

## H-Bridge Drivers for DC Brush Motors

# Single H-Bridge Driver High-Speed Switching Type

BD6376GUL

### General Description

The BD6376GUL provides a single H-bridge motor driver which features wide range of motor power supply voltage from 2.0V to 9.0V and low power consumption to switch low ON-Resistance DMOS transistors at high speed. This small surface mounting package is most suitable for mobile system, home appliance and various applications.

### Features

- Low ON-Resistance Power DMOS Output
- Charge Pump-Less with PDMOS High-Side Driver
- Under Voltage Locked Out protection & Thermal Shut Down Function

### Applications

- Mobile System
- Home Appliance
- Amusement System, etc

### Key Specifications

- Power Supply Voltage Range: 2.5V to 3.6V
- Motor Power Supply Voltage Range: 2.0V to 9.0V
- Circuit Current (Open Mode): 360 $\mu$ A(Typ)
- Stand-By Current: 1 $\mu$ A(Max)
- Control Input Voltage Range: 0V to V<sub>CC</sub>V
- Logic Input Frequency: 200kHz(Max)
- Minimum Logic Input Pulse Width: 0.5 $\mu$ s(Min)
- Turn On Time: 200ns(Typ)
- Turn Off Time: 60ns(Typ)
- H-Bridge Output Current (DC): -1.0A to +1.0A
- Output ON-Resistance (Total): 0.45 $\Omega$ (Typ)
- Operating Temperature Range: -30°C to +85°C

### Package

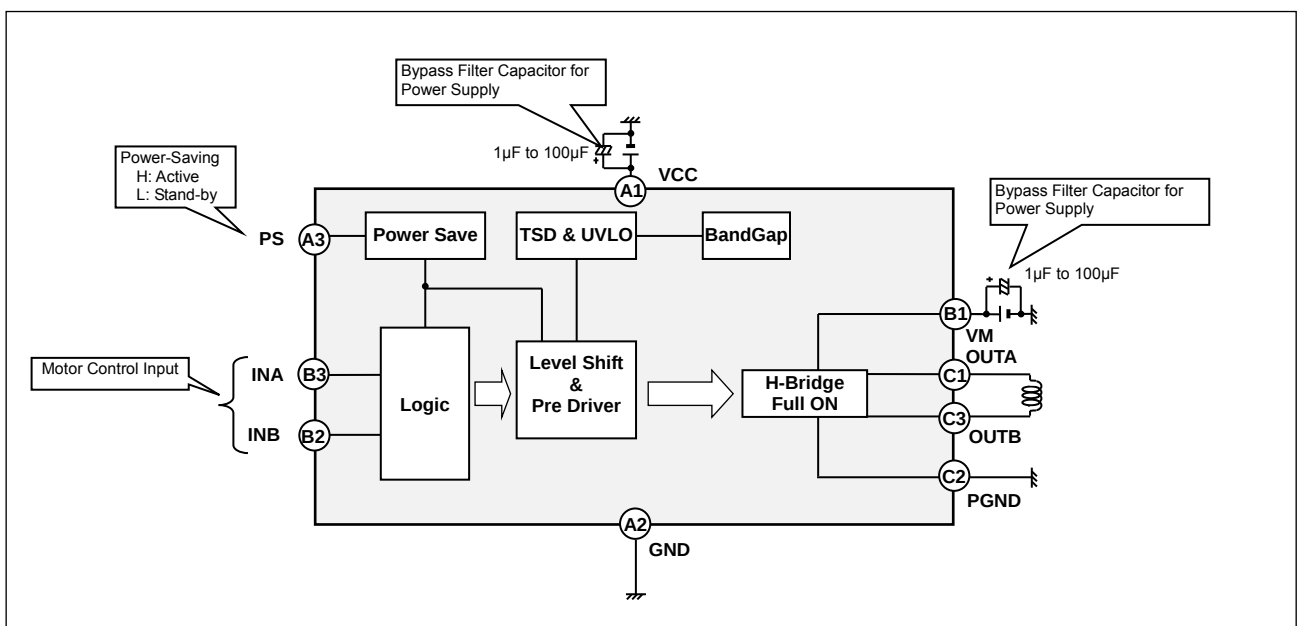
VCSP50L1

W(Typ) x D(Typ) x H(Max)

1.60mm x 1.60mm x 0.55mm



### Typical Application Circuit



Pin Configuration

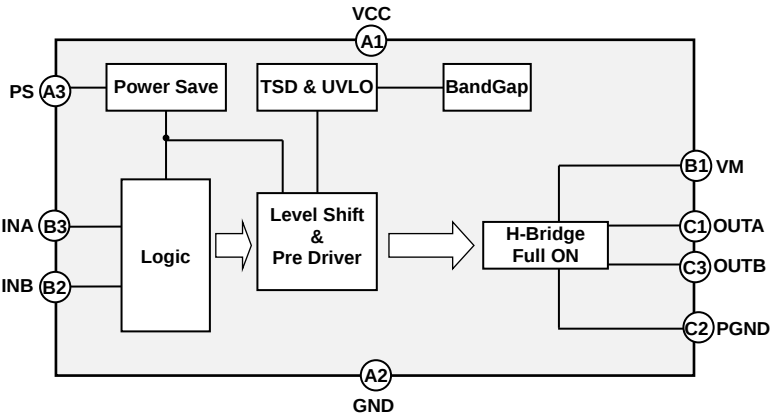
(Top View)

|   | 1    | 2    | 3    |
|---|------|------|------|
| A | VCC  | GND  | PS   |
| B | VM   | INB  | INA  |
| C | OUTA | PGND | OUTB |

Pin Description

| Pin No. | Pin Name | Function              |
|---------|----------|-----------------------|
| A1      | VCC      | Power supply          |
| A2      | GND      | Ground                |
| A3      | PS       | Power-saving function |
| B1      | VM       | Motor power supply    |
| B2      | INB      | Control logic input B |
| B3      | INA      | Control logic input A |
| C1      | OUTA     | H-bridge output A     |
| C2      | PGND     | Motor ground          |
| C3      | OUTB     | H-bridge output B     |

Block Diagram



## Description of Blocks

1. Power-Saving Function  
A power-saving function is included, which allows the system to save power when not driving the motor. The voltage level on this pin should be set high so as to keep the operation mode. (See the Electrical Characteristics; p.4/14)
2. Motor Control Input: INA and INB Pins  
Logic level controls the output logic of H-Bridge.  
(See the Electrical Characteristics; p.4/14, and I/O Truth Table; p.7/14)

## Absolute Maximum Ratings (Ta=25°C)

| Parameter                    | Symbol            | Limit                         | Unit |
|------------------------------|-------------------|-------------------------------|------|
| Power Supply Voltage         | V <sub>CC</sub>   | -0.3 to +4.5                  | V    |
| Motor Power Supply Voltage   | V <sub>M</sub>    | -0.3 to +10.0                 | V    |
| Control Input Voltage        | V <sub>IN</sub>   | -0.3 to +V <sub>CC</sub> +0.3 | V    |
| Power Dissipation            | P <sub>d</sub>    | 0.72 (Note 1)                 | W    |
| H-bridge Output Current (DC) | I <sub>OUT</sub>  | -1.0 to +1.0 (Note 2)         | A    |
| Storage Temperature Range    | T <sub>stg</sub>  | -55 to +150                   | °C   |
| Junction Temperature         | T <sub>jmax</sub> | 150                           | °C   |

(Note 1) Reduced by 5.8mW/°C over 25°C, when mounted on a glass epoxy 8-layers board (50mm x 58mm x 1.75mm).

(Note 2) Must not exceed P<sub>d</sub>, A<sub>SO</sub>, or T<sub>jmax</sub> of 150°C.

**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 Conditions

| Parameter                       | Symbol           | Min | Typ | Max             | Unit |
|---------------------------------|------------------|-----|-----|-----------------|------|
| Power Supply Voltage            | V <sub>CC</sub>  | 2.5 | -   | 3.6             | V    |
| Motor Power Supply Voltage      | V <sub>M</sub>   | 2.0 | -   | 9.0             | V    |
| Control Input Voltage           | V <sub>IN</sub>  | 0   | -   | V <sub>CC</sub> | V    |
| Logic Input Frequency           | F <sub>IN</sub>  | 0   | -   | 200             | kHz  |
| Minimum Logic Input Pulse Width | T <sub>IN</sub>  | 0.5 | -   | -               | μs   |
| Operating Temperature Range     | T <sub>opr</sub> | -30 | -   | +85             | °C   |

**Electrical Characteristics (Unless otherwise specified  $V_{CC}=3.0V$ ,  $V_M=5.0V$ ,  $T_a=25^\circ C$ )**

| Parameter                       | Symbol     | Min | Typ  | Max      | Unit     | Conditions                                  |
|---------------------------------|------------|-----|------|----------|----------|---------------------------------------------|
| All Circuits                    |            |     |      |          |          |                                             |
| Stand-by Current                | $I_{CCST}$ | -   | 0    | 1        | $\mu A$  | $V_{PS}=0V$                                 |
| Circuit Current 1               | $I_{CC1}$  | 180 | 360  | 550      | $\mu A$  | $V_{PS}=3V$ , Open Mode                     |
| Circuit Current 2               | $I_{CC2}$  | 180 | 375  | 550      | $\mu A$  | $V_{PS}=3V$ , CW & CCW Mode                 |
| Circuit Current 3               | $I_{CC3}$  | 180 | 375  | 550      | $\mu A$  | $V_{PS}=3V$ , Short Brake Mode              |
| PS Input (PS)                   |            |     |      |          |          |                                             |
| High-Level Input Voltage        | $V_{PSH}$  | 2.0 | -    | $V_{CC}$ | V        |                                             |
| Low-Level Input Voltage         | $V_{PSL}$  | 0   | -    | 0.7      | V        |                                             |
| High-Level Input Current        | $I_{PSH}$  | 6   | 15   | 30       | $\mu A$  | $V_{PS}=3V$                                 |
| Low-Level Input Current         | $I_{PSL}$  | -1  | 0    | +1       | $\mu A$  | $V_{PS}=0V$                                 |
| Control Input (IN=INA, INB)     |            |     |      |          |          |                                             |
| High-Level Input Voltage        | $V_{INH}$  | 2.0 | -    | $V_{CC}$ | V        |                                             |
| Low-Level Input Voltage         | $V_{INL}$  | 0   | -    | 0.7      | V        |                                             |
| High-Level Input Current        | $I_{INH}$  | 6   | 15   | 30       | $\mu A$  | $V_{IN}=3V$                                 |
| Low-Level Input Current         | $I_{INL}$  | -1  | 0    | +1       | $\mu A$  | $V_{IN}=0V$                                 |
| Under Voltage Locked Out (UVLO) |            |     |      |          |          |                                             |
| UVLO Voltage                    | $V_{UVLO}$ | 2.0 | -    | 2.4      | V        |                                             |
| Full ON Type H-Bridge Driver    |            |     |      |          |          |                                             |
| Output On-Resistance            | $R_{ON}$   | -   | 0.45 | 0.60     | $\Omega$ | $I_{OUT}=\pm 500mA$ , High & Low-side total |
| Turn On Time                    | $T_{ON0}$  | -   | 200  | 400      | ns       | 20 $\Omega$ Loading                         |
| Turn Off Time                   | $T_{OFF0}$ | -   | 60   | 400      | ns       | 20 $\Omega$ Loading                         |

## Typical Performance Curves (Reference data)

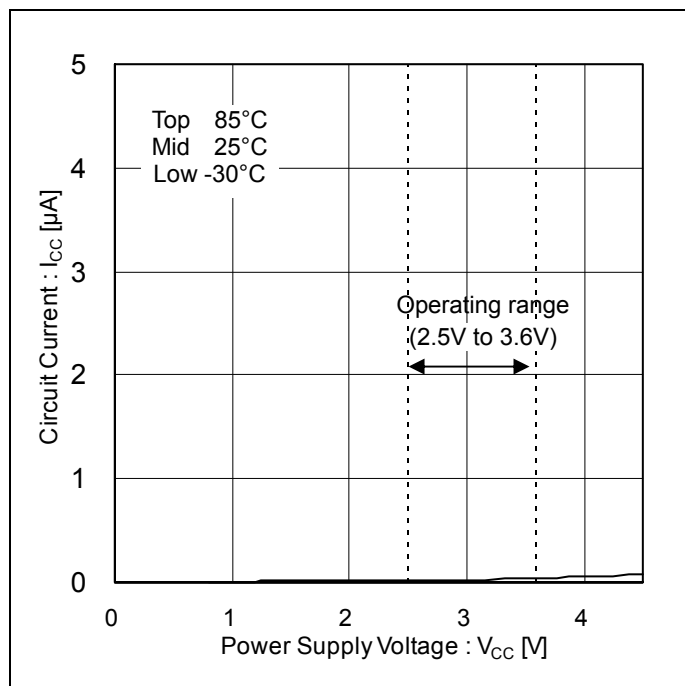


Figure 1.  
Circuit Current vs Supply Voltage  
(Stand-by Mode)

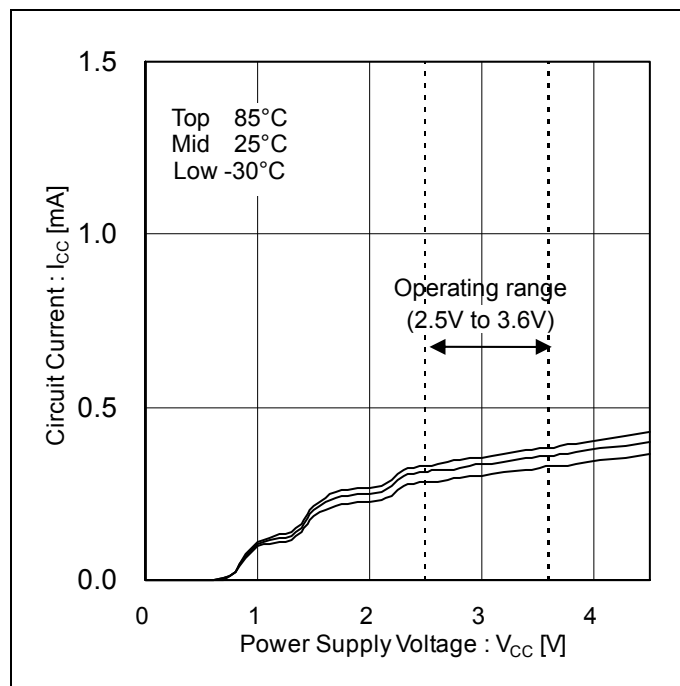


Figure 2.  
Circuit Current vs Supply Voltage  
(Open Mode)

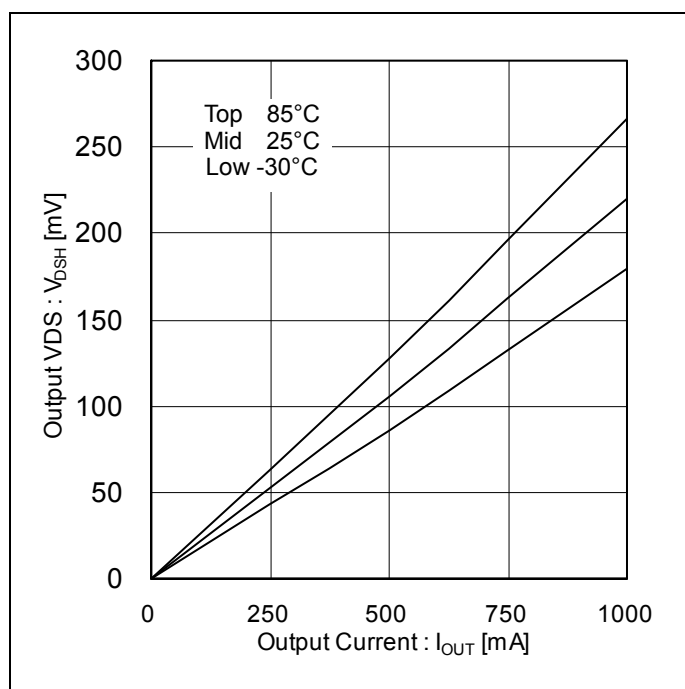


Figure 3.  
Output VDS vs Output Current  
(Output On-Resistance on high-side,  $V_M=5V$ ,  $V_{CC}=3V$ )

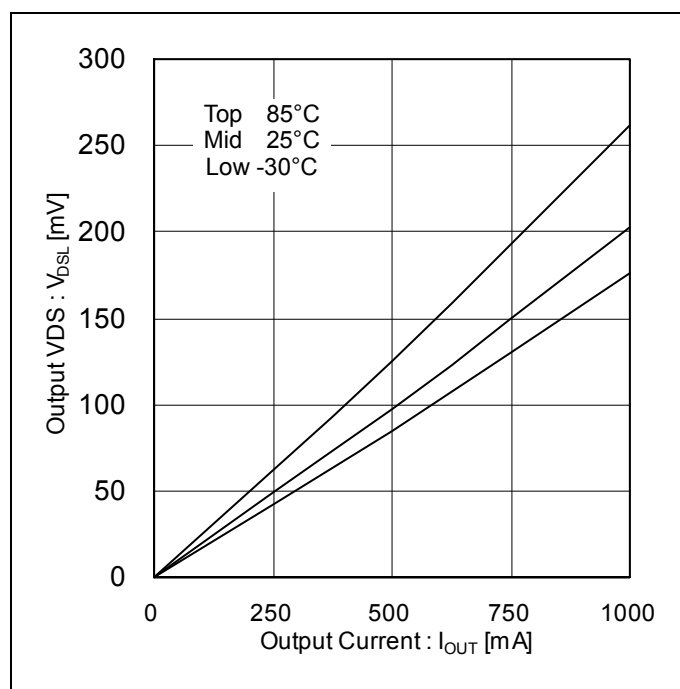


Figure 4.  
Output VDS vs Output Current  
(Output On-Resistance on low-side,  $V_M=5V$ ,  $V_{CC}=3V$ )

Typical Performance Curves (Reference Data) - continued

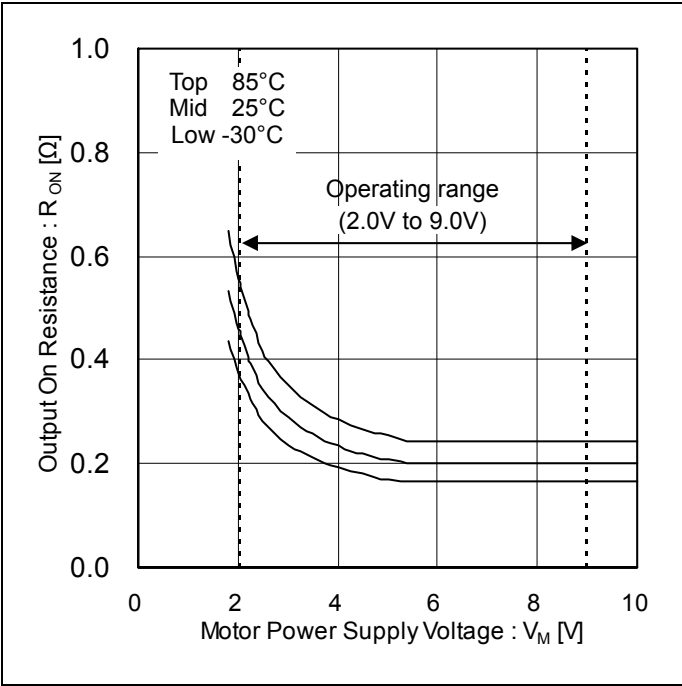


Figure 5.  
Output On-Resistance vs Motor Power Supply Voltage  
(Output On-Resistance on high-side  $V_M$  Dependency,  $V_{CC}=3V$ )

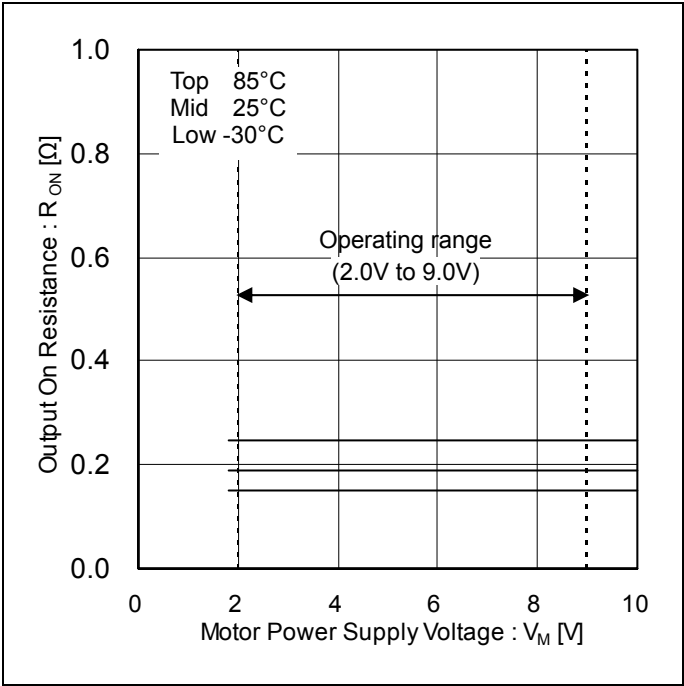


Figure 6.  
Output On-Resistance vs Motor Power Supply Voltage  
(Output On-Resistance on low-side  $V_M$  Dependency,  $V_{CC}=3V$ )

Timing Chart

Table 1. I/O Truth Table

| Input Mode | INPUT                  |     |     | OUTPUT |      |                                 |
|------------|------------------------|-----|-----|--------|------|---------------------------------|
|            | PS <sup>(Note 3)</sup> | INA | INB | OUTA   | OUTB | Output Mode <sup>(Note 4)</sup> |
| IN/IN      | H                      | L   | L   | Z      | Z    | Open                            |
|            |                        | H   | L   | H      | L    | CW                              |
|            |                        | L   | H   | L      | H    | CCW                             |
|            |                        | H   | H   | L      | L    | Short Brake                     |
| -          | L                      | X   | X   | Z      | Z    | Open                            |

L: Low, H: High, X: Don't care, Z: High-Impedance  
(Note 3) PS=High: Operation Mode, PS=Low: Stand-by Mode  
(Note 4) CW: Current flows from OUTA to OUTB, CCW: Current flows from OUTB to OUTA

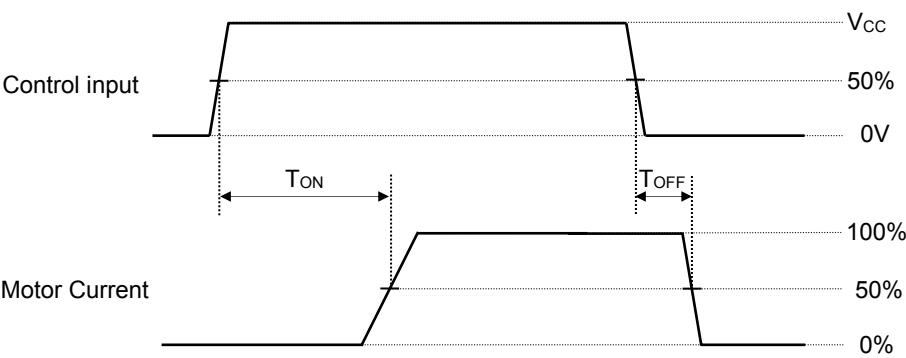
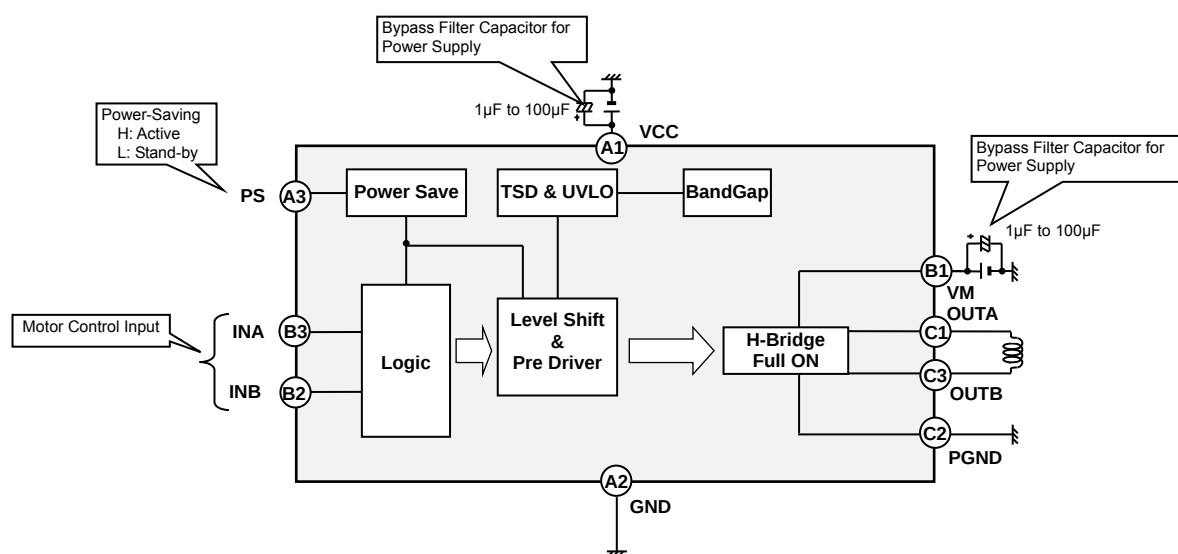


Figure 7.  
Input-Output AC Characteristic

## Application Example



## Selection of Components Externally Connected

When using the circuit with changes to the external circuit constants, make sure to leave an adequate margin for external components including static and transitional characteristics as well as dispersion of the IC.

Power Dissipation

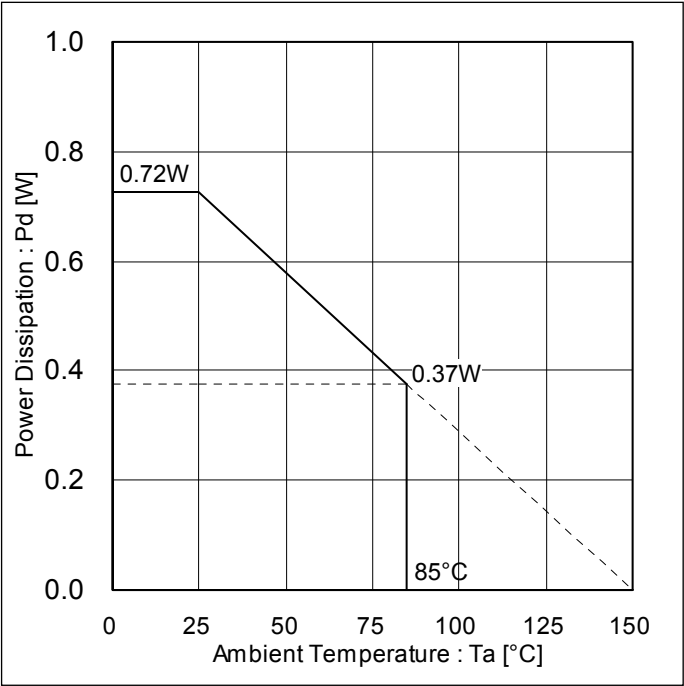
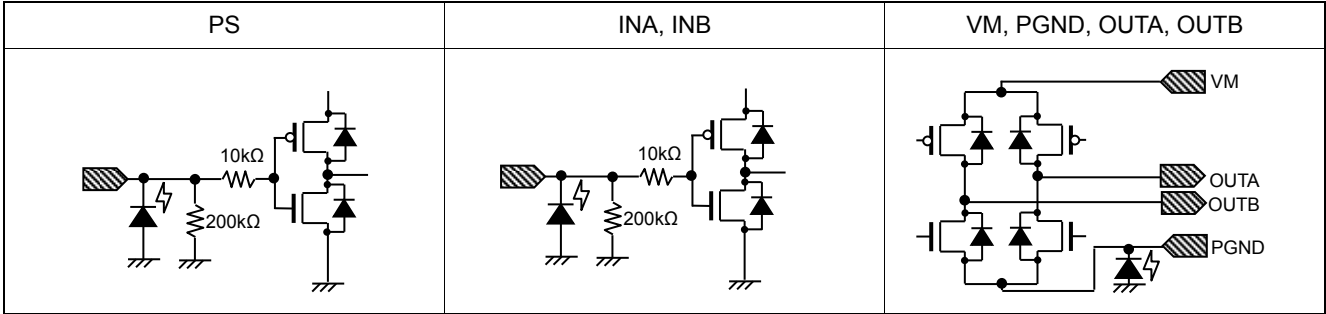


Figure 8.  
Power Dissipation vs Ambient Temperature

I/O equivalent circuits



## 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. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. 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(GND) and large-current ground(PGND) 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.

### 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.

## Operational Notes – continued

**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.

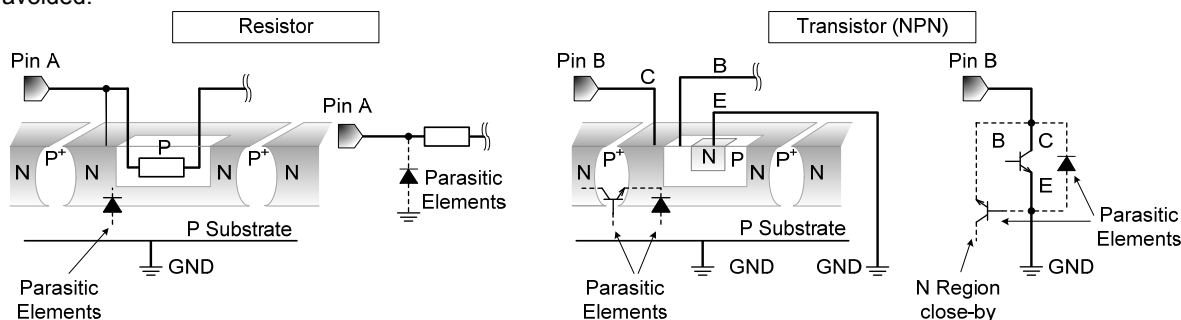


Figure 9.

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. Area of Safe Operation (ASO)**

Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

**15. Thermal Shutdown Circuit(TSD)**

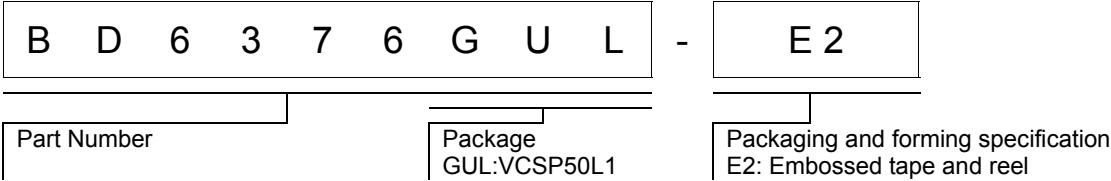
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that 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.

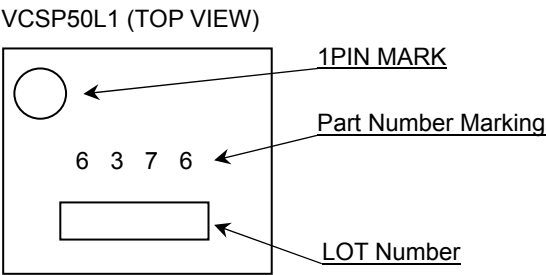
**16. Disturbance light**

In a device where a portion of silicon is exposed to light such as in a WL-CSP, IC characteristics may be affected due to photoelectric effect. For this reason, it is recommended to come up with countermeasures that will prevent the chip from being exposed to light.

Ordering Information



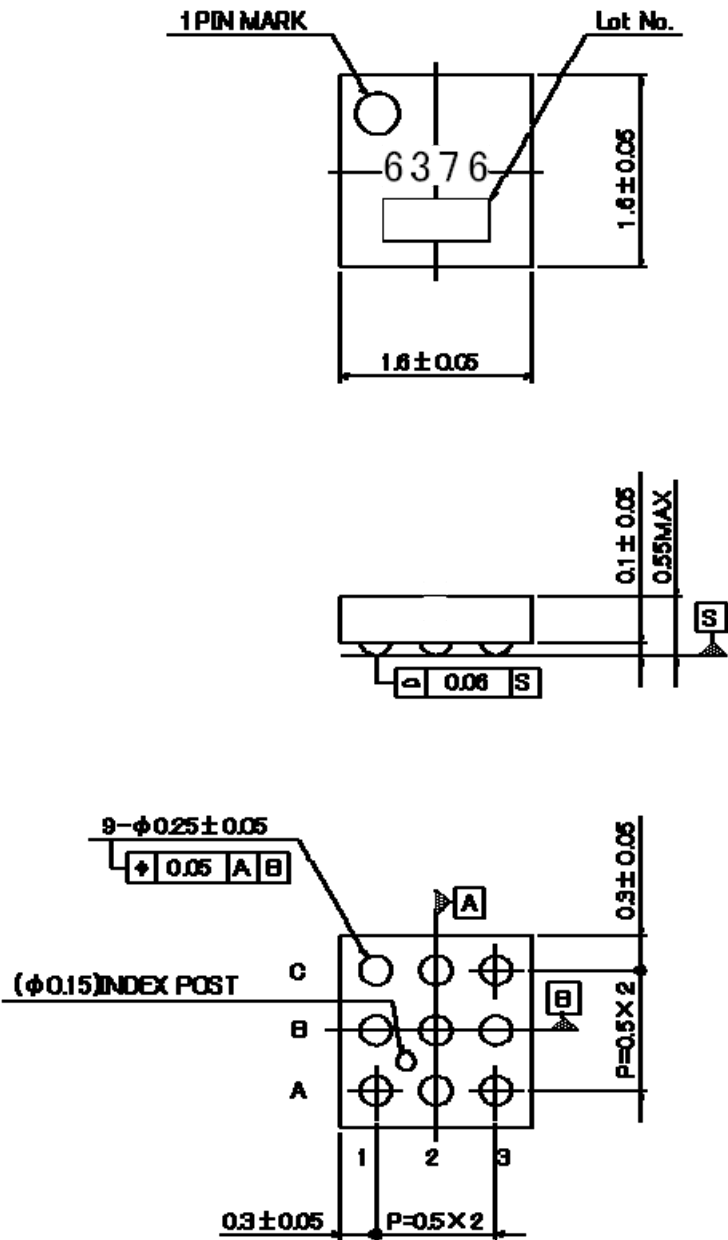
Marking Diagram



| Part Number Marking | Package  | Orderable Part Number |
|---------------------|----------|-----------------------|
| 6376                | VCSP50L1 | BD6376GUL-E2          |

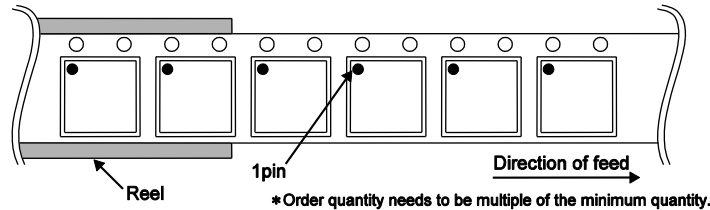
Physical Dimension, Tape and Reel Information

|              |          |
|--------------|----------|
| Package Name | VCSP50L1 |
|--------------|----------|



<Tape and Reel information>

|                   |                                                                                                                                                   |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Tape              | Embossed carrier tape                                                                                                                             |
| Quantity          | 3000pcs                                                                                                                                           |
| Direction of feed | E2<br>(The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand) |



## Revision History

| Date        | Revision | Changes                                                         |
|-------------|----------|-----------------------------------------------------------------|
| 03.Aug.2012 | 001      | New release                                                     |
| 06.Feb.2014 | 002      | p1 Change [1-2ch] to [1ch]                                      |
| 10.Feb.2016 | 003      | Applied the ROHM Standard Style and improved understandability. |

# Notice

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(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

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  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
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  - Use of our Products in places where the Products are exposed to sea wind 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>
  - 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
  - Sealing or coating our Products with resin or other coating materials
  - 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 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.
- 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.

## Precaution for Mounting / Circuit board design

- 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

## Precautions Regarding Application Examples and External Circuits

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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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