

DRV8351-SEP: 40-V Three-Phase BLDC Gate Driver

1 Features

- 40V Three Phase Half-Bridge Gate driver
 - Drives N-Channel MOSFETs (NMOS)
 - Gate Driver Supply (GVDD): 5-15V
 - MOSFET supply (SHx) supports up to 40V
- Target Radiation Performance
 - SEL, SEB, and SET immune up to LET = 43 MeV-cm² /mg
 - SET and SEFI characterized up to LET = 43 MeV-cm² /mg
 - TID assured for every wafer lot up to 30 krad(Si)
 - TID characterized up to 30 krad(Si)
- Space-enhanced plastic (space EP):
 - Controlled Baseline
 - One Assembly/Test Site
 - One Fabrication site
 - Extended Product Life Cycle
 - Product Traceability
- Integrated Bootstrap Diodes
- Supports Inverting and Non-Inverting INLx inputs
- Bootstrap gate drive architecture
 - 750mA source current
 - 1.5- sink current
- Low leakage current on SHx pins (<55µA)
- Absolute maximum BSTx voltage up to 57.5V
- Supports negative transients up to -22V on SHx
- Built-in cross conduction prevention
- Fixed deadtime insertion of 200nS
- Supports 3.3V and 5V logic inputs with 20V Abs max
- 4nS typical propagation delay matching
- Compact TSSOP package
- Efficient system design with [Power Blocks](#)
- Integrated protection features
 - BST undervoltage lockout (BSTUV)
 - GVDD undervoltage (GVDDUV)

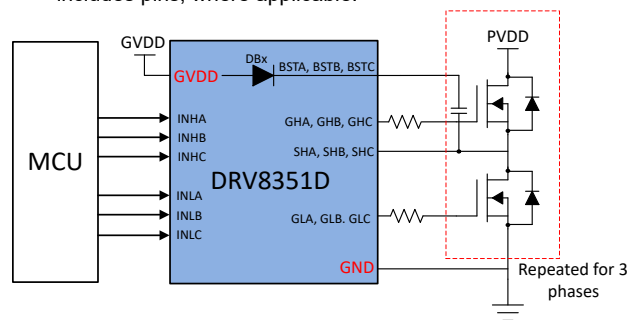
generates the correct gate drive voltages using an integrated bootstrap diode and external capacitor for the high-side MOSFETs. GVDD is used to generate gate drive voltage for the low-side MOSFETs. The Gate Drive architecture supports peak up to 750mA source and 1.5A sink currents.

The phase pins SHx are able to tolerate significant negative voltage transients; while high side gate driver supply BSTx and GHx can support higher positive voltage transients (57.5V) abs max voltage which improve the robustness of the system. Small propagation delay and delay matching specifications minimize the dead-time requirement which further improves efficiency. Undervoltage protection is provided for both low and high sides through GVDD and BST undervoltage lockout.

Device Information (1)

| PART NUMBER | PACKAGE | PACKAGE SIZE ⁽²⁾ | BODY SIZE (NOM) |
|-------------------|------------|-----------------------------|-----------------|
| DRV8351DMP WTSEP | TSSOP (20) | 6.50mm × 6.40mm | 6.40mm × 4.40mm |
| DRV8351DIMP WTSEP | TSSOP (20) | 6.50mm × 6.40mm | 6.40mm × 4.40mm |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Schematic for DRV8351-SEP

2 Applications

Supports Defence, Aerospace and Medical Applications

- [Thruster Gimbal Mechanism](#)
- [Antenna Pointing Mechanism](#)
- [Reaction Wheel](#)
- [Propellant Control Valve](#)

3 Description

DRV8351-SEP is a three phase half-bridge gate driver, capable of driving high-side and low-side N-channel power MOSFETs. The DRV8351-SEP



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4 Device Comparison Table

| Device Variants | Package | Integrated Bootstrap Diode | GLx polarity with respect to INLx Input | Deadtime |
|-----------------|--------------|----------------------------|---|----------|
| DRV8351-SEPD1 | 20-Pin TSSOP | Yes | Inverted | Fixed |
| DRV8351-SEPD | | Yes | Non-Inverted | Fixed |

5 Pin Configuration and Functions

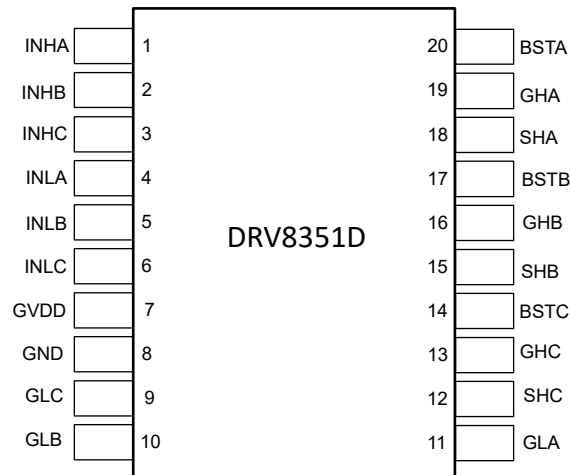


Figure 5-1. DRV8351-SEPD, DRV8351-SEPD1 Package 20-Pin TSSOP Top View

Table 5-1. Pin Functions—20-Pin DRV8351-SEP Devices

| PIN | | TYPE ¹ | DESCRIPTION |
|------|-----|-------------------|---|
| NAME | NO. | | |
| BSTA | 20 | O | Bootstrap output pin. Connect capacitor between BSTA and SHA |
| BSTB | 17 | O | Bootstrap output pin. Connect capacitor between BSTB and SHB |
| BSTC | 14 | O | Bootstrap output pin. Connect capacitor between BSTC and SHC |
| GHA | 19 | O | High-side gate driver output. Connect to the gate of the high-side power MOSFET. |
| GHB | 16 | O | High-side gate driver output. Connect to the gate of the high-side power MOSFET. |
| GHC | 13 | O | High-side gate driver output. Connect to the gate of the high-side power MOSFET. |
| GLA | 11 | O | Low-side gate driver output. Connect to the gate of the low-side power MOSFET. |
| GLB | 10 | O | Low-side gate driver output. Connect to the gate of the low-side power MOSFET. |
| GLC | 9 | O | Low-side gate driver output. Connect to the gate of the low-side power MOSFET. |
| INHA | 1 | I | High-side gate driver control input. This pin controls the output of the high-side gate driver. |
| INHB | 2 | I | High-side gate driver control input. This pin controls the output of the high-side gate driver. |
| INHC | 3 | I | High-side gate driver control input. This pin controls the output of the high-side gate driver. |
| INLA | 4 | I | Low-side gate driver control input. This pin controls the output of the low-side gate driver. |
| INLB | 5 | I | Low-side gate driver control input. This pin controls the output of the low-side gate driver. |
| INLC | 6 | I | Low-side gate driver control input. This pin controls the output of the low-side gate driver. |
| GND | 8 | PWR | Device ground. |
| SHA | 18 | I | High-side source sense input. Connect to the high-side power MOSFET source. |

Table 5-1. Pin Functions—20-Pin DRV8351-SEP Devices (continued)

| PIN | | TYPE ¹ | DESCRIPTION |
|------|-----|-------------------|--|
| NAME | NO. | | |
| SHB | 15 | I | High-side source sense input. Connect to the high-side power MOSFET source. |
| SHC | 12 | I | High-side source sense input. Connect to the high-side power MOSFET source. |
| GVDD | 7 | PWR | Gate driver power supply input. Connect a X5R or X7R, GVDD-rated ceramic and greater than or equal to 10-uF local capacitance between the GVDD and GND pins. |

1. PWR = power, I = input, O = output, NC = no connection

6 Specifications

6.1 Absolute Maximum Ratings

over operating temperature range (unless otherwise noted)⁽¹⁾

| | | MIN | MAX | UNIT |
|---|--------------------------|------|------------------------|------|
| Gate driver regulator pin voltage | GVDD | -0.3 | 15 | V |
| Bootstrap pin voltage | BSTx | -0.3 | 57.5 | V |
| Bootstrap pin voltage | BSTx with respect to SHx | -0.3 | 15 | V |
| Logic pin voltage | INHx, INLx | -0.3 | V _{GVDD} +0.3 | V |
| High-side gate drive pin voltage | GHx | -22 | 55 | V |
| High-side gate drive pin voltage | GHx with respect to SHx | -0.3 | 15 | V |
| Transient 500-ns high-side gate drive pin voltage | GHx with respect to SHx | -5 | 15 | V |
| Low-side gate drive pin voltage | GLx | -0.3 | V _{GVDD} +0.3 | V |
| Transient 500-ns low-side gate drive pin voltage | GLx | -5 | V _{GVDD} +0.3 | V |
| High-side source pin voltage | SHx | -22 | 42.5 | V |
| Ambient temperature, T _A | | -55 | 125 | °C |
| Junction temperature, T _J | | -55 | 150 | °C |
| Storage temperature, T _{stg} | | -65 | 150 | °C |

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime

6.2 ESD Ratings Comm

| | | | VALUE | UNIT |
|--------------------|-------------------------|--|-------|------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±1000 | V |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±250 | |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating temperature range (unless otherwise noted)

| | | | MIN | NOM | MAX | UNIT |
|----------------------------------|--|--------------------------|-----|-----|------|------|
| V _{GVDD} | Power supply voltage | GVDD | 5 | | 15 | V |
| V _{SHx} | High-side source pin voltage | SHx | -2 | | 40 | V |
| V _{SHx} | Transient 2μs high-side source pin voltage | SHx | -22 | | 40 | V |
| V _{BST} | Bootstrap pin voltage | BSTx | 5 | | 55 | V |
| V _{BST} | Bootstrap pin voltage | BSTx with respect to SHx | 5 | | 15 | V |
| V _{IN} | Logic input voltage | INHx, INLx | 0 | | GVDD | V |
| f _{PWM} | PWM frequency | INHx, INLx | 0 | | 100 | kHz |
| V _{SHSL} | Slew rate on SHx pin | | | | 2 | V/ns |
| C _{BOOT} ⁽¹⁾ | Capacitor between BSTx and SHx | | | | 1 | μF |
| T _A | Operating ambient temperature | | -55 | | 125 | °C |
| T _J | Operating junction temperature | | -55 | | 150 | °C |

- (1) Current flowing through boot diode (D_{BOOT}) needs to be limited for C_{BOOT} > 1μF

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | DRV8351-SEP | UNIT |
|-------------------------------|--|-------------|------|
| | | PW (TSSOP) | |
| | | 20 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 97.4 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 38.3 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 48.8 | °C/W |
| Ψ _{JT} | Junction-to-top characterization parameter | 4.3 | °C/W |
| Ψ _{JB} | Junction-to-board characterization parameter | 48.4 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | N/A | °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

4.8 V ≤ V_{GVDD} ≤ 20 V, -55°C ≤ T_J ≤ 150°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|---|---|-----|------|------|------|
| POWER SUPPLIES (GVDD, BSTx) | | | | | | |
| I _{GVDD} | GVDD standby mode current | INHx = INLx = 0; V _{BSTx} = V _{GVDD} | 400 | 800 | 1500 | μA |
| | GVDD active mode current | INHx = INLx = Switching @20kHz; V _{BSTx} = V _{GVDD} ; NO FETs connected | 400 | 825 | 1500 | μA |
| I _{BSx} | Bootstrap pin leakage current | V _{BSTx} = V _{SHx} = 40V; V _{GVDD} = 0V | 2 | 7 | 13 | μA |
| I _{BS_TRAN} | Bootstrap pin active mode transient leakage current | INHx = Switching@20kHz | 30 | 105 | 220 | μA |
| I _{BS_DC} | Bootstrap pin active mode leakage static current | INHx = High | 30 | 85 | 150 | μA |
| I _{SHx} | High-side source pin leakage current | INHx = INLx = 0; V _{BSTx} - V _{SHx} = 12V; V _{SHx} = 0 to 40V | 30 | 55 | 90 | μA |
| LOGIC-LEVEL INPUTS (INHx, INLx, MODE) | | | | | | |
| V _{IL} | Input logic low voltage | INLx, INHx pins | | | 0.8 | V |
| V _{HYS} | Input hysteresis | INLx, INHx pins | 40 | 100 | 260 | mV |
| I _{IL_INLx} | INLx Input logic low current | V _{PIN} (Pin Voltage) = 0 V; INLx in non-inverting mode | -1 | 0 | 1 | μA |
| I _{IH_INLx} | INLx Input logic high current | V _{PIN} (Pin Voltage) = 5 V; INLx in non-inverting mode | 5 | 20 | 30 | μA |
| I _{IL} | INHx Input logic low current | V _{PIN} (Pin Voltage) = 0 V; | -1 | 0 | 1 | μA |
| I _{IH} | INHx Input logic high current | V _{PIN} (Pin Voltage) = 5 V; | 5 | 20 | 30 | μA |
| R _{PD_INHx} | INHx Input pulldown resistance | To GND | 120 | 200 | 280 | kΩ |
| R _{PD_INLx} | INLx Input pulldown resistance | To GND, INLx in non-inverting mode | 120 | 200 | 280 | kΩ |
| R _{PD_MODE} | MODE Input pulldown resistance | To GND | 120 | 200 | 280 | kΩ |
| GATE DRIVERS (GHx, GLx, SHx, SLx) | | | | | | |
| V _{GHx_LO} | High-side gate drive low level voltage | I _{GLx} = -100 mA; V _{GVDD} = 12V; No FETs connected | 0 | 0.15 | 0.35 | V |
| V _{GHx_HI} | High-side gate drive high level voltage (V _{BSTx} - V _{GHx}) | I _{GHx} = 100 mA; V _{GVDD} = 12V; No FETs connected | 0.3 | 0.6 | 1.2 | V |
| V _{GLx_LO} | Low-side gate drive low level voltage | I _{GLx} = -100 mA; V _{GVDD} = 12V; No FETs connected | 0 | 0.15 | 0.35 | V |
| V _{GLx_HI} | Low-side gate drive high level voltage (V _{GVDD} - V _{GHx}) | I _{GHx} = 100 mA; V _{GVDD} = 12V; No FETs connected | 0.3 | 0.6 | 1.2 | V |
| I _{DRIVEP_HS} | High-side peak source gate current | GHx-SHx = 12V | 400 | 750 | 1200 | mA |
| I _{DRIVEN_HS} | High-side peak sink gate current | GHx-SHx = 0V | 850 | 1500 | 2100 | mA |
| I _{DRIVEP_LS} | Low-side peak source gate current | GLx = 12V | 400 | 750 | 1200 | mA |

4.8 V ≤ V_{GVDD} ≤ 20 V, -55°C ≤ T_J ≤ 150°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------------|---|---|------|------|------|------|
| I _{DRIVEN_LS} | Low-side peak sink gate current | GLx = 0V | 850 | 1500 | 2100 | mA |
| t _{PD} | Input to output propagation delay | INHx, INLx to GHx, GLx; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V, No load on GHx and GLx | 70 | 125 | 180 | ns |
| t _{PD_match} | Matching propagation delay per phase | GHx turning OFF to GLx turning ON, GLx turning OFF to GHx turning ON; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V, No load on GHx and GLx | -30 | ±4 | 30 | ns |
| t _{PD_match} | Matching propagation delay phase to phase | GHx/GLx turning ON to GHy/GLy turning ON, GHx/GLx turning OFF to GHy/GLy turning OFF; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V, No load on GHx and GLx | -30 | ±4 | 30 | ns |
| t _{R_GLx} | GLx rise time (10% to 90%) | C _{LOAD} = 1000 pF; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V | 10 | 24 | 50 | ns |
| t _{R_GHx} | GHx rise time (10% to 90%) | C _{LOAD} = 1000 pF; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V | 10 | 24 | 50 | ns |
| t _{F_GLx} | GLx fall time (90% to 10%) | C _{LOAD} = 1000 pF; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V | 5 | 12 | 30 | ns |
| t _{F_GHx} | GHx fall time (90% to 10%) | C _{LOAD} = 1000 pF; V _{GVDD} = V _{BSTx} - V _{SHx} > 8V; SHx = 0V | 5 | 12 | 30 | ns |
| t _{DEAD} | Gate drive dead time | | 150 | 215 | 280 | ns |
| t _{PW_MIN} | Minimum input pulse width on INHx, INLx that changes the output on GHx, GLx | | 40 | 70 | 150 | ns |
| BOOTSTRAP DIODES | | | | | | |
| V _{BOOTD} | Bootstrap diode forward voltage | I _{BOOT} = 100 μA | 0.45 | 0.7 | 0.85 | V |
| | | I _{BOOT} = 100 mA | 2 | 2.3 | 3.1 | V |
| R _{BOOTD} | Bootstrap dynamic resistance (ΔV _{BOOTD} /ΔI _{BOOT}) | I _{BOOT} = 100 mA and 80 mA | 11 | 15 | 25 | Ω |
| PROTECTION CIRCUITS | | | | | | |
| V _{GVDDUV} | Gate Driver Supply undervoltage lockout (GVDDUV) | Supply rising | 4.45 | 4.6 | 4.7 | V |
| | | Supply falling | 4.2 | 4.35 | 4.4 | V |
| V _{GVDDUV_HYS} | Gate Driver Supply UV hysteresis | Rising to falling threshold | 250 | 280 | 310 | mV |
| t _{GVDDUV} | Gate Driver Supply undervoltage deglitch time | | 5 | 10 | 13 | μs |
| V _{BSTUV} | Boot Strap undervoltage lockout (V _{BSTx} - V _{SHx}) | Supply rising | 3.6 | 4.2 | 4.8 | V |
| | | Supply falling | 3.5 | 4 | 4.5 | V |
| V _{BSTUV_HYS} | Bootstrap UV hysteresis | Rising to falling threshold | | 200 | | mV |
| t _{BSTUV} | Bootstrap undervoltage deglitch time | | 6 | 10 | 22 | μs |

6.6 Timing Diagrams

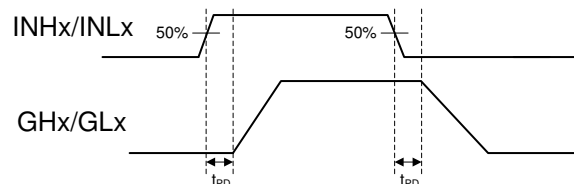


Figure 6-1. Propagation Delay(t_{PD})

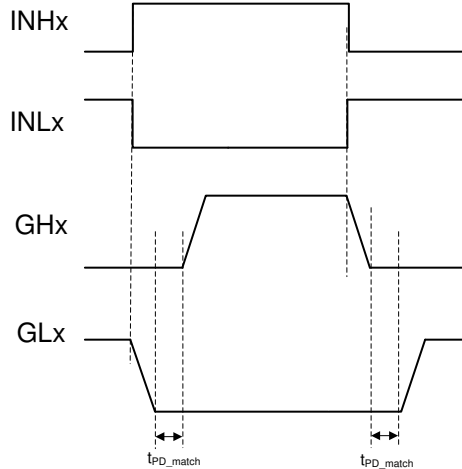


Figure 6-2. Propagation Delay Match (t_{PD_match})

6.7 Typical Characteristics

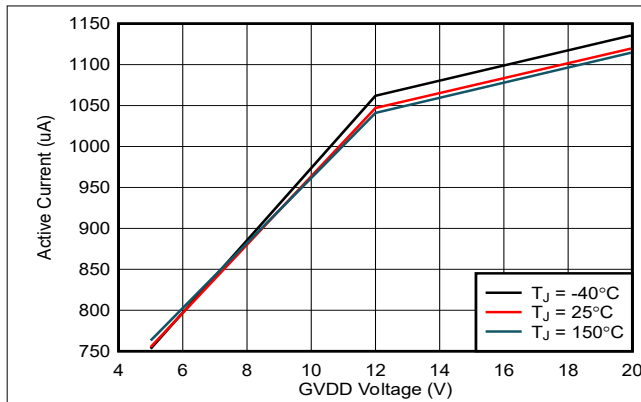


Figure 6-3. Supply Current Over GVDD Voltage

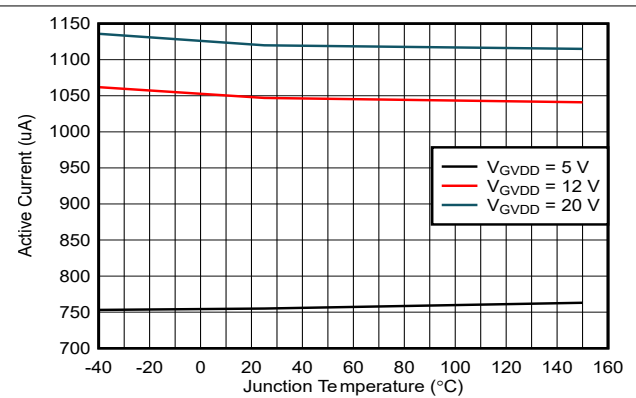


Figure 6-4. Supply Current Over Temperature

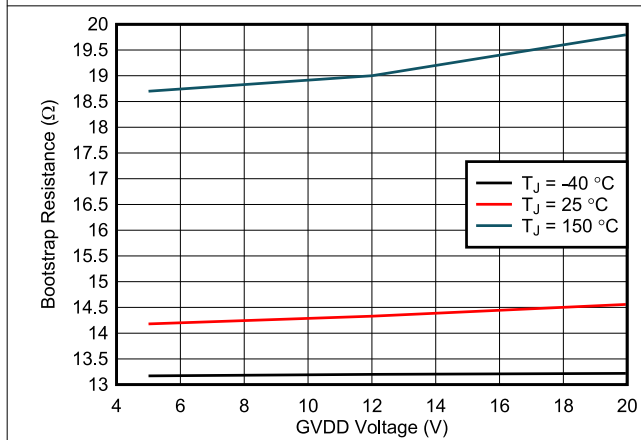


Figure 6-5. Bootstrap Resistance Over GVDD Voltage

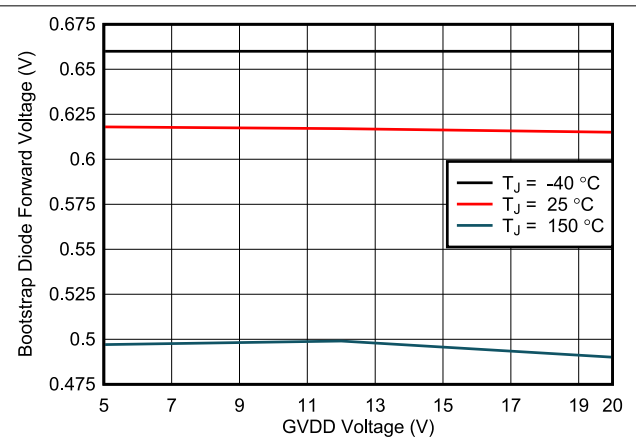


Figure 6-6. Bootstrap Diode Forward Voltage over GVDD Voltage

7 Detailed Description

7.1 Overview

The DRV8351-SEP family of devices are gate drivers for three-phase motor drive applications. These devices decrease system component count, saves PCB space and cost by integrating three independent half-bridge gate drivers and optional bootstrap diodes.

DRV8351-SEP supports external N-channel high-side and low-side power MOSFETs and can drive 750mA source, 1.5A sink peak currents with a total combined 30mA average output current. The DRV8351-SEP family of devices are available in 0.65mm pitch TSSOP surface-mount packages. The TSSOP body size is 6.5 × 4.4mm (0.65mm pin pitch) for the 20-pin package.

7.2 Functional Block Diagram

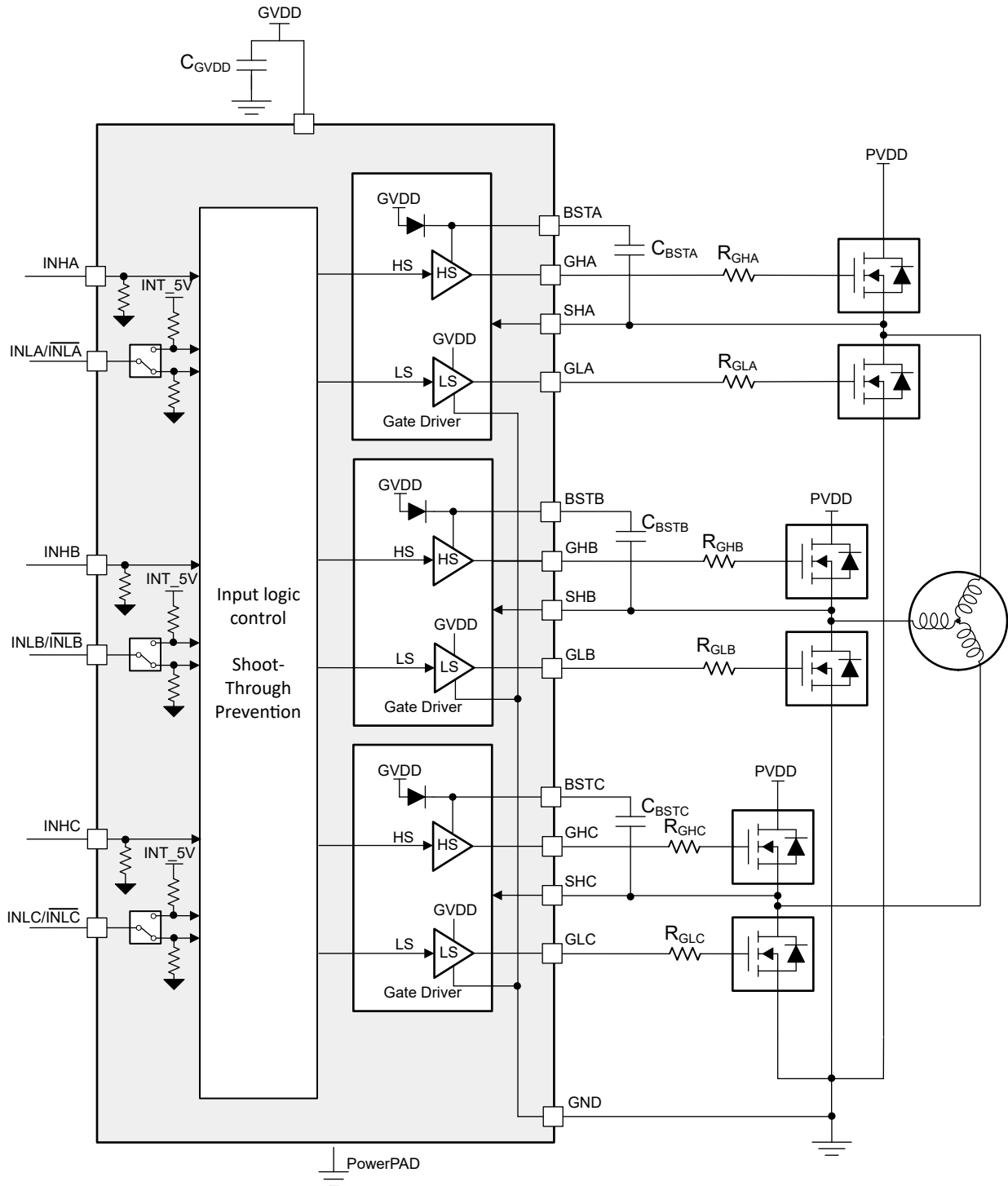


Figure 7-1. Block Diagram for DRV8351-SEP

7.3 Feature Description

7.3.1 Three BLDC Gate Drivers

The DRV8351-SEP integrates three half-bridge gate drivers, each capable of driving high-side and low-side N-channel power MOSFETs. Input on GVDD provides the gate bias voltage for the low-side MOSFETs. The high voltage is generated using bootstrap capacitors and GVDD supply. The half-bridge gate drivers can be used in combination to drive a three-phase motor or separately to drive other types of loads.

7.3.1.1 Gate Driver Timings

7.3.1.1.1 Propagation Delay

The propagation delay time (t_{pd}) is measured as the time between an input logic edge to a detected output change. This time has two parts consisting of the input deglitcher delay and the delay through the analog gate drivers.

The input deglitcher prevents high-frequency noise on the input pins from affecting the output state of the gate drivers. The analog gate drivers have a small delay that contributes to the overall propagation delay of the device.

7.3.1.1.2 Deadtime and Cross-Conduction Prevention

In the DRV8351-SEP, high-side and low-side inputs operate independently, with an exception to prevent cross conduction when high and low side are turned ON at the same time. The DRV8351-SEP turns OFF high-side and low-side output to prevent shoot through when both high-side and low-side inputs are at logic HIGH at the same time.

In DRV8351D-SEP, fixed deadtime of 200 ns (typical value) is inserted to prevent high and low side gate output turning ON at same time.

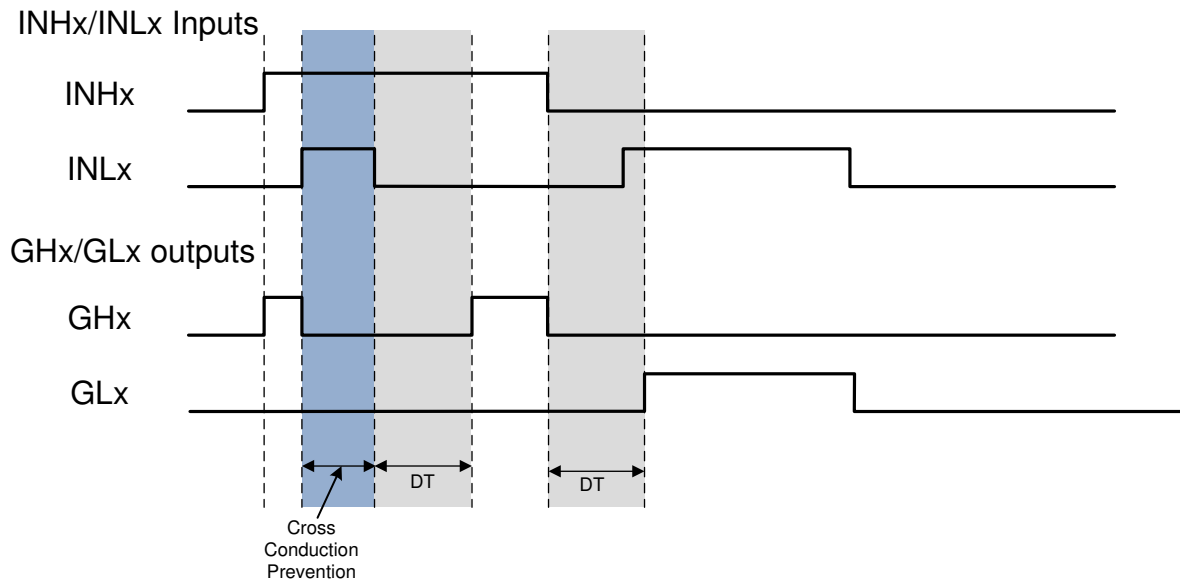


Figure 7-2. Cross Conduction Prevention and Deadtime Insertion

7.3.1.2 Mode (Inverting and non inverting INLx)

The DRV8351-SEP has flexibility of accepting different kind of inputs on INLx. In DRV8351-SEP, there are different device options available for inverting and non inverting inputs (see [Section 4](#)).

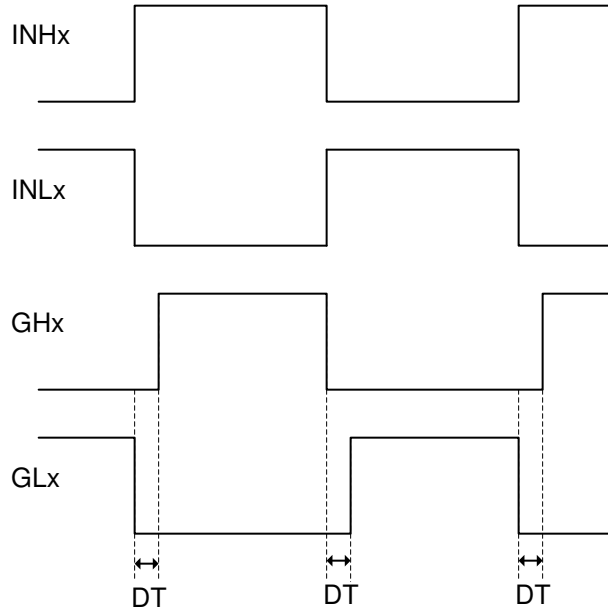


Figure 7-3. Non-Inverted INLx inputs

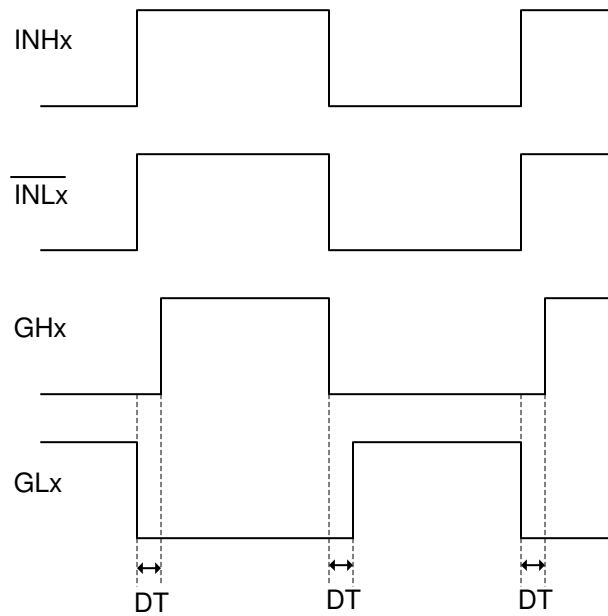
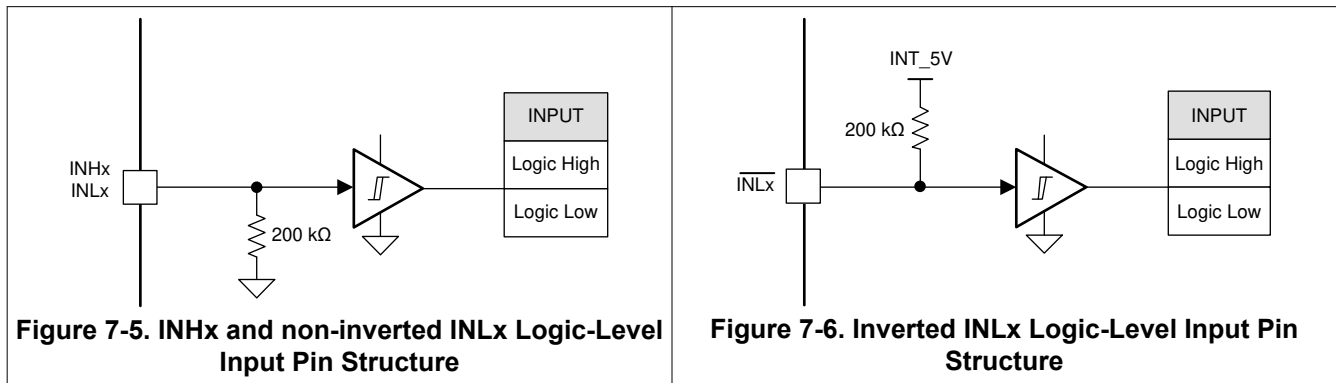


Figure 7-4. Inverted INLx inputs

7.3.2 Pin Diagrams

Figure 7-5 shows the input structure for the logic level pins INHx, INLx. INHx and non-inverted INLx has passive pull down, so when inputs are floating the output the gate driver will be pulled low. Figure 7-6 shows the input structure for the inverted INLx pins. The inverted INLx has passive pull up, so when inputs are floating the output of the low-side gate driver will be pulled low.



7.3.3 Gate Driver Protective Circuits

The DRV8351-SEP is protected against BSTx undervoltage and GVDD undervoltage events.

Table 7-1. Fault Action and Response

| FAULT | CONDITION | GATE DRIVER | RECOVERY |
|--|---|-------------|--|
| V _{BSTx} undervoltage (BSTUV) | V _{BSTx} < V _{BSTUV} | GHx - Hi-Z | Automatic: V _{BSTx} > V _{BSTUV} and low to high PWM edge detected on INHx pin |
| GVDD undervoltage (GVDDUV) | V _{GVDD} < V _{GVDDUV} | Hi-Z | Automatic: V _{GVDD} > V _{GVDDUV} |

7.3.3.1 V_{BSTx} Undervoltage Lockout (BSTUV)

The DRV8351-SEP has separate voltage comparator to detect undervoltage condition for each phases. If at any time the voltage on the BSTx pin falls lower than the V_{BSTUV} threshold, high side external MOSFETs of that particular phase is disabled by disabling (Hi-Z) GHx pin. Normal operation starts again when the BSTUV condition clears and low to high PWM edge is detected on INHx input of the same phase that BSTUV condition was detected. BSTUV protection ensures that high-side MOSFETs are not driven when the BSTx pins has lower value.

7.3.3.2 GVDD Undervoltage Lockout (GVDDUV)

If at any time the voltage on the GVDD pin falls lower than the V_{GVDDUV} threshold voltage, all of the external MOSFETs are disabled. Normal operation starts again when the GVDDUV condition clears. GVDDUV protection ensures that external MOSFETs are not driven when the GVDD input is at lower value.

7.4 Device Functional Modes

The DRV8351-SEP is in operating (active) mode, whenever the GVDD and BST pins are higher than the UV threshold (GVDD > V_{GVDDUV} and V_{BSTx} > V_{BSTUV}). In active mode, the gate driver output GHx and GLx will follow respective inputs INHx and INLx.

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 DRV8351-SEP family of devices is primarily used in applications for three-phase brushless DC motor control. The design procedures in the [Section 8.2](#) section highlight how to use and configure the DRV8351-SEP.

8.2 Typical Application

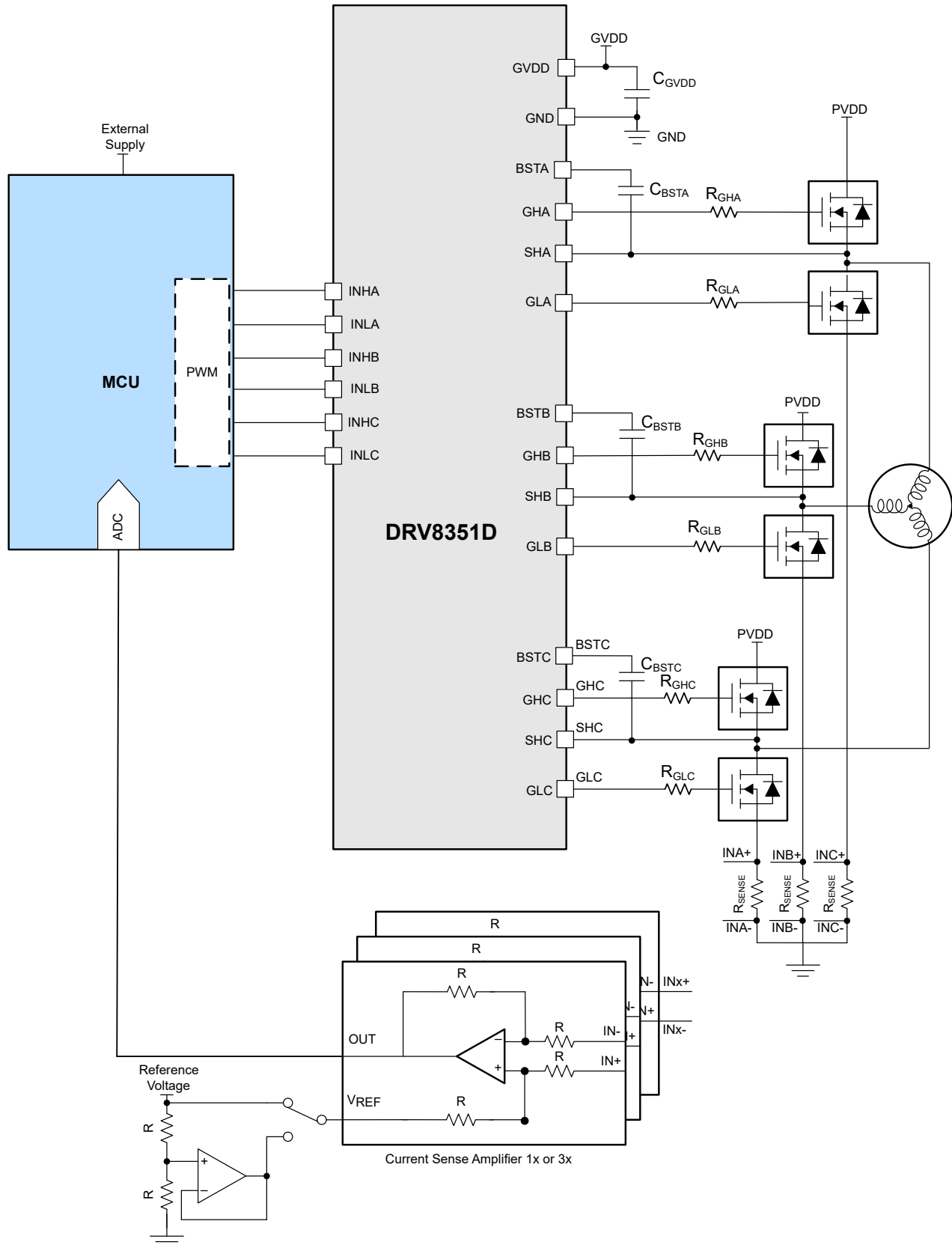


Figure 8-1. Application Schematic

8.2.1 Design Requirements

Table 8-1 lists the example design input parameters for system design.

Table 8-1. Design Parameters

| EXAMPLE DESIGN PARAMETER | REFERENCE | EXAMPLE VALUE |
|--------------------------|-------------------|---------------|
| MOSFET | - | CSD19532Q5B |
| Gate Supply Voltage | V _{GVDD} | 12V |
| Gate Charge | Q _G | 48nC |

8.2.2 Bootstrap Capacitor and GVDD Capacitor Selection

The bootstrap capacitor must be sized to maintain the bootstrap voltage above the undervoltage lockout for normal operation. Equation 1 calculates the maximum allowable voltage drop across the bootstrap capacitor:

$$\Delta V_{BSTX} = V_{GVDD} - V_{BOOTD} - V_{BSTUV} \quad (1)$$

$$= 12V - 0.85V - 4.5V = 6.65V$$

where

- V_{GVDD} is the supply voltage of the gate drive
- V_{BOOTD} is the forward voltage drop of the bootstrap diode
- V_{BSTUV} is the threshold of the bootstrap undervoltage lockout

In this example the allowed voltage drop across bootstrap capacitor is 6.65V. It is generally recommended that ripple voltage on both the bootstrap capacitor and GVDD capacitor should be minimized as much as possible. Many commercial, industrial, and automotive applications use ripple values between 0.5V to 1V.

The total charge needed per switching cycle can be estimated with Equation 2:

$$Q_{TOT} = Q_G + \frac{I_{LBS_TRANS}}{f_{SW}} \quad (2)$$

$$= 48nC + 220\mu A / 20kHz = 50nC + 11nC = 59nC$$

where

- Q_G is the total MOSFET gate charge
- I_{LBS_TRAN} is the bootstrap pin leakage current
- f_{SW} is the PWM frequency

The minimum bootstrap capacitor can then be estimated as below assuming 1V ΔV_{BSTX}:

$$C_{BST_MIN} = Q_{TOT} / \Delta V_{BSTX} \quad (3)$$

$$= 59nC / 1V = 59nF$$

The calculated value of the minimum bootstrap capacitor is 59nF. It should be noted that this value of capacitance is needed at full bias voltage. In practice, the value of the bootstrap capacitor must be greater than the calculated value to allow for situations where the power stage may skip pulse due to various transient conditions. It is recommended to use a 100nF bootstrap capacitor in this example. It is also recommended to include enough margin and place the bootstrap capacitor as close to the BSTx and SHx pins as possible.

$$C_{GVDD} \geq 10 \times C_{BSTX} \quad (4)$$

$$= 10 \times 100nF = 1\mu F$$

For this example application choose 1µF C_{GVDD} capacitor. Choose a capacitor with a voltage rating at least twice the maximum voltage that it will be exposed to because most ceramic capacitors lose significant capacitance when biased. This value also improves the long term reliability of the system.

8.2.3 Application Curves

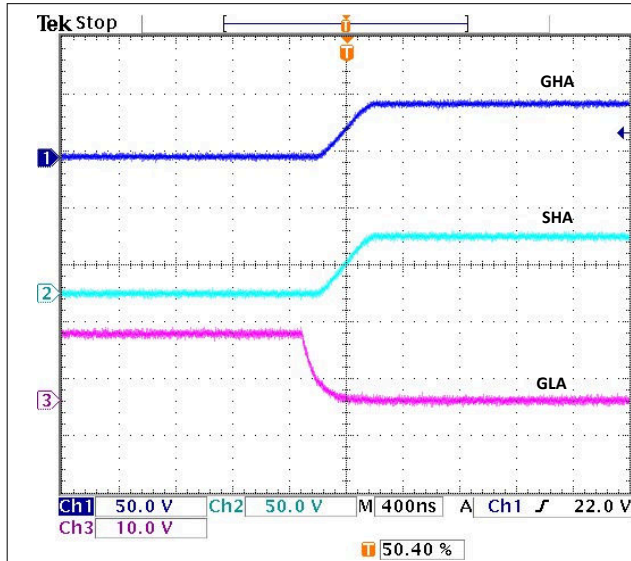


Figure 8-2. Gate voltages, SHx rising with 15ohm gate resistor and CSD19532Q5B MOSFET

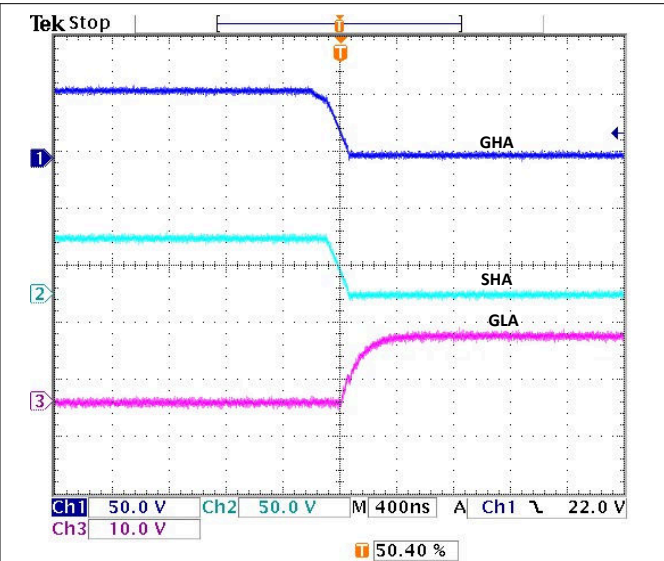


Figure 8-3. Gate voltages, SHx falling with 15ohm gate resistor and CSD19532Q5B MOSFET

9 Power Supply Recommendations

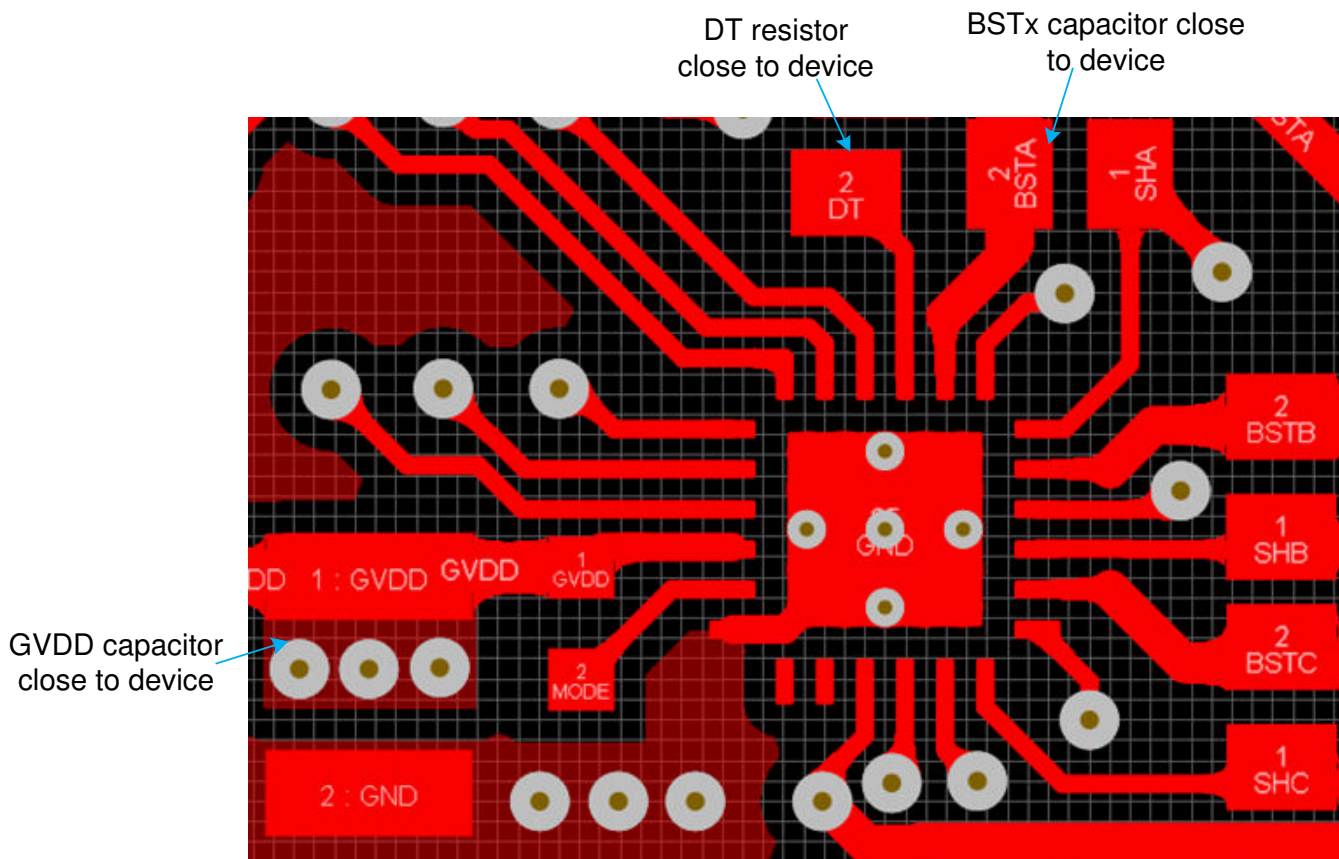
The DRV8351-SEP is designed to operate from an input voltage supply (GVDD) range from 4.8V to 15V. A local bypass capacitor should be placed between the GVDD and GND pins. This capacitor should be located as close to the device as possible. A low ESR, ceramic surface mount capacitor is recommended. It is recommended to use two capacitors across GVDD and GND: a low capacitance ceramic surface-mount capacitor for high frequency filtering placed very close to GVDD and GND pin, and another high capacitance value surface mount capacitor for device bias requirements. Similarly, the current pulses delivered by the GHx pins are sourced from the BSTx pins. Therefore, a capacitor across the BSTx to SHx is recommended, it should be a high enough capacitance value capacitor to deliver GHx pulses.

10 Layout

10.1 Layout Guidelines

- Low ESR/ESL capacitors must be connected close to the device between GVDD and GND and between BSTx and SHx pins to support high peak currents drawn from GVDD and BSTx pins during the turn-on of the external MOSFETs.
- To prevent large voltage transients at the drain of the top MOSFET, a low ESR electrolytic capacitor and a good quality ceramic capacitor must be connected between the high side MOSFET drain and ground.
- In order to avoid large negative transients on the switch node (SHx) pin, the parasitic inductances between the source of the high-side MOSFET and the source of the low-side MOSFET must be minimized.
- In order to avoid unexpected transients, the parasitic inductance of the GHx, SHx, and GLx connections must be minimized. Minimize the trace length and number of vias wherever possible. Minimum 10mil and typical 15mil trace width is recommended.
- Place the gate driver as close to the MOSFETs as possible. Confine the high peak currents that charge and discharge the MOSFET gates to a minimal physical area by reducing trace length. This confinement decreases the loop inductance and minimize noise issues on the gate terminals of the MOSFETs.
- Refer to sections *General Routing Techniques* and *MOSFET Placement and Power Stage Routing* in [Application Report](#)

10.2 Layout Example



11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* 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.

11.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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11.3 Trademarks

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11.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

12 Revision History

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

| DATE | REVISION | NOTES |
|---------------|----------|-----------------|
| December 2024 | * | Initial Release |

13 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 (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| DRV8351DIMPWTSEP | ACTIVE | TSSOP | PW | 20 | 250 | RoHS & Green | NIPDAU | Level-2-260C-1 YEAR | -55 to 125 | 8351DIM | Samples |
| V62/24612-01XE | ACTIVE | TSSOP | PW | 20 | 250 | RoHS & Green | NIPDAU | Level-2-260C-1 YEAR | -55 to 125 | 8351DIM | Samples |

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

(6) Lead finish/Ball material - Orderable Devices 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.

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TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|------------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DRV8351DIMPWTSEP | TSSOP | PW | 20 | 250 | 330.0 | 16.4 | 6.95 | 7.1 | 1.6 | 8.0 | 16.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| DRV8351DIMPWTSEP | TSSOP | PW | 20 | 250 | 353.0 | 353.0 | 32.0 |

EXAMPLE BOARD LAYOUT

PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220206/A 02/2017

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0020A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220206/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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