

# 3-phase brushless motor pre-driver

## BD63002MUV

### General Description

BD63002MUV is pre-driver of 3-phase brushless motor. It generates a driving signal from the Hall sensor and drives PWM through the input control signal. Since there is a built-in booster circuit, Nch-Nch MOS transistors can be used on the external power transistor. In addition, the power supply can use 12V or 24V and it has various controls and protection functions built-in, making it useful for a variety of purposes. Because it adopts small packages, it can also be used on small diameter motors.

### Features

- Built-in 120° commutation logic circuit.
- Driving with Nch-Nch MOS transistors.
- PWM control mode (low side arm switching).
- Built-in power-saving circuit.
- CW/CCW function.
- Short brake function.
- FG output (Open drain).
- Built-in protection circuit for current limiting, overheating, under voltage, over voltage, motor lock.

### Applications

- OA machines.
- Other general civil equipments.

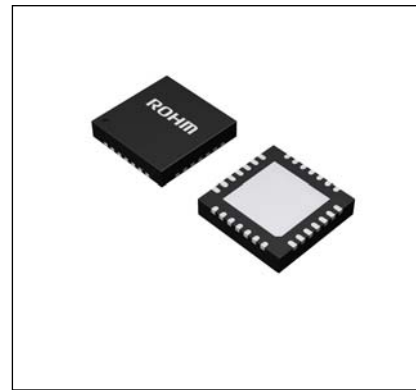
### Key Specifications

- Power supply voltage rating: 30V
- Operating temperature range: -40°C to +85°C
- Stand-by current: 1.2mA(Max.)
- Range of in-phase input voltage for hall input:  $V_{REG}-1.7V(\text{Max.})$
- Current limit detect voltage:  $0.2V \pm 10\%$
- UVLO Lock out voltage: 6.0V(Typ.)
- OVLO Lock out voltage 1: 16.0V(Typ.)
- OVLO Lock out voltage 2: 28.5V(Typ.)

### Package

VQFN028V5050

W(Typ) x D(Typ) x H(Max)  
 5.00mm x 5.00mm x 1.00mm



VQFN028V5050

### Typical Application Circuit

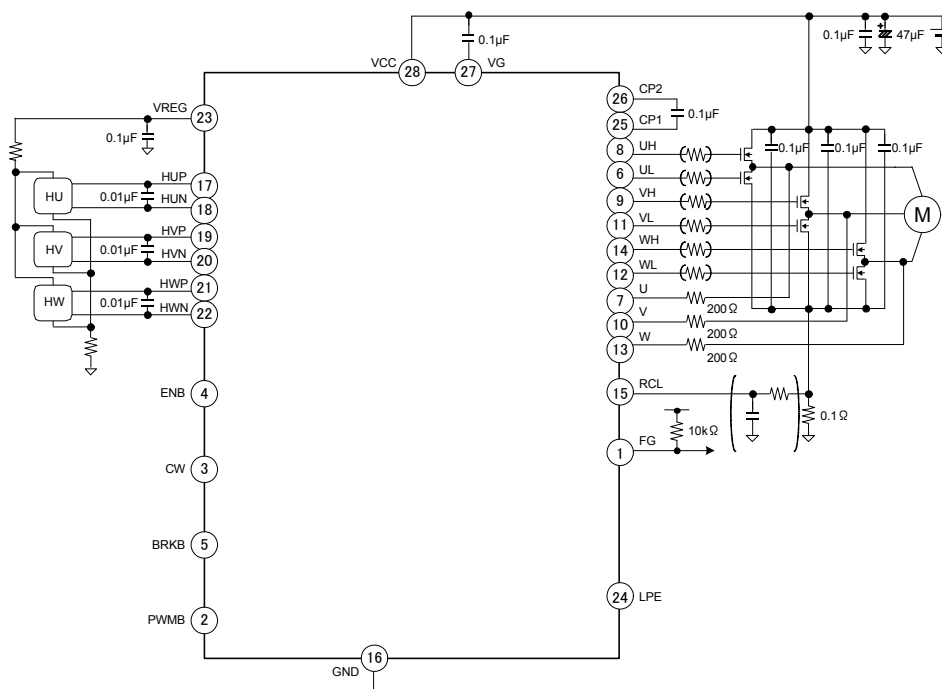


Figure 1. Application circuit

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

## ●Pin Configuration

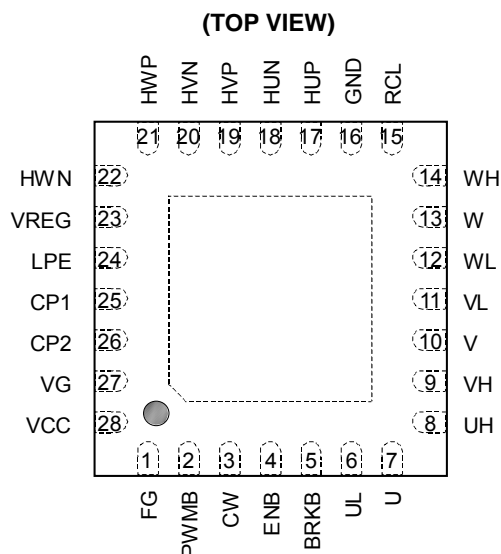


Figure 2. Pin configuration

## ●Block Diagram

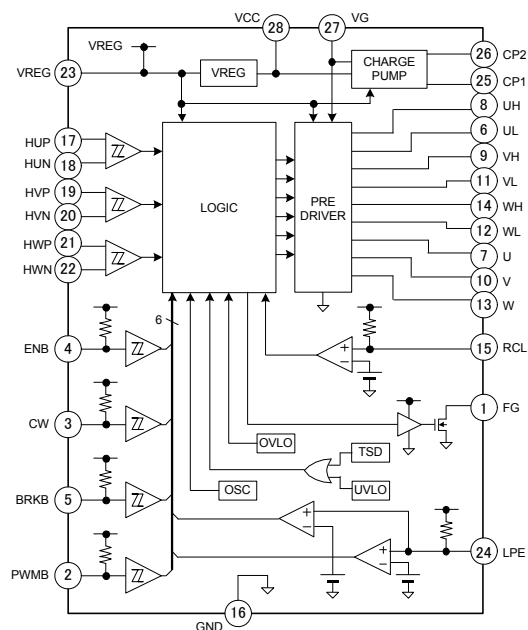


Figure 3. Block diagram

## ●Pin Description

| Pin No. | Pin name | Function                     | Pin No. | Pin name | Function                                                   |
|---------|----------|------------------------------|---------|----------|------------------------------------------------------------|
| 1       | FG       | FG output                    | 15      | RCL      | Detect voltage input for over current                      |
| 2       | PWMB     | PWM input (negative logic)   | 16      | GND      | GND                                                        |
| 3       | CW       | CW/CCW input (H: CW, L: CCW) | 17      | HUP      | U phase Hall input +                                       |
| 4       | ENB      | Enable (negative logic)      | 18      | HUN      | U phase Hall input -                                       |
| 5       | BRKB     | Brake input (negative logic) | 19      | HVP      | V phase Hall input +                                       |
| 6       | UL       | U phase lower output         | 20      | HVN      | V phase Hall input -                                       |
| 7       | U        | U phase output feedback      | 21      | HWP      | W phase Hall input +                                       |
| 8       | UH       | U phase upper output         | 22      | HWN      | W phase Hall input -                                       |
| 9       | VH       | V phase upper output         | 23      | VREG     | VREG output (turn off at stand-by)                         |
| 10      | V        | V phase output feedback      | 24      | LPE      | Setting about motor lock protection and OLVO (H/M/L input) |
| 11      | VL       | V phase lower output         | 25      | CP1      | Charge pump setting 1                                      |
| 12      | WL       | W phase lower output         | 26      | CP2      | Charge pump setting 2                                      |
| 13      | W        | W phase output feedback      | 27      | VG       | Charge pump output                                         |
| 14      | WH       | W phase upper output         | 28      | VCC      | Power supply                                               |

## ●Description of operation

### 1) Commutation logic (120° commutation)

Truth table

| HU | HV | HW | CW (CW=H or open) |      |     |      |     |      | CCW (CW=L) |      |     |      |     |      | FG   |
|----|----|----|-------------------|------|-----|------|-----|------|------------|------|-----|------|-----|------|------|
|    |    |    | UH                | UL   | VH  | VL   | WH  | WL   | UH         | UL   | VH  | VL   | WH  | WL   |      |
| H  | L  | H  | PWM               | PWM* | H   | L    | L   | L    | H          | L    | PWM | PWM* | L   | L    | L    |
| H  | L  | L  | PWM               | PWM* | L   | L    | H   | L    | H          | L    | L   | L    | PWM | PWM* | L    |
| H  | H  | L  | L                 | L    | PWM | PWM* | H   | L    | L          | L    | H   | L    | PWM | PWM* | L    |
| L  | H  | L  | H                 | L    | PWM | PWM* | L   | L    | PWM        | PWM* | H   | L    | L   | L    | Hi-z |
| L  | H  | H  | H                 | L    | L   | L    | PWM | PWM* | PWM        | PWM* | L   | L    | H   | L    | Hi-z |
| L  | L  | H  | L                 | L    | H   | L    | PWM | PWM* | L          | L    | PWM | PWM* | H   | L    | Hi-z |
| H  | H  | H  | L                 | L    | L   | L    | L   | L    | L          | L    | L   | L    | L   | L    | L    |
| L  | L  | L  | L                 | L    | L   | L    | L   | L    | L          | L    | L   | L    | L   | L    | Hi-z |

\* When PWMB=L, PWM="H", When PWMB=H, PWM="L".

### 2) Enable input terminal (ENB)

Output of each phase can be set to ON/OFF (negative logic) through ENB terminal. When applied voltage is below  $V_{ENA}$ , the motor is driven (enable), when applied voltage is  $V_{STBY}$ , the motor suspends (stand-by). Stand-by mode has precedence to other control input signal, VREG output will be OFF. In addition, ENB terminal is pulled up by internal power supply through a resistance of  $100k\Omega(Typ) \pm 30k\Omega$ .

| ENB       | Operation |
|-----------|-----------|
| H or open | Stand-by  |
| L         | Enable    |

### 3) PWM input terminal (PWMB)

Speed can be controlled by inputting PWM signal into PWMB terminal (negative logic). Synchronous rectifier PWM can be realized through lower switching. When PWMB="L", lower output that belongs to Hall input logic is "H". When PWMB="H" or open, lower output is "L". When PWMB="H" or OPEN status is detected  $104\mu s(Typ)$ , the synchronous rectifier will be OFF. Synchronous rectifier will be ON through rising and falling edges of subsequent PWMB. Additionally, PWMB terminal is pulled up by VREG through a resistance of  $100k\Omega(Typ) \pm 30k\Omega$ .

| PWMB      | Low side output |
|-----------|-----------------|
| H or open | L               |
| L         | H               |

### 4) Brake input terminal (BRKB)

Motor rotation can be quickly stopped by BRKB terminal (negative logic). When BRKB="L", lower output will short brake all "H". When BRKB="H" or OPEN, then short brake action will be released. What's more, BRKB terminal is pulled up by VREG through a resistance of  $100k\Omega(Typ) \pm 30k\Omega$ .

| BRKB      | Operation   |
|-----------|-------------|
| H or open | Normal      |
| L         | Short brake |

## 5) CW/CCW input terminal (CW)

Rotation direction can be switched with CW terminal. When CW="H" or OPEN, the direction is CW, when CW="L", the direction will be CCW. Though we do not recommend switching rotation direction when motor is rotating, if rotation direction is switched when rotating, the rotation speed will become hall frequency, which will be up to less than 40Hz and it will be switched to set rotation direction after the action short brake. And the CW terminal is pulled up by VREG through a resistance of  $100\text{k}\Omega(\text{Typ}) \pm 30\text{k}\Omega$ .

| CW        | Direction |
|-----------|-----------|
| H or open | CW        |
| L         | CCW       |

## 6) FG output

FG output is reshaped Hall U phase signal and output through FG terminal. It is not output in stand-by mode. In addition, because FG terminal is output from open drain, please use resistance of about  $10\text{k}\Omega \sim 100\text{k}\Omega$  to pulled up from outside.

## 7) Hall input

Hall input amplifier is designed with hysteresis ( $\pm 15\text{mV}(\text{Typ})$ ) in order to prevent incorrect action due to noise inside. So please set bias current for Hall element to make amplitude of Hall input voltage over minimum input voltage ( $V_{\text{HALLMIN}}$ ). Here, we recommend you to connect the ceramic capacitor with about  $100\text{pF} \sim 0.01\mu\text{F}$  between difference input terminals of Hall amplifier. What's more, because the in-phase input voltage range ( $V_{\text{HALLCM}}, 0\text{V} \sim V_{\text{REG}}-1.7\text{V}(\text{Typ})$ ) is designed for Hall input amplifier, so when bias to Hall element, please set within this range. When Hall inputs all become "H" or "L", detect circuit through Hall input abnormalities to make driver output all "L".

## 8) Booster circuit

There is built-in booster circuit used to drive upper Nch MOS transistor. VG terminals can produce a boost voltage (from the VCC voltage +  $2 \times V_F$  voltage ( $7\text{V}(\text{Typ})$ ) reduced by internal regulator) through connecting capacitors between CP1-CP2 and between VG-VCC. We recommend connected condensers to be over  $0.1\mu\text{F}$ . In addition, because there is built-in protection circuit for insufficient booster, when VG voltage is below  $V_{\text{GUVON}} (V_{\text{CC}}+4\text{V}(\text{Typ}))$ , driver outputs will all be "L".

## 9) Current limit circuit (CL circuit)

Output current limit (Current limit: CL) circuit can be formed by connecting a low resistor used for testing current between RCL terminal & GND terminal. When RCL voltage is detected over  $0.2\text{V}(\text{Typ})$ , lower output will all become "L". It ( $32\mu\text{s}(\text{Typ})$ ) resets automatically after a set amount of time. This action does not synchronize with the action that PWM signal is input into PWMB terminal. In addition, in order to avoid misdetection of output current due to RCL noise, the IC employs detection-masking period ( $1 \sim 2\mu\text{sec}(\text{Typ})$ ), during which current detection is disabled immediately after the output transistor is turned on.

## 10) Thermal Shut Down circuit (TSD circuit)

When chip temperature of driver IC rises and exceeds the set temperature ( $175^\circ\text{C}(\text{Typ})$ ), the thermal shut down circuit (Thermal Shut Down: TSD) begins working. At this time, the driver outputs all become "L". In addition, the TSD circuit is designed with hysteresis ( $25^\circ\text{C}(\text{Typ})$ ), therefore, when the chip temperature drops, it will return to normal working condition. Moreover, the purpose of the TSD circuit is to protect driver IC from thermal breakdown, therefore, temperature of this circuit will be over working temperature when it is started up. Thus, thermal design should have sufficient margin, so do not take continuous use and action of the circuit as precondition.

## 11) Under voltage lock out circuit (UVLO circuit)

There is a built-in under voltage lock out circuit (Under Voltage Lock Out: UVLO circuit) used to ensure the lowest power supply voltage for drive IC to work and to prevent error action of IC. When VCC voltage declined to  $V_{\text{UVL}} (6\text{V}(\text{Typ}))$ , all of the driver outputs should be "L". At the same time, UVLO circuit is designed with hysteresis ( $1\text{V}(\text{Typ})$ ), so when VCC voltage reaches more than  $V_{\text{UVH}} (7\text{V}(\text{Typ}))$ , it will enter normal working condition.

## 12) Over voltage lock out circuit (OVLO circuit)

There is built-in over voltage lock out circuit (Over Voltage Lock Out: OVLO circuit) used to restrain rise of VCC voltage when motor decelerating. When LPE terminal is at "M" and VCC voltage is over  $V_{\text{OVH1}} (16\text{V}(\text{Typ}))$ , and when LPE terminal is at "H" or "M" and VCC voltage of is over  $V_{\text{OVH2}} (28.5\text{V}(\text{Typ}))$ , a certain time ( $4\text{ms}(\text{Typ})$ ) of short brake action will be conducted. What's more, because OVLO circuit is designed with hysteresis ( $1\text{V}(\text{Typ})$ ), therefore, when  $V_{\text{OVH1}}$  is below  $V_{\text{OVL1}} (15\text{V}(\text{Typ}))$  and when  $V_{\text{OVH2}}$  is below  $V_{\text{OVL2}} (27.5\text{V}(\text{Typ}))$ , it can return to normal working condition after a certain time of short brake action.

## 13) Motor Lock Protection circuit (MLP circuit)

There is built-in motor lock protection circuit (Motor Lock Protection: MLP), ON/OFF of MLP circuit and OVLO threshold can be set from LPE terminal. Monitor Hall signals, when the LPE = "H" or "M", if Hall signal logic does not change to 1.1sec(Typ), driver outputs will all be locked as "L". Latch can be released via standby status or through switching BRKB/CW logic. Moreover, when PWMB = "H" or open state is detected for about 15ms, latch can be released by rising and falling edges of subsequent PWMB. However, when LPE = "L", when short brake action (including switching rotation direction) enables or TSD circuit works, MLP circuit doesn't work. And LPE terminal is pulled up by VREG through a resistance of 50kΩ(Typ)±15 kΩ.

| LPE       | Monitoring time | OVLO threshold                        |
|-----------|-----------------|---------------------------------------|
| H or open | 1.1sec(Typ)±30% | V <sub>OVH2</sub> , V <sub>OVL2</sub> |
| M         | 1.1sec(Typ)±30% | V <sub>OVH1</sub> , V <sub>OVL1</sub> |
| L         | Disable         | V <sub>OVH2</sub> , V <sub>OVL2</sub> |

## 14) Pre-driver output

Driving signal is output to external output power transistor through drive signal generated from internal logic output drive signal is output for external power supply transistor. Driving voltage of upper gate is VG voltage (V<sub>cc</sub>+7V(Typ)) and driving voltage of lower gate is VREG voltage (5V(Typ)). In addition, a dead time (1μs(Typ)±30%) is designed between driving signals of upper gate and lower gate in order to prevent upper and lower FET from being set to ON synchronously when PWM is rectified synchronously. Due to the influence of the motor's counter electromotive force, the output feedback terminal might swing under GND potential. When excessive current occurs (about over 30mA), incorrect action or even damage might be caused. Therefore, please insert a resistor of about 100Ω ~ 510 Ω before putting into use. Moreover, we recommend you to use output feedback terminal with a slow rate of over 50ns.

## 15) Control signal sequence

Though we recommend you input control signals of ENB, CW, PWMB, BRKB and LPE terminals after inputting VCC, if input control signals before inputting VCC, there won't be any problem. If LPE terminal is set to "H" or "M" when being started, please be informed that if motor rotation cannot be detected within the set time (edge of FG signal cannot be input), then the MLP circuit starts and motor fails to start. Moreover, the order of priority is set to control signal and IC internal signal. Please refer to the following table.

Priority of control signal

| Priority        | Input / Internal signals |
|-----------------|--------------------------|
| 1 <sup>st</sup> | ENB, UVLO                |
| 2 <sup>nd</sup> | BRKB↑↓, CW↑↓, PWMB ↓     |
| 3 <sup>rd</sup> | TSD, MLP, HALLERR        |
| 4 <sup>th</sup> | OVLO                     |
| 5 <sup>th</sup> | VG_UVLO                  |
| 6 <sup>th</sup> | BRKB                     |
| 7 <sup>th</sup> | CL                       |
| 8 <sup>th</sup> | PWMB, CW                 |

Note) ↑↓ means rising and falling edges of signal.  
For signal name, please see state transition diagram.

### ●Absolute Maximum Ratings (Ta=25°C)

| Item                                           | Symbol                  | Limit                             | Unit |
|------------------------------------------------|-------------------------|-----------------------------------|------|
| Power supply voltage                           | V <sub>CC</sub>         | -0.3 to +30.0 <sup>(Note 1)</sup> | V    |
| VG voltage                                     | V <sub>G</sub>          | -0.3 to +38.0 <sup>(Note 1)</sup> | V    |
| Output voltage of pre-driver                   | V <sub>(UH,VH,WH)</sub> | -0.3 to +38.0                     | V    |
|                                                | V <sub>(UL,VL,WL)</sub> | -0.3 to +7.0                      | V    |
| FG terminal voltage                            | V <sub>FG</sub>         | -0.3 to +7.0                      | V    |
| RCL terminal voltage                           | V <sub>RCL</sub>        | -0.3 to +5.5                      | V    |
| Voltage of input of control and Hall terminals | V <sub>I/O</sub>        | -0.3 to +5.5                      | V    |
| Output current of pre-driver(DC)               | I <sub>OMAX(OUT)</sub>  | ±15 <sup>(Note 1)</sup>           | mA   |
| FG output current                              | I <sub>OMAX(FG)</sub>   | 5 <sup>(Note 1)</sup>             | mA   |
| VREG output current                            | I <sub>OMAX(VREG)</sub> | -30 <sup>(Note 1)</sup>           | mA   |
| Operating temperature range                    | T <sub>OPR</sub>        | -40 to +85                        | °C   |
| Storage temperature range                      | T <sub>STG</sub>        | -55 to +150                       | °C   |
| Power dissipation                              | P <sub>d</sub>          | 0.38 <sup>(Note 2)</sup>          | W    |
| Junction temperature                           | T <sub>Jmax</sub>       | 150                               | °C   |

(Note 1) Do not exceed P<sub>d</sub>.

(Note 2) Derate by 3.04mW/°C when operating above Ta=25°C (IC only).

Caution: 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.

### ●Recommended Operating Range (Ta=25°C)

| Item                 | Symbol          | Range       | Unit |
|----------------------|-----------------|-------------|------|
| Power supply voltage | V <sub>CC</sub> | 8.0 to 26.4 | V    |

●Electrical Characteristic (Unless otherwise specified Ta=25°C, V<sub>CC</sub>=24V)

| Item                                | Symbol               | Limit                |                     |                       | Unit              | Condition             |
|-------------------------------------|----------------------|----------------------|---------------------|-----------------------|-------------------|-----------------------|
|                                     |                      | Min                  | Typ                 | Max                   |                   |                       |
| [Whole]                             |                      |                      |                     |                       |                   |                       |
| Circuit current                     | I <sub>CC</sub>      | -                    | 2.5                 | 5.0                   | mA                | V <sub>ENB</sub> =0V  |
| Stand-by current                    | I <sub>STBY</sub>    | -                    | 0.6                 | 1.2                   | mA                | ENB=OPEN              |
| VREG voltage                        | V <sub>REG</sub>     | 4.5                  | 5.0                 | 5.5                   | V                 | I <sub>O</sub> =-10mA |
| [Booster circuit]                   |                      |                      |                     |                       |                   |                       |
| VG voltage                          | V <sub>G</sub>       | V <sub>CC</sub> +6   | V <sub>CC</sub> +7  | V <sub>CC</sub> +8    | V                 |                       |
| VG UVLO voltage                     | V <sub>GUVON</sub>   | V <sub>CC</sub> +3   | V <sub>CC</sub> +4  | V <sub>CC</sub> +5    | V                 |                       |
| [Driver output]                     |                      |                      |                     |                       |                   |                       |
| High side output voltage H          | V <sub>OHH</sub>     | V <sub>G</sub> -0.6  | V <sub>G</sub> -0.2 | V <sub>G</sub>        | V                 | I <sub>O</sub> =-5mA  |
| High side output voltage L          | V <sub>OHL</sub>     | 0                    | 0.2                 | 0.6                   | V                 | I <sub>O</sub> =5mA   |
| Low side output voltage H           | V <sub>OLH</sub>     | 4.1                  | 4.8                 | 5.5                   | V                 | I <sub>O</sub> =-5mA  |
| Low side output voltage L           | V <sub>OLL</sub>     | 0                    | 0.2                 | 0.6                   | V                 | I <sub>O</sub> =5mA   |
| Source current of High side         | I <sub>HSOURCE</sub> | 100                  | 130                 | -                     | mA                | Pulse width tw≤1usec  |
| Sink current of High side           | I <sub>HSINK</sub>   | 50                   | 65                  | -                     | mA                | Pulse width tw≤1usec  |
| Source current of Low side          | I <sub>LSOURCE</sub> | 50                   | 65                  | -                     | mA                | Pulse width tw≤1usec  |
| Sink current of Low side            | I <sub>LSINK</sub>   | 100                  | 130                 | -                     | mA                | Pulse width tw≤1usec  |
| Dead Time                           | T <sub>DT</sub>      | 0.7                  | 1.0                 | 1.3                   | μsec              |                       |
| [Hall input]                        |                      |                      |                     |                       |                   |                       |
| Input bias current                  | I <sub>HALL</sub>    | -2.0                 | -0.1                | 2.0                   | μA                | V <sub>IN</sub> =0V   |
| Range of in-phase input voltage     | V <sub>HALLCM</sub>  | 0                    | -                   | V <sub>REG</sub> -1.7 | V                 |                       |
| Minimum input voltage               | V <sub>HALLMIN</sub> | 50                   | -                   | -                     | mV <sub>p-p</sub> |                       |
| HYS level +                         | V <sub>HALLHY+</sub> | 5                    | 15                  | 25                    | mV                |                       |
| HYS level -                         | V <sub>HALLHY-</sub> | -25                  | -15                 | -5                    | mV                |                       |
| [Input of control : ENB]            |                      |                      |                     |                       |                   |                       |
| Input current                       | I <sub>ENB</sub>     | -75                  | -45                 | -25                   | μA                | V <sub>ENB</sub> =0V  |
| Standby voltage                     | V <sub>STBY</sub>    | 2.0                  | -                   | 5.5                   | V                 |                       |
| Enable voltage                      | V <sub>ENA</sub>     | 0                    | -                   | 0.8                   | V                 |                       |
| [Input of control : PWMB, CW, BRKB] |                      |                      |                     |                       |                   |                       |
| Input current                       | I <sub>IN</sub>      | -80                  | -50                 | -30                   | μA                | V <sub>IN</sub> =0V   |
| Voltage input H                     | V <sub>INH</sub>     | 2.0                  | -                   | 5.5                   | V                 |                       |
| Voltage input L                     | V <sub>INL</sub>     | 0                    | -                   | 0.8                   | V                 |                       |
| Minimum input pulse width           | t <sub>PLSMIN</sub>  | 1                    | -                   | -                     | msec              | CW, BRKB              |
| Range of input frequency            | F <sub>PWM</sub>     | 10                   | -                   | 50                    | kHz               | PWMB                  |
| [Input of control : LPE]            |                      |                      |                     |                       |                   |                       |
| Input current                       | I <sub>LPE</sub>     | -160                 | -100                | -60                   | μA                | V <sub>LPE</sub> =0V  |
| Input voltage H                     | V <sub>LPH</sub>     | 0.8×V <sub>REG</sub> | -                   | V <sub>REG</sub>      | V                 |                       |
| Input voltage M                     | V <sub>LPM</sub>     | 0.4×V <sub>REG</sub> | -                   | 0.6×V <sub>REG</sub>  | V                 |                       |
| Input voltage L                     | V <sub>LPL</sub>     | 0                    | -                   | 0.2×V <sub>REG</sub>  | V                 |                       |
| [FG output]                         |                      |                      |                     |                       |                   |                       |
| Output voltage L                    | V <sub>FGOL</sub>    | 0                    | 0.1                 | 0.3                   | V                 | I <sub>O</sub> =2mA   |
| Leak current                        | I <sub>FGLEAK</sub>  | -                    | 0                   | 1                     | μA                | V <sub>FG</sub> =5V   |
| [Current limit]                     |                      |                      |                     |                       |                   |                       |
| Detect voltage                      | V <sub>CL</sub>      | 0.18                 | 0.20                | 0.22                  | V                 |                       |
| Input bias current                  | I <sub>RCL</sub>     | -32                  | -20                 | -12                   | μA                | V <sub>RCL</sub> =0V  |
| Range of input voltage              | V <sub>RCL</sub>     | -0.3                 | -                   | 1.0                   | V                 |                       |

**●Electrical Characteristic (Unless otherwise specified Ta=25°C, V<sub>CC</sub>=24V)**

| Item                              | Symbol            | Limit |      |      | Unit | Condition      |
|-----------------------------------|-------------------|-------|------|------|------|----------------|
|                                   |                   | Min   | Typ  | Max  |      |                |
| [UVLO]                            |                   |       |      |      |      |                |
| Release voltage                   | V <sub>UVH</sub>  | 6.5   | 7.0  | 7.5  | V    |                |
| Lock out voltage                  | V <sub>UVL</sub>  | 5.5   | 6.0  | 6.5  | V    |                |
| [OVLO]                            |                   |       |      |      |      |                |
| Release voltage1                  | V <sub>OVL1</sub> | 14.0  | 15.0 | 16.0 | V    | LPE="M"        |
| Lock out voltage1                 | V <sub>OVH1</sub> | 15.0  | 16.0 | 17.0 | V    | LPE="M"        |
| Release voltage2                  | V <sub>OVL2</sub> | 26.5  | 27.5 | 28.5 | V    | LPE="H" or "L" |
| Lock out voltage2                 | V <sub>OVH2</sub> | 27.5  | 28.5 | 29.5 | V    | LPE="H" or "L" |
| [MLP]                             |                   |       |      |      |      |                |
| Motor lock protection detect time | T <sub>LPE</sub>  | 0.77  | 1.10 | 1.43 | sec  | LPE="H" or "M" |

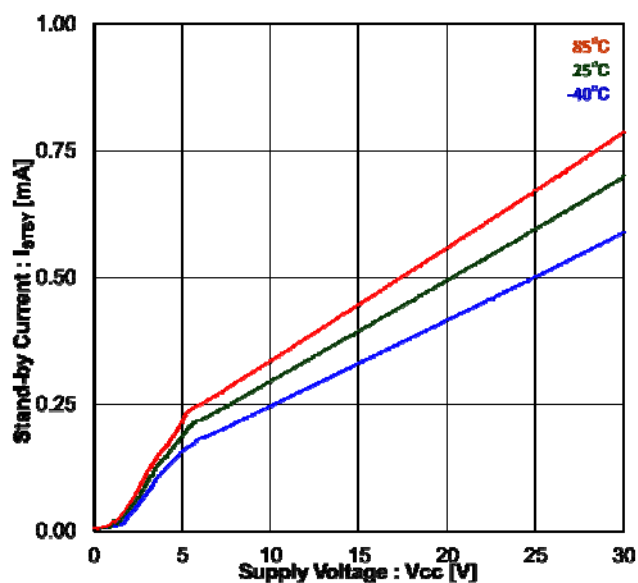
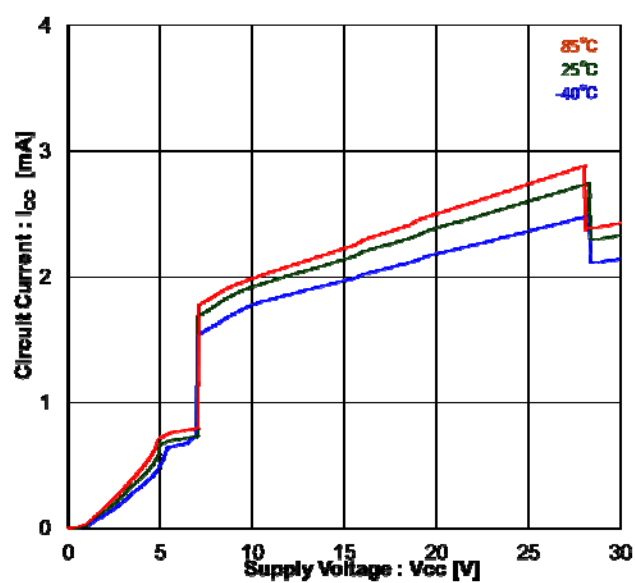
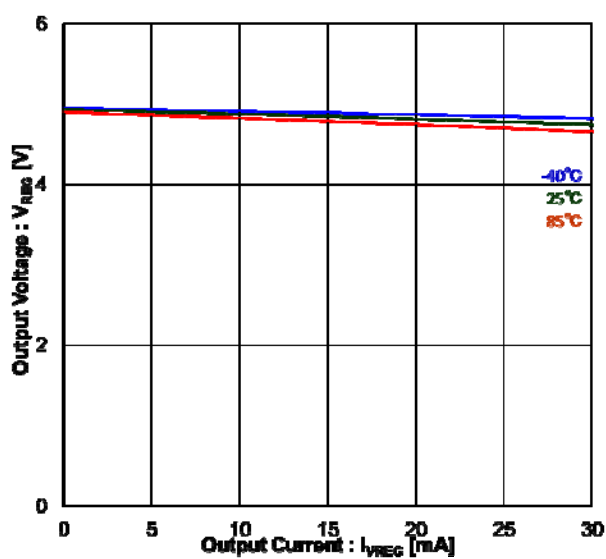
**●Reference Data (Unless otherwise specified V<sub>CC</sub>=24V)**

| Reference Data (Unless Otherwise Specified VCC=2.4V) |                     |           |     |     |      |                           |
|------------------------------------------------------|---------------------|-----------|-----|-----|------|---------------------------|
| Item                                                 | Symbol              | Reference |     |     | Unit | Condition                 |
|                                                      |                     | Min       | Typ | Max |      |                           |
| [Current limit]                                      |                     |           |     |     |      |                           |
| Mask time                                            | T <sub>CLMASK</sub> | 0.7       | -   | 2.6 | μsec | Ta=25°C                   |
| [Protect]                                            |                     |           |     |     |      |                           |
| TSD ON temperature                                   | T <sub>TSDON</sub>  | 150       | 175 | 200 | °C   | Junction temperature (Tj) |
| TSD Hysteresis                                       | T <sub>TSDHYS</sub> | 15        | 25  | 35  | °C   | Junction temperature (Tj) |

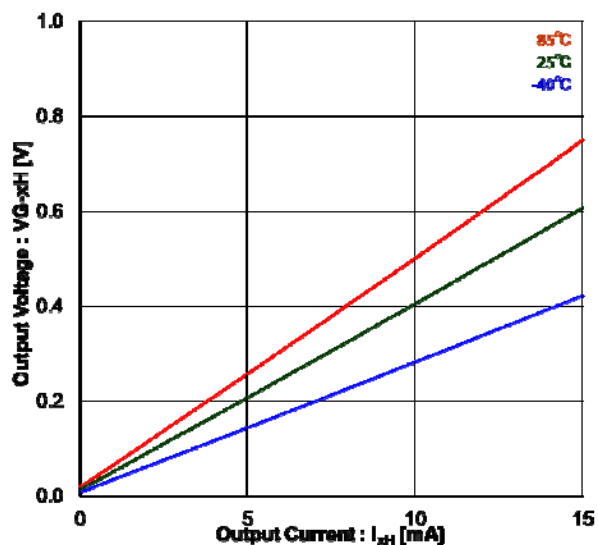
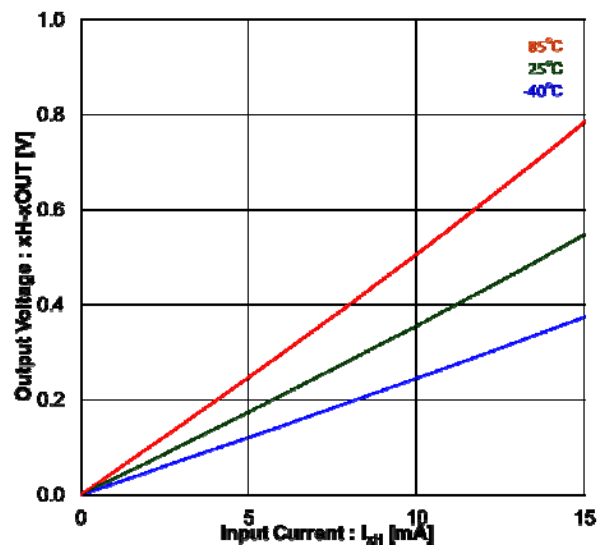
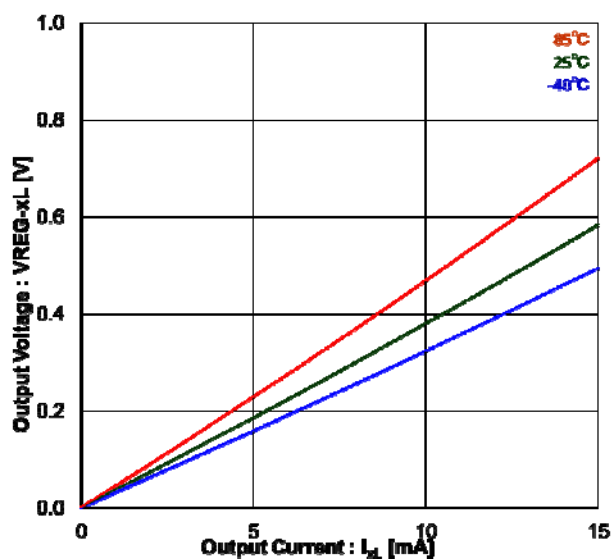
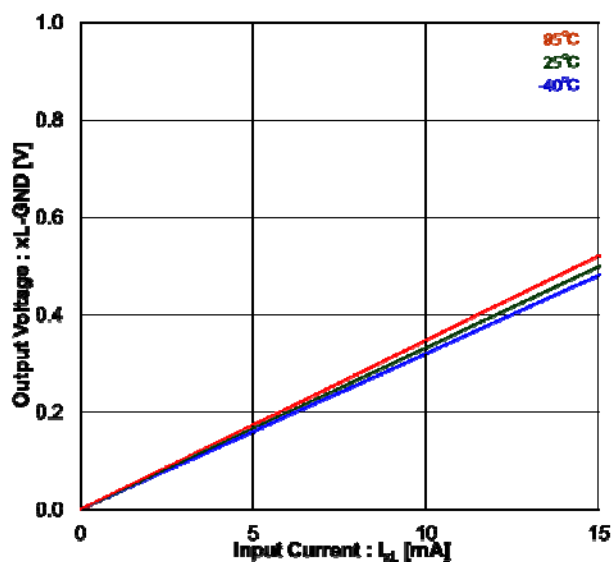
Above-Data for reference, not under guaranteed.



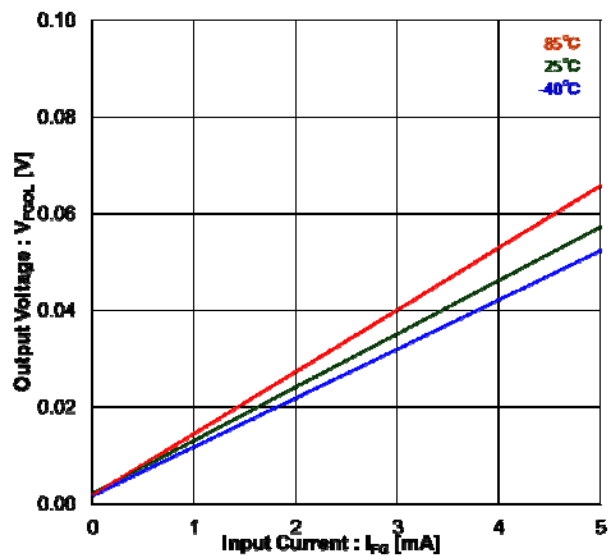
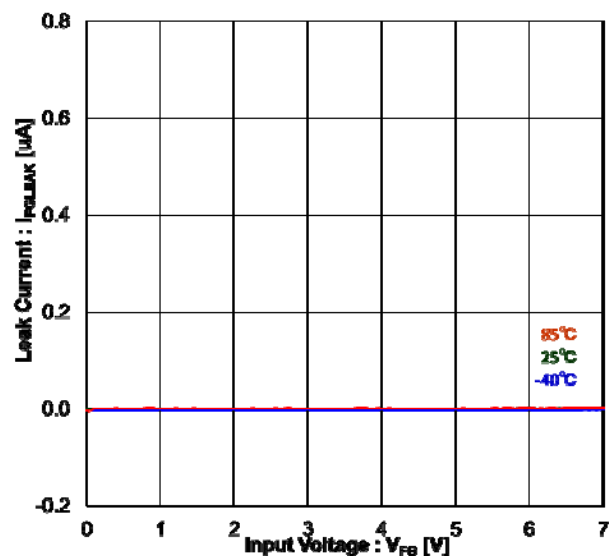
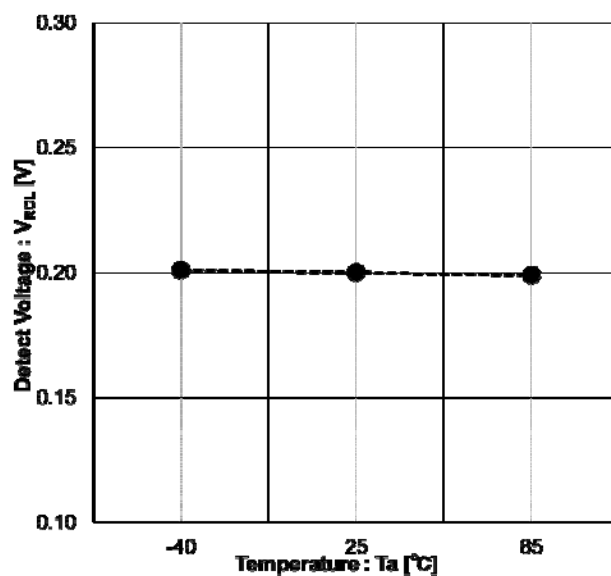
## Typical Performance Curves (Reference Data)

Figure 4. Stand-by Current vs Supply Voltage  
(Stand-by Current)Figure 5. Circuit Current vs Supply Voltage  
(Circuit Current)Figure 6. Output Voltage vs Output Current  
(VREG Voltage)

## Typical Performance Curves (Reference Data) - continued

Figure 7. Output Voltage vs Output Current  
(High side Output voltage H)Figure 8. Output Voltage vs Output Current  
(High side Output voltage L)Figure 9. Output Voltage vs Output Current  
(Low side Output voltage H)Figure 10. Output Voltage vs Output Current  
(Low side Output voltage L)

## Typical Performance Curves (Reference Data) - continued

Figure 11. Output Voltage vs Input Current  
(FG Output Voltage L)Figure 12. Leak Current vs Input Voltage  
(FG Leak Current)Figure 13. Detect Voltage vs Temperature  
(CL Detect Voltage)

## Typical Performance Curves (Reference Data) - continued

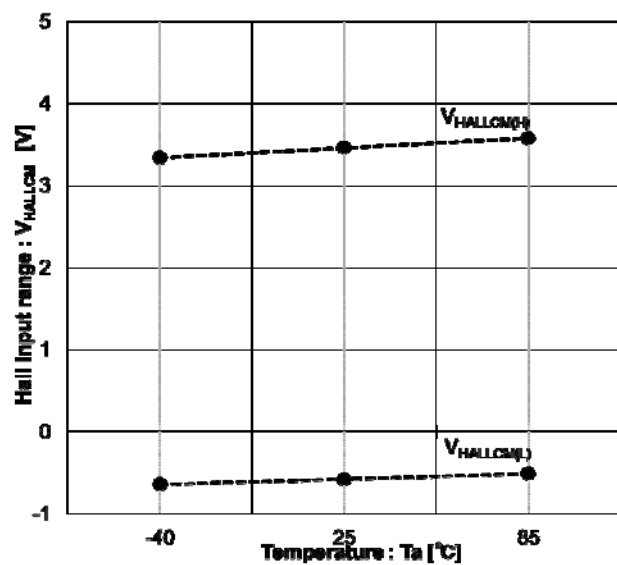


Figure 14. Input Range vs Temperature  
(Range of in-phase input voltage for Hall input)

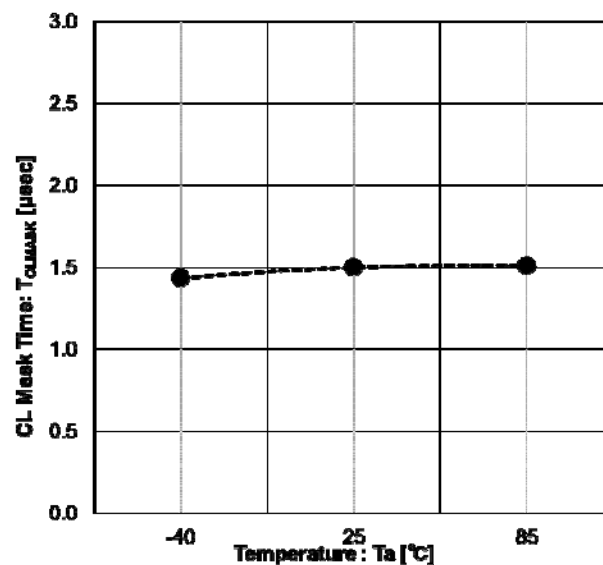


Figure 15. CL Mask Time vs Temperature  
(Current Limit Mask time)

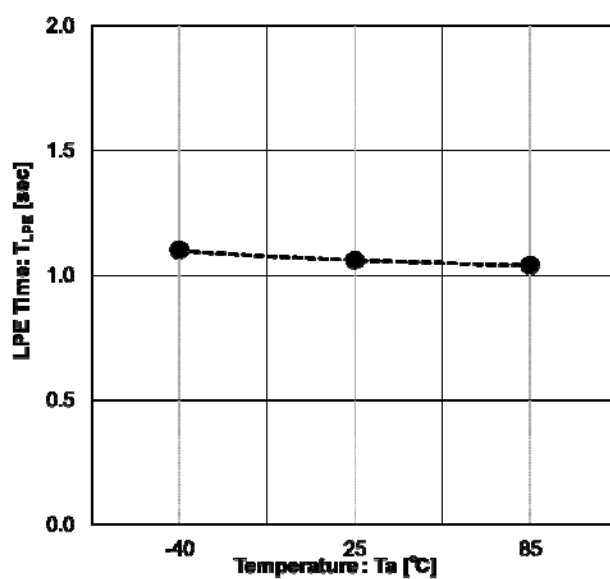
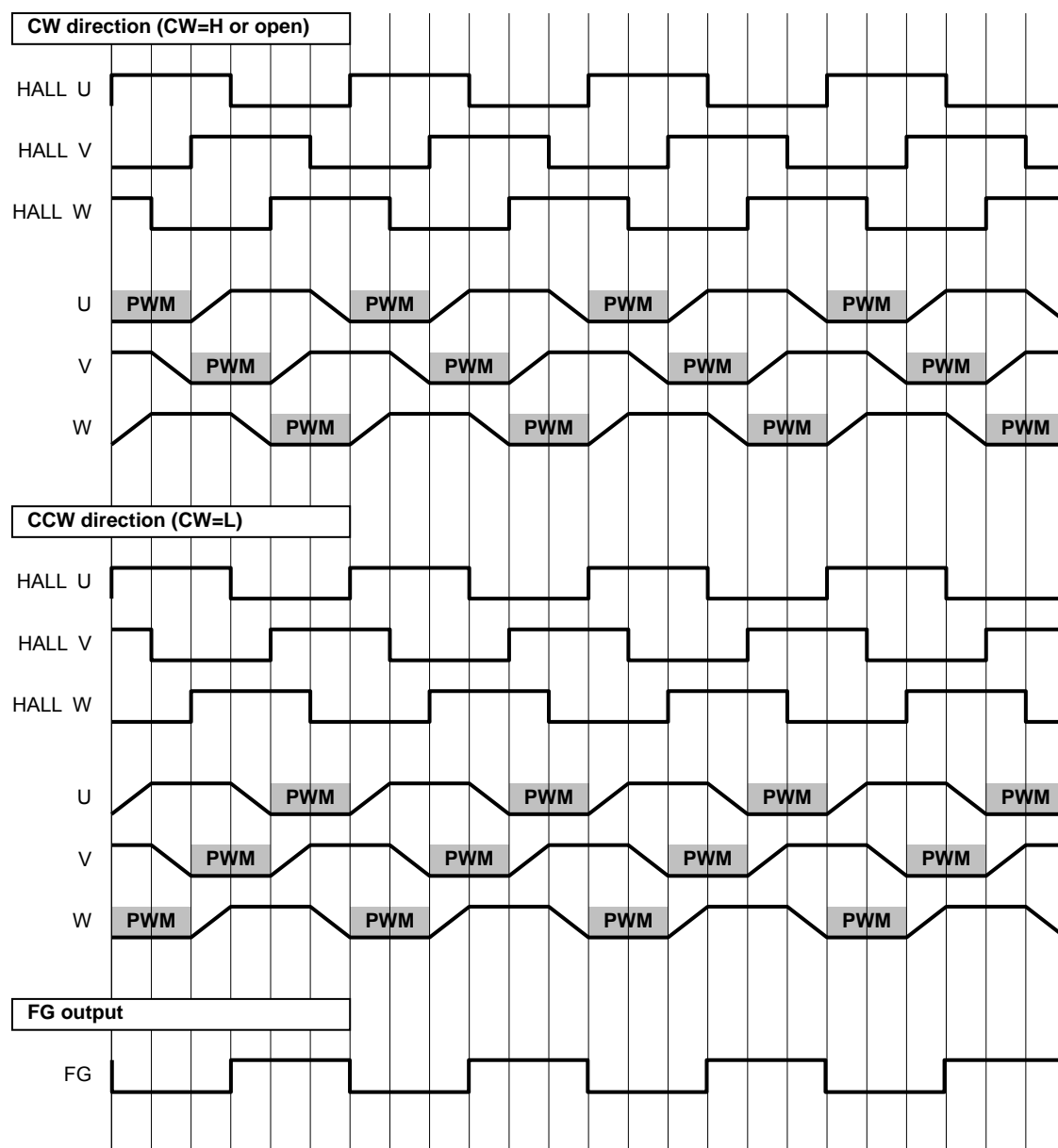
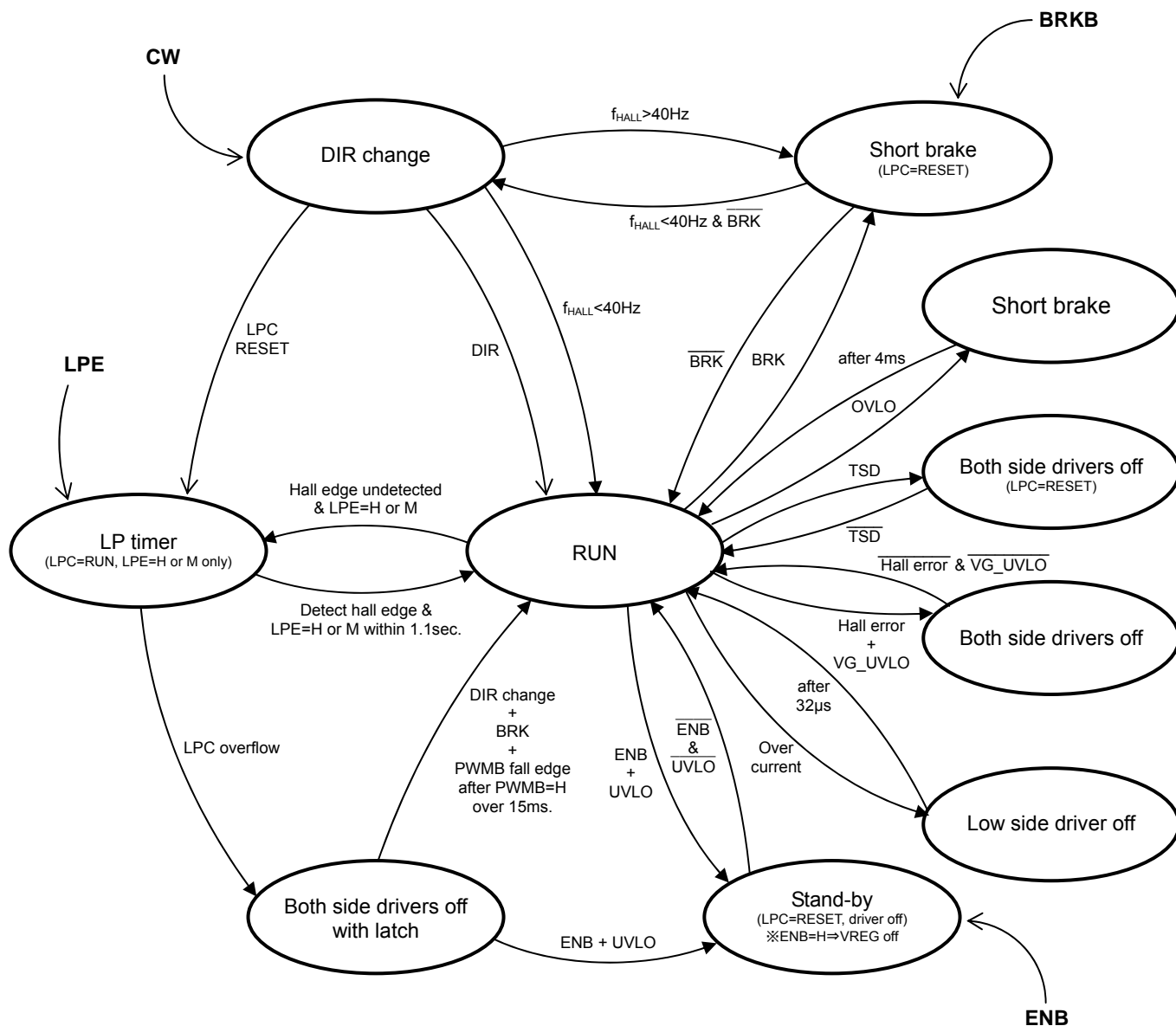


Figure 16. LPE Time vs Temperature  
(Detect Time of Motor Lock Protection)

# ●Timing Chart



## ●State transition diagram

**Legend:**

DIR: motor rotational direction  
 LP: motor lock protection  
 LPC: internal counter for the motor lock protection (watch-dog timer)  
 $f_{HALL}$ : hall signal frequency  
 Hall error: HU=HV=HW  
 &: logical "AND"  
 +: logical "OR"

Note) All values are typical.

→ State transition  
 → Command signal

I/O equivalence circuits

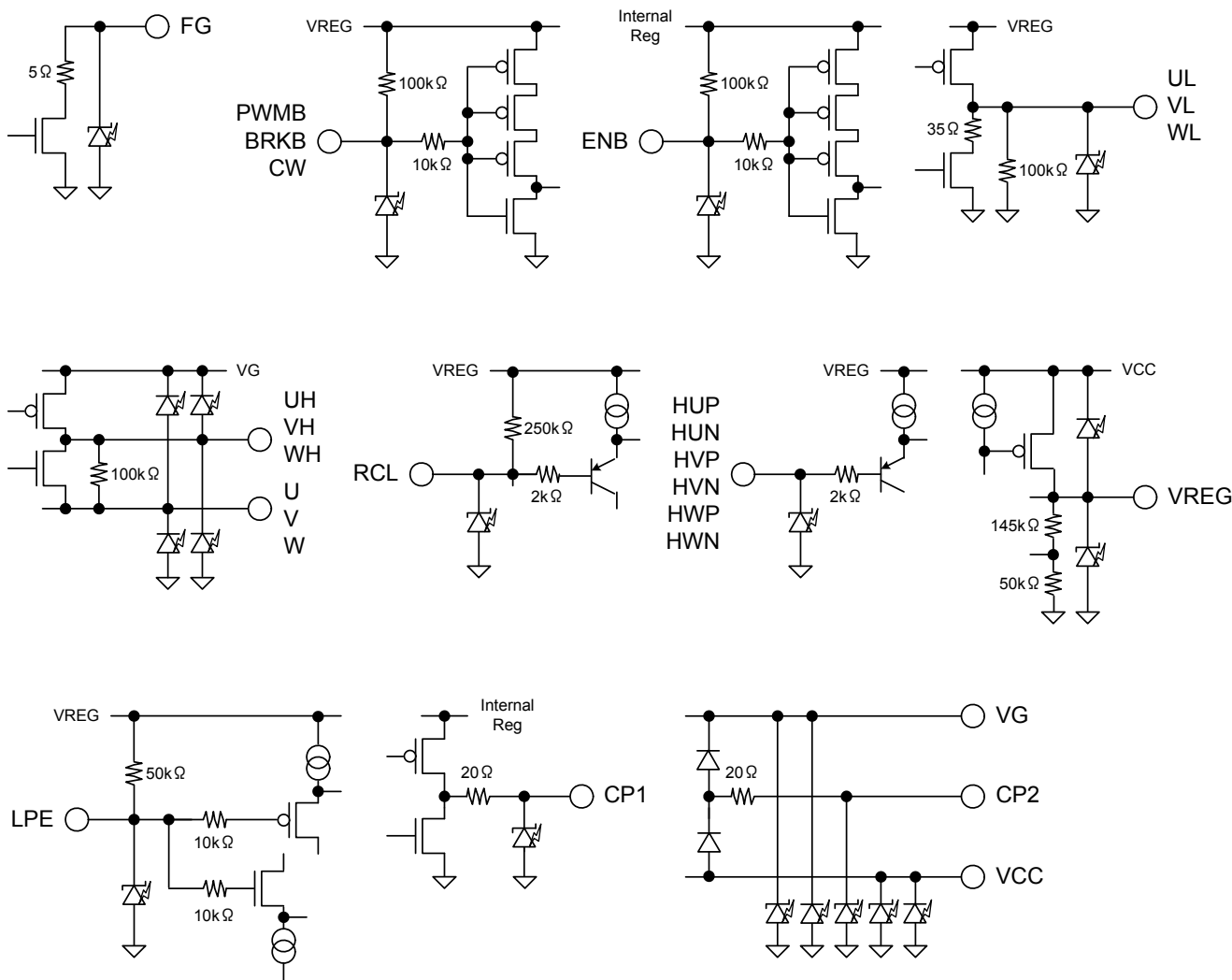


Figure 17. I/O equivalence circuits

Power Dissipation

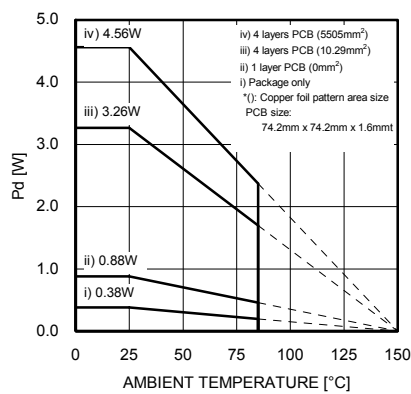


Figure 18. Derating curve (VQFN028V5050)

Package thermal resistor

| Board     | $\theta_{j-a}$ [°C/W] |
|-----------|-----------------------|
| Board (4) | 27.4                  |
| Board (3) | 38.3                  |
| Board (2) | 142.0                 |
| Board (1) | 328.9                 |

Note) Values about heat reducing curve and packaged thermal resistor are tested values.

## 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**

Except for pins the output and the input of which were designed to go below ground, ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

**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. Thermal Consideration**

Should by any chance the power dissipation 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, increase the board size and copper area to prevent exceeding the Pd rating.

**6. Recommended Operating Conditions**

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

**7. 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.

**8. Operation Under Strong Electromagnetic Field**

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

**9. 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.

**10. 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.



## Operational Notes – continued

**11. 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.

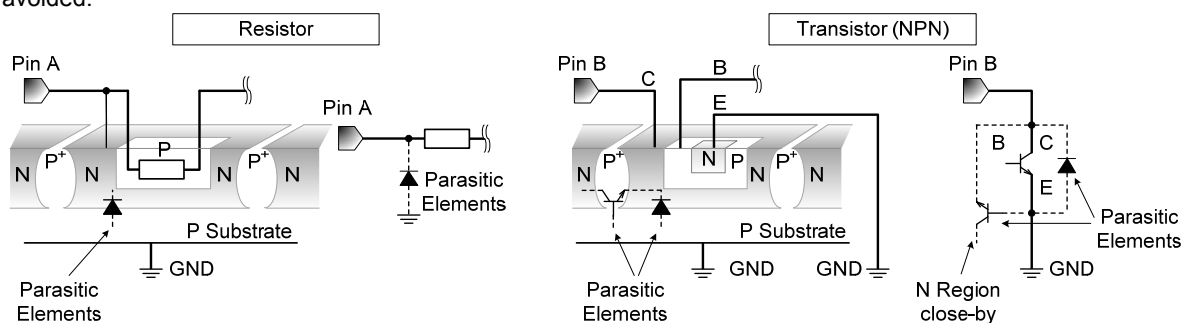
**12. Regarding the Input Pin of the IC**

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 19. Example of monolithic IC structure**

**13. Ceramic Capacitor**

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

**14. 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 power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that will turn OFF all output pins. When the  $T_j$  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.

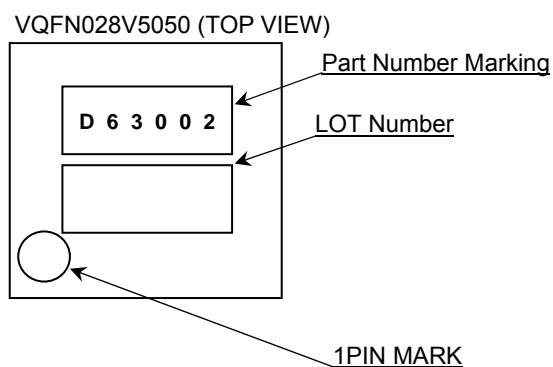
**15. Metal on the backside (Define the side where product markings are printed as front)**

The metal on the backside is shorted with the backside of IC chip therefore it should be connected to GND. Be aware that here is a possibility of malfunction or destruction if it is shorted with any potential other than GND.

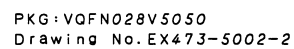
### ●Ordering Information

|                     |  |  |  |  |  |  |  |  |  |                   |                                     |
|---------------------|--|--|--|--|--|--|--|--|--|-------------------|-------------------------------------|
| B D 6 3 0 0 2 M U V |  |  |  |  |  |  |  |  |  | -                 | E 2                                 |
| Part Number         |  |  |  |  |  |  |  |  |  | Package           | Packaging and forming specification |
|                     |  |  |  |  |  |  |  |  |  | MUV: VQFN028V5050 | E2: Embossed tape and reel          |

### ●Marking Diagram



|              |              |
|--------------|--------------|
| Package Name | VQFN028V5050 |
|--------------|--------------|



TSZ02201-0P2P0B000840-1-2  
3.Jul.2015 Rev.002

## ●Revision History

| Date        | Revision | Changes                                                       |
|-------------|----------|---------------------------------------------------------------|
| 25.Feb.2015 | 001      | New Release                                                   |
| 3.Jul.2015  | 002      | Add Electrical Characteristics and Typical Performance Curves |

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|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

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  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
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  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- 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.
- De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

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

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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<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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.

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Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А