



## LM5112, LM5112-Q1 Tiny 7-A MOSFET Gate Driver

### 1 Features

- LM5112-Q1 is Qualified for Automotive Applications
- AEC-Q100 Grade 1 Qualified
- Manufactured on an Automotive Grade Flow
- Compound CMOS and Bipolar Outputs Reduce Output Current Variation
- 7-A Sink and 3-A Source Current
- Fast Propagation Times: 25 ns (Typical)
- Fast Rise and Fall Times: 14 ns or 12 ns Rise or Fall With 2-nF Load
- Inverting and Non-Inverting Inputs Provide Either Configuration With a Single Device
- Supply Rail Undervoltage Lockout Protection
- Dedicated Input Ground (IN\_REF) for Split Supply or Single Supply Operation
- Power Enhanced 6-Pin WSON Package (3 mm × 3 mm) or Thermally Enhanced MSOP-PowerPAD Package
- Output Swings From  $V_{CC}$  to  $V_{EE}$  Which Are Negative Relative to Input Ground

### 2 Applications

- DC to DC Switch-Mode Power Supplies
- AC to DC Switch-Mode Power Supplies
- Solar Microinverters
- Solenoid and Motor Drives

### 3 Description

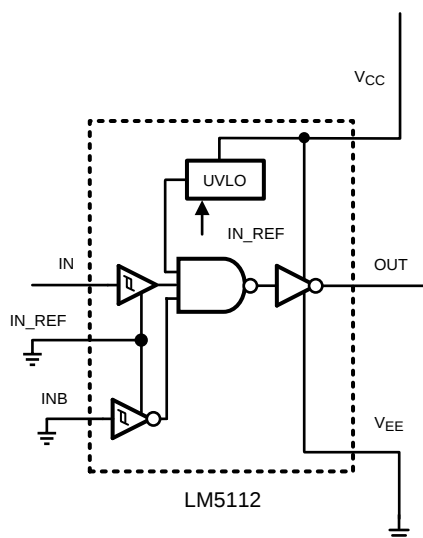
The LM5112 device MOSFET gate driver provides high peak gate drive current in the tiny 6-pin WSON package (SOT-23 equivalent footprint) or an 8-pin exposed-pad MSOP package with improved power dissipation required for high frequency operation. The compound output driver stage includes MOS and bipolar transistors operating in parallel that together sink more than 7 A peak from capacitive loads. Combining the unique characteristics of MOS and bipolar devices reduces drive current variation with voltage and temperature. Undervoltage lockout protection is provided to prevent damage to the MOSFET due to insufficient gate turnon voltage. The LM5112 device provides both inverting and non-inverting inputs to satisfy requirements for inverting and non-inverting gate drive with a single device type.

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

| PART NUMBER          | PACKAGE           | BODY SIZE (NOM)   |
|----------------------|-------------------|-------------------|
| LM5112,<br>LM5112-Q1 | WSON (6)          | 3.00 mm × 3.00 mm |
|                      | MSOP PowerPAD (8) | 3.00 mm × 3.00 mm |

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

#### Simplified Block Diagram



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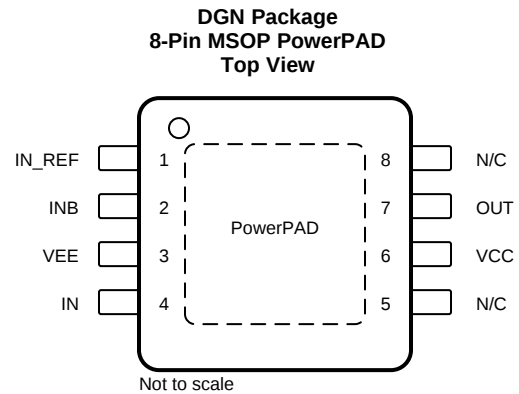
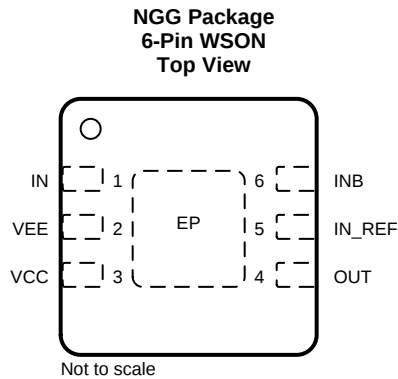
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision B (April 2006) to Revision C                                                                                                                                                                                                                                                                                                   | Page     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| • Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | <b>1</b> |
| • Changed values in the <i>Thermal Information</i> table to align with JEDEC standards .....                                                                                                                                                                                                                                                         | <b>4</b> |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN             |      |      | I/O | DESCRIPTION                                                                                                                                                                                                                        |
|-----------------|------|------|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME            | WSON | MSOP |     |                                                                                                                                                                                                                                    |
| Exposed Pad     | —    | —    | —   | Exposed pad, underside of package: Internally bonded to the die substrate. Connect to V <sub>EE</sub> ground pin for low thermal impedance.                                                                                        |
| IN              | 1    | 4    | I   | Non-inverting input pin: TTL compatible thresholds. Pull up to V <sub>CC</sub> when not used.                                                                                                                                      |
| INB             | 6    | 2    | I   | Inverting input pin: TTL compatible thresholds. Connect to IN_REF when not used.                                                                                                                                                   |
| IN_REF          | 5    | 1    | —   | Ground reference for control inputs: Connect to power ground (V <sub>EE</sub> ) for standard positive only output voltage swing. Connect to system logic ground when V <sub>EE</sub> is connected to a negative gate drive supply. |
| N/C             | —    | 5, 8 | —   | Not internally connected                                                                                                                                                                                                           |
| OUT             | 4    | 7    | O   | Gate drive output: Capable of sourcing 3 A and sinking 7 A. Voltage swing of this output is from V <sub>EE</sub> to V <sub>CC</sub> .                                                                                              |
| V <sub>CC</sub> | 3    | 6    | I   | Positive supply voltage input: Locally decouple to V <sub>EE</sub> . The decoupling capacitor must be placed close to the chip.                                                                                                    |
| V <sub>EE</sub> | 2    | 3    | —   | Power ground for driver outputs: Connect to either power ground or a negative gate drive supply for positive or negative voltage swing.                                                                                            |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)(2)</sup>

|                                | MIN  | MAX | UNIT |
|--------------------------------|------|-----|------|
| $V_{CC}$ to $V_{EE}$           | −0.3 | 15  | V    |
| $V_{CC}$ to IN_REF             | −0.3 | 15  | V    |
| IN/INB to IN_REF               | −0.3 | 15  | V    |
| IN_REF to $V_{EE}$             | −0.3 | 5   | V    |
| Maximum junction temperature   |      | 150 | °C   |
| Operating junction temperature | −40  | 125 | °C   |
| Storage temperature, $T_{stg}$ | −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

over operating free-air temperature range (unless otherwise noted)

|                                                                      | MIN | MAX | UNIT |
|----------------------------------------------------------------------|-----|-----|------|
| $V_{CC}$ Operating voltage, $V_{CC} - IN\_REF$ and $V_{CC} - V_{EE}$ | 3.5 | 14  | V    |
| Operating junction temperature                                       | −40 | 125 | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | LM5112, LM5112-Q1 |                     | UNIT |
|-------------------------------|----------------------------------------------|-------------------|---------------------|------|
|                               |                                              | NGG (WSON)        | DGN (MSOP PowerPAD) |      |
|                               |                                              | 6 PINS            | 8 PINS              |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 40                | 53.7                | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 50.8              | 61.1                | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 29.3              | 37.2                | °C/W |
| $\psi_{JT}$                   | Junction-to-top characterization parameter   | 0.7               | 7.2                 | °C/W |
| $\psi_{JB}$                   | Junction-to-board characterization parameter | 29.5              | 36.9                | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case (bottom) thermal resistance | 7.5               | 4.7                 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

$T_J = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ,  $V_{CC} = 12\text{ V}$ ,  $\text{INB} = \text{IN\_REF} = V_{EE} = 0\text{ V}$ , and no Load on output (unless otherwise noted).

| PARAMETER                 |                               | CONDITIONS                                             | MIN | TYP  | MAX | UNIT          |
|---------------------------|-------------------------------|--------------------------------------------------------|-----|------|-----|---------------|
| <b>SUPPLY</b>             |                               |                                                        |     |      |     |               |
| $V_{CC}$                  | Operating voltage             | $V_{CC} - \text{IN\_REF}$ and $V_{CC} - V_{EE}$        | 3.5 |      | 14  | V             |
| UVLO                      | Undervoltage lockout (rising) | $V_{CC} - \text{IN\_REF}$                              | 2.4 | 3    | 3.5 | V             |
| $V_{CCH}$                 | Undervoltage hysteresis       |                                                        |     | 230  |     | mV            |
| $I_{CC}$                  | Supply current                |                                                        |     | 1    | 2   | mA            |
| <b>CONTROL INPUTS</b>     |                               |                                                        |     |      |     |               |
| $V_{IH}$                  | Logic high                    |                                                        | 2.3 |      |     | V             |
| $V_{IL}$                  | Logic low                     |                                                        |     |      | 0.8 | V             |
| $V_{thH}$                 | High threshold                |                                                        | 1.3 | 1.75 | 2.3 | V             |
| $V_{thL}$                 | Low threshold                 |                                                        | 0.8 | 1.35 | 2   | V             |
| HYS                       | Input hysteresis              |                                                        |     | 400  |     | mV            |
| $I_{IL}$                  | Input current low             | $\text{IN} = \text{INB} = 0\text{ V}$                  | -1  | 0.1  | 1   | $\mu\text{A}$ |
| $I_{IH}$                  | Input current high            | $\text{IN} = \text{INB} = V_{CC}$                      | -1  | 0.1  | 1   | $\mu\text{A}$ |
| <b>OUTPUT DRIVER</b>      |                               |                                                        |     |      |     |               |
| $R_{OH}$                  | Output resistance high        | $I_{OUT} = -10\text{ mA}^{(1)}$                        |     | 30   | 50  | $\Omega$      |
| $R_{OL}$                  | Output resistance low         | $I_{OUT} = 10\text{ mA}^{(1)}$                         |     | 1.4  | 2.5 | $\Omega$      |
| $I_{SOURCE}$              | Peak source current           | $\text{OUT} = V_{CC} / 2,200\text{ ns}$ pulsed current |     | 3    |     | A             |
| $I_{SINK}$                | Peak sink current             | $\text{OUT} = V_{CC} / 2,200\text{ ns}$ pulsed current |     | 7    |     | A             |
| <b>LATCHUP PROTECTION</b> |                               |                                                        |     |      |     |               |
| AEC-Q100, METHOD 004      |                               | $T_J = 150^{\circ}\text{C}$                            |     | 500  |     | mA            |

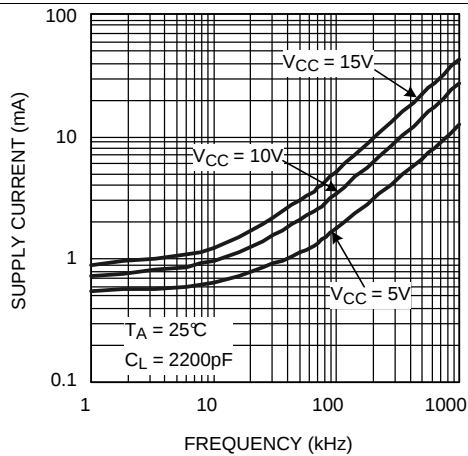
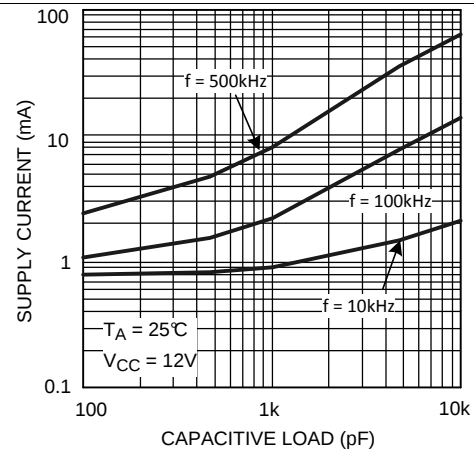
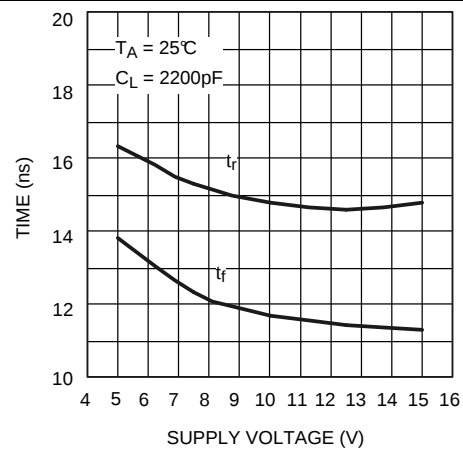
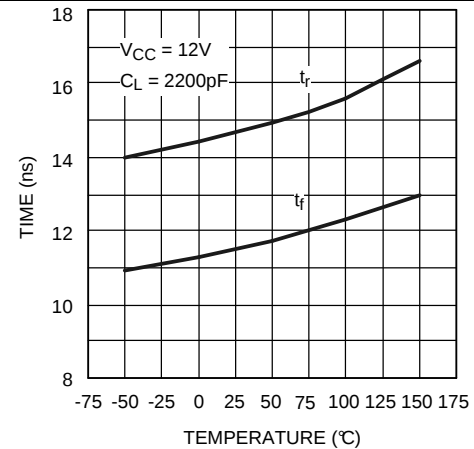
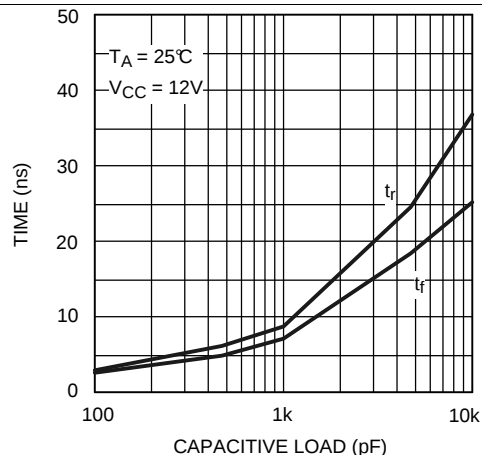
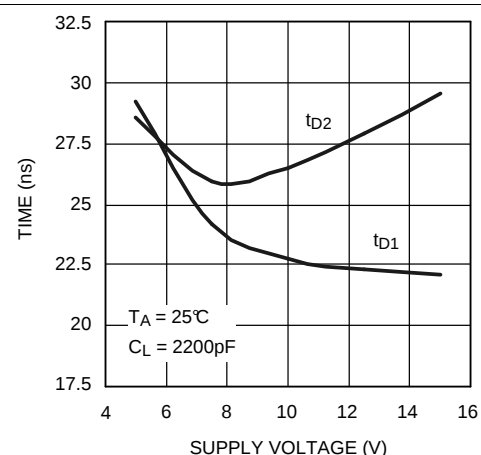
(1) The output resistance specification applies to the MOS device only. The total output current capability is the sum of the MOS and bipolar devices.

## 6.6 Switching Characteristics

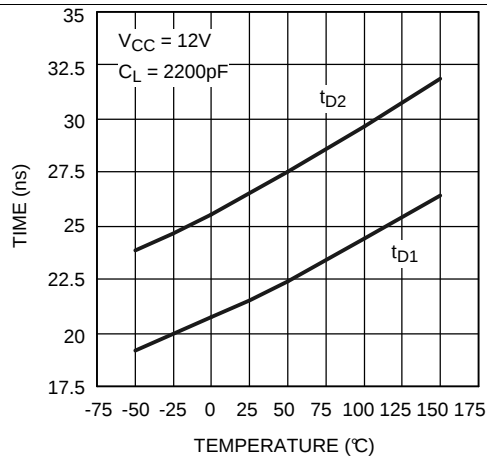
over operating free-air temperature range (unless otherwise noted)

| PARAMETER |                                                                   | TEST CONDITIONS                                          | MIN | TYP | MAX | UNIT |
|-----------|-------------------------------------------------------------------|----------------------------------------------------------|-----|-----|-----|------|
| td1       | Propagation delay time low to high, IN or INB rising (IN to OUT)  | $C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 13</a> |     | 25  | 40  | ns   |
| td2       | Propagation delay time high to low, IN or INB falling (IN to OUT) | $C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 13</a> |     | 25  | 40  | ns   |
| tr        | Rise time                                                         | $C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 13</a> |     | 14  |     | ns   |
| tf        | Fall time                                                         | $C_{LOAD} = 2\text{ nF}$ , see <a href="#">Figure 13</a> |     | 12  |     | ns   |

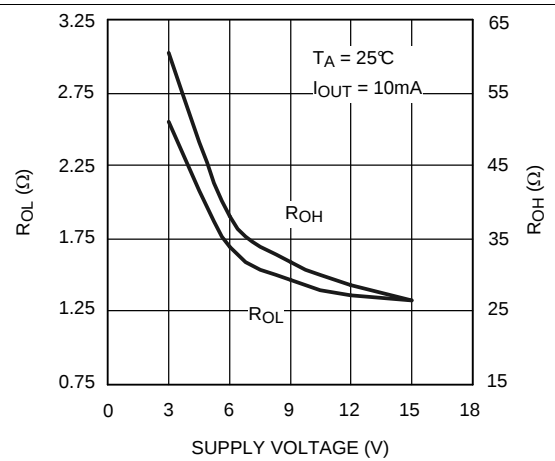
## 6.7 Typical Characteristics


**Figure 1. Supply Current vs Frequency**

**Figure 2. Supply Current vs Capacitive Load**

**Figure 3. Rise and Fall Time vs Supply Voltage**

**Figure 4. Rise and Fall Time vs Temperature**

**Figure 5. Rise and Fall Time vs Capacitive Load**

**Figure 6. Delay Time vs Supply Voltage**

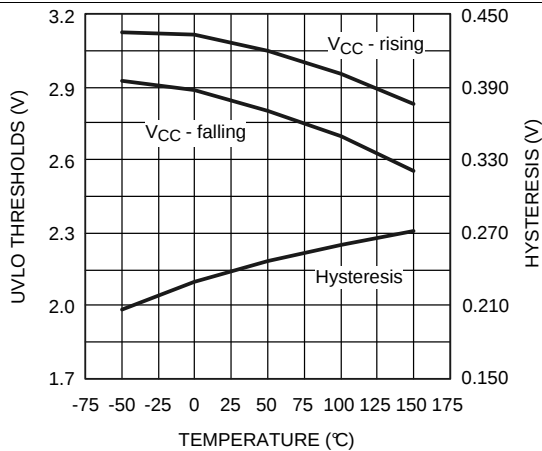
## Typical Characteristics (continued)



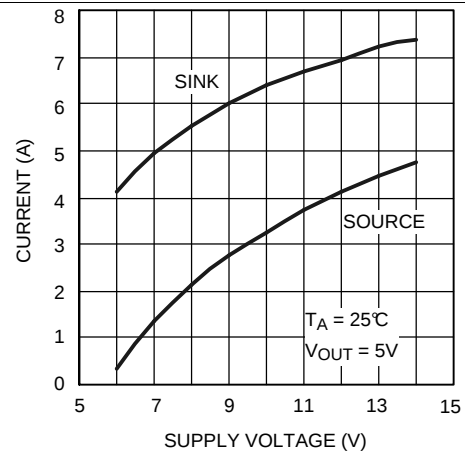
**Figure 7. Delay Time vs Temperature**



**Figure 8.  $R_{DS(on)}$  vs Supply Voltage**



**Figure 9. UVLO Thresholds and Hysteresis vs Temperature**



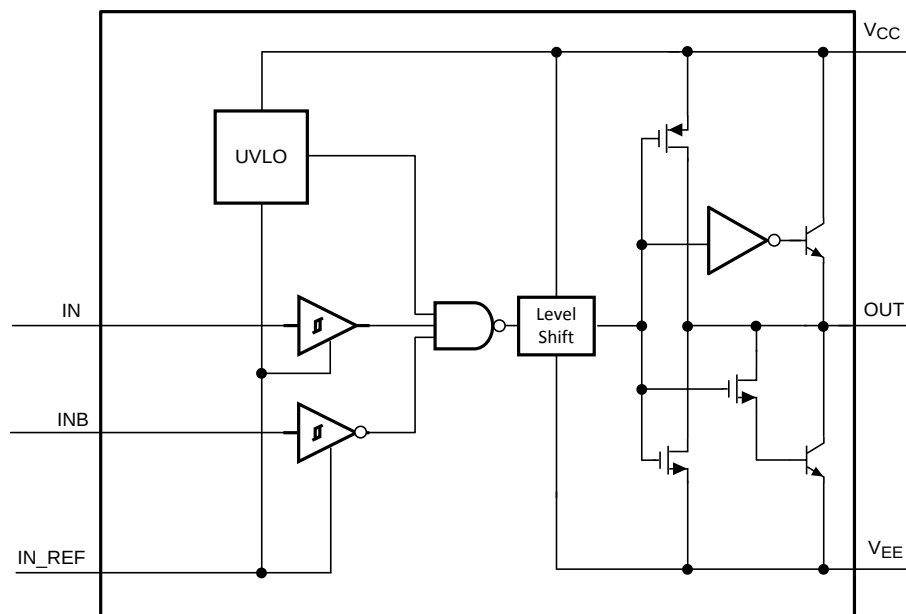
**Figure 10. Peak Current vs Supply Voltage**

## 7 Detailed Description

### 7.1 Overview

The LM5112 device is a high-speed, high-peak current (7 A) single-channel MOSFET driver. The high-peak output current of the LM5112 device switches power MOSFETs on and off with short rise and fall times, thereby reducing switching losses considerably. The LM5112 device includes both inverting and non-inverting inputs that give the user flexibility to drive the MOSFET with either active low or active high logic signals. The driver output stage consists of a compound structure with MOS and bipolar transistor operating in parallel to optimize current capability over a wide output voltage and operating temperature range. The bipolar device provides high peak current at the critical Miller plateau region of the MOSFET  $V_{GS}$ , while the MOS device provides rail-to-rail output swing. The totem pole output drives the MOSFET gate between the gate drive supply voltage  $V_{CC}$  and the power ground potential at the  $V_{EE}$  pin.

### 7.2 Functional Block Diagram



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**Figure 11. LM5112 Functional Block Diagram**

### 7.3 Feature Description

The control inputs of the driver are high impedance CMOS buffers with TTL compatible threshold voltages. The negative supply of the input buffer is connected to the input ground pin IN\_REF. An internal level shifting circuit connects the logic input buffers to the totem pole output drivers. The level shift circuit and the separate input or output ground pins provide the option of single supply or split supply configurations. When driving the MOSFET gate from a single positive supply, the IN\_REF and V<sub>EE</sub> pins are both connected to the power ground.

The isolated input and output stage grounds provide the capability to drive the MOSFET to a negative V<sub>GS</sub> voltage for a more robust and reliable off state. In split supply configuration, the IN\_REF pin is connected to the ground of the controller which drives the LM5112 inputs. The V<sub>EE</sub> pin is connected to a negative bias supply that can range from the IN\_REF potential to as low as 14 V below the V<sub>CC</sub> gate drive supply. For reliable operation, the maximum voltage difference between V<sub>CC</sub> and IN\_REF or between V<sub>CC</sub> and V<sub>EE</sub> is 14 V.

The minimum recommended operating voltage between V<sub>CC</sub> and IN\_REF is 3.5 V. An undervoltage lockout (UVLO) circuit is included in the LM5112 which senses the voltage difference between V<sub>CC</sub> and the input ground pin, IN\_REF. When the V<sub>CC</sub> to IN\_REF voltage difference falls below 2.8 V the driver is disabled and the output pin is held in the low state. The UVLO hysteresis prevents chattering during brown-out conditions; the driver resumes normal operation when the V<sub>CC</sub> to IN\_REF differential voltage exceeds 3 V.

## 7.4 Device Functional Modes

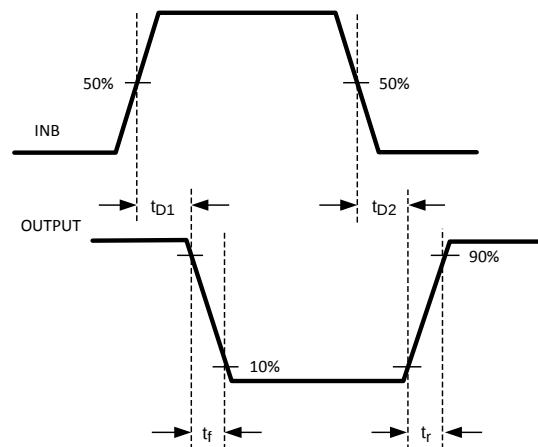
The device output state is dependent on states of the IN and INB pins. [Table 1](#) lists the output states for different input pin combinations.

**Table 1. Device Logic Table**

| IN PIN | INB PIN | OUT PIN |
|--------|---------|---------|
| L      | L       | L       |
| L      | H       | L       |
| H      | L       | H       |
| H      | H       | L       |

### 7.4.1 Inverting Mode

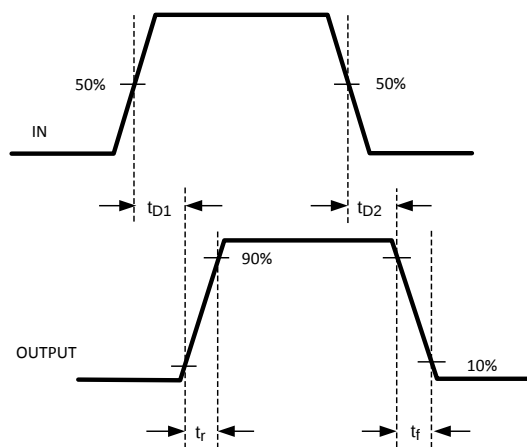
During the inverting mode of operation, INB is used as the control input and the polarity of OUT is reversed with respect to INB. [Figure 12](#) shows a timing diagram of this mode. The IN pin is not used in this mode of operation and must be pulled up to  $V_{CC}$ .



**Figure 12. Inverting**

### 7.4.2 Non-Inverting Mode

During the non-inverting mode of operation, IN is used as the control input and the polarity of OUT is the same with respect to IN. [Figure 13](#) shows a timing diagram of this mode. The INB pin is not used in this mode of operation and must be connected to IN\_REF.



**Figure 13. Non-Inverting**

## 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.

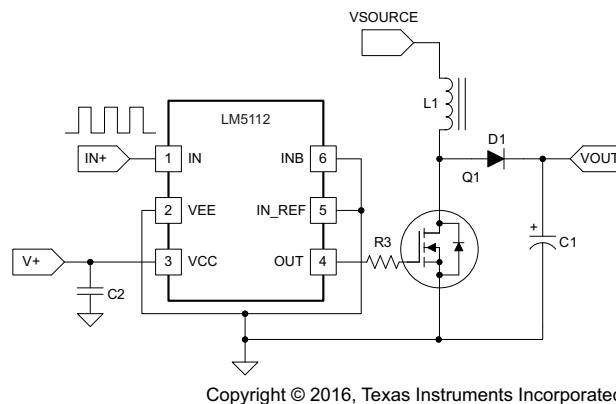
### 8.1 Application Information

A leading application for gate drivers such as the LM5112 is providing a high power buffer stage between the PWM output of a control IC and the gates of the primary power switching devices. In other cases, the driver IC is used to drive the power device gates through a drive transformer. Driver ICs are used when it is not feasible to have the primary PWM regulator IC directly drive the switching devices for one or more reasons. The PWM IC may not have the brute drive capability required for the intended switching MOSFET, limiting the switching performance in the application.

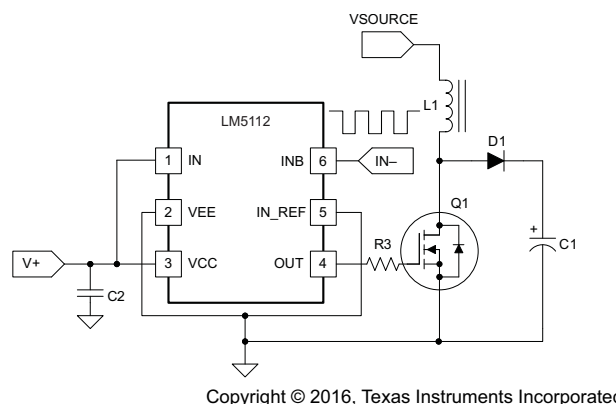
The LM5112 is used to drive a low side MOSFET with low switching losses. Either one of the control input pins, IN or INB, are used to control the gate drive to the MOSFET. The choice of the control input pin used depends on the polarity of operation.

### 8.2 Typical Application

Typical application diagrams for the LM5112 device are shown below, illustrating use in non-inverting and inverting driver configurations. The high peak gate drive current of the LM5112 allows for short rise and fall times on the low-side MOSFET, thereby improving overall efficiency of the system and reducing switching losses.



**Figure 14. Typical Application Diagram (Using Non-Inverting Control Input)**



**Figure 15. Typical Application Diagram (Using Inverting Control Input)**

## Typical Application (continued)

### 8.2.1 Design Requirements

When selecting the proper gate driver device for an end application, some design considerations must be evaluated first to make the most appropriate selection. Among these considerations are input-to-output configuration, the input threshold type, bias supply voltage levels, peak source and sink currents, capacitive load, and switching frequency. [Table 2](#) shows some sample values for a typical application.

**Table 2. Design Parameters**

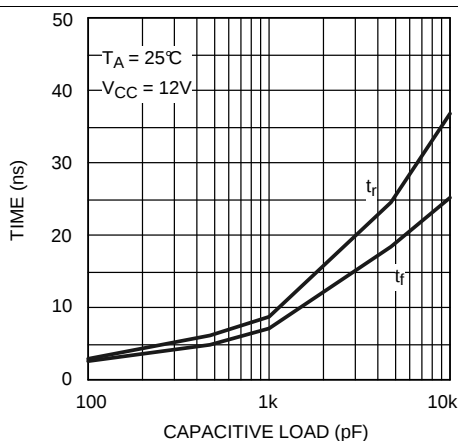
| PARAMETER                                                                          | VALUE         |
|------------------------------------------------------------------------------------|---------------|
| Input-to-output logic                                                              | Non-inverting |
| V <sub>CC</sub> bias supply voltage<br>(measured with respect to V <sub>EE</sub> ) | 12 V          |
| Supply configuration                                                               | Split supply  |
| Peak source current                                                                | 3 A           |
| Peak sink current                                                                  | 7 A           |
| Output load (MOSFET gate capacitance)                                              | 2 nF          |
| Gate drive resistor                                                                | 1 $\Omega$    |
| Switching frequency                                                                | 300 kHz       |

### 8.2.2 Detailed Design Procedure

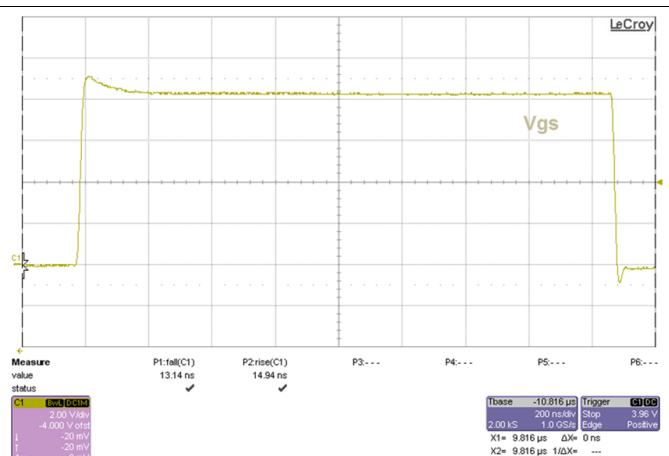
See [Power Supply Recommendations](#), [Layout](#), and [Thermal Considerations](#) for key design considerations regarding the input supply, grounding, and thermal calculations specific to the LM5112.

### 8.2.3 Application Curves

The rise and fall times of the OUT signal depends on the capacitance of the MOSFET gate. Therefore, an appropriate MOSFET must be selected to meet the switching speed and efficiency requirements of the system. [Figure 16](#) shows the rise and fall time curves as a function of capacitive load. [Figure 17](#) shows output rise and fall time measured on an application board, showing actual device performance. The testing conditions for this figure are C<sub>load</sub> = 2.2 nF, R<sub>drive</sub> = 1  $\Omega$ , and f<sub>s</sub> = 300 kHz.



**Figure 16. Rise and Fall Time vs Capacitive Load**



**Figure 17. Measured Rise and Fall Time**

## 9 Power Supply Recommendations

The recommended bias supply voltage range for LM5112 is from 3.5 V to 14 V. The lower end of this range is governed by the internal UVLO protection feature of the  $V_{CC}$  supply circuit. The upper end of this range is driven by the 14 V maximum recommended operating voltage rating of the  $V_{CC}$  supply. It is recommended to keep proper margin to allow for transient voltage spikes. The dedicated input ground pin (IN\_REF) allows split output supply operation. For such applications, ensure  $V_{EE}$  is not connected to IN\_REF.

The UVLO protection feature also involves a hysteresis function. This means that once the device is operating in normal mode, if the  $V_{CC}$  voltage drops, the device continues to operate in normal mode as long as the voltage drop does not exceed the hysteresis specification,  $V_{CCH}$ . If the voltage drop is greater than the hysteresis specification, the device shuts down. Therefore, while operating at or near the 3.5 V range, the voltage ripple on the auxiliary power supply output must be smaller than the hysteresis specification of LM5112 to avoid triggering device-shutdown.

A low-ESR or low-ESL capacitor must be connected close to the IC and between the  $V_{CC}$  and  $V_{EE}$  pins to support high peak currents being drawn from  $V_{CC}$  during turnon of the MOSFET. Also, if input pin (IN or INB) is not being used, it must be connected to  $V_{CC}$  or IN\_REF, respectively, to avoid spurious output signals.

## 10 Layout

### 10.1 Layout Guidelines

Attention must be given to board layout when using the LM5112 device. Some important considerations include:

Proper grounding is crucial. The driver required a low impedance path for current return to ground avoiding inductive loops. Two paths for returning current to ground are a) between the LM5112 device IN\_REF pin and the ground of the circuit that controls the driver inputs and b) between the LM5112 device  $V_{EE}$  pin and the source of the power MOSFET being driven. Both paths must be as short as possible to reduce inductance and be as wide as possible to reduce resistance. These ground paths must be distinctly separate to avoid coupling between the high current output paths and the logic signals that drive the LM5112 device. With rise and fall times in the range of 10 nsec to 30 nsec, care is required to minimize the lengths of current carrying conductors to reduce their inductance and EMI from the high di/dt transients generated when driving large capacitive loads.

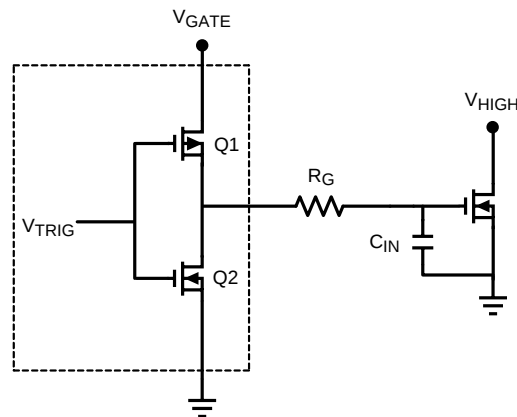
#### 10.1.1 Thermal Considerations

The primary goal of the thermal management is to maintain the integrated circuit (IC) junction temperature ( $T_J$ ) below a specified limit to ensure reliable long term operation. The maximum  $T_J$  of IC components must be estimated in worst case operating conditions. The junction temperature is calculated based on the power dissipated on the IC and the junction to ambient thermal resistance  $R_{\theta JA}$  for the IC package in the application board and environment. The  $R_{\theta JA}$  is not a given constant for the package and depends on the PCB design and the operating environment.

## Layout Guidelines (continued)

### 10.1.1.1 Drive Power Requirement Calculations In LM5112

The LM5112 device is a single, low-side MOSFET driver capable of sourcing and sinking 3-A or 7-A peak currents for short intervals to drive a MOSFET without exceeding package power dissipation limits. High peak currents are required to switch the MOSFET gate quickly for operation at high frequencies.



**Figure 18. MOSFET Driver Diagram**

Figure 18 shows a conceptual diagram of the LM5112 device output and MOSFET load. Q1 and Q2 are the switches within the gate driver.  $R_G$  is the gate resistance of the external MOSFET, and  $C_{in}$  is the equivalent gate capacitance of the MOSFET. The equivalent gate capacitance is a difficult parameter to measure as it is the combination of  $C_{GD}$  (gate to source capacitance) and  $C_{GD}$  (gate to drain capacitance). The  $C_{GD}$  is not a constant and varies with the drain voltage. The better way of quantifying gate capacitance is the gate charge  $Q_G$  in coulombs.  $Q_G$  combines the charge required by  $C_{GD}$  and  $C_{GD}$  for a given gate drive voltage  $V_{GATE}$ . The gate resistance  $R_G$  is usually small and losses in it are neglected. The total power dissipated in the MOSFET driver due to gate charge is approximated by Equation 1.

$$P_{DRIVER} = V_{GATE} \times Q_G \times F_{SW}$$

where

- $F_{SW}$  = switching frequency of the MOSFET (1)

For example, consider the MOSFET MTD6N15 whose gate charge specified as 30 nC for  $V_{GATE} = 12$  V.

Therefore, the power dissipation in the driver due to charging and discharging of MOSFET gate capacitances at switching frequency of 300 kHz and  $V_{GATE}$  of 12 V is equal to Equation 2.

$$P_{DRIVER} = 12 \text{ V} \times 30 \text{ nC} \times 300 \text{ kHz} = 0.108 \text{ W} \quad (2)$$

In addition to the above gate charge power dissipation, - transient power is dissipated in the driver during output transitions. When either output of the LM5112 device changes state, current flows from  $V_{CC}$  to  $V_{EE}$  for a brief interval of time through the output totem-pole N and P channel MOSFETs. The final component of power dissipation in the driver is the power associated with the quiescent bias current consumed by the driver input stage and Undervoltage lockout sections.

## Layout Guidelines (continued)

Characterization of the LM5112 device provides accurate estimates of the transient and quiescent power dissipation components. At 300 kHz switching frequency and 30 nC load used in the example, the transient power is 8 mW. The 1 mA nominal quiescent current and 12 V  $V_{GATE}$  supply produce a 12 mW typical quiescent power.

Therefore, the total power dissipation is calculated with [Equation 3](#).

$$P_D = 0.118 + 0.008 + 0.012 = 0.138 \text{ W} \quad (3)$$

The junction temperature is given by [Equation 4](#).

$$T_J = P_D \times R_{\theta JA} + T_A \quad (4)$$

Or the rise in temperature is given by [Equation 5](#).

$$T_{RISE} = T_J - T_A = P_D \times R_{\theta JA} \quad (5)$$

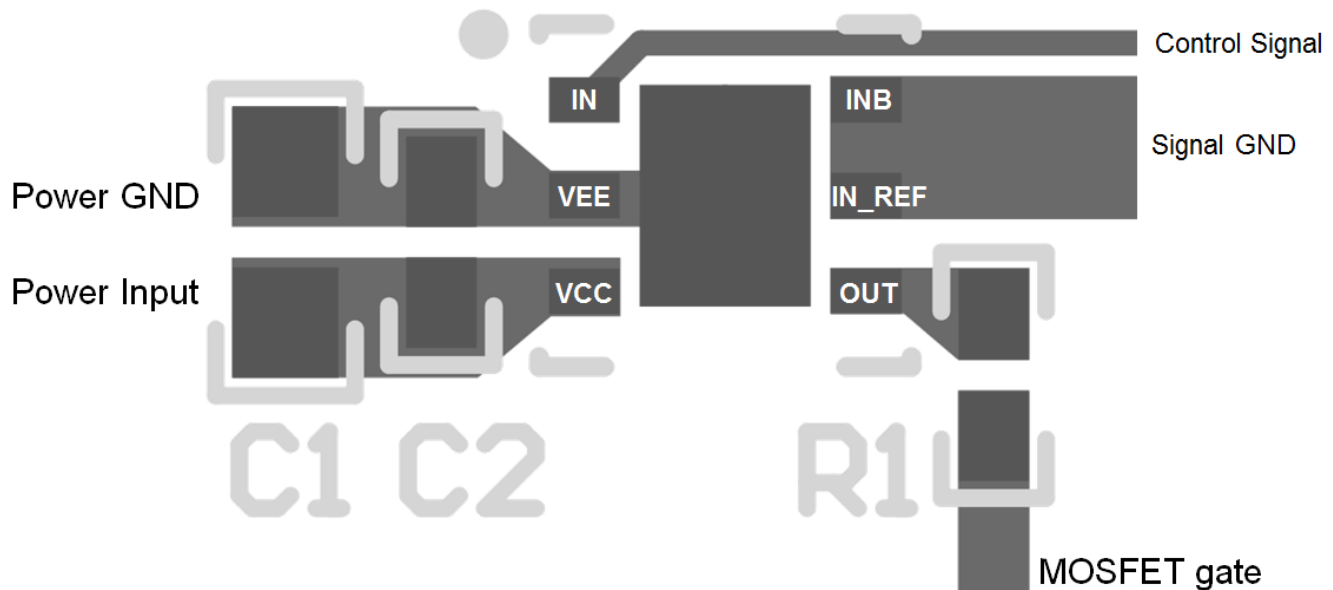
For 6-pin WSON package, the integrated circuit die is attached to leadframe die pad which is soldered directly to the printed circuit board. This substantially decreases the junction to ambient thermal resistance ( $R_{\theta JA}$ ). By providing suitable means of heat dispersion from the IC to the ambient through exposed copper pad, which can readily dissipate heat to the surroundings,  $R_{\theta JA}$  as low as 40°C/W is achievable with the package. The resulting  $T_{RISE}$  for the driver example above is thereby reduced to just 5.5°C.

Therefore,  $T_{RISE}$  is equal to [Equation 6](#).

$$T_{RISE} = 0.138 \times 40 = 5.5^\circ\text{C} \quad (6)$$

For MSOP-PowerPAD,  $R_{\theta JA}$  is typically 60°C/W.

## 10.2 Layout Example



**Figure 19. LM5112 Layout Example**

## 11 Device and Documentation Support

### 11.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

**Table 3. Related Links**

| PARTS     | PRODUCT FOLDER             | SAMPLE & BUY               | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| LM5112    | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| LM5112-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

### 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 11.4 Trademarks

E2E is a trademark of Texas Instruments.  
All other trademarks are the property of their respective owners.

### 11.5 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.

### 11.6 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 part number            | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|----------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">LM5112MY/NOPB</a>    | Active        | Production           | HVSSOP (DGN)   8 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -            | SJJB                |
| LM5112MY/NOPB.A                  | Active        | Production           | HVSSOP (DGN)   8 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SJJB                |
| LM5112MY/NOPB.B                  | Active        | Production           | HVSSOP (DGN)   8 | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SJJB                |
| <a href="#">LM5112MYX/NOPB</a>   | Active        | Production           | HVSSOP (DGN)   8 | 3500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -            | SJJB                |
| LM5112MYX/NOPB.A                 | Active        | Production           | HVSSOP (DGN)   8 | 3500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SJJB                |
| LM5112MYX/NOPB.B                 | Active        | Production           | HVSSOP (DGN)   8 | 3500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | SJJB                |
| <a href="#">LM5112Q1SD/NOPB</a>  | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| LM5112Q1SD/NOPB.A                | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| LM5112Q1SD/NOPB.B                | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| <a href="#">LM5112Q1SDX/NOPB</a> | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| LM5112Q1SDX/NOPB.A               | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| LM5112Q1SDX/NOPB.B               | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L250B               |
| <a href="#">LM5112SD/NOPB</a>    | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | NIPDAU   SN                          | Level-1-260C-UNLIM                | -40 to 125   | L132B               |
| LM5112SD/NOPB.A                  | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L132B               |
| LM5112SD/NOPB.B                  | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L132B               |
| LM5112SD/NOPBG4.A                | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | -           | Call TI                              | Call TI                           | -40 to 125   |                     |
| LM5112SD/NOPBG4.B                | Active        | Production           | WSON (NGG)   6   | 1000   SMALL T&R      | -           | Call TI                              | Call TI                           | -40 to 125   |                     |
| <a href="#">LM5112SDX/NOPB</a>   | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | NIPDAU   SN                          | Level-1-260C-UNLIM                | -40 to 125   | L132B               |
| LM5112SDX/NOPB.A                 | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L132B               |
| LM5112SDX/NOPB.B                 | Active        | Production           | WSON (NGG)   6   | 4500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | L132B               |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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**OTHER QUALIFIED VERSIONS OF LM5112, LM5112-Q1 :**

- Catalog : [LM5112](#)
- Automotive : [LM5112-Q1](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

## 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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM5112MY/NOPB    | HVSSOP       | DGN             | 8    | 1000 | 177.8              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| LM5112MYX/NOPB   | HVSSOP       | DGN             | 8    | 3500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| LM5112Q1SD/NOPB  | WSO          | NGG             | 6    | 1000 | 177.8              | 12.4               | 3.3     | 3.3     | 1.0     | 8.0     | 12.0   | Q1            |
| LM5112Q1SDX/NOPB | WSO          | NGG             | 6    | 4500 | 330.0              | 12.4               | 3.3     | 3.3     | 1.0     | 8.0     | 12.0   | Q1            |
| LM5112SD/NOPB    | WSO          | NGG             | 6    | 1000 | 177.8              | 12.4               | 3.3     | 3.3     | 1.0     | 8.0     | 12.0   | Q1            |
| LM5112SD/NOPB    | WSO          | NGG             | 6    | 1000 | 180.0              | 12.4               | 3.3     | 3.3     | 1.0     | 8.0     | 12.0   | Q1            |
| LM5112SDX/NOPB   | WSO          | NGG             | 6    | 4500 | 330.0              | 12.4               | 3.3     | 3.3     | 1.0     | 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) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM5112MY/NOPB    | HVSSOP       | DGN             | 8    | 1000 | 208.0       | 191.0      | 35.0        |
| LM5112MYX/NOPB   | HVSSOP       | DGN             | 8    | 3500 | 367.0       | 367.0      | 35.0        |
| LM5112Q1SD/NOPB  | WSON         | NGG             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LM5112Q1SDX/NOPB | WSON         | NGG             | 6    | 4500 | 367.0       | 367.0      | 35.0        |
| LM5112SD/NOPB    | WSON         | NGG             | 6    | 1000 | 208.0       | 191.0      | 35.0        |
| LM5112SD/NOPB    | WSON         | NGG             | 6    | 1000 | 200.0       | 183.0      | 25.0        |
| LM5112SDX/NOPB   | WSON         | NGG             | 6    | 4500 | 367.0       | 367.0      | 35.0        |

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