



# LM5102 High-Voltage Half-Bridge Gate Driver With Programmable Delay

## 1 Features

- Drives Both a High-Side and Low-Side N-Channel MOSFET
- Independently Programmable High and Low Side Rising Edge Delay
- Bootstrap Supply Voltage Range up to 118 V dc
- Fast Turn-Off Propagation Delay (25 ns Typical)
- Drives 1000-pF Loads with 15-ns Rise and Fall Times
- Supply Rail Undervoltage Lockout
- Low Power Consumption
- Timer Can Be Terminated Midway Through Sequence

## 2 Applications

- Current Fed Push-Pull Power Converters
- Half and Full Bridge Power Converters
- Synchronous Buck Converters
- Two Switch Forward Power Converters
- Forward with Active Clamp Converters

## 3 Description

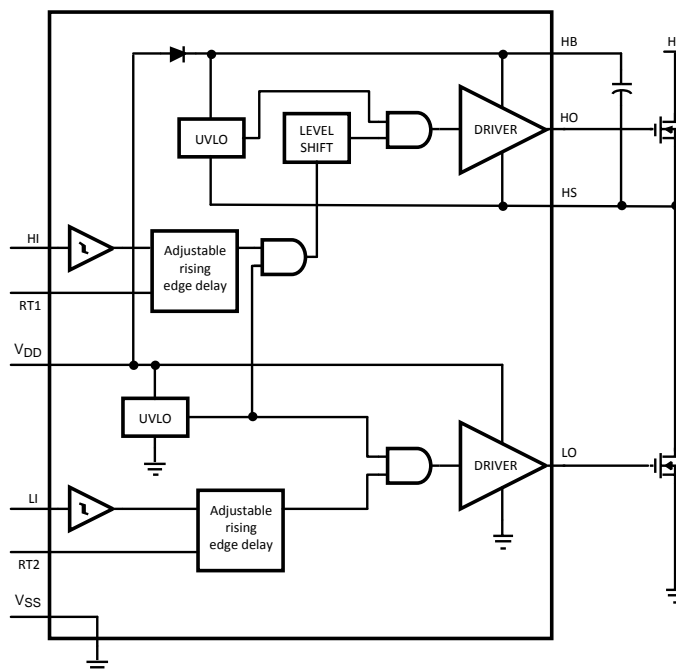
The LM5102 high-voltage gate driver is designed to drive both the high side and the low side N-Channel MOSFETs in a synchronous buck or a half bridge configuration. The floating high-side driver is capable of working with supply voltages up to 100 V. The outputs are independently controlled. The rising edge of each output can be independently delayed with a programming resistor. An integrated high voltage diode is provided to charge the high side gate drive bootstrap capacitor. A robust level shifter operates at high speed while consuming low power and providing clean level transitions from control logic to the high side gate driver. Undervoltage lockout is provided on both the low side and the high side power rails. This device is available in the standard VSSOP 10 pin and the WSON 10 pin packages.

**Device Information<sup>(1)</sup>**

| PART NUMBER | PACKAGE    | BODY SIZE (NOM)   |
|-------------|------------|-------------------|
| LM5102      | VSSOP (10) | 3.00 mm x 3.00 mm |
|             | WSON (10)  | 4.00 mm x 4.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

**Simplified Block Diagram**



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## 4 Revision History

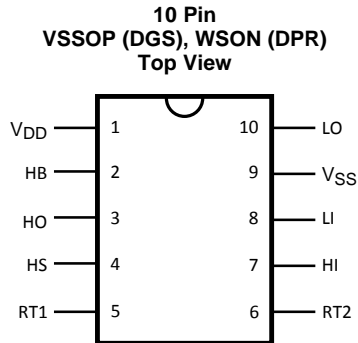
### Changes from Revision A (March 2013) to Revision B Page

- Added Handling Rating table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section. .... **1**

### Changes from Original (March 2013) to Revision A Page

- Changed layout of National Data Sheet to TI format ..... **11**

## 5 Pin Configuration and Functions



### Pin Functions

| PIN             |                                | TYPE <sup>(1)</sup> | DESCRIPTION                             | APPLICATION INFORMATION   |
|-----------------|--------------------------------|---------------------|---|---|
| NAME            | WSON <sup>(2)</sup> ,<br>VSSOP |                     |   |   |
| HB              | 2                              | P                   | High-side gate driver bootstrap rail    | Connect the positive terminal of bootstrap capacitor to the HB pin and connect negative terminal of bootstrap capacitor to HS. The Bootstrap capacitor should be placed as close to IC as possible. |
| HI              | 7                              | I                   | High-side driver control input          | TTL compatible thresholds. Unused inputs should be tied to ground and not left open.  |
| HO              | 3                              | O                   | High-side gate driver output            | Connect to gate of high-side MOSFET with short low-inductance path.   |
| HS              | 4                              | P                   | High-side MOSFET source connection      | Connect bootstrap capacitor negative terminal and source of high side MOSFET.   |
| LI              | 8                              | I                   | Low-side driver control input           | TTL compatible thresholds. Unused inputs should be tied to ground and not left open.  |
| LO              | 10                             | O                   | Low-side gate driver output             | Connect to the gate of the low side MOSFET with a short low inductance path.  |
| RT1             | 5                              | A                   | High-side output edge delay programming | Resistor from RT1 to ground programs the leading edge delay of the high side gate driver. The resistor should be placed close to the IC to minimize noise coupling from adjacent traces.            |
| RT2             | 6                              | A                   | Low-side output edge delay programming  | Resistor from RT2 to ground programs the leading edge delay of the low side gate driver. The resistor should be placed close to the IC to minimize noise coupling from adjacent traces.             |
| V <sub>DD</sub> | 1                              | P                   | Positive gate drive supply              | Locally decouple to VSS using low ESR/ESL capacitor, located as close to IC as possible.  |
| V <sub>SS</sub> | 9                              | G                   | Ground return                           | All signals are referenced to this ground.  |

(1) P = Power, G = Ground, I = Input, O = Output, A = Analog

(2) For the WSON package, it is recommended that the exposed pad on the bottom of the LM5100 and LM5101 be soldered to ground plane on the PC board, and the ground plane should extend out from beneath the IC to help dissipate the heat.

## 6 Specifications

### 6.1 Absolute Maximum Ratings<sup>(1)(2)</sup>

|                             | MIN            | MAX            | UNIT |
|-----------------------------|----------------|----------------|------|
| $V_{DD}$ to $V_{SS}$        | –0.3           | 18             | V    |
| $V_{HB}$ to $V_{HS}$        | –0.3           | 18             | V    |
| LI or HI Inputs to $V_{SS}$ | –0.3           | $V_{DD} + 0.3$ | V    |
| LO Output                   | –0.3           | $V_{DD} + 0.3$ | V    |
| HO Output                   | $V_{HS} - 0.3$ | $V_{HB} + 0.3$ | V    |
| $V_{HS}$ to $V_{SS}$        | –1             | 100            | V    |
| $V_{HB}$ to $V_{SS}$        |                | 118            | V    |
| RT1 and RT2 to $V_{SS}$     | –0.3           | 5              | V    |
| Junction Temperature        |                | 150            | °C   |
| Storage Temperature Range   | –55            | 150            | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

### 6.2 ESD Ratings

|   | VALUE | UNIT |
|---|-------|------|
| $V_{(ESD)}$ Electrostatic discharge Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> | ±2000 | V    |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

|                      | MIN          | MAX           | UNIT |
|----------------------|--------------|---------------|------|
| $V_{DD}$             | 9            | 14            | V    |
| HS                   | –1           | 100           | V    |
| HB                   | $V_{HS} + 8$ | $V_{HS} + 14$ | V    |
| HS Slew Rate         |              | < 50          | V/ns |
| Junction Temperature | –40          | 125           | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | LM5102  |                    | UNIT |
|-------------------------------|--|---------|--------------------|------|
|                               |  | DGS     | DPR <sup>(2)</sup> |      |
|                               |  | 10 PINS | 10 PINS            |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 165.3   | 37.9               | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 58.9    | 38.1               |      |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 54.4    | 14.9               |      |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 6.2     | 0.4                |      |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 83.6    | 15.2               |      |
| $R_{\theta JC(bot)}$          | Junction-to-case (bottom) thermal resistance | N/A     | 4.4                |      |

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report (SPRA953).
- (2) 4 layer board with Cu finished thickness 1.5 oz, 1 oz, 1 oz, 1.5 oz. Maximum die size used. 5x body length of Cu trace on PCB top. 50 x 50 mm ground and power planes embedded in PCB. See Application Note AN-1187 *Leadless Leadframe Package (LLP)* (SNOA401).

## 6.5 Electrical Characteristics

Specifications in standard typeface are for  $T_J = +25^\circ\text{C}$ . Unless otherwise specified,  $V_{DD} = V_{HB} = 12\text{ V}$ ,  $V_{SS} = V_{HS} = 0\text{ V}$ ,  $RT1 = RT2 = 100\text{ k}\Omega$ . No load on LO or HO.

| PARAMETER                           |  | TEST CONDITIONS  | MIN <sup>(1)</sup> | TYP  | MAX <sup>(1)</sup> | UNIT |
|-------------------------------------|--|--|--------------------|------|--------------------|------|
| SUPPLY CURRENTS                     |  |  |                    |      |                    |      |
| I <sub>DD</sub>                     | V <sub>DD</sub> Quiescent Current        | LI = HI = 0 V  |                    | 0.4  |                    | mA   |
|                                     |  | LI = HI = 0 V, −40°C to +125°C                             |                    |      | 0.6                |      |
| I <sub>DDO</sub>                    | V <sub>DD</sub> Operating Current        | f = 500 kHz  |                    | 1.5  |                    | mA   |
|                                     |  | f = 500 kHz, −40°C to +125°C                               |                    |      | 3                  |      |
| I <sub>HB</sub>                     | Total HB Quiescent Current               | LI = HI = 0 V  |                    | 0.06 |                    | mA   |
|                                     |  | LI = HI = 0 V, −40°C to +125°C                             |                    |      | 0.2                |      |
| I <sub>HBO</sub>                    | Total HB Operating Current               | f = 500 kHz  |                    | 1.3  |                    | mA   |
|                                     |  | f = 500 kHz, −40°C to +125°C                               |                    |      | 3                  |      |
| I <sub>HBS</sub>                    | HB to V <sub>SS</sub> Current, Quiescent | V <sub>HS</sub> = V <sub>HB</sub> = 100 V                  |                    | 0.05 |                    | μA   |
|                                     |  | V <sub>HS</sub> = V <sub>HB</sub> = 100 V, −40°C to +125°C |                    |      | 10                 |      |
| I <sub>HBSO</sub>                   | HB to V <sub>SS</sub> Current, Operating | f = 500 kHz  |                    | 0.08 |                    | mA   |
| INPUT PINS                          |  |  |                    |      |                    |      |
| V <sub>IL</sub>                     | Low Level Input Voltage Threshold        |  |                    | 1.8  |                    | V    |
|                                     |  | −40°C to +125°C  |                    | 0.8  |                    |      |
| V <sub>IH</sub>                     | High Level Input Voltage Threshold       |  |                    | 1.8  |                    | V    |
|                                     |  | −40°C to +125°C  |                    |      | 2.2                |      |
| R <sub>I</sub>                      | Input Pulldown Resistance                |  |                    | 200  |                    | kΩ   |
|                                     |  | −40°C to +125°C  |                    | 100  | 500                |      |
| TIME DELAY CONTROLS                 |  |  |                    |      |                    |      |
| V <sub>RT</sub>                     | Nominal Voltage at RT1, RT2              |  |                    | 3    |                    | V    |
|                                     |  | −40°C to +125°C  |                    | 2.7  | 3.3                |      |
| I <sub>RT</sub>                     | RT Pin Current Limit                     | RT1 = RT2 = 0 V  |                    | 1.5  |                    | mA   |
|                                     |  | RT1 = RT2 = 0 V, −40°C to +125°C                           |                    | 0.75 | 2.25               |      |
| V <sub>th</sub>                     | Timer Termination Threshold              |  |                    | 1.8  |                    | V    |
| T <sub>DL1</sub> , T <sub>DH1</sub> | Rising edge turn-on delay, RT = 10 kΩ    |  |                    | 105  |                    | ns   |
|                                     |  | −40°C to +125°C  |                    | 75   | 150                |      |
| T <sub>DL2</sub> , T <sub>DH2</sub> | Rising edge turn-on delay, RT = 100 kΩ   |  |                    | 630  |                    | ns   |
|                                     |  | −40°C to +125°C  |                    | 530  | 750                |      |
| UNDER VOLTAGE PROTECTION            |  |  |                    |      |                    |      |
| V <sub>DDR</sub>                    | V <sub>DD</sub> Rising Threshold         |  |                    | 6.9  |                    | V    |
|                                     |  | −40°C to +125°C  |                    | 6.0  | 7.4                |      |
| V <sub>DDH</sub>                    | V <sub>DD</sub> Threshold Hysteresis     |  |                    | 0.5  |                    | V    |
| V <sub>HBR</sub>                    | HB Rising Threshold                      |  |                    | 6.6  |                    | V    |
|                                     |  | −40°C to +125°C  |                    | 5.7  | 7.1                |      |
| V <sub>HBH</sub>                    | HB Threshold Hysteresis                  |  |                    | 0.4  |                    | V    |
| BOOTSTRAP DIODE                     |  |  |                    |      |                    |      |
| V <sub>DL</sub>                     | Low-Current Forward Voltage              | I <sub>VDD-HB</sub> = 100 μA                               |                    | 0.60 |                    | V    |
|                                     |  | I <sub>VDD-HB</sub> = 100 μA, −40°C to +125°C              |                    |      | 0.9                |      |
| V <sub>DH</sub>                     | High-Current Forward Voltage             | I <sub>VDD-HB</sub> = 100 mA                               |                    | 0.85 |                    | V    |
|                                     |  | I <sub>VDD-HB</sub> = 100 mA, −40°C to +125°C              |                    |      | 1.1                |      |

(1) MIN and MAX limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are specified through correlation using Statistical Quality Control (SQC) methods. Limits are used to calculate TI's Average Outgoing Quality Level (AOQL).

## Electrical Characteristics (continued)

Specifications in standard typeface are for  $T_J = +25^\circ\text{C}$ . Unless otherwise specified,  $V_{DD} = V_{HB} = 12\text{ V}$ ,  $V_{SS} = V_{HS} = 0\text{ V}$ ,  $RT1 = RT2 = 100\text{ k}\Omega$ . No load on LO or HO.

| PARAMETER        |                           | TEST CONDITIONS   | MIN <sup>(1)</sup> | TYP  | MAX <sup>(1)</sup> | UNIT |
|------------------|---------------------------|---|--------------------|------|--------------------|------|
| R <sub>D</sub>   | Dynamic Resistance        | I <sub>VDD-HB</sub> = 100 mA  |                    | 0.8  |                    | Ω    |
|                  |                           | I <sub>VDD-HB</sub> = 100 mA, −40°C to +125°C   |                    |      | 1.5                |      |
| LO GATE DRIVER   |                           |   |                    |      |                    |      |
| V <sub>OLL</sub> | Low-Level Output Voltage  | I <sub>LO</sub> = 100 mA  |                    | 0.25 |                    | V    |
|                  |                           | I <sub>LO</sub> = 100 mA, −40°C to +125°C   |                    |      | 0.4                |      |
| V <sub>OHL</sub> | High-Level Output Voltage | I <sub>LO</sub> = −100 mA, V <sub>OHL</sub> = V <sub>DD</sub> − V <sub>LO</sub>                   |                    | 0.35 |                    | V    |
|                  |                           | I <sub>LO</sub> = −100 mA, V <sub>OHL</sub> = V <sub>DD</sub> − V <sub>LO</sub> , −40°C to +125°C |                    |      | 0.55               |      |
| I <sub>OHL</sub> | Peak Pullup Current       | V <sub>LO</sub> = 0 V   |                    | 1.6  |                    | A    |
| I <sub>OLL</sub> | Peak Pulldown Current     | V <sub>LO</sub> = 12 V  |                    | 1.8  |                    | A    |
| HO GATE DRIVER   |                           |   |                    |      |                    |      |
| V <sub>OLH</sub> | Low-Level Output Voltage  | I <sub>HO</sub> = 100 mA  |                    | 0.25 |                    | V    |
|                  |                           | I <sub>HO</sub> = 100 mA, −40°C to +125°C   |                    |      | 0.4                |      |
| V <sub>OHH</sub> | High-Level Output Voltage | I <sub>HO</sub> = −100 mA, V <sub>OHH</sub> = V <sub>HB</sub> − V <sub>HO</sub>                   |                    | 0.35 |                    | V    |
|                  |                           | I <sub>HO</sub> = −100 mA, V <sub>OHH</sub> = V <sub>HB</sub> − V <sub>HO</sub> , −40°C to +125°C |                    |      | 0.55               |      |
| I <sub>OHH</sub> | Peak Pullup Current       | V <sub>HO</sub> = 0 V   |                    | 1.6  |                    | A    |
| I <sub>OLH</sub> | Peak Pulldown Current     | V <sub>HO</sub> = 12 V  |                    | 1.8  |                    | A    |

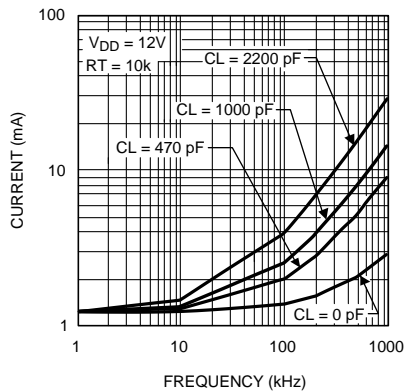
## 6.6 Switching Characteristics

Specifications in standard typeface are for  $T_J = +25^\circ\text{C}$ . Unless otherwise specified,  $V_{DD} = V_{HB} = 12\text{ V}$ ,  $V_{SS} = V_{HS} = 0\text{ V}$ , No Load on LO or HO.

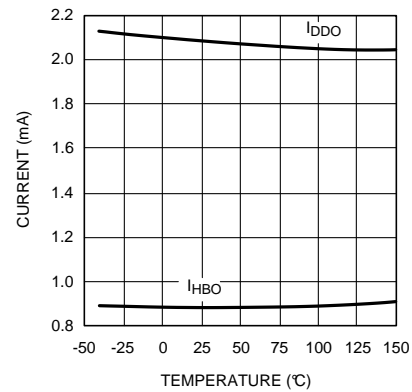
| PARAMETER   | TEST CONDITIONS                              | MIN <sup>(1)</sup> | TYP | MAX <sup>(1)</sup> | UNIT          |
|---|--|--------------------|-----|--------------------|---------------|
| $t_{LPHL}$ Lower Turn-Off Propagation Delay LM5102 (LI Falling to LO Falling) |  |                    | 27  |                    | ns            |
|   | $-40^\circ\text{C}$ to $+125^\circ\text{C}$  |                    |     | 56                 |               |
| $t_{HPLH}$ Upper Turn-Off Propagation Delay LM5102 (HI Falling to HO Falling) |  |                    | 27  |                    | ns            |
|   | $-40^\circ\text{C}$ to $+125^\circ\text{C}$  |                    |     | 56                 |               |
| $t_{RC}$ , $t_{FC}$ Either Output Rise/Fall Time                              | $C_L = 1000\text{ pF}$                       |                    | 15  |                    | ns            |
| $t_R$ , $t_F$ Either Output Rise/Fall Time (3 V to 9 V)                       | $C_L = 0.1\text{ }\mu\text{F}$               |                    | 0.6 |                    | $\mu\text{s}$ |
| $t_{BS}$ Bootstrap Diode Turn-Off Time  | $I_F = 20\text{ mA}$ , $I_R = 200\text{ mA}$ |                    | 50  |                    | ns            |

(1) MIN and MAX limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are specified through correlation using Statistical Quality Control (SQC) methods. Limits are used to calculate TI's Average Outgoing Quality Level (AOQL).

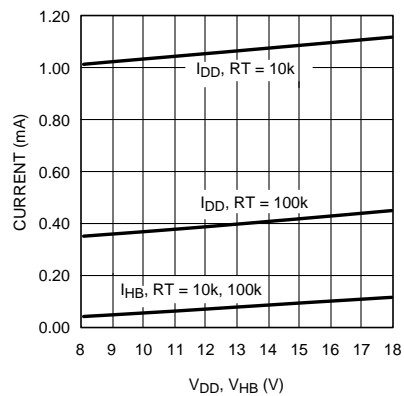
## 6.7 Typical Characteristics



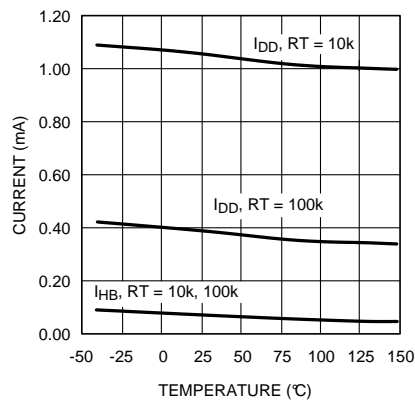
**Figure 1.  $I_{DD}$  vs Frequency**



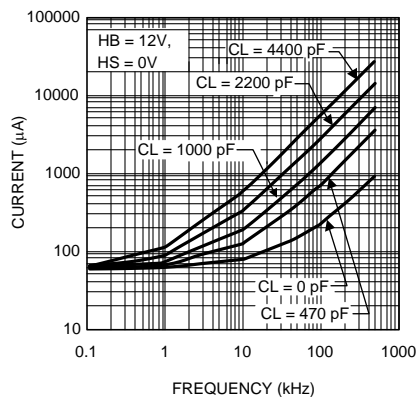
**Figure 2. Operating Current vs Temperature**



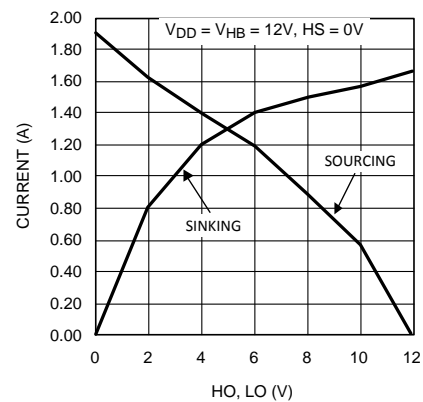
**Figure 3. Quiescent Current vs Supply Voltage**



**Figure 4. Quiescent Current vs Temperature**

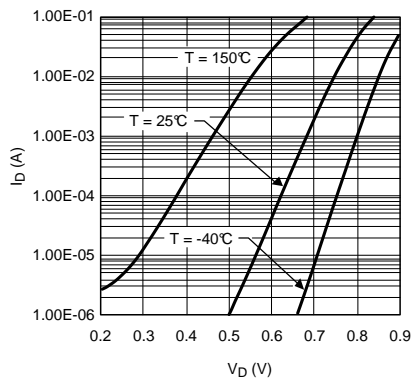
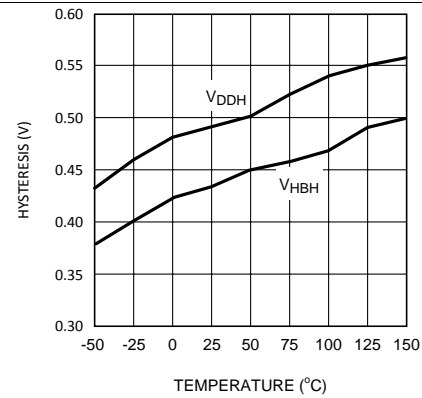
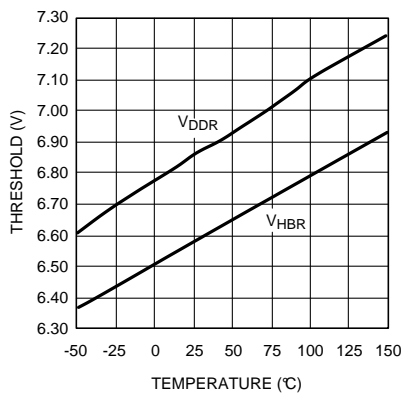
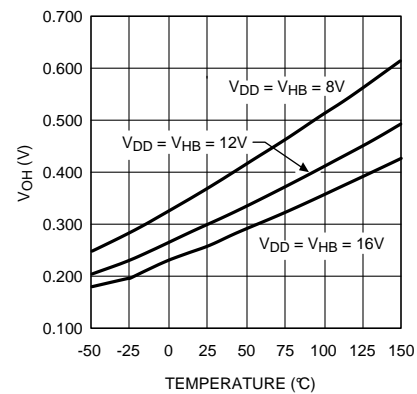
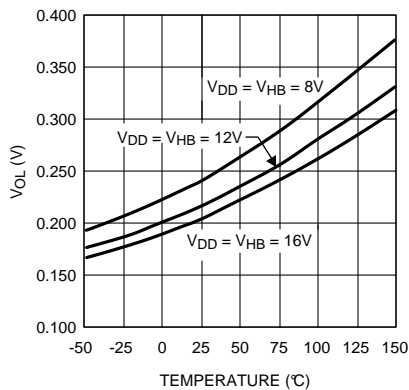
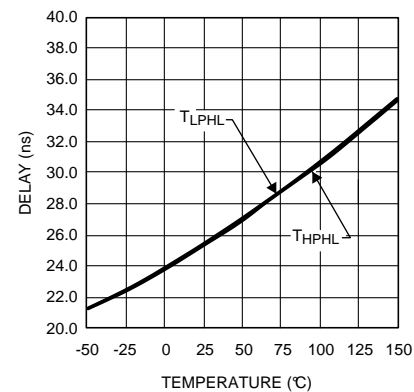


**Figure 5.  $I_{HB}$  vs Frequency**

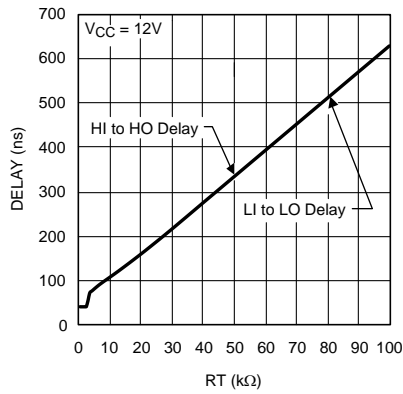


**Figure 6. HO and LO Peak Output Current vs Output Voltage**

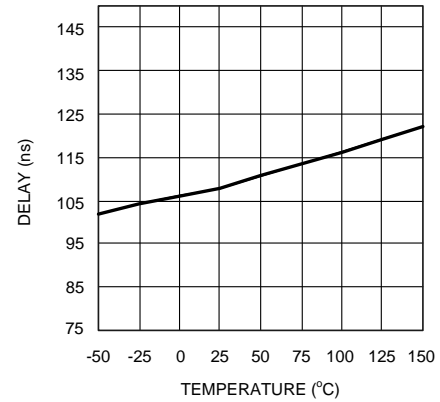
## Typical Characteristics (continued)


**Figure 7. Diode Forward Voltage**

**Figure 8. Undervoltage Threshold Hysteresis vs Temperature**

**Figure 9. Undervoltage Rising Threshold vs Temperature**

**Figure 10. LO and HO Gate Drive — High Level Output Voltage vs Temperature**

**Figure 11. LO and HO Gate Drive — Low Level Output Voltage vs Temperature**

**Figure 12. Turn Off Propagation Delay vs Temperature**

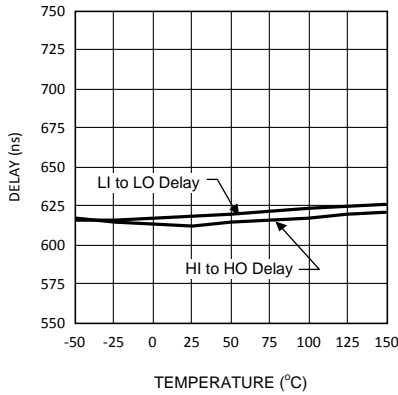
## Typical Characteristics (continued)



**Figure 13. Turn On Delay vs RT Resistor Value**



**Figure 14. Turn On Delay vs Temperature (RT = 10 k)**



**Figure 15. Turn On Delay vs Temperature (RT = 100 k)**

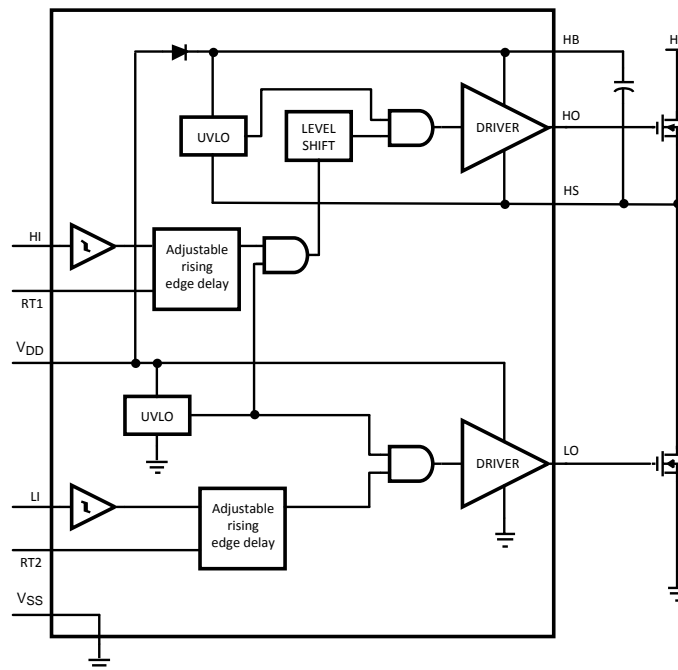
## 7 Detailed Description

### 7.1 Overview

The LM5102 device offers a unique flexibility with independently programmable delay of the rising edge for both high and low side driver outputs independently. The delays are set with resistors at the RT1 and RT2 pins, and can be adjusted from 100 ns to 600 ns. This feature reduces component count, board space and cost compared to discrete solutions for adjusting driver dead time. The wide delay programming range provides the flexibility to optimize drive signal timing for a wide range of MOSFETs and applications.

The RT pins are biased at 3 V and current limited to 1 mA maximum programming current. The time delay generator will accommodate resistor values from 5 k to 100 k with turn-on delay times that are proportional to the RT resistance. In addition, each RT pin is monitored by a comparator that will bypass the turn-on delay if the RT pin is pulled below the timer elimination threshold (1.8 V typical). Grounding the RT pins programs the LM5102 to drive both outputs with minimum turn-on delay.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Startup and UVLO

Both top and bottom drivers include undervoltage lockout (UVLO) protection circuitry which monitors the supply voltage ( $V_{DD}$ ) and bootstrap capacitor voltage ( $V_{HB} - V_{HS}$ ) independently. The UVLO circuit inhibits each driver until sufficient supply voltage is available to turn-on the external MOSFETs, and the built-in hysteresis prevents chattering during supply voltage transitions. When the supply voltage is applied to  $V_{DD}$  pin of LM5102, the top and bottom gates are held low until  $V_{DD}$  exceeds UVLO threshold, typically about 6.9 V. Any UVLO condition on the bootstrap capacitor will disable only the high side output (HO).

### 7.4 Device Functional Modes

| LI Pin | LO Pin | HI Pin | HO Pin |
|--------|--------|--------|--------|
| L      | L      | L      | L      |
| H      | H      | H      | H      |

## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The LM5102 is one of the latest generation of high voltage gate drivers which are designed to drive both the high-side and low-side N-Channel MOSFETs in a half-bridge/full bridge configuration or in a synchronous buck circuit. The floating high side driver is capable of operating with supply voltages up to 100 V. This allows for N-Channel MOSFET control in half-bridge, full-bridge, push-pull, two switch forward and active clamp topologies.

In the LM5102 the outputs are independently controlled. The rising edge of each output can be independently delayed with a programming resistor.

Table 1. LM5102 Highlights

| FEATURE  | BENEFIT  |
|--|--|
| Independently programmable high and low side delay | Allows optimisation of gate drive timings to account for device differences between high-side and low-side positions |
| Low power consumption                              | Improves light load efficiency figures   |
| Internal bootstrap diode                           | Reduces parts count and PCB real estate  |

### 8.2 Typical Application

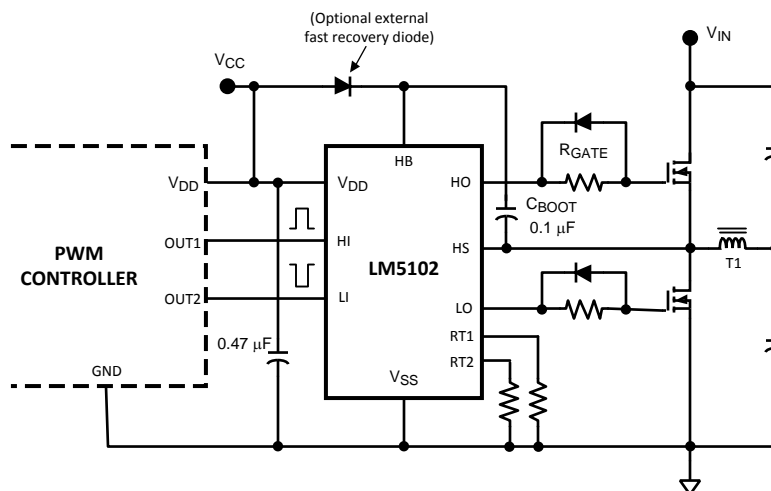


Figure 16. LM5102 Driving MOSFETS Connected in Half-Bridge Configuration

## Typical Application (continued)

### 8.2.1 Design Requirements

| PARAMETERS        | VALUES      |
|-------------------|-------------|
| Gate Drive IC     | LM5102      |
| Mosfet            | CSD18531Q5A |
| V <sub>DD</sub>   | 10 V        |
| Q <sub>gmax</sub> | 43 nC       |
| F <sub>sw</sub>   | 100 kHz     |
| D <sub>Max</sub>  | 95%         |
| I <sub>HBO</sub>  | 10 μA       |
| V <sub>DH</sub>   | 1.1 V       |
| V <sub>HBR</sub>  | 7.1 V       |
| V <sub>HBH</sub>  | 0.4 V       |

### 8.2.2 Detailed Design Procedure

$$\Delta V_{HB} = V_{DD} - V_{DH} - V_{HBL}$$

where

- V<sub>DD</sub> = Supply voltage of the gate drive IC
- V<sub>DH</sub> = Bootstrap diode forward voltage drop
- V<sub>gsmin</sub> = Minimum gate source threshold voltage

$$C_{BOOT} = \frac{Q_{TOTAL}}{\Delta V_{HB}} \quad (1)$$

$$Q_{TOTAL} = Q_{gmax} + I_{HBO} \times \frac{D_{Max}}{F_{SW}} \quad (2)$$

The quiescent current of the bootstrap circuit is 10 μA which is negligible compared to the Qgs of the mosfet.

$$Q_{TOTAL} = 43nC + 10\mu A \times \frac{0.95}{100kHz} \quad (3)$$

$$Q_{TOTAL} = 43.01 \text{ nC} \quad (4)$$

In practice the value for the C<sub>BOOT</sub> capacitor should be greater than that calculated to allow for situations where the power stage may skip pulse due to load transients. In this circumstance the boot capacitor must maintain the HB Pin voltage above the UVLO Voltage for the HB circuit.

As a general rule the local V<sub>DD</sub> bypass capacitor should be 10 times greater than the value of C<sub>BOOT</sub>.

$$V_{HBL} = V_{HBR} - V_{HBH} \quad (5)$$

$$V_{HBL} = 6.7 \text{ V} \quad (6)$$

$$\Delta V_{HB} = 10 \text{ V} - 1.1 \text{ V} - 6.7 \text{ V} \quad (7)$$

$$\Delta V_{HB} = 2.2 \text{ V} \quad (8)$$

$$C_{BOOT} = \frac{43.01nC}{2.2V} \quad (9)$$

$$C_{BOOT} = 19.54 \text{ nF} \quad (10)$$

The bootstrap and bias capacitors should be ceramic types with X7R dielectric. The voltage rating should be twice that of the maximum V<sub>DD</sub> to allow for loss of capacitance once the devices have a dc bias voltage across them and to ensure long term reliability of the devices.

The resistor values, RT1 and RT2, for setting turn on delay can be found in [Figure 18](#).

## 8.2.3 Application Curves

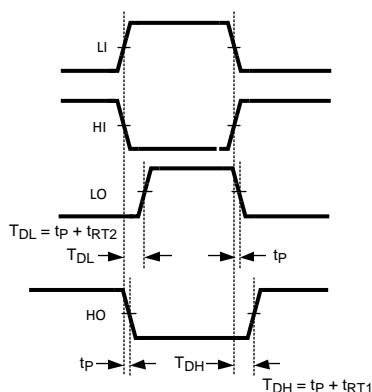


Figure 17. Application Timing Waveforms

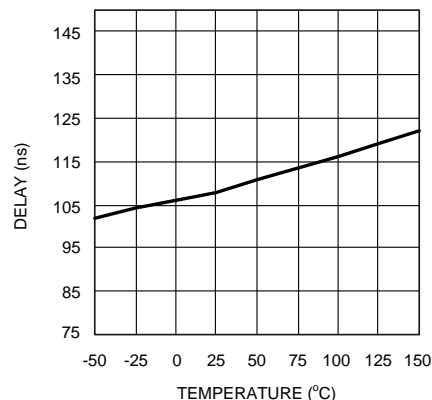


Figure 18. Turn On Delay vs Temperature  
(RT = 10 k)

## 9 Power Supply Recommendations

### 9.1 Power Dissipation Considerations

The total IC power dissipation is the sum of the gate driver losses and the bootstrap diode losses. The gate driver losses are related to the switching frequency ( $f$ ), output load capacitance on LO and HO ( $C_L$ ), and supply voltage ( $V_{DD}$ ) and can be roughly calculated as shown in Equation 12.

$$P_{DGATES} = 2 \times f \times C_L \times V_{DD}^2 \quad (12)$$

There are some additional losses in the gate drivers due to the internal CMOS stages used to buffer the LO and HO outputs. The following plot shows the measured gate driver power dissipation versus frequency and load capacitance. At higher frequencies and load capacitance values, the power dissipation is dominated by the power losses driving the output loads and agrees well with the above equation. This plot can be used to approximate the power losses due to the gate drivers.

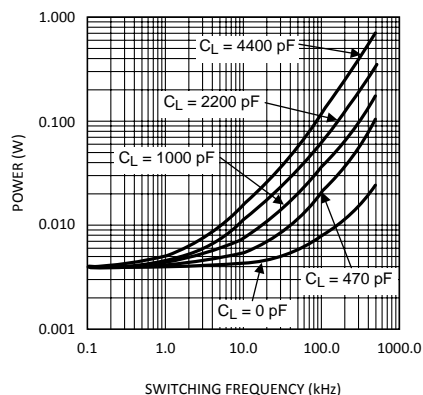
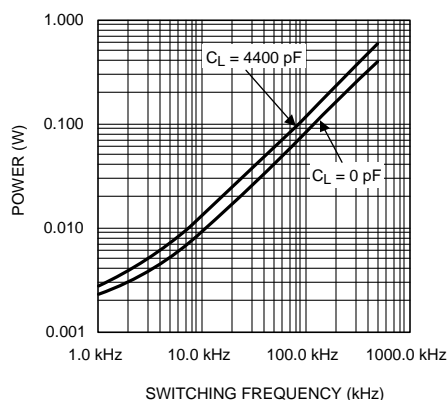


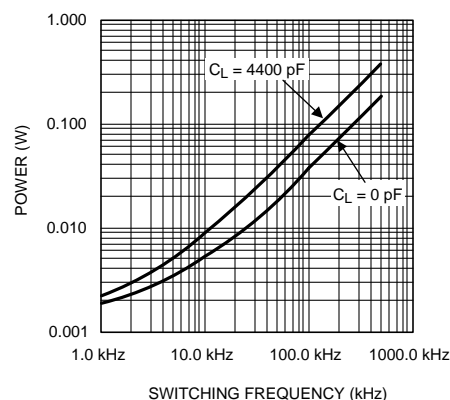
Figure 19. Gate Driver Power Dissipation (LO + HO)  
 $V_{CC} = 12\text{ V}$ , Neglecting Diode Losses

The bootstrap diode power loss is the sum of the forward bias power loss that occurs while charging the bootstrap capacitor and the reverse bias power loss that occurs during reverse recovery. Because each of these events happens once per cycle, the diode power loss is proportional to frequency. Larger capacitive loads require more current to recharge the bootstrap capacitor resulting in more losses. Higher input voltages ( $V_{IN}$ ) to the half bridge result in higher reverse recovery losses. Figure 20 was generated based on calculations and lab measurements of the diode recovery time and current under several operating conditions. This can be useful for approximating the diode power dissipation.

## Power Dissipation Considerations (continued)



**Figure 20. Diode Power Dissipation  $V_{IN} = 80\text{ V}$**



**Figure 21. Diode Power Dissipation  $V_{IN} = 40\text{ V}$**

The total IC power dissipation can be estimated from the above plots by summing the gate drive losses with the bootstrap diode losses for the intended application. Because the diode losses can be significant, an external diode placed in parallel with the internal bootstrap diode (refer to [Figure 16](#)) and can be helpful in removing power from the IC. For this to be effective, the external diode must be placed close to the IC to minimize series inductance and have a significantly lower forward voltage drop than the internal diode.

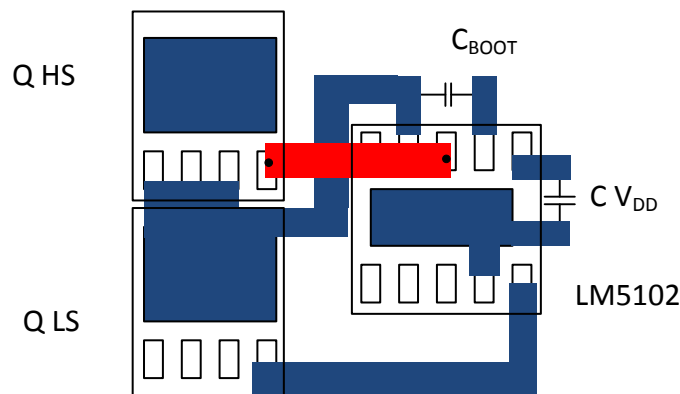
## 10 Layout

### 10.1 Layout Guidelines

The optimum performance of high and low side gate drivers cannot be achieved without taking due considerations during circuit board layout. Following points are emphasized.

1. A low ESR/ESL capacitor must be connected close to the IC, and between  $V_{DD}$  and  $V_{SS}$  pins and between HB and HS pins to support high peak currents being drawn from  $V_{DD}$  during turn-on of the external MOSFET.
2. To prevent large voltage transients at the drain of the top MOSFET, a low ESR electrolytic capacitor must be connected between MOSFET drain and ground ( $V_{SS}$ ).
3. In order to avoid large negative transients on the switch node (HS) pin, the parasitic inductances in the source of top MOSFET and in the drain of the bottom MOSFET (synchronous rectifier) must be minimized.
4. Grounding considerations:
  - The first priority in designing grounding connections is to confine the high peak currents from charging and discharging the MOSFET gate in a minimal physical area. This will decrease the loop inductance and minimize noise issues on the gate terminal of the MOSFET. The MOSFETs should be placed as close as possible to the gate driver.
  - The second high current path includes the bootstrap capacitor, the bootstrap diode, the local ground referenced bypass capacitor and low side MOSFET body diode. The bootstrap capacitor is recharged on the cycle-by-cycle basis through the bootstrap diode from the ground referenced  $V_{DD}$  bypass capacitor. The recharging occurs in a short time interval and involves high peak current. Minimizing this loop length and area on the circuit board is important to ensure reliable operation.
5. The resistors on the RT1 and RT2 timer pins must be placed very close to the IC and separated from high current paths to avoid noise coupling to the time delay generator which could disrupt timer operation.

## 10.2 Layout Example



**Figure 22. LM5102 Component Placement**

## 11 Device and Documentation Support

### 11.1 Trademarks

All trademarks are the property of their respective owners.

### 11.2 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 11.3 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM5102MM/NOPB    | ACTIVE        | VSSOP        | DGS                | 10   | 1000           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 5102                    | <a href="#">Samples</a> |
| LM5102MMX/NOPB   | ACTIVE        | VSSOP        | DGS                | 10   | 3500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 5102                    | <a href="#">Samples</a> |
| LM5102SD/NOPB    | ACTIVE        | WSO          | DPR                | 10   | 1000           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 5102SD                  | <a href="#">Samples</a> |
| LM5102SDX/NOPB   | ACTIVE        | WSO          | DPR                | 10   | 4500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 5102SD                  | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

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**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

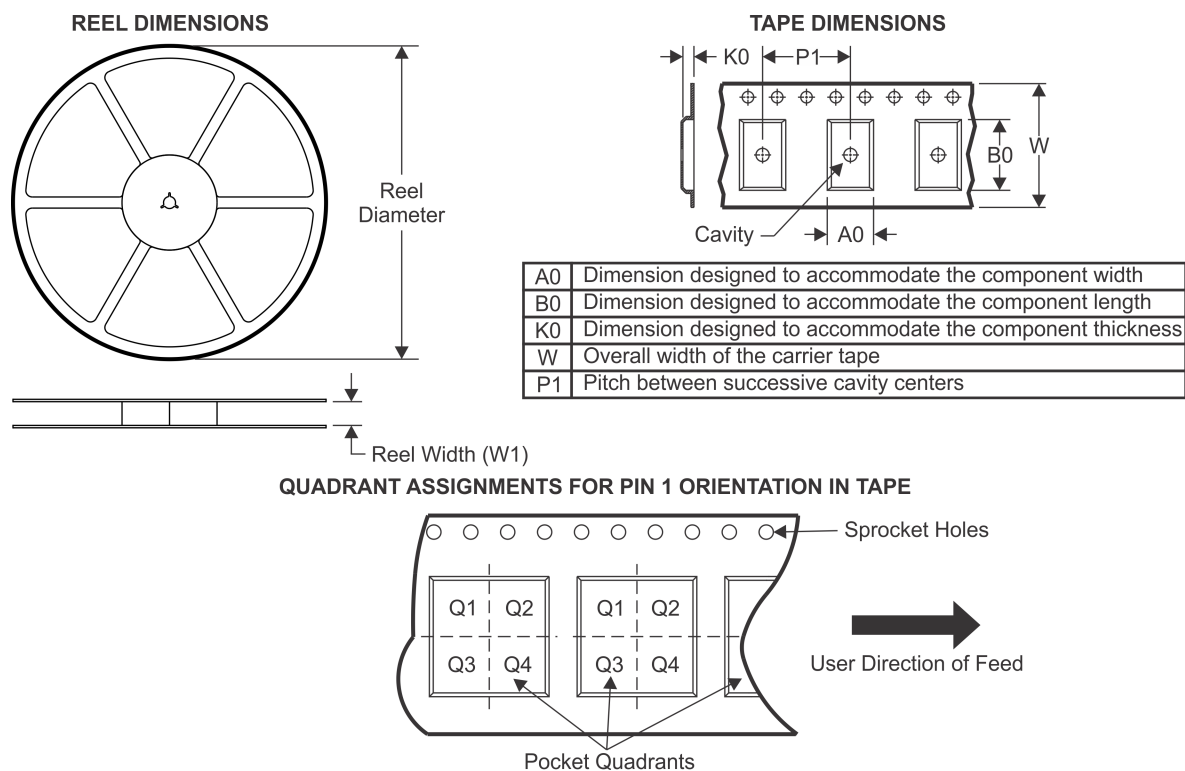
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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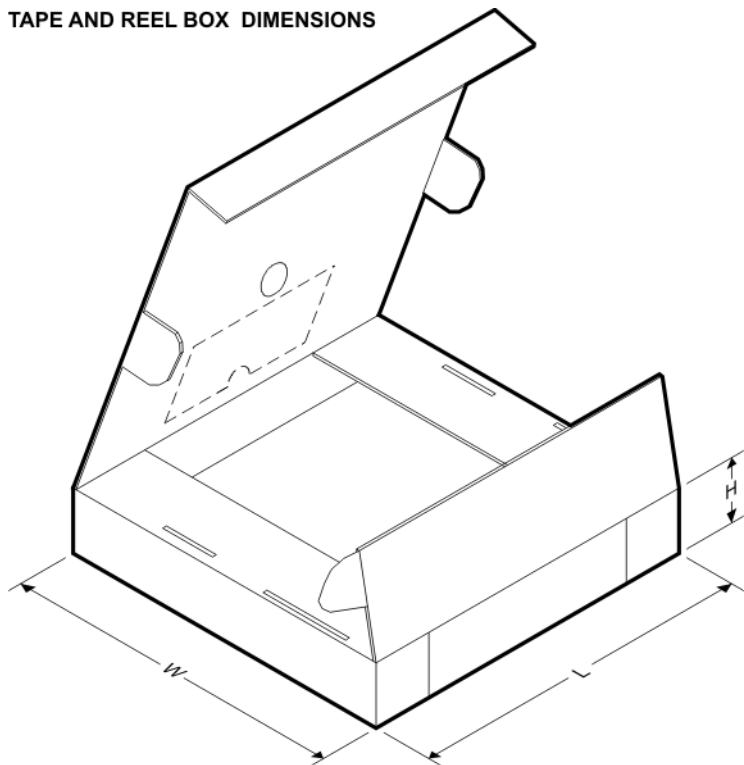
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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM5102MM/NOPB  | VSSOP        | DGS             | 10   | 1000 | 178.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| LM5102MMX/NOPB | VSSOP        | DGS             | 10   | 3500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| LM5102SD/NOPB  | WSO          | DPR             | 10   | 1000 | 178.0              | 12.4               | 4.3     | 4.3     | 1.3     | 8.0     | 12.0   | Q1            |
| LM5102SDX/NOPB | WSO          | DPR             | 10   | 4500 | 330.0              | 12.4               | 4.3     | 4.3     | 1.3     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

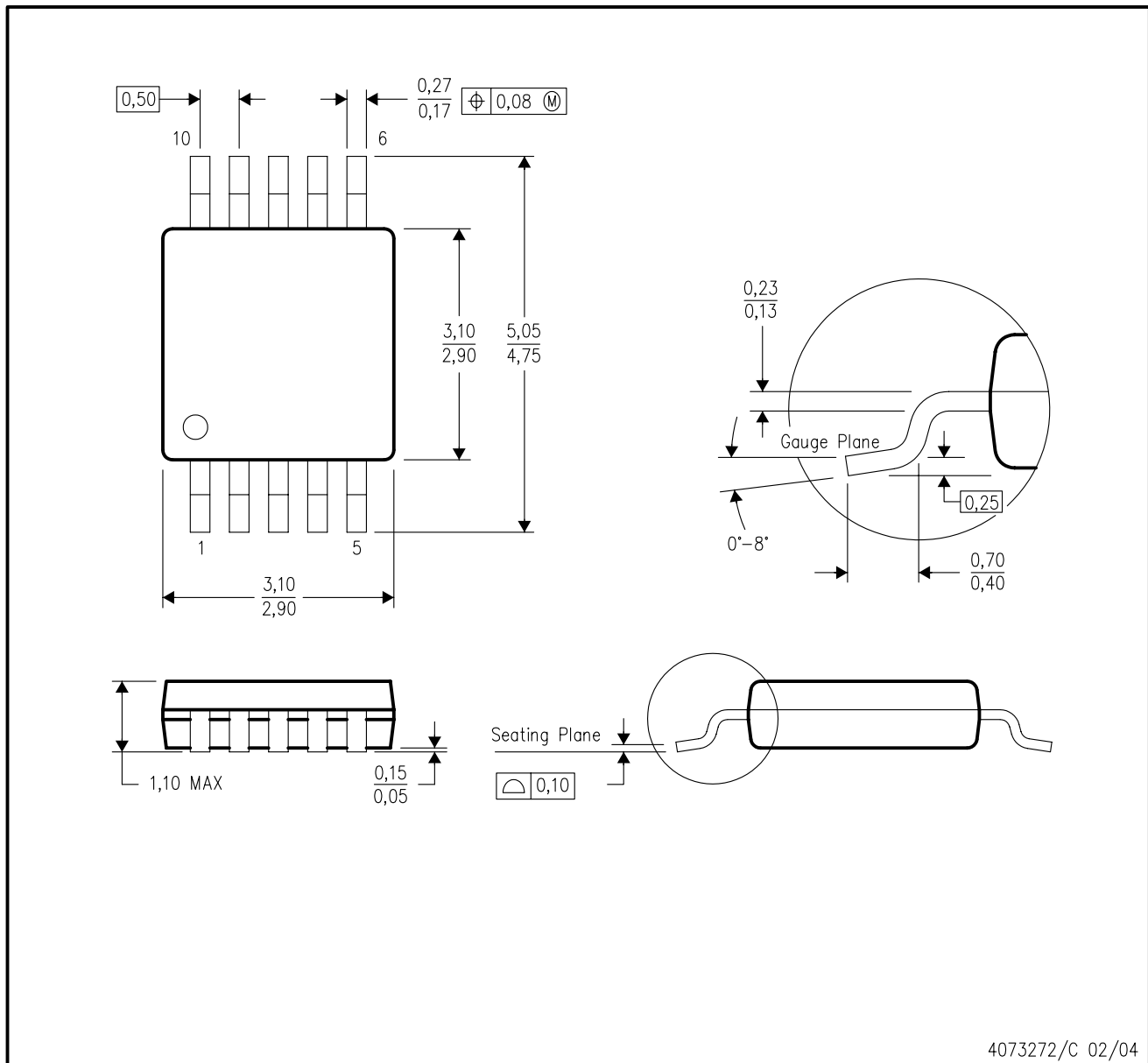


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM5102MM/NOPB  | VSSOP        | DGS             | 10   | 1000 | 210.0       | 185.0      | 35.0        |
| LM5102MMX/NOPB | VSSOP        | DGS             | 10   | 3500 | 367.0       | 367.0      | 35.0        |
| LM5102SD/NOPB  | WSON         | DPR             | 10   | 1000 | 210.0       | 185.0      | 35.0        |
| LM5102SDX/NOPB | WSON         | DPR             | 10   | 4500 | 367.0       | 367.0      | 35.0        |

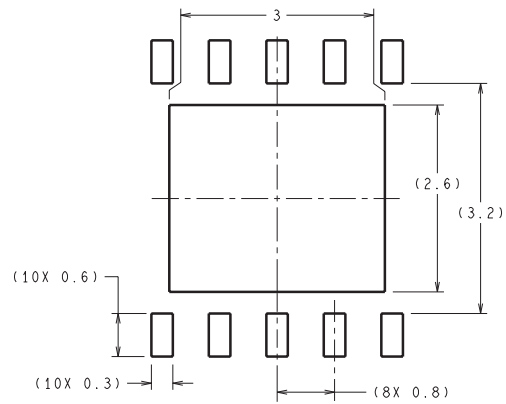
## DGS (S-PDSO-G10)

## PLASTIC SMALL-OUTLINE PACKAGE

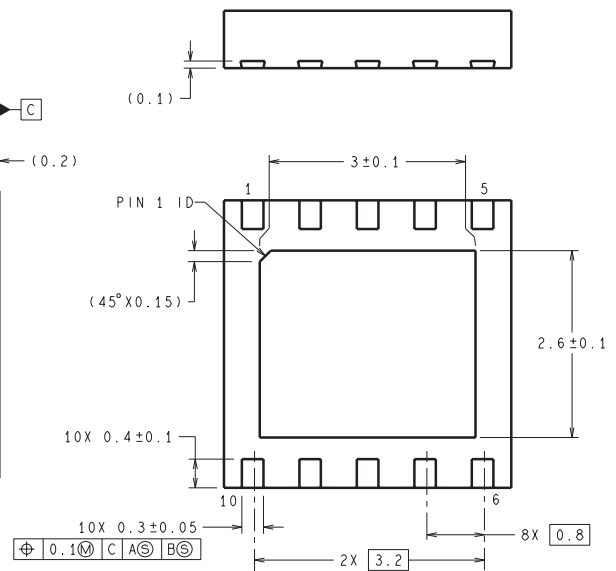
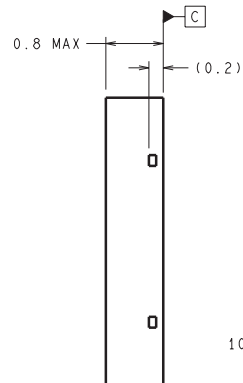
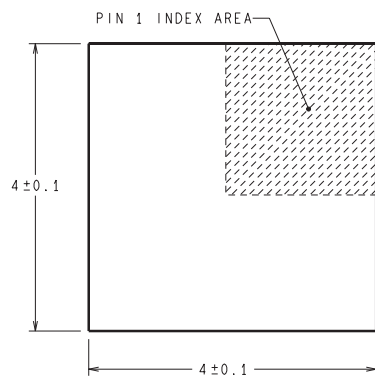


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion.
  - Falls within JEDEC MO-187 variation BA.

DPR0010A



### RECOMMENDED LAND PATTERN



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