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Datasheet

# For 3-phase DC Brushless Motor Level Shifter

## BD67891MUV

### General Description

BD67891MUV is a level-shifter that converts control logic signals from the ASIC to signals for direct driving of the external FET's gate as well as Hall and FG output signals from the motor side for input signals to the ASIC during 3-phase DC brushless motor driving.
Additional features include a current limit function that enables setting of the OFF time by external CR, a thermal shutdown circuit and under voltage lock out circuit for high reliability operation.
A power save function is also integrated that reduces circuit current during standby, contributing to greater overall energy savings.

### Features

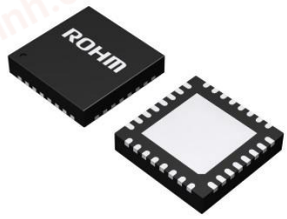
- Compatible with 2.5 V to 5.0 V ASICs
- Compatible with a Wide Range of Motor Power Supply Voltage (20 V to 40 V)
- Power Save Function (standby mode circuit current: $I_{MM}$ = 200 µA (Max))
- Current Limiter Function (OFF time set by external CR)
- Directly Driving External Pch/Nch FETs
- Built-in Logic Input Pull-down Resistor
- Thermal Shutdown Circuit (TSD)
- Under Voltage Lock Out Circuit (UVLO)
- Microminiature, Ultra-thin and High Heat-radiation (exposed metal type) Package

### Applications

- Pre-drivers for 3-phase Motor
- Level Shifter

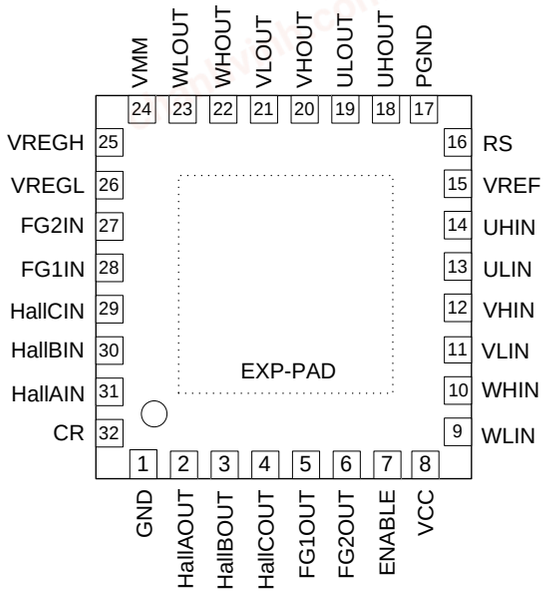
### Package

| | W (Typ) x D (Typ) x H (Max) |
|---|---|
| VQFN032V5050 | 5.0 mm x 5.0 mm x 1.0 mm |



### Pin Configuration

(TOP VIEW)




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○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays


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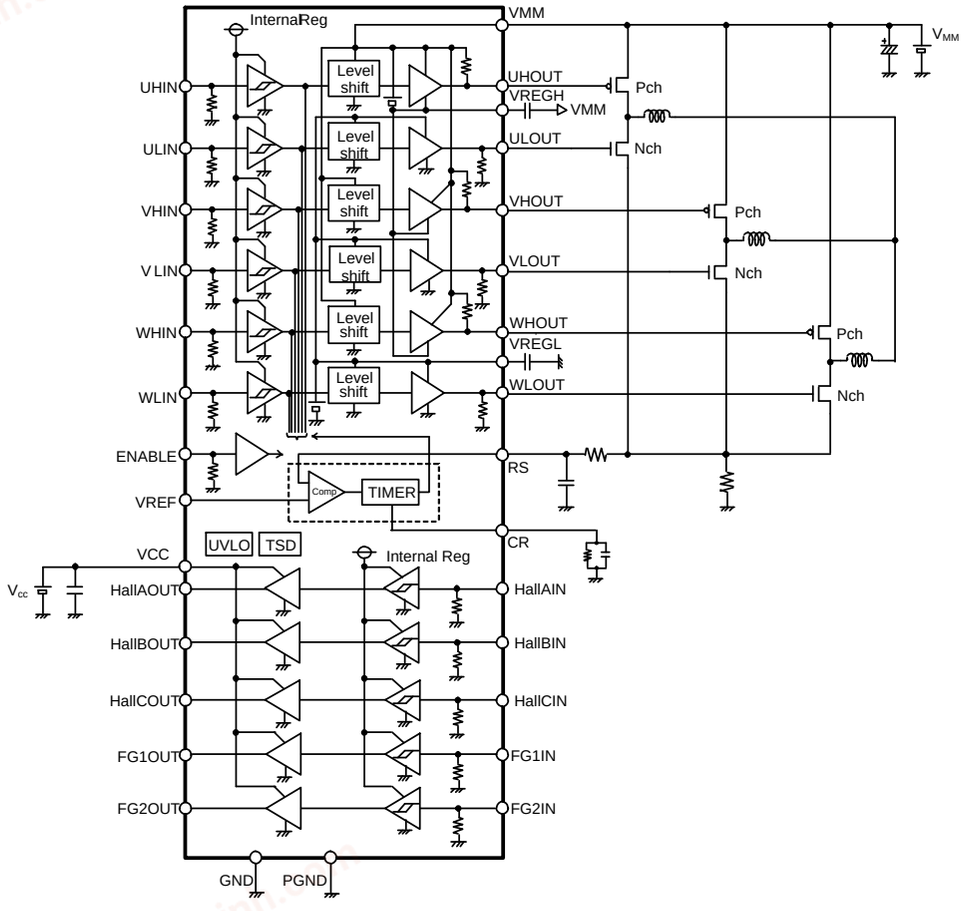
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## Pin Description

| Pin No. | Pin name | Function | Pin No. | Pin name | Function |
|---|---|---|---|---|---|
| 1 | GND | Ground pin | 17 | PGND | Ground pin |
| 2 | HallAOUT | Hall signal output pin | 18 | UHOUT | External FET gate driving pin |
| 3 | HallBOUT | Hall signal output pin | 19 | ULOUT | External FET gate driving pin |
| 4 | HallCOUT | Hall signal output pin | 20 | VHOUT | External FET gate driving pin |
| 5 | FG1OUT | FG signal output pin | 21 | VLOUT | External FET gate driving pin |
| 6 | FG2OUT | FG signal output pin | 22 | WHOUT | External FET gate driving pin |
| 7 | ENABLE | Power save pin | 23 | WLOUT | External FET gate driving pin |
| 8 | VCC | Power supply pin | 24 | VMM | Power supply pin |
| 9 | WLIN | Logic input pin | 25 | VREGH | Reference voltage pin for external FET gate driving |
| 10 | WHIN | Logic input pin | 26 | VREGL | Reference voltage pin for external FET gate driving |
| 11 | VLIN | Logic input pin | 27 | FG2IN | FG signal input pin |
| 12 | VHIN | Logic input pin | 28 | FG1IN | FG signal input pin |
| 13 | ULIN | Logic input pin | 29 | HallCIN | Hall signal input pin |
| 14 | UHIN | Logic input pin | 30 | HallBIN | Hall signal input pin |
| 15 | VREF | Current limit value setting pin | 31 | HallAIN | Hall signal input pin |
| 16 | RS | Current limit comparator input pin | 32 | CR | Current limit off-time setting pin |
| - | EXP-PAD | The EXP-PAD is connected to GND. | - | - | - |

## Block Diagram and Applications Circuit Diagram





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

| Parameter | Symbol | Limit | Unit |
|---|---|---|---|
| Supply Voltage | $V_{MM}$ | 45 | V |
| Supply Voltage | $V_{CC}$ | 7 | V |
| Control Input Voltage | $V_{IN}$ | -0.2 to +7.0 | V |
| Power Dissipation | Pd | 880*(Note 1)* | mW |
| Output Current | $I_{OUT(DC)}$ | 50*(Note 2)* | mA |
| Storage Temperature Range | Tstg | -55 to +150 | °C |
| Maximum Junction Temperature | Tjmax | 150 | °C |

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

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

*(Note 1)* When mounted on a 74.2 mm × 74.2 mm × 1.6 mm glass epoxy board (Single-layer board with 20.2 $mm^2$ copper foil).
Derated at 7.04 mW/*°C* above Ta = 25 *°C*.

*(Note 2)* Do not exceed Pd and Tjmax = 150 *°C*.

## Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Supply Voltage | $V_{MM}$ | 20 | 24 | 40 | V |
| Supply Voltage | $V_{CC}$ | 2.3 | 3.3 | 5.5 | V |
| Operating Temperature | Topr | -25 | +25 | +85 | °C |


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**Electrical Characteristics (Unless otherwise specified $V_{MM}$ = 24 V, Ta = 25 °C, Vcc = 3.3 V)**

| Parameter | Symbol | Limit | | | Unit | Conditions |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| **[Overall]** | | | | | | |
| Circuit Current 1 | $I_{MM1}$ | - | 2.5 | 4.0 | mA | ENABLE = L |
| Circuit Current 2 | $I_{MM2}$ | - | 90 | 200 | µA | ENABLE = H |
| Circuit Current 3 | $I_{CC}$ | - | 65 | 200 | µA | |
| **[Driver Block]** | | | | | | |
| **<Input>** (UHIN, ULIN, VHIN, VLIN, WHIN, WLIN) | | | | | | |
| High Level Input Current | $I_{INH}$ | 40 | 55 | 80 | µA | xHIN = 5.5 V, xLIN = 5.5 V |
| High Level Input Voltage | $V_{INH}$ | 2.0 | - | Vcc | V | |
| Low Level Input Voltage | $V_{INL}$ | 0 | - | 0.8 | V | |
| **<High Side FET Driver>** (UHOUT, VHOUT, WHOUT, VREGH) | | | | | | |
| VREGH Voltage | $V_{REGH}$ | $V_{MM}$ - 8.95 | $V_{MM}$ - 8.15 | $V_{MM}$ - 7.35 | V | |
| High Level Output Voltage | $V_{OH}H_{OUT}$ | $V_{MM}$ - 0.50 | $V_{MM}$ - 0.25 | $V_{MM}$ - 0.10 | V | $I_O$ = -10 mA |
| Low Level Output Voltage | $V_{OL}H_{OUT}$ | $V_{MM}$ - 8.75 | $V_{MM}$ - 7.80 | $V_{MM}$ - 6.75 | V | $I_O$ = 10 mA |
| **<Low Side FET Driver>** (ULOUT, VLOUT, WLOUT, VREGL) | | | | | | |
| VREGL Voltage | $V_{REGL}$ | 7.35 | 8.15 | 8.95 | V | |
| High Level Output Voltage | $V_{OH}L_{OUT}$ | 6.75 | 7.80 | 8.75 | V | $I_O$ = -10 mA |
| Low Level Output Voltage | $V_{OL}L_{OUT}$ | 0.10 | 0.25 | 0.50 | V | $I_O$ = 10 mA |
| **[Current Limit Block]** | | | | | | |
| RS Input Current | $I_{RS}$ | -2.0 | -0.1 | - | µA | RS = 0 V, VREF = 1.0 V |
| VREF Input Current | $I_{VREF}$ | -2.0 | -0.1 | - | µA | RS = 1.0 V, VREF = 0 V |
| VREF Input Voltage | $V_{REF}$ | 0 | - | 1.0 | V | |
| Comparator Input Offset Voltage | $V_{OFS}$ | -8 | - | 8 | mV | Ta = -25 °C to +85 °C |
| **[Hall/FG Signal Block]** (HallAIN, HallBIN, HallCIN, FG1IN, FG2IN, HallAOUT, HallBOUT, HallCOUT, FG1OUT, FG2OUT) | | | | | | |
| High Level Input Current | $I_{INH}$ | 40 | 55 | 80 | µA | HallxIN = 5.5 V, FGxIN = 5.5 V |
| High Level Input Voltage | $V_{INH}$ | 2.0 | - | 5.5 | V | |
| Low Level Input Voltage | $V_{INL}$ | 0 | - | 0.8 | V | |
| High Level Output Voltage | $V_{OH}$ | Vcc - 0.08 | Vcc - 0.04 | - | V | $I_O$ = -1 mA |
| Low Level Output Voltage | $V_{OL}$ | - | 0.04 | 0.08 | V | $I_O$ = 1 mA |
| **[ENABLE Signal Block]** | | | | | | |
| High Level Input Current | $I_{ENH}$ | 70 | 100 | 140 | µA | ENABLE = 5.5 V |
| High Level Input Voltage | $V_{ENH}$ | 2.0 | - | Vcc | V | |
| Low Level Input Voltage | $V_{ENL}$ | 0 | - | 0.8 | V | |


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## Function Explanation

### 1 ENABLE Pin

This pin is used to saving power. Supplying H voltage to the ENABLE pin initiates power save mode and reduces the circuit current $I_{MM}$ to 200 µA or less. In power save mode, all pre-driver outputs are OFF. But the external FET does not turn on because a pull-down or pull-up resistor is integrated. Be careful because there is a delay of 40 µs (Max) before it is returned from standby state to normal state and the pre-driver output becomes ACTIVE.

| ENABLE | State |
|---|---|
| L | ACTIVE |
| H | STAND-BY |

### 2 UHIN, ULIN, VHIN, VLIN, WHIN, WLIN Pin

These pins control the logic of the pre-driver output.

| ENABLE | xHIN | xLIN | xHOUT | xLOUT |
|---|---|---|---|---|
| L | L | L | $V_{MM}$ | 0 V |
| L | L | H | $V_{MM}$ | 8.15 V (Typ) |
| L | H | L | $V_{MM}$ - 8.15 V (Typ) | 0 V |
| L | H | H | $V_{MM}$ | 0 V |
| H | Don't care | Don't care | $V_{MM}$ (OPEN) | 0 V (OPEN) |

A pull-down resistor of 100 kΩ is integrated, along with a hysteresis function (200 mV (Typ)). In order to prevent malfunction and/or damage due to simultaneous ON, all external FETs are turned OFF when (xHIN, xLIN) is (H, H). Dead time that occurs during simultaneous ON while the motor is in operation can be controlled by ASIC signals.

### 3 VREGH Pin

This internally generated reference voltage is used for driving external high side Pch FET gate.
The VREGH pin should be decoupled with a 0.1 µF to 0.22 µF capacitor to VMM.

### 4 VREGL Pin

This internally generated reference voltage is used for driving external low side Nch FET gate.
The VREGL pin should be decoupled with a 0.1 µF to 0.22 µF capacitor to GND.

### 5 UHOUT, VHOUT, WHOUT Pin

These pins drive the gate of the external high side Pch FET.
A pull-up resistor of 200 kΩ is integrated between the output pin and VMM.

### 6 ULOUT, VLOUT, WLOUT Pin

These pins drive the gate of the external low side Nch FET.
A pull-down resistor of 200 kΩ is integrated between the output pin and GND.

### 7 HallAIN, HallBIN, HallCIN, FG1IN, FG2IN Pin

These pins are used for inputting the Hall and FG signals.
A pull-down resistor of 100 kΩ is integrated, along with hysteresis (200 mV (Typ)).

### 8 HallAOUT, HallBOUT, HallCOUT, FG1OUT, FG2OUT Pin

The signals inputted to the HallAIN, HallBIN, HallCIN, FG1IN, and FG2IN pins are output from these pins through the level shifter circuit. The output H voltage is approx the Vcc. Therefore, connecting the VCC pin to the ASIC power supply will cause the voltages to be equal and ensure that the signals output from the IC is matched to the ASIC.


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## Function Explanation – continued

### 9 VREF Pin

This pin is used to set the value of the current limit.
The current limit value ($I_{LIMIT}$) can be set by the VREF pin voltage and current-detecting resistor(RNF), be expressed the following equation:

$$I_{LIMIT} = \{(V_{REF} + V_{OFS})\} \times \frac{1}{RNF} \quad [A]$$

$I_{LIMIT}$ : is the output current.
$V_{REF}$ : is the voltage of output current value-setting pin.
$V_{OFS}$ : Is comparator input offset voltage.
$RNF$ : is the current-detecting resistor.

Set the VREF pin voltage to within the VREF input voltage range (0 V to 1 V).
Avoid leaving the VREF pin open, since doing so may cause the input to become unstable and VREF pin voltage to increase, which may lead to over-current and, ultimately, malfunction and/or damage. In addition, take into consideration the outflow current (2 μA (Max)) when selecting the resistor value for the resistor divider.

### 10 RS Pin

This pin is used to input the voltage transformed by the current-detecting resistor from the current flowing through the motor. The current-detecting resistor should be connected between the RS pin and GND.
In addition, select a resistor value for the current-detecting resistor so that the power consumption W = $I_{OUT}^2 \cdot R$ [W] does not exceed the rated power dissipation of the resistor. Current limiting operation is performed by comparing the VREF pin voltage with the RS pin voltage. Note that signals input to the RS pin may include PWM switching noise contained in the RS pin voltage. Therefore, it is recommended that the voltage input to the RS pin be processed by a low pass filter. Consideration must also be given to the wiring pattern in order to minimize impedance and prevent common impedance from occurring with other Ground patterns. Because the motor drive current flows from the Source pin of the external Nch FET through the current detection resistor to GND.

### 11 CR Pin

This pin is used to set the OFF time during current limiting operation.
Connect the external C (330 pF to 1500 pF) and R (15 kΩ to 200 kΩ) between the CR pin and GND.
The following formula is used to determine the OFF time:

$t_{OFF}$ [s] = C・R・0.916

Configure the circuit so that other Ground patterns do not share common impedance with the pattern between the external CR circuit and Ground. And implement designs in such a way that steep pulses (i.e. square waves) are not generated or noise introduced.

### 12 IC Back metal

The VQFN032V5050 package has a metal for heat dissipation on the back of the IC. Since it is assumed to be used by applying heat dissipation treatment to this metal, always GND on the substrate connect with the plane and solder, and use the GND pattern widely to ensure sufficient heat dissipation area. In addition, the backside metal is short with the back of the IC chip, so it has become a GND potential. Because there is a possibility of malfunction and destruction when it is short and the potential other than GND, never pass the wiring pattern other than GND on the back of the IC.


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## Current Limiting Function

### 1 Current Limit Operation

The motor rotates by switching ON and OFF the external FET, which causes current to flow through the motor. This current is transformed to voltage by the current detecting resistor, then passed through a CR filter before being input to the RS pin (since it most likely contains PWM switching noise). If the motor current increases and the RS pin voltage reaches the VREF pin voltage, the current limit comparator will activate and turn OFF the external FET. The output will be turned ON once the OFF time ($t_{OFF}$) is reached (determined by the CR timer).

### 2 Minimum ON time

During this time current limit operation is in effect and the output stage will turn ON after the OFF time has elapsed. The minimum ON time is determined by the external CR timer.

### 3 Current Limit Value Setting Example

First let us suppose that the current detecting resistor (RNF) is 0.05 Ω with an output current of 5 A:
If the Comparator Input Offset Voltage is 0 mV, the formula becomes:

5 [A] = VREF / 0.05 [Ω] → VREF = 0.25 [V]

The VREF pin voltage should be set 0.25 V by resistors.
The outflow current at the VREF pin is 2 μA (Max). It is important to set a bias current that will not cause fluctuation of the reference potential of the resistor division due to this outflow current.
For example, we will consider the effects of supplying a current 100 times larger than 2 μA (200 μA).
If the voltage applied to the resistor division is 5 V:

5 [V] / 200 [μA] = 25 [kΩ]

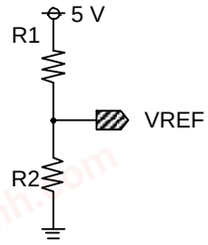
This resistor value is then broken up among two resistors,

($R_1$ + $R_2$ = 25 [kΩ])

Therefore, to ensure a VREF pin voltage of 0.25 V,

$$5\ [V] \times \frac{R2}{R1+R2} = 0.25\ [V]$$

$$\therefore R2 = 1.25\ [k\Omega]$$




From the total resistor requirement above, we arrive at the appropriate resistor values:

$R_1$ = 23.75 kΩ and $R_2$ = 1.25 kΩ

### 4 CR Timer

The CR filter connected to the CR pin is repeatedly charged and discharged between the VCRH and VCRL levels. The output of the internal comparator is masked while charging from VCRL to VCRH in order to cancel noise. This period defines the minimum ON-time of the motor output transistor. The CR pin begins discharging once the voltage reaches VCRH. When the output current reaches the current limit during this period (i.e. RS voltage reaches the VREF pin voltage), then the output is switched turn off. The CR continues to discharge during this period until it reaches VCRL, at which point the IC output is switched back ON. The current output and CR pin begin charging simultaneously. The CR charge time ($t_{ONMIN}$) and discharge time ($t_{DISCHARGE}$) are set by external components, according to the following formulas (Typ).

$$t_{ONMIN} \fallingdotseq C \times \frac{R' \times R}{R' + R} \times ln\left(\frac{V_{CR} - 1.0}{V_{CR} - 2.5}\right)\ [s]$$

$t_{ONMIN}$ : is the minimum ON-time.
$C$ : is the capacitance of the CR Pin.
$R$ : is the resistance of the CR Pin.
$R'$ : is the CR Pin internal impedance 5 kΩ (Typ)
$V_{CR}$ : is the CR Pin voltage.

$$V_{CR} = V \times \frac{R}{R' + R}\ [V]$$

$V$ : is the internal regulator voltage 5 V (Typ)

$$t_{DISCHARGE} \fallingdotseq C \times R \times 0.916\ [s]$$

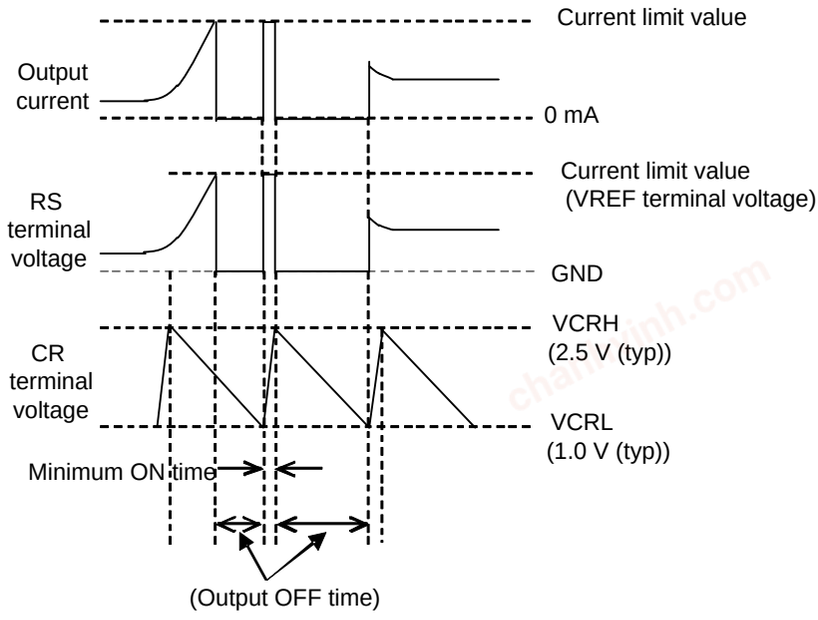
$t_{DISCHARGE}$ : is the CR discharge time.


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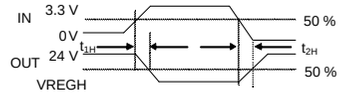
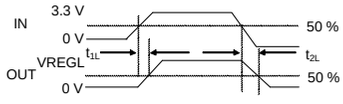
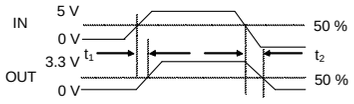
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### 4 CR Timer – continued




### Input/Output Delay Times

| Parameter | Symbol | Limit | | | Unit | Condition |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| **Driver block** | | | | | | |
| **<High side FET driver>** (UHOUT, VHOUT, WHOUT) | | | | | | |
| Propagation delay time 1 | $t_{1H}$ | - | 50 | 100 | ns |  |
| Propagation delay time 2 | $t_{2H}$ | - | 60 | 100 | ns | |
| **<Low side FET driver>** (ULOUT, VLOUT, WLOUT) | | | | | | |
| Propagation delay time 1 | $t_{1L}$ | - | 40 | 100 | ns |  |
| Propagation delay time 2 | $t_{2L}$ | - | 50 | 100 | ns | |
| **Hall/FG signal block** (HallAIN, HallBIN, HallCIN, FG1IN, FG2IN, HallAOUT, HallBOUT, HallCOUT, FG1OUT, FG2OUT) | | | | | | |
| Propagation delay time 1 | $t_1$ | - | 20 | 100 | ns |  |
| Propagation delay time 2 | $t_2$ | - | 50 | 100 | ns | |

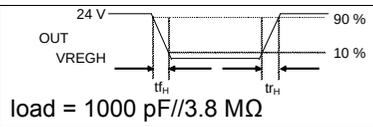
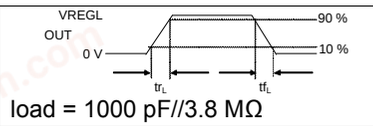
Input control signals after taking into consideration the delay time of the driver block in order to prevent turning on the external FETs simultaneously, which may result in malfunction and/or damage.


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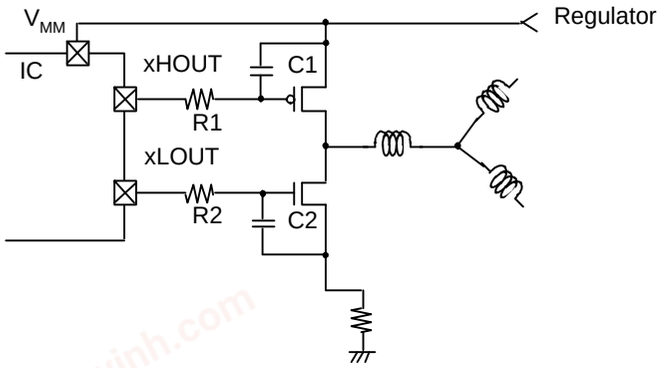
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### Rise/Fall times

| Parameter | Symbol | Limit | | | Unit | Condition |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| **Driver block** | | | | | | |
| **<High side FET driver>** (UHOUT, VHOUT, WHOUT) | | | | | | |
| Output transition time 1 | $tr_H$ | - | 60 | 200 | ns |  load = 1000 pF//3.8 MΩ |
| Output transition time 2 | $tf_H$ | - | 80 | 200 | ns | |
| **<Low side FET driver>** (ULOUT, VLOUT, WLOUT) | | | | | | |
| Output transition time 1 | $tr_L$ | - | 70 | 200 | ns |  load = 1000 pF//3.8 MΩ |
| Output transition time 2 | $tf_L$ | - | 70 | 200 | ns | |

Lengthen the times by connecting external CR circuits as shown below.




### Protection Circuits

**1 Thermal Shutdown (TSD)**

A thermal shutdown circuit is built in for protection against overheating. When the chip temperature rises 175 °C (Typ) or more, the output of pre-driver is controlled as the external FETs turns OFF. Normal operation automatically resumes once the temperature decreases to 150 °C (Typ) or less. Note that if heat is externally added damage may occur, even if TSD is in operation.

**2 Under Voltage Lock Out (UVLO)**

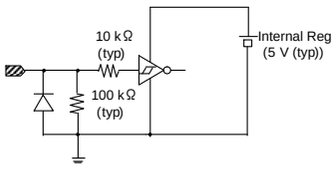
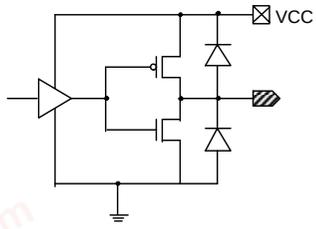
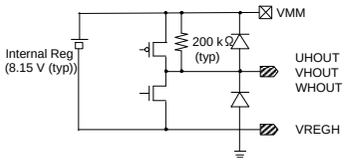
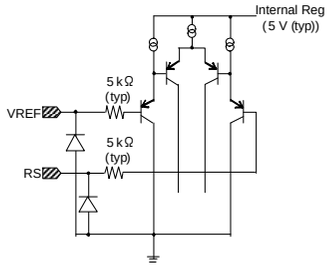
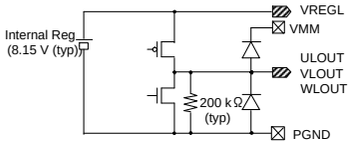
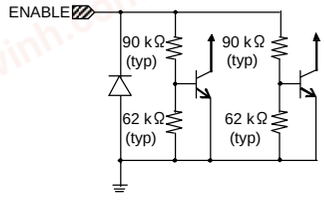
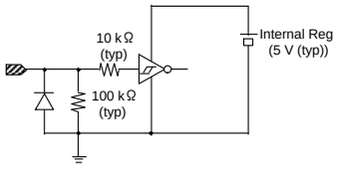
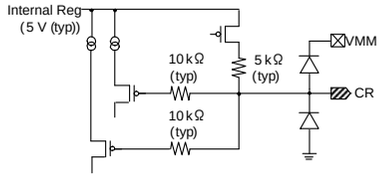
This IC has a built-in under voltage lock out function to prevent false operation such as IC output during power supply under voltage. When the applied voltage to the VMM pin goes to 15 V (Typ) or less, the output of pre-driver is controlled as the external FETs turn OFF. This switching voltage has 1 V (Typ) hysteresis to prevent false operation by noise etc. Be aware that this circuit does not operate during power save mode.


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## I/O Equivalence Circuit

| No. | Pin Name | Equivalence Circuit | No. | Pin Name | Equivalence Circuit |
|---|---|---|---|---|---|
| 31 | HallAIN |  | 2 | HallAOUT |  |
| 30 | HallBIN | | 3 | HallBOUT | |
| 29 | HallCIN | | 4 | HallCOUT | |
| 28 | FG1IN | | 5 | FG1OUT | |
| 27 | FG2IN | | 6 | FG2OUT | |
| 18 | UHOUT |  | 15 | VREF |  |
| 20 | VHOUT | | | | |
| 22 | WHOUT | | 16 | RS | |
| 25 | VREGH | | | | |
| 19 | ULOUT |  | 7 | ENABLE |  |
| 21 | VLOUT | | | | |
| 23 | WLOUT | | | | |
| 26 | VREGL | | | | |
| 14 | UHIN |  | 32 | CR |  |
| 13 | ULIN | | | | |
| 12 | VHIN | | | | |
| 11 | VLIN | | | | |
| 10 | WHIN | | | | |
| 9 | WLIN | | | | |


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## Operational Notes

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

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

**3 Ground Voltage**
Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

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

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

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

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

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

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


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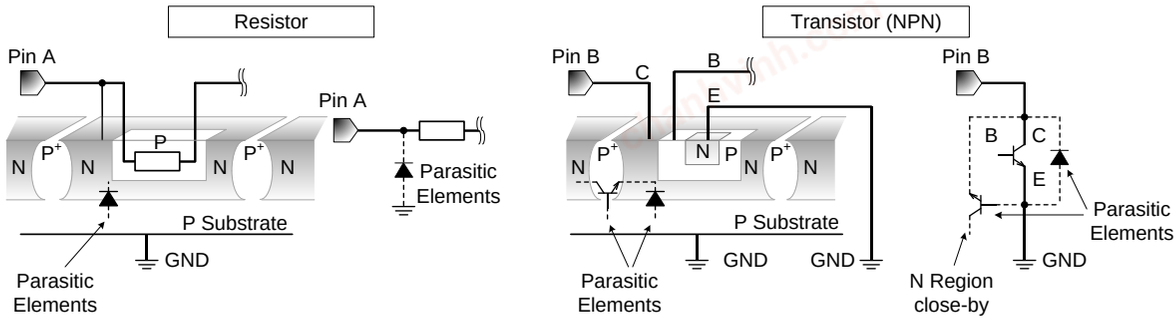
## Operational Notes – continued

### 10 Regarding the Input Pin of the IC

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

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

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




Example of Monolithic IC Structure

### 11 Ceramic Capacitor

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

### 12 Thermal Shutdown Circuit (TSD)

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

### 13 Over Current Protection Circuit (OCP)

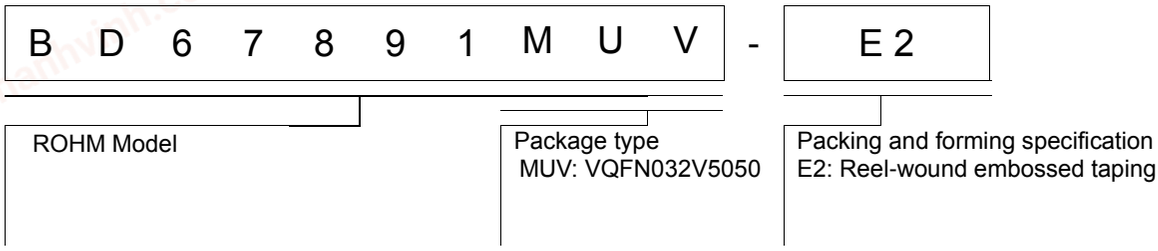
This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning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


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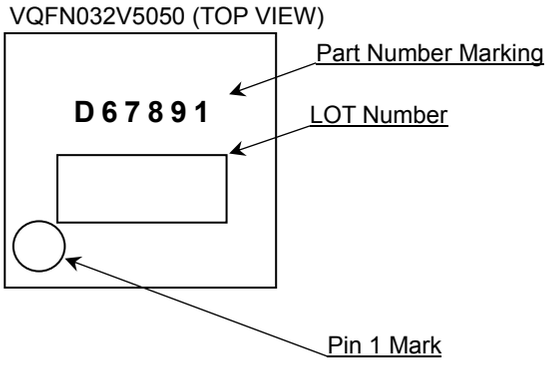
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## Ordering Information




## Marking Diagram





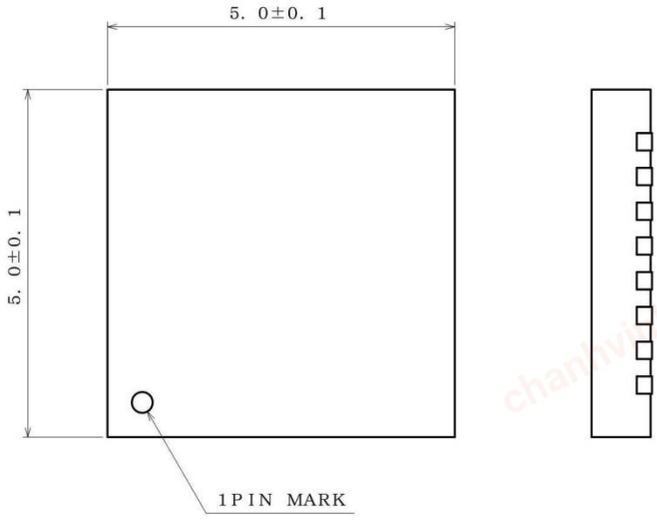
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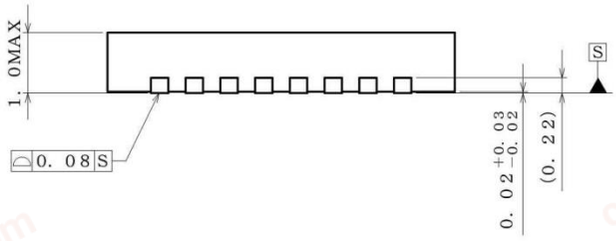
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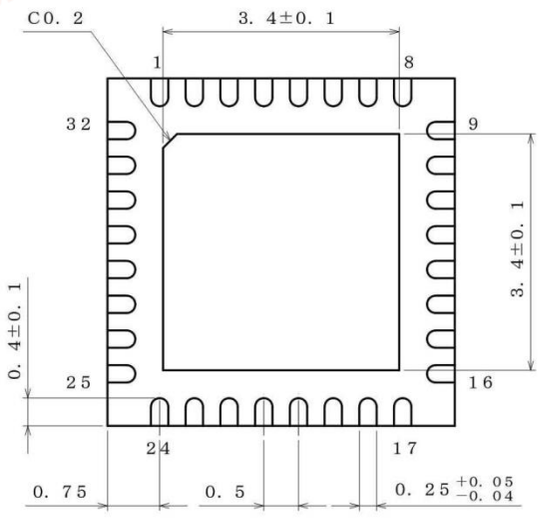


## Physical Dimension and Packing Information

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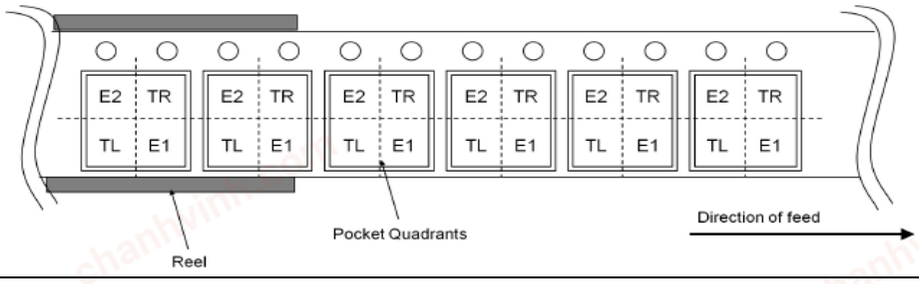




(UNIT : mm)
PKG : VQFN032V5050
Drawing No. EX461−5001−2

< Tape and Reel Information >

| Tape | Embossed carrier tape |
|---|---|
| Quantity | 2500pcs |
| Direction of feed | E2<br>The direction is the pin 1 of product is at the upper left<br>when you hold reel on the left hand and you pull out the tape on the right hand |





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## Revision History

| Date | Revision | Changes |
|---|---|---|
| 21.Dec.2020 | 001 | New Release |

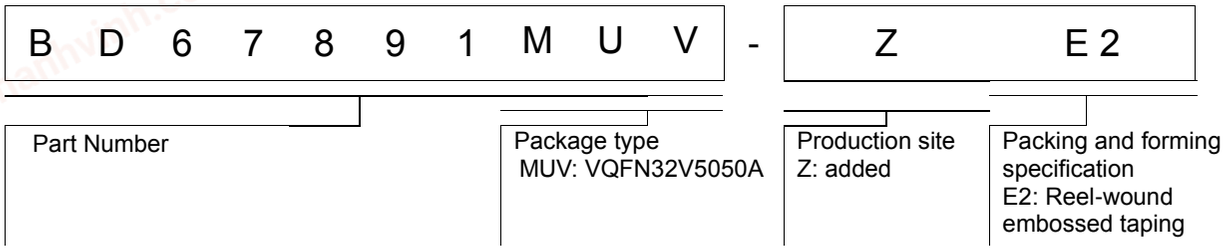
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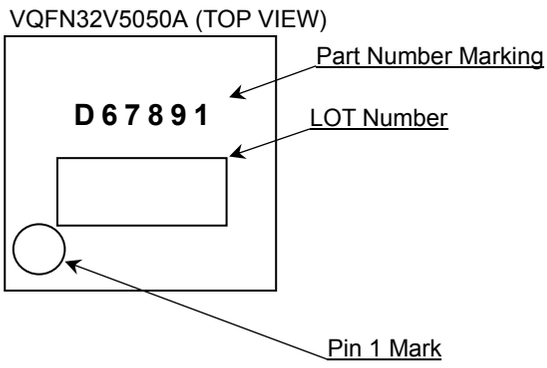
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## Ordering Information




## Marking Diagram





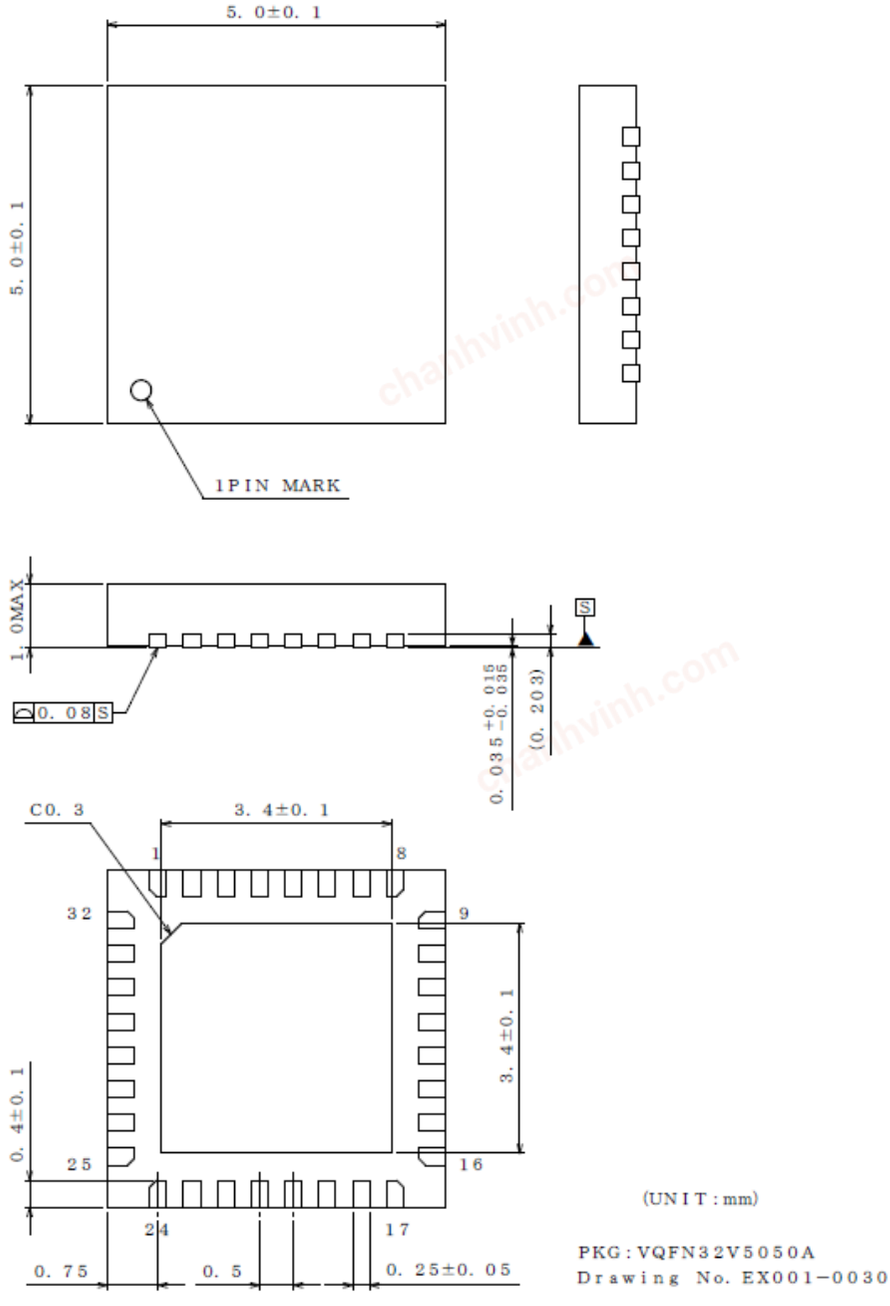
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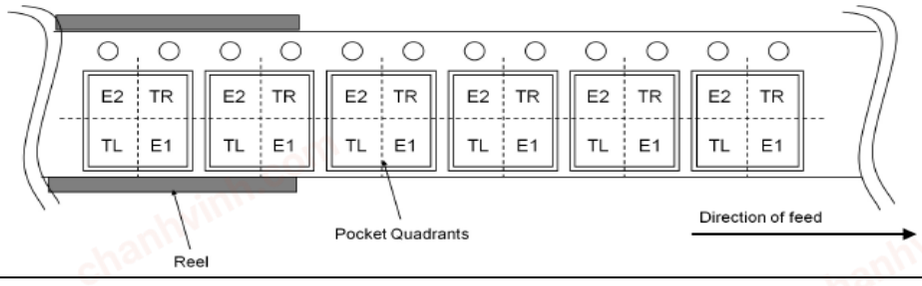
## Physical Dimension and Packing Information

| Package Name | VQFN32V5050A |
|---|---|




< Tape and Reel Information >

| | |
|---|---|
| Tape | Embossed carrier tape |
| Quantity | 2500pcs |
| Direction of feed | E2<br>The direction is the pin 1 of product is at the upper left<br>when you hold reel on the left hand and you pull out the tape on the right hand |





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(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN | USA | EU | CHINA |
|---|---|---|---|
| CLASSⅢ | CLASSⅢ | CLASSⅡb | CLASSⅢ |
| CLASSⅣ | | CLASSⅢ | |

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   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including $Cl_2$, $H_2S$, $NH_3$, $SO_2$, and $NO_2$
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

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

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification


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## Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

## Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

## Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including $Cl_2$, $H_2S$, $NH_3$, $SO_2$, and $NO_2$
   - [b] the temperature or humidity exceeds those recommended by ROHM
   - [c] the Products are exposed to direct sunshine or condensation
   - [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

## Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

## Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

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