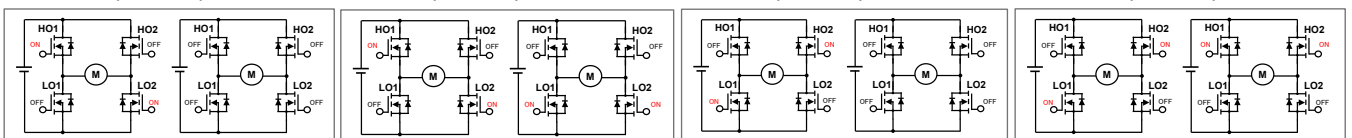
- * 1 : Timing charts may be simplified for explanatory purpose.
- * 2 : Please VCC5A connect with VDD or VCC5A turn on before VDD-turn-on.
- ※ Driver operation pattern of above timing chart is as follow.

Driver operation pattern (1)

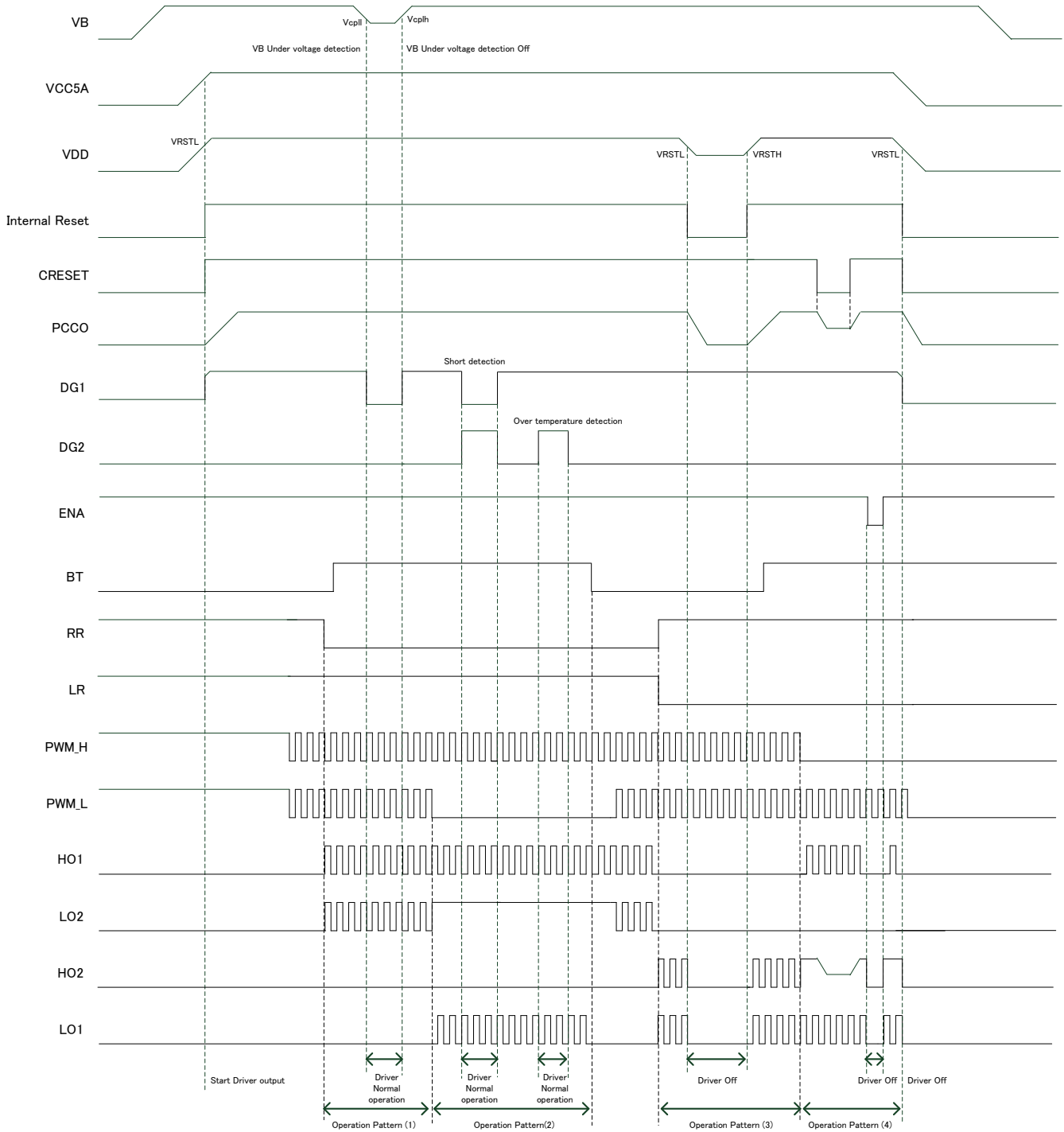
Driver operation pattern (2)

Driver operation pattern (3)

Driver operation pattern (4)



- SEL1 = "Low" (Sequence Control)
- SEL2 = "High" (When detected Short Detection and VB Under voltage detection, Pre-Driver is Normal operation.)

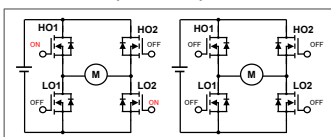


* 1 : Timing charts may be simplified for explanatory purpose.

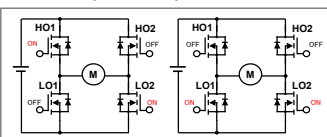
* 2 : Please VCC5A connect with VDD or VCC5A turn on before VDD-turn-on.

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

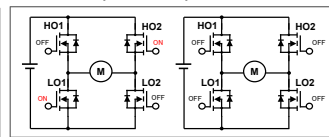
Driver operation pattern (1)



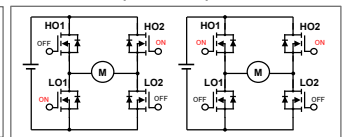
Driver operation pattern (2)



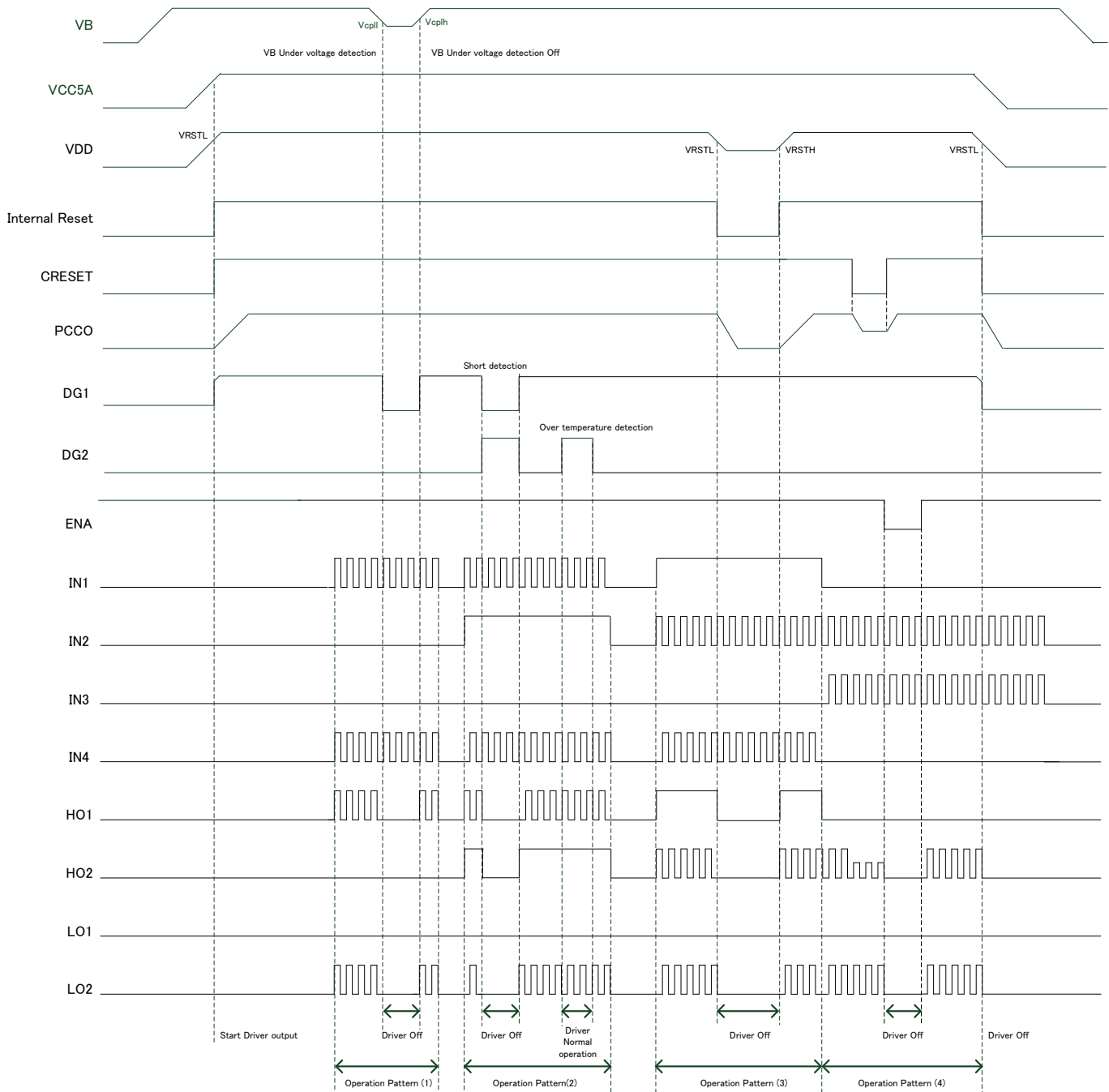
Driver operation pattern (3)



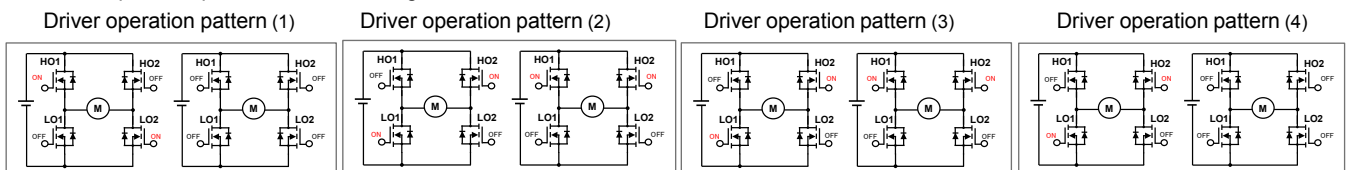
Driver operation pattern (4)



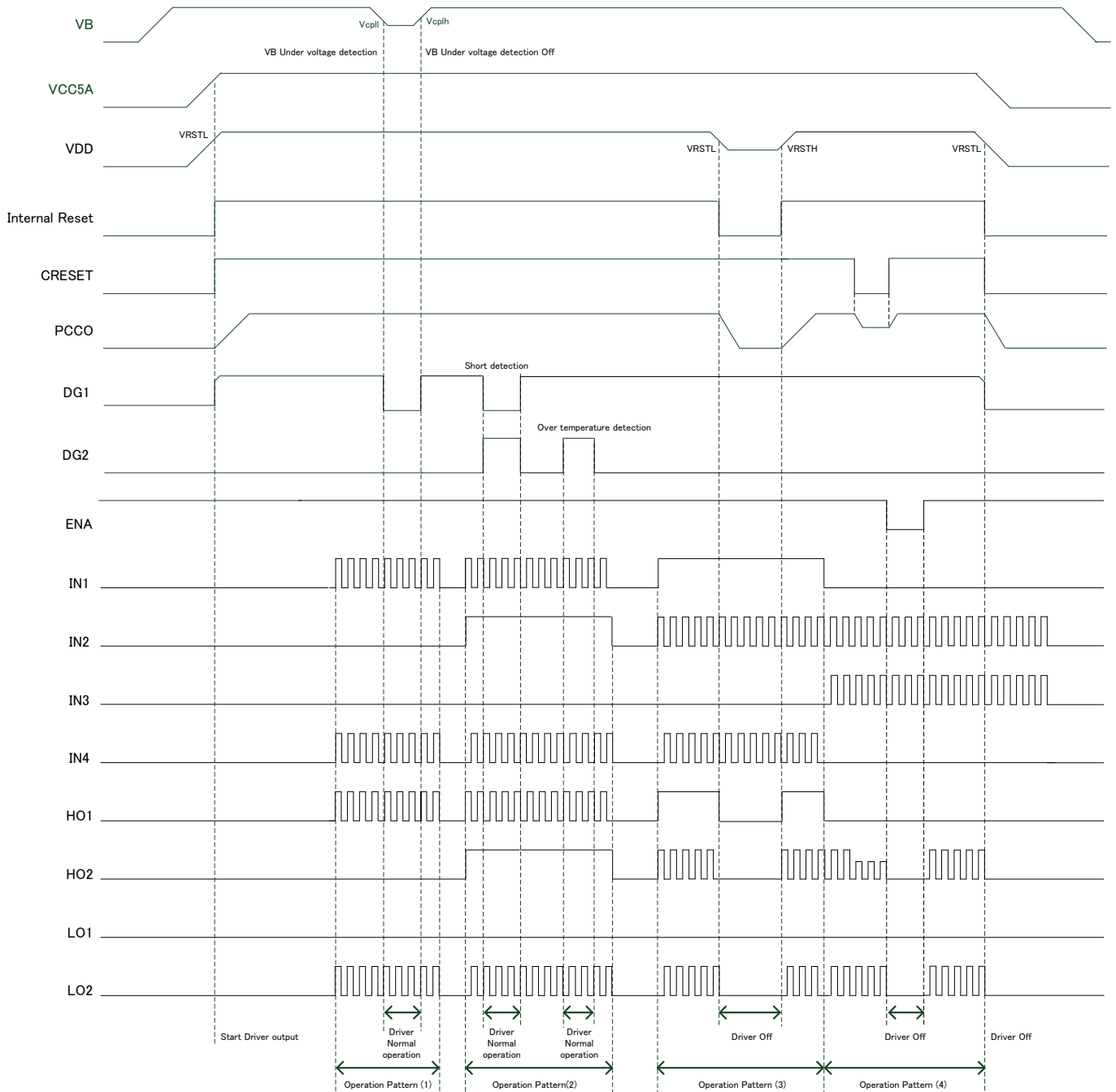
- SEL1 = "High" (Direct Control)
- SEL2 = "Low" (When detected Short Detection and VB Under voltage detection, Pre-Driver is OFF)



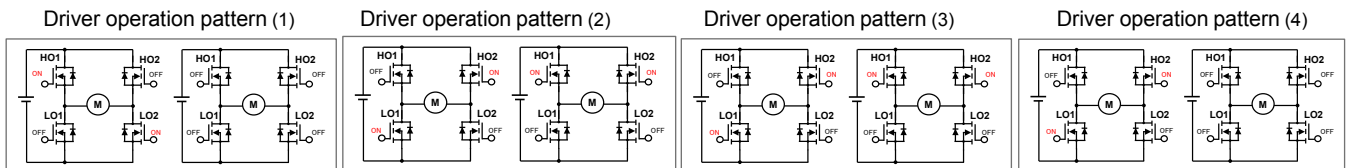
- * 1 : Timing charts may be simplified for explanatory purpose.
- * 2 : Please VCC5A connect with VDD or VCC5A turn on before VDD-turn-on.
- ※ Driver operation pattern of above timing chart is as follow.



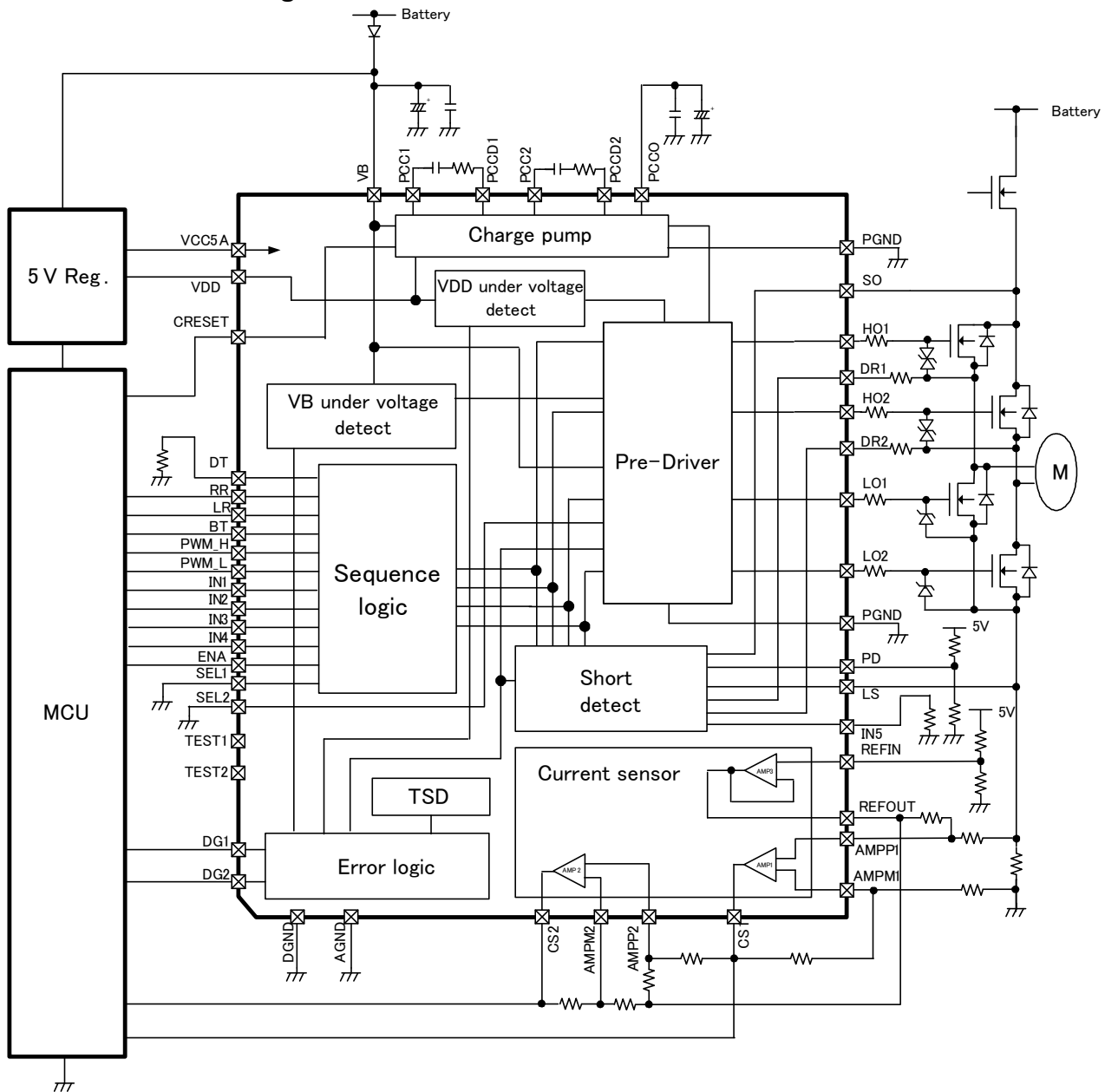
- SEL1 = "High" (Sequence Control)
- SEL2 = "High" (When detected Short Detection and VB Under voltage detection, Pre-Driver is Normal operation.)



- * 1 : Timing charts may be simplified for explanatory purpose.
- * 2 : Please VCC5A connect with VDD or VCC5A turn on before VDD-turn-on.
- ※ Driver operation pattern of above timing chart is as follow.



Reference Circuit Diagram

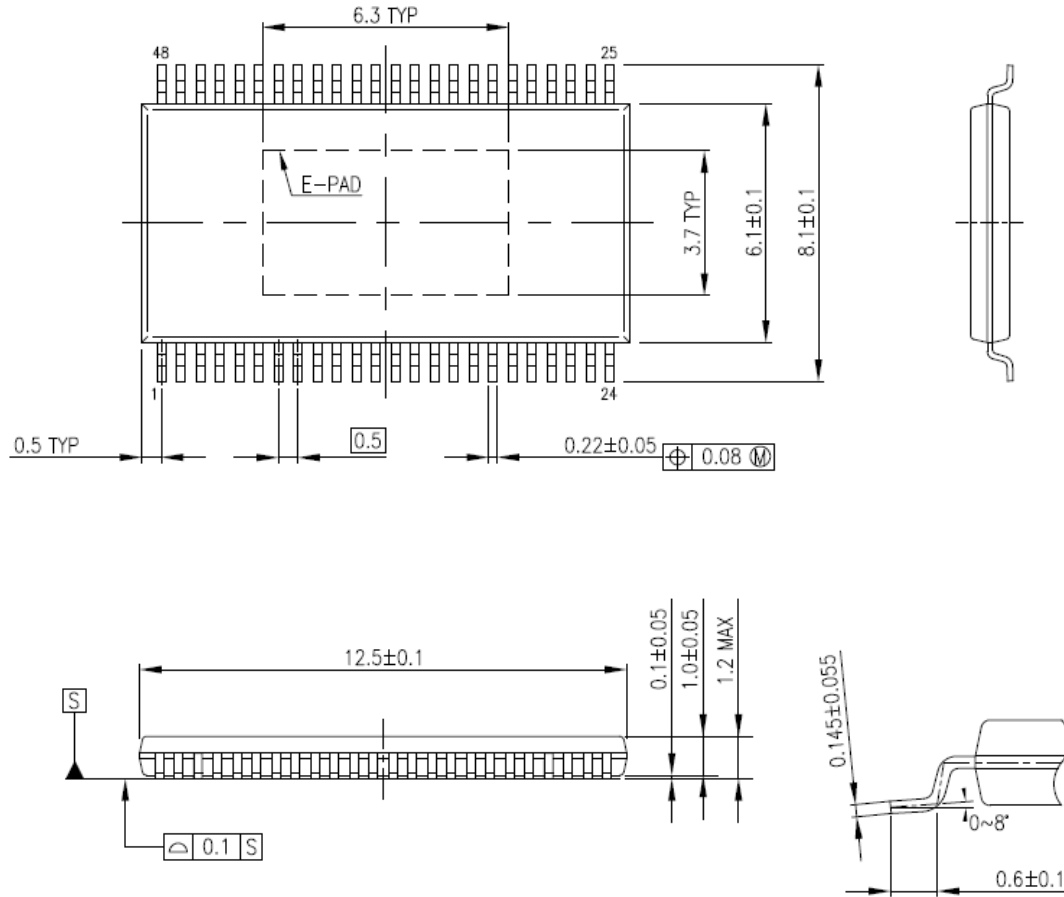


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- * 2 : The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purpose.
- * 3 : Timing charts may be simplified for explanatory purpose.
- * 4 : Install the product correctly. Otherwise, it may result in break down, damage and/or deterioration to the product or equipment.
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PACKAGE

HTSSOP48-P-300-0.50

Unit: mm



Weight: 0.24g(typ.)

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