UCC27712-Q1 Automotive, 620-V, 1.8-A, 2.8-A High-Side Low-Side Gate Driver with Interlock

1 Features

- AEC-Q100 Qualified for Automotive Application
  - Device HBM Classification Level 1C
  - Device CDM Classification Level C4B
- High-Side and Low-Side Configuration
- Dual Inputs With Output Interlock and 150-ns Deadtime
- Fully Operational up to 620-V, 700-V Absolute Maximum on HB Pin
- 10-V to 20-V VDD Recommended Range
- Peak Output Current 2.8-A Sink, 1.8-A Source
- dv/dt Immunity of 50 V/ns
- Logic Operational up to –11 V on HS Pin
- Negative Voltage Tolerance On Inputs of –5 V
- Large Negative Transient Safe Operating Area
- UVLO Protection for Both Channels
- Small Propagation Delay (100-ns Typical)
- Delay Matching (12-ns Typical)
- Low Quiescent Current
- TTL and CMOS Compatible Inputs
- Industry Standard SOIC-8 Package
- All Parameters Specified Over Temperature Range, –40 °C to +125 °C

2 Applications

- Automotive Inverters
- On-Board Chargers (PFC, Phase-Shifted Full Bridge)
- Motor Drive for Automotive Applications (Stepper Motors, Fans)

3 Description

The UCC27712-Q1 is a 620-V high-side and low-side gate driver with 1.8-A source, 2.8-A sink current, targeted to drive power MOSFETs or IGBTs.

The recommended VDD operating voltage is 10-V to 20-V for IGBT's and 10-V to 17-V for power MOSFETs.

The UCC27712-Q1 includes protection features where the outputs are held low when the inputs are left open or when the minimum input pulse width specification is not met. Interlock and deadtime functions prevent both outputs from being turned on simultaneously. In addition, the device accepts a wide range bias supply range from 10 V to 22 V, and offers UVLO protection for both the VDD and HB bias supply.

Developed with TI's state of the art high-voltage device technology, the device features robust drive with excellent noise and transient immunity including large negative voltage tolerance on its inputs, high dV/dt tolerance, wide negative transient safe operating area (NTSOA) on the switch node (HS), and interlock.

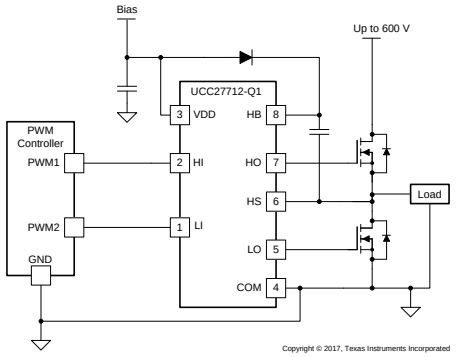
The device consists of one ground-referenced channel (LO) and one floating channel (HO) which is designed for operating with bootstrap or isolated power supplies. The device features fast propagation delays and excellent delay matching between both channels. On the UCC27712-Q1, each channel is controlled by its respective input pins, HI and LI.

Device Information(1)

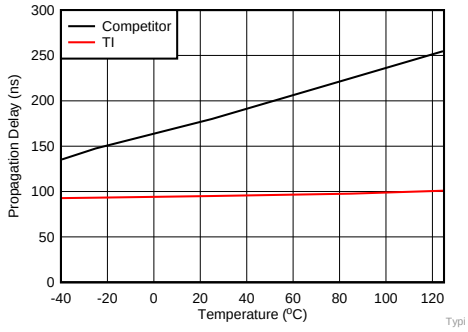
PART NUMBER	PACKAGE	BODY SIZE (NOM)
UCC27712-Q1	SOIC (8)	3.91 mm × 8.65 mm

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

4 Simplified Schematic



Typical Propagation Delay Comparison



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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5 Revision History

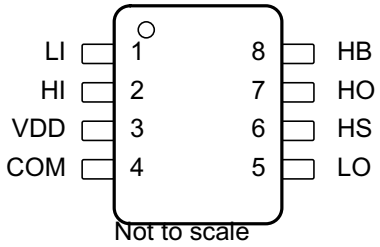
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
August 2017	*	Initial release.

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6 Pin Configuration and Functions

D Package
8-Pin SOIC
Top View



Not to scale

Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
COM	4	–	Ground
HB	8	I	High-side floating supply. Bypass this pin to HS with a suitable capacitor to sustain boot-strap circuit operation, typically 10 times bigger than the MOSFETs/IGBTs gate capacitance.
HI	2	I	Logic input for high-side driver. If HI is unbiased or floating, HO is held low
HO	7	O	High-side driver output.
HS	6	–	Return for high-side floating supply.
LI	1	I	Logic input for low-side driver. If LI is unbiased or floating, LO is held low
LO	5	O	Low-side driver output.
VDD	3	I	Bias supply input. Power supply for the input logic side of the device and also low-side driver output. Bypass this pin to COM with a 0.1-µF or larger value ceramic capacitor.

7 Specifications

7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted), all voltages are with respect to COM (unless otherwise noted), currents are positive into and negative out of the specified terminal.(1)

PARAMETER			MIN	MAX	UNIT
Input voltage	HI, LI (2)		–5	22	V
	VDD supply voltage		–0.3	22	
	HB		–0.3	700	
	HB–HS		–0.3	22	
Output voltage	HO	DC	HS–0.3	HB+0.3	V
		Transient, less than 100 ns(3)	HS–2	HB+0.3	
	LO	DC	–0.3	VDD+0.3	V
		Transient, less than 100 ns(3)	–2	VDD+0.3	
Output current	HO, LO	I_{OUT_PULSED} (100 ns)		2.8/–1.8	A
		I_{OUT_DC}		0.15	
dV_{HS}/dt	Allowable offset supply voltage transient		–50	50	V/ns
T_J	Junction temperature		–40	150	°C
T_{stg}	Storage temperature		–65	150	

(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) The maximum voltage on the input pins is not restricted by the voltage on the VDD pin
(3) Values are verified by characterization on bench.

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7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 (1)	±1500	V
		Charged-device model (CDM), per AEC Q100-011	±750	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

7.3 Recommended Operating Conditions

All voltages are with respect to COM, over operating free-air temperature range (unless otherwise noted)

			MIN	NOM	MAX	UNIT
VDD	Supply voltage	IGBT applications	10		20	V
		MOSFET applications	10		17	
HB–HS	Driver bootstrap voltage	IGBT applications	10		20	
		MOSFET applications	10		17	
HS	Source terminal voltage (1)		–11		600	
HI, LI	Input voltage with respect to COM		–4		20	
T_A	Ambient temperature		–40		125	°C

(1) Logic operational for HS of –11 V to +600 V at HB–HS = 15 V

7.4 Thermal Information

THERMAL METRIC (1)		UCC27712-Q1 (SOIC) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	108.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	61.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	57.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	15.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	57.2	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

7.5 Electrical Characteristics

At VDD = VHB = 15 V, COM = VHS = 0, all voltages are with respect to COM, no load on LO and HO, –40°C < T_J < +125°C (unless otherwise noted). Currents are positive into and negative out of the specified terminal.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY BLOCK						
$V_{VDD\ ON}$	Turn-on threshold voltage of VDD		8.0	8.9	9.8	V
$V_{VDD\ OFF}$	Turn-off threshold voltage of VDD		7.5	8.4	9.3	
$V_{VDD\ HYS}$	Hysteresis of VDD			0.5		
$V_{VHB\ ON}$	Turn-on threshold voltage of VHB–VHS		7.2	8.2	9.2	
$V_{VHB\ OFF}$	Turn-off threshold voltage of VHB–VHS		6.4	7.3	8.3	
$V_{VHB\ HYS}$	Hysteresis of VHB–VHS		0.5	0.9		
I_Q	Total quiescent supply current	HI = LI = 0 V or 5 V, DC on/off state	180	255	420	µA
I_{QVDD}	Quiescent VDD-COM supply current	HI = LI = 0 V or 5 V, DC on/off state		190	320	
I_{QBS}	Quiescent HB-HS supply current	HI = 0 V or 5 V, HO in DC on/off state		65	100	
I_{BL}	Bootstrap supply leakage current	HB = HS = 600 V			20	
I_{OP}	Dynamic operating current	HI = LI = 0 V or 5 V, f = 100 kHz, duty = 50%, C_L= 1 nF		3800 (1)	4500	

(1) Ensured by design, not tested in production

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Electrical Characteristics (continued)

At VDD = VHB = 15 V, COM = VHS = 0, all voltages are with respect to COM, no load on LO and HO, –40°C < T_J < +125°C (unless otherwise noted). Currents are positive into and negative out of the specified terminal.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT BLOCK						
V_{INH}	Input Pin (HI, LI) high threshold		1.6	2.0	2.4	V
V_{INL}	Input Pin (HI, LI) low threshold		0.8	1.2	1.5	
V_{INHYS}	Input Pin (HI, LI) threshold hysteresis			0.8		
I_{INL}	HI, LI input low bias current	HI, LI = 0 V	–5	0	5	µA
I_{INH}	HI, LI input high bias current	HI, LI = 5 V	1.7		70	
OUTPUT BLOCK						
V_{DD}-V_{LOH}	LO output high voltage	LI = 5 V, I_{LO} = –20 mA		60	136	mV
V_{HB}-V_{HOH}	HO output high voltage	HI = 5 V, I_{HO} = –20 mA		60	136	
V_{LOL}	LO output low voltage	LI = 0 V, I_{LO} = 20 mA		30	80	
V_{HOL}	HO output low voltage	HI = 0 V, I_{HO} = 20 mA		30	80	
R_{LOL}, R_{HOL}	LO, HO output pull-down resistance	I_{LO} = I_{HO} = 20 mA		1.5	4	Ω
R_{LOH}, R_{HOH}	LO, HO output pull-up resistance	I_{LO} = I_{HO} = –20 mA		3.0	6.8	
I_{GPK-} (1)	HO, LO output low short circuit pulsed current	HI = LI = 0 V, HO = LO = 15 V, PW < 10 µs		2.8		A
I_{GPK+} (1)	HO, LO output high short circuit pulsed current	HI = LI = 5 V, HO = LO = 0 V, PW < 10 µs		–1.8		

7.6 Dynamic Electrical Characteristics

At VDD = VHB = 15 V, COM = VHS = 0, all voltages are with respect to COM, no load on LO and HO, –40°C < T_J < +125°C (unless otherwise noted). Currents are positive into and negative out of the specified terminal.

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
DYNAMIC CHARACTERISTICS						
t_{PDLH}	Turn-on propagation delay (without deadtime)	LI to LO, HI to HO, HS = COM = 0 V		100	160	ns
t_{PDHL}	Turn-off propagation delay	LI to LO, HI to HO, HS = COM = 0 V		100	160	
t_{PDRM}	Low-to-high delay matching			5	30	
t_{PDFM}	High-to-low delay matching			12	30	
t_{RISE}	Turn-on rise time	10% to 90%, HO/LO with 1000-pF load		16	50	
t_{FALL}	Turn-off fall time	10% to 90%, HO/LO with 1000-pF load		10	30	
t_{ON}	Minimum HI/LI ON pulse that changes output state	0-V to 5-V input signal on HI and LI pins		25	45	
t_{OFF}	Minimum HI/LI OFF pulse that changes output state	5-V to 0-V input signal on HI and LI pins		35	45	
DT	Deadtime	Internal deadtime for Interlock	100	150	200	

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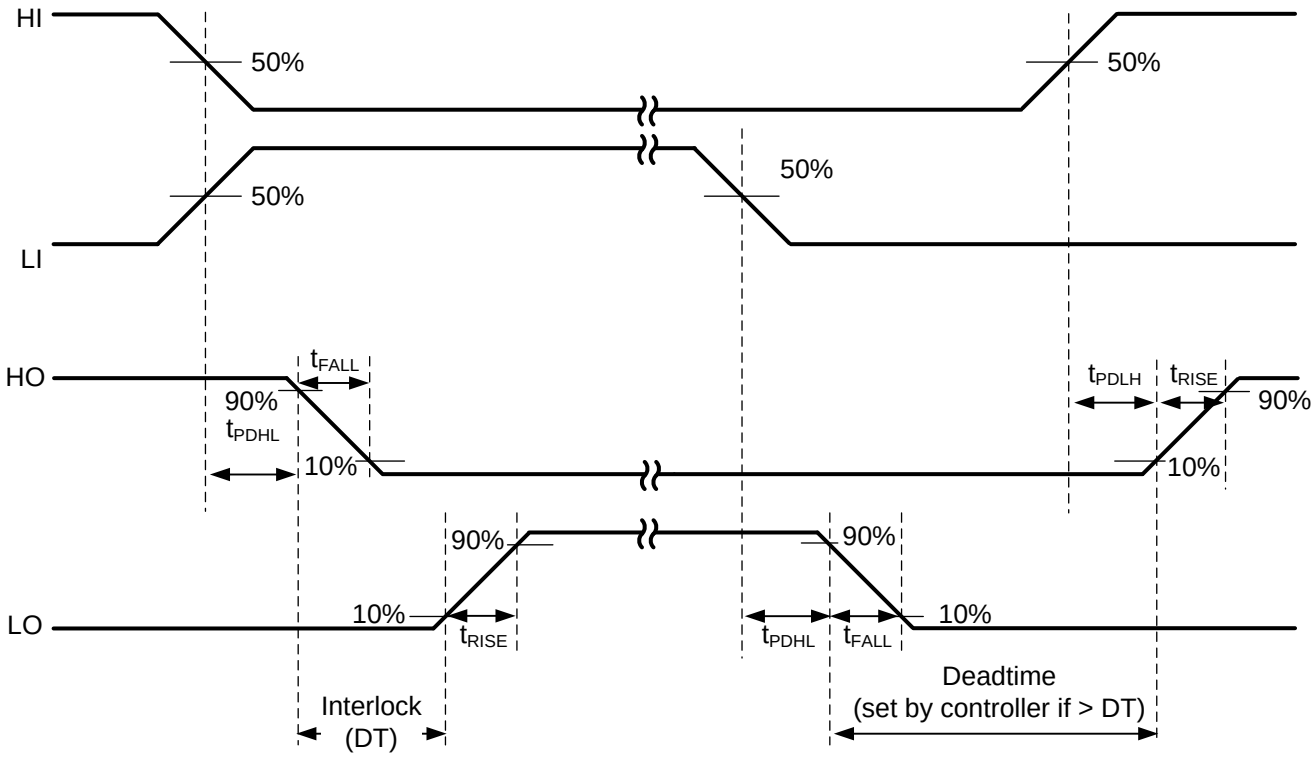


Figure 1. Typical Test Timing Diagram

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7.7 Typical Characteristics

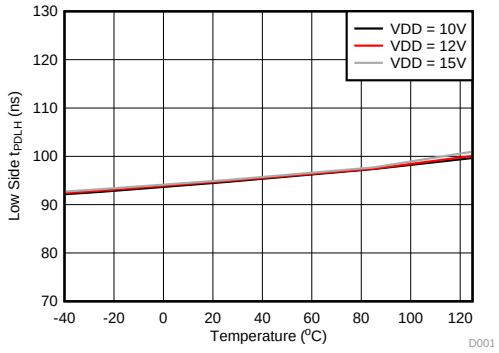


Figure 2. Low-Side, Turn-On Propagation Delay vs Temperature

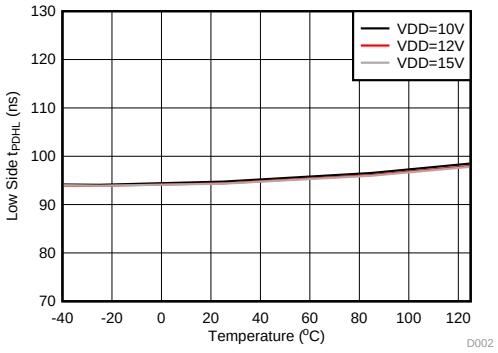


Figure 3. Low-Side, Turn-Off Propagation Delay vs Temperature

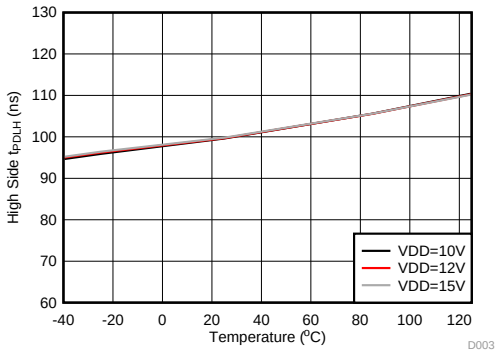


Figure 4. High-Side, Turn-On Propagation Delay vs Temperature

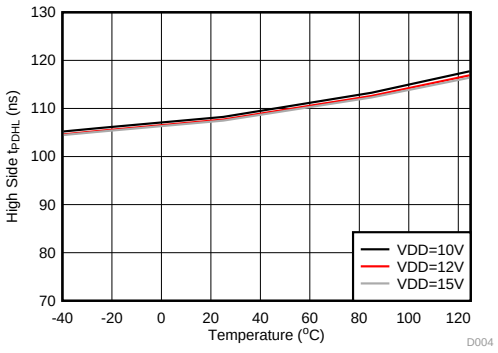


Figure 5. High-Side, Turn-Off Propagation Delay vs Temperature

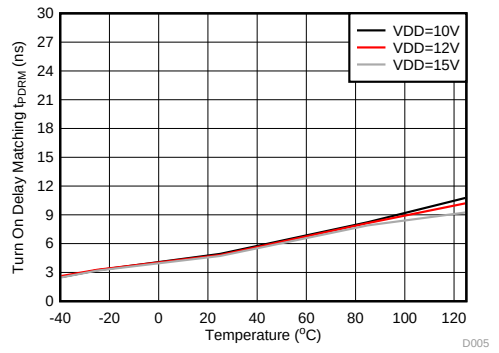


Figure 6. Turn-On Delay Matching vs Temperature

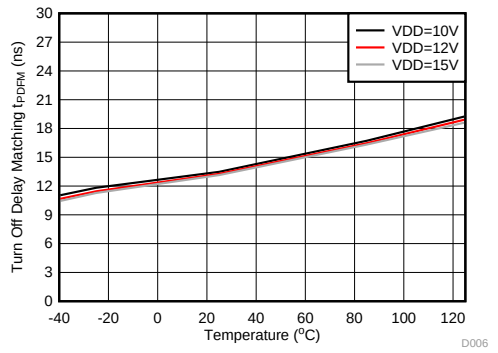


Figure 7. Turn-Off Delay Matching vs Temperature

Typical Characteristics (continued)

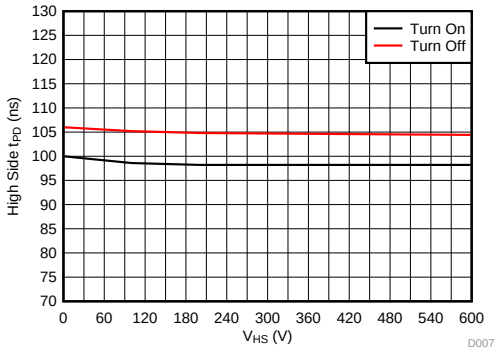


Figure 8. High-Side Propagation Delay vs HS

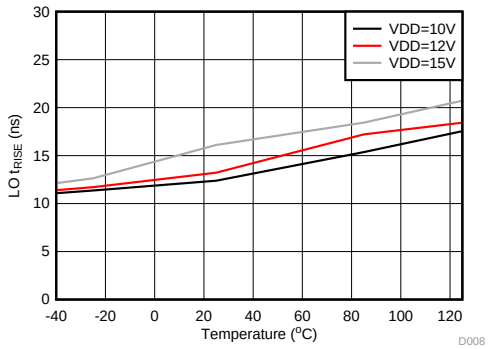


Figure 9. LO Rise Time with 1000-pF Load vs Temperature

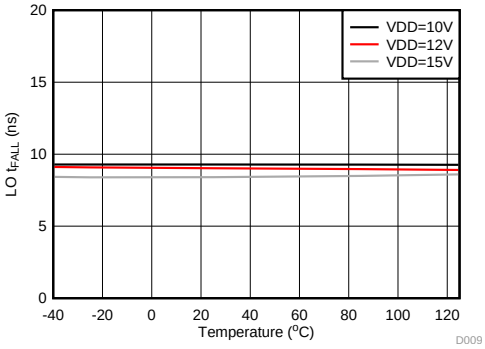


Figure 10. LO Fall Time with 1000-pF Load vs Temperature

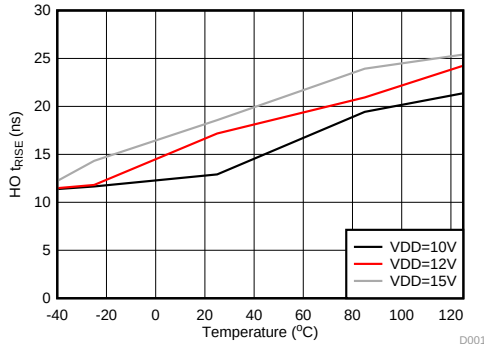


Figure 11. HO Rise Time with 1000-pF Load vs Temperature

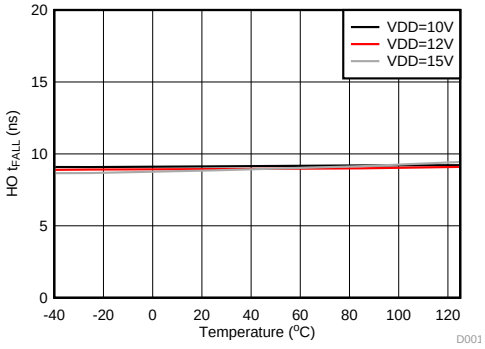


Figure 12. HO Fall Time with 1000-pF Load vs Temperature

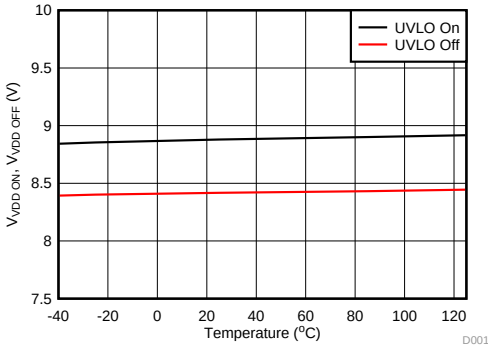


Figure 13. VDD UVLO Thresholds vs Temperature

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Typical Characteristics (continued)

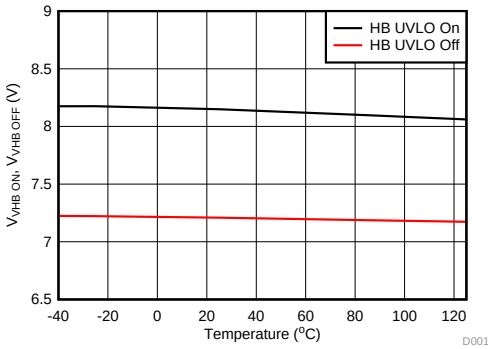


Figure 14. VHB-VHS UVLO Thresholds vs Temperature

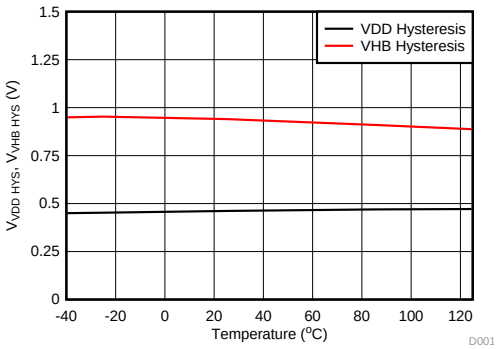


Figure 15. VDD and VHB-VHS UVLO Hysteresis vs Temperature

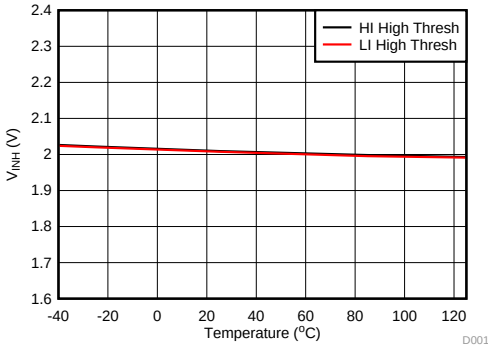


Figure 16. HI/LI Pin High Threshold vs Temperature

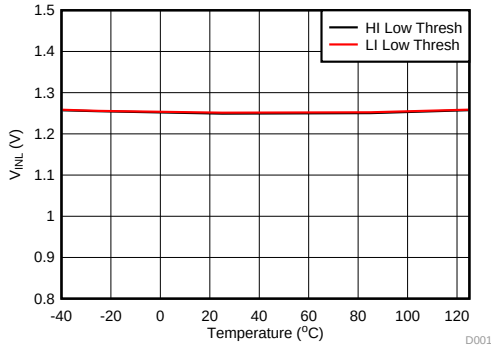


Figure 17. HI/LI Pin Low Threshold vs Temperature

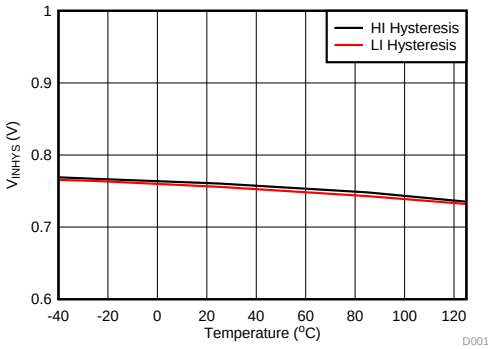


Figure 18. HI/LI Pin Hysteresis vs Temperature

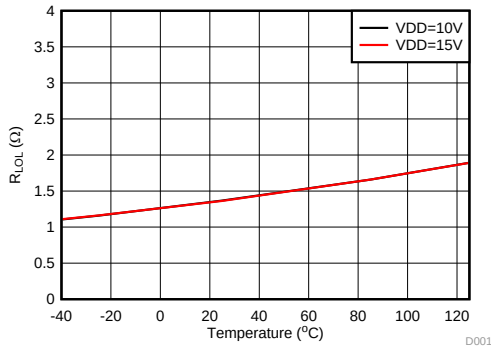


Figure 19. LO Output Pull-Down Resistance vs Temperature

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Typical Characteristics (continued)

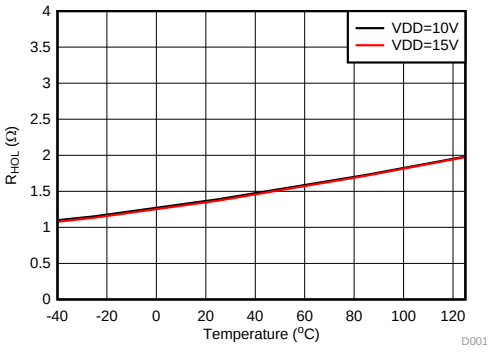


Figure 20. HO Output Pull-Down Resistance vs Temperature

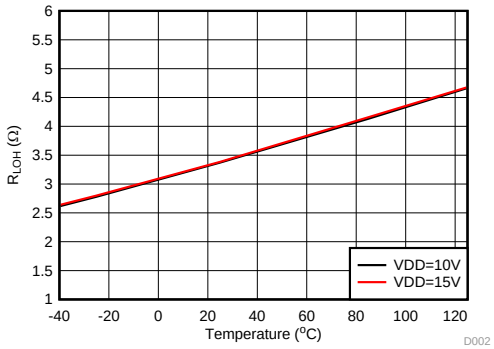


Figure 21. LO Output Pull-Up Resistance vs Temperature

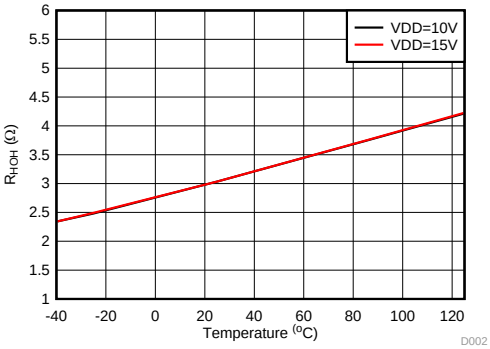


Figure 22. HO Output Pull-Up Resistance vs Temperature

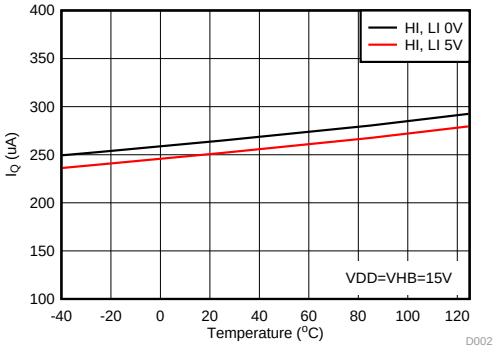


Figure 23. Total Quiescent VDD plus HB Supply Current vs Temperature

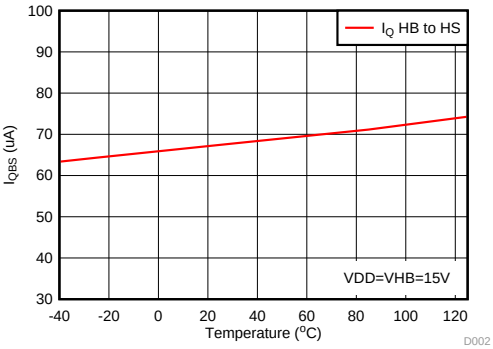


Figure 24. Quiescent HB to HS Supply Current vs Temperature

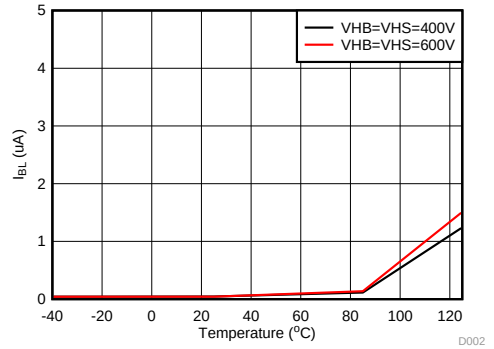


Figure 25. HB to COM Bootstrap Supply Leakage Current vs Temperature

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Typical Characteristics (continued)

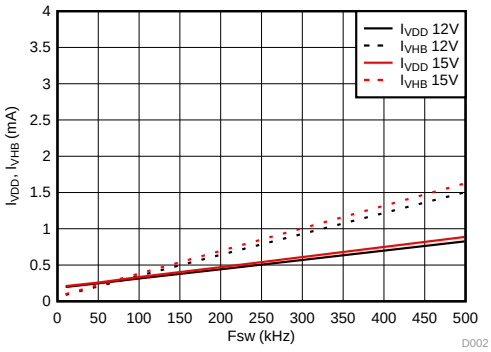


Figure 26. VDD and HB Operating Current with No Load vs Switching Frequency

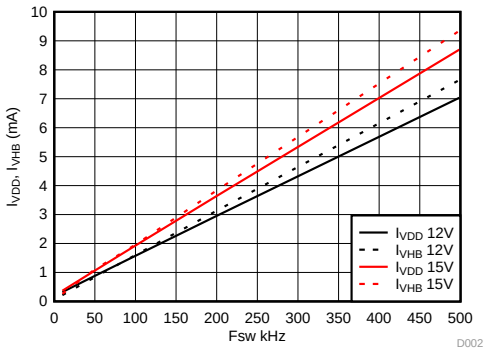


Figure 27. VDD and HB Operating Current with 1000-pF Load vs Switching Frequency

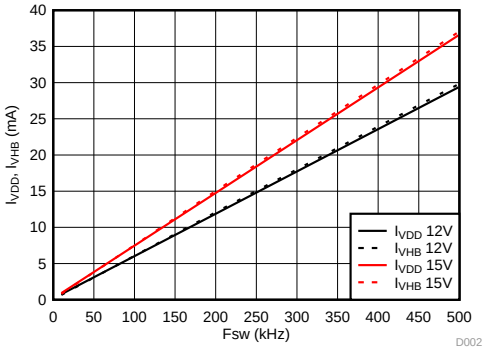


Figure 28. VDD and HB Operating Current with 4700-pF Load vs Switching Frequency

8 Detailed Description

8.1 Overview

The UCC27712-Q1 consists of one ground-referenced channel (LO) and one floating channel (HO) which is designed for operating with bootstrap or isolated power supplies. The device features fast propagation delays and excellent delay matching between both channels. On the UCC27712-Q1, each channel is controlled by its respective input pins,

Developed with TI's state of the art high-voltage technology, the device features robust drive with excellent noise and transient immunity including large negative voltage tolerance on its inputs, high dv/dt tolerance, and wide negative transient safe operating area (NTSOA) on the switch node (HS).

The UCC27712-Q1 includes protection features where the outputs are held low when the inputs are floating or when the minimum input pulse width specification is not met. Interlock and deadtime functions prevent both outputs from being turned on simultaneously. In addition, the device accepts a wide range bias supply range from 10 V ~ 22 V, and offers UVLO protection for both the VDD and HB bias supply.

High-current, gate-driver devices are required in switching power applications for a variety of reasons. In order to implement fast switching of power devices and reduce associated switching power losses, a powerful gate-driver device is employed between the PWM output of control devices and the gates of the power semiconductor devices. Further, gate-driver devices are indispensable when having the PWM controller device directly drive the gates of the switching devices is sometimes not feasible. In the case of digital power supply controllers, this situation is often encountered because the PWM signal from the digital controller is often a 3.3-V logic signal which is not capable of effectively turning on a power switch.

In bridge topologies, like hard-switch half bridge, hard-switch full bridge, half-bridge and full-bridge LLC, and phase-shift full bridge, the source and emitter pin of the top-side power MOSFET and IGBT switch is referenced to a node whose voltage changes dynamically; that is, not referenced to a fixed potential, so floating-driver devices are necessary in these topologies.

The UCC27712-Q1 is a high-side and low-side driver dedicated for offline AC-to-DC power supplies and inverters. The high side is a floating driver that can be biased effectively using a bootstrap circuit, and can handle up to 600-V. The driver can be used with 100% duty cycle as long as HB-HS can be above UVLO of the high side.

The device features industry best-in-class propagation delay and delay matching between both channels aimed at minimizing pulse width distortion in high-frequency switching applications. Each channel is controlled by its respective input pins (HI and LI), allowing independent flexibility to control on and off state of the output but does not allow the HO and LO outputs to be on at the same time. The UCC27712-Q1 includes an interlock feature which guarantees a 150ns dead time between the HO and LO outputs if the HI and LI inputs are complimentary. The UCC27712-Q1 includes protection features wherein the outputs are held low when inputs are floating or when the minimum input pulse width specification is not met. The driver inputs are CMOS and TTL compatible for easy interface to digital power controllers and analog controllers alike.

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8.2 Functional Block Diagram

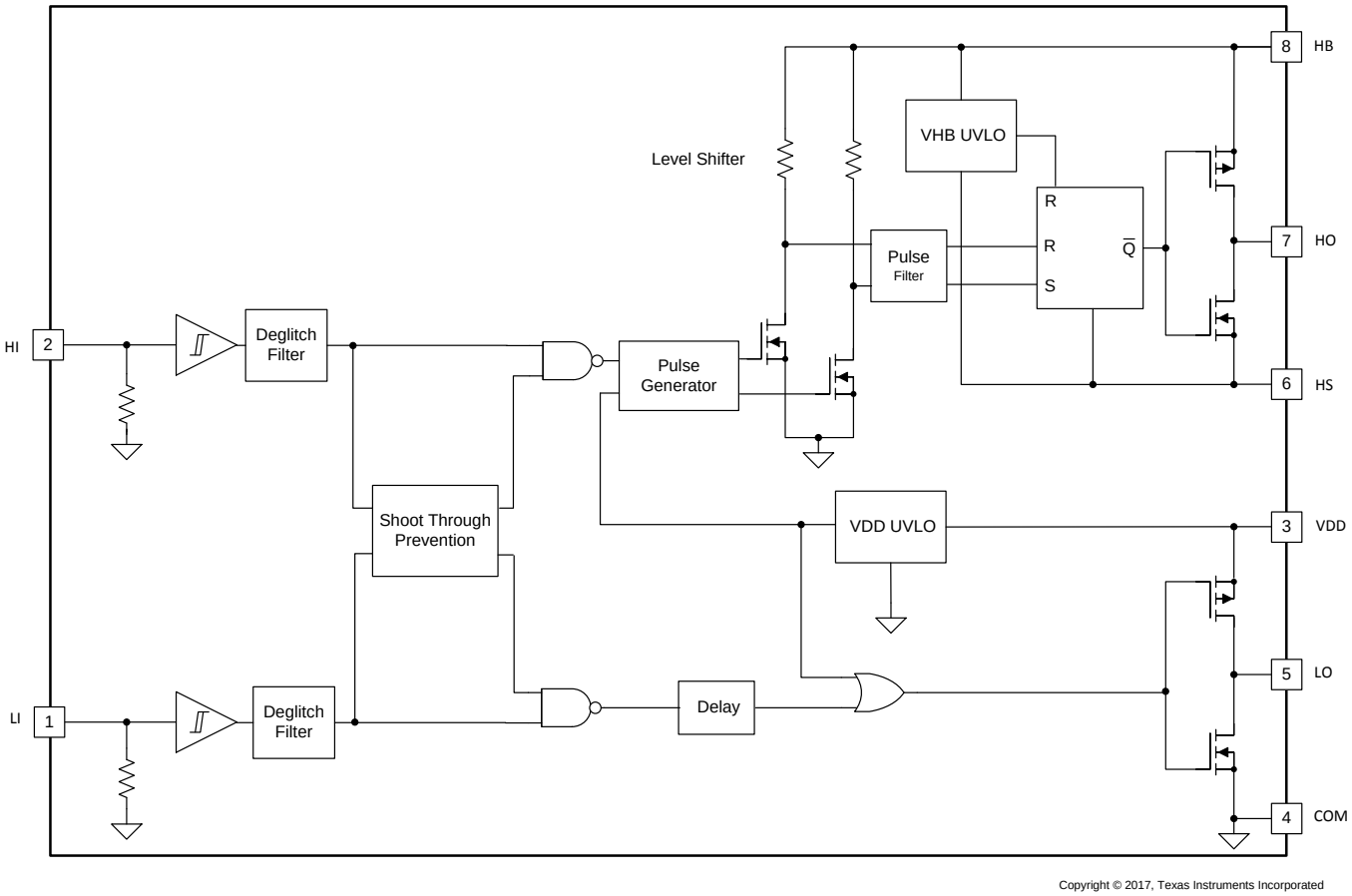


Figure 29. UCC27712-Q1 Block Diagram

8.3 Feature Description

8.3.1 VDD and Under Voltage Lockout

The UCC27712-Q1 has an internal under voltage-lockout (UVLO) protection feature on the supply circuit blocks between VDD and VSS pins, as well as between HB and HS pins. When VDD bias voltage is lower than the $V_{VDD(on)}$ threshold at device start-up or lower than $V_{VDD(off)}$ after start-up, the VDD UVLO feature holds both the LO and HO outputs low, regardless of the status of the HI and LI inputs. On the other hand, if HB-HS bias supply voltage is lower than the $V_{VHB(on)}$ threshold at start-up or $V_{VHB(off)}$ after start-up, the HB-HS UVLO feature only holds HO to low, regardless of the status of the HI. The LO output status is not affected by the HB-HS UVLO feature (see Table 1 and Table 2). This allows the LO output to turn-on and re-charge the HB-HS capacitor using the boot-strap circuit and thus allows HB-HS bias voltage to surpass the $V_{VHB(on)}$ threshold.

Both the VDD and VHB UVLO protection functions are provided with a hysteresis feature. This hysteresis prevents chatter when there is ground noise from the power supply. Also this allows the device to accept a small drop in the bias voltage which is bound to happen when the device starts switching and quiescent current consumption increases instantaneously, as well as when the boot-strap circuit charges the HB-HS capacitor during the first instance of LO turn-on causing a drop in VDD voltage.

The UVLO circuit of VDD-VSS and HB-HS in UCC27712-Q1 generate internal signals to enable/disable the outputs after UVLO_ON/UVLO_OFF thresholds are crossed respectively (please refer to Figure 30). Design considerations indicate that the UVLO propagation delay before the outputs are enabled and disabled can vary from 20 μs to 50 μs.

Table 1. VDD UVLO Feature Logic Operation

CONDITION (VHB-VHS>$V_{VHB,\ ON}$ FOR ALL CASES BELOW)	HI	LI	HO	LO
VDD-VSS < $V_{VDD(on)}$ during device start up	H	L	L	L
VDD-VSS < $V_{VDD(on)}$ during device start up	L	H	L	L
VDD-VSS < $V_{VDD(on)}$ during device start up	H	H	L	L
VDD-VSS < $V_{VDD(on)}$ during device start up	L	L	L	L
VDD-VSS < $V_{VDD(off)}$ after device start up	H	L	L	L
VDD-VSS < $V_{VDD(off)}$ after device start up	L	H	L	L
VDD-VSS < $V_{VDD(off)}$ after device start up	H	H	L	L
VDD-VSS < $V_{VDD(off)}$ after device start up	L	L	L	L

Table 2. VHB UVLO Feature Logic Operation

CONDITION (VDD-VSS > $V_{VDD,ON}$ FOR ALL CASES BELOW)	HI	LI	HO	LO
VHB-VHS < $V_{VHB(on)}$ during device start up	H	L	L	L
VHB-VHS < $V_{VHB(on)}$ during device start up	L	H	L	H
VHB-VHS < $V_{VHB(on)}$ during device start up	H	H	L	L
VHB-VHS < $V_{VHB(on)}$ during device start up	L	L	L	L
VHB-VHS < $V_{VHB(off)}$ after device start up	H	L	L	L
VHB-VHS < $V_{VHB(off)}$ after device start up	L	H	L	H
VHB-VHS < $V_{VHB(off)}$ after device start up	H	H	L	L
VHB-VHS < $V_{VHB(off)}$ after device start up	L	L	L	L

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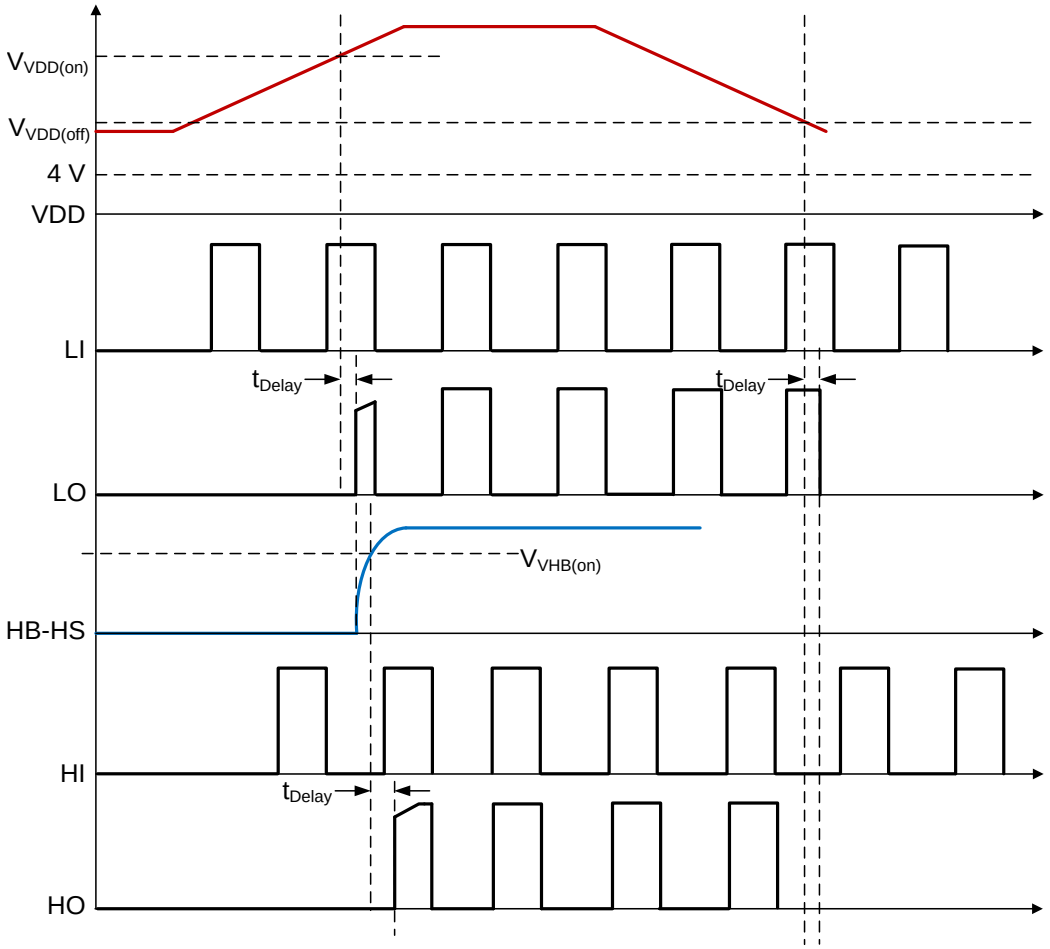


Figure 30. Power-Up Driver

8.3.2 Input and Output Logic Table

UCC27712-Q1 features separate inputs, HI and LI, for controlling the state of the outputs, HO and LO, respectively. The device does include internal cross-conduction prevention logic and does not allow both HO and LO outputs to be turned on simultaneously (refer to Table 3). This feature prevents cross conduction in bridge topologies in the case of incorrect timing from the controller.

Table 3. Input/Output Logic Table
(Assuming no UVLO fault condition exists for VDD and VHB)

HI	LI	HO	LO	Note
L	L	L	L	
L	H	L	H	Output transitions occur after the dead time expires
H	L	H	L	
H	H	L	L	
Left Open	Left Open	L	L	

8.3.3 Input Stage

The input pins of UCC27712-Q1 are based on a TTL and CMOS compatible input-threshold logic that is independent of the VDD supply voltage. With typical high threshold (V_{INH}) of 2.0 V and typical low threshold (V_{INL}) of 1.2 V, along with very little temperature variation as summarized in Figure 16 and Figure 17, the input pins are conveniently driven with logic level PWM control signals derived from 3.3-V and 5-V digital power-controller devices. Wider hysteresis (typically 0.8 V) offers enhanced noise immunity compared to traditional TTL logic implementations, where the hysteresis is typically less than 0.5 V. UCC27712-Q1 also features tight control of the input pin threshold voltage levels which eases system design considerations and ensures stable operation across temperature.

The UCC27712-Q1 includes an important feature: wherein, whenever any of the input pins is in a floating condition, the output of the respective channel is held in the low state. This is achieved using COM pull-down resistors on all the input pins (HI, LI).

The UCC27712-Q1 input pins are capable of sustaining voltages higher than the bias voltage applied on the VDD pin of the device, as long as the absolute magnitude is less than the recommended operating condition's maximum ratings. This features offers the convenience of driving the PWM controller at a higher VDD bias voltage than the UCC27712-Q1 helping to reduce gate charge related switching losses. This capability is envisaged in UCC27712-Q1 by way of two ESD diodes tied back-to-front as shown in Figure 31.

Additionally, the input pins are also capable of sustaining negative voltages below COM, as long as the magnitude of the negative voltage is less than the recommended operating condition minimum ratings. A similar diode arrangement exists between the input pins and COM as illustrated in Figure 31.

The input stage of each driver must be driven by a signal with a short rise or fall time. This condition is satisfied in typical power supply applications, when the input signals are provided by a PWM controller or logic gates with fast transition times. With a slow changing input voltage, the output of driver may switch repeatedly at a high frequency. While the wide hysteresis offered in UCC27712-Q1 definitely alleviates this concern over most other TTL input threshold devices, extra care is necessary in these implementations. If limiting the rise or fall times to the power device is the primary goal, then an external resistance is highly recommended between the output of the driver and the power device. This external resistor has the additional benefit of reducing part of the gate-charge related power dissipation in the gate-driver device package and transferring it into the external resistor itself. If an RC filter is to be added on the input pins for reducing the impact of system noise and ground bounce, the time constant of the RC filter is recommended to be 20 ns or less, for example, 50 Ω with 220 pF is an acceptable choice.

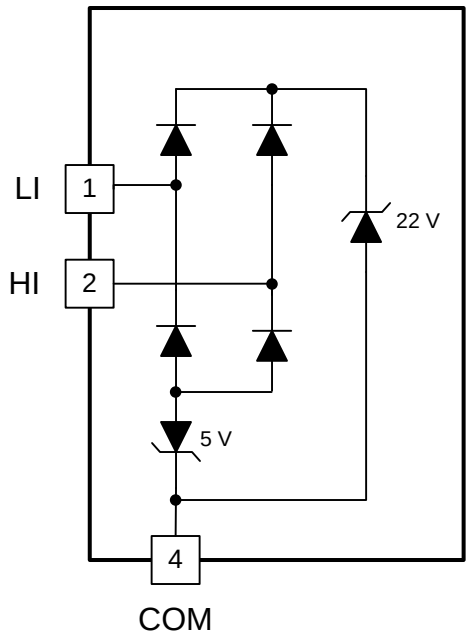


Figure 31. Diode Structure of Input Stage

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8.3.4 Output Stage

The UCC27712-Q1 device output stage pull-up structure features a P-Channel MOSFET to provide source current until the output is saturated to VDD or HB. The R_{OH} parameter (see Figure 21) is a DC measurement and it is representative of the on-resistance of the P-Channel device.

The pull-down structure in UCC27712-Q1 is composed of a N-Channel MOSFET. The R_{OL} parameter (see Figure 19), which is also a DC measurement, is representative of the impedance of the pull-down stage in the device.

Each output stage in UCC27712-Q1 is capable of supplying 1.8-A peak source and 2.8-A peak sink current pulses. The output voltage swings between (VDD and COM) / (HB and HS) providing rail-to-rail operation, thanks to the MOSFET output stage which delivers very low drop-out.

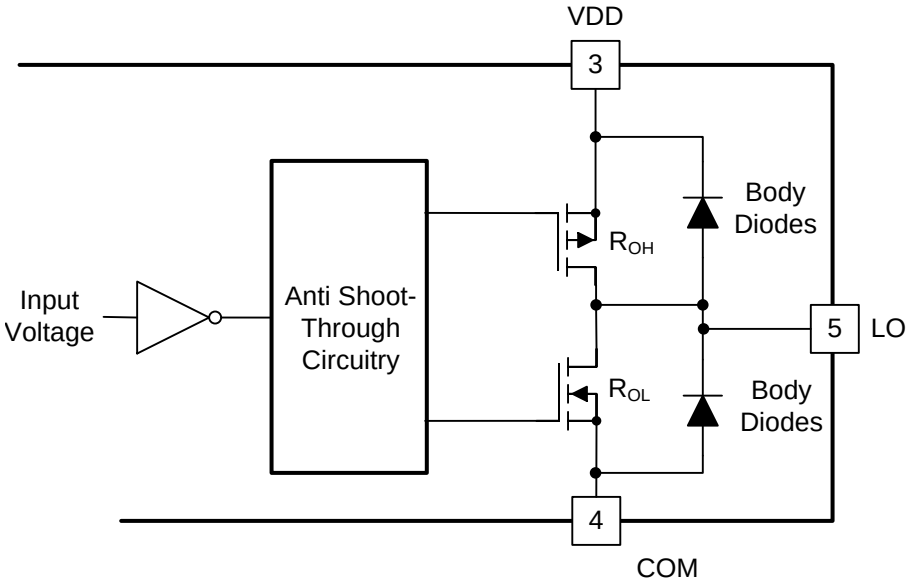


Figure 32. Output Stage Structure

8.3.5 Level Shift

The level shift circuit (refer to the Functional Block Diagram) is the interface from the high-side input to the high-side driver stage which is referenced to the switch node (HS). It is a pulsed generated level shifter. With an input signal the pulse generator generates "on" pulses based on the rising edge of the signal and "off" pulses based on the falling edge. On pulses and off pulses turn on each branch of the level shifter so that current flows in each branch to generate different voltages, which is transferred to the set and reset signal in the high side. The signal is rebuilt by the RS latch in the high side domain. The level shift allows control of the HO output referenced to the HS pin and provides excellent delay matching with the low-side driver. The delay matching of UCC27712-Q1 is summarized in Figure 6 and Figure 7.

The level shifter in UCC27712-Q1 offers best-in-class capability while operating under negative voltage conditions on HS pin. The level shifter is able to transfer signals from the HI input to HO output with only 4-V headroom between HB and COM. Refer to Operation Under Negative HS Voltage Condition for detailed explanations.

8.3.6 Low Propagation Delays and Tightly Matched Outputs

The UCC27712-Q1 features a best in class, 100-ns (typical) propagation delay (refer to Figure 2, Figure 3, Figure 4 and Figure 5) between input and output in high voltage 600-V driver, which goes to offer a low level of pulse width distortion for high frequency switching applications.

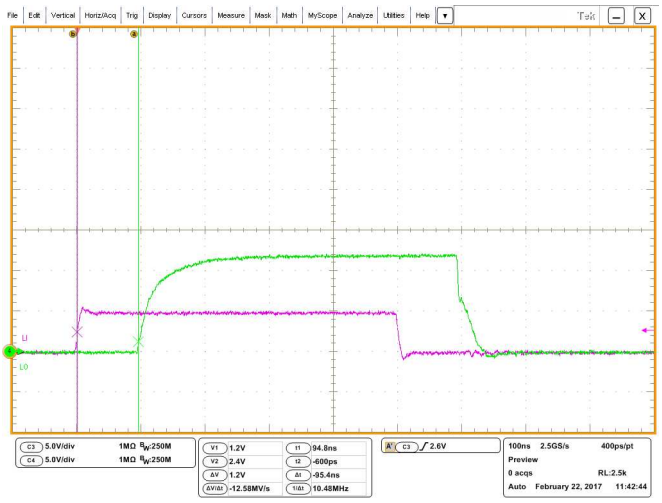


Figure 33. Turn-On Propagation Delay

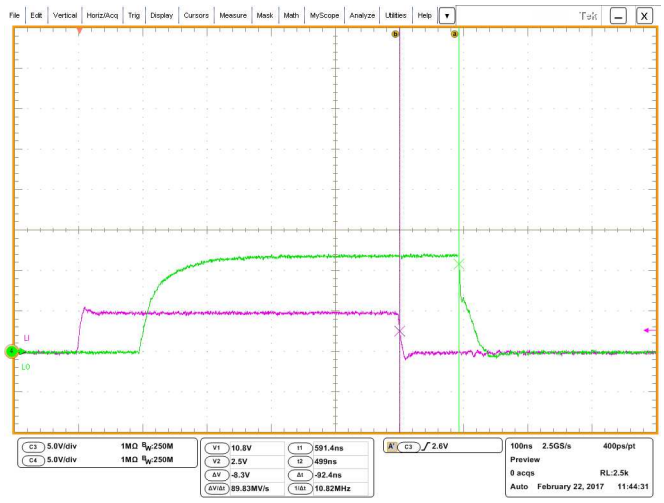


Figure 34. Turn-Off Propagation Delay

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8.3.7 Parasitic Diode Structure

Figure 35 illustrates the multiple parasitic diodes involved in the ESD protection components of UCC27712-Q1 device. This provides a pictorial representation of the absolute maximum rating for the device.

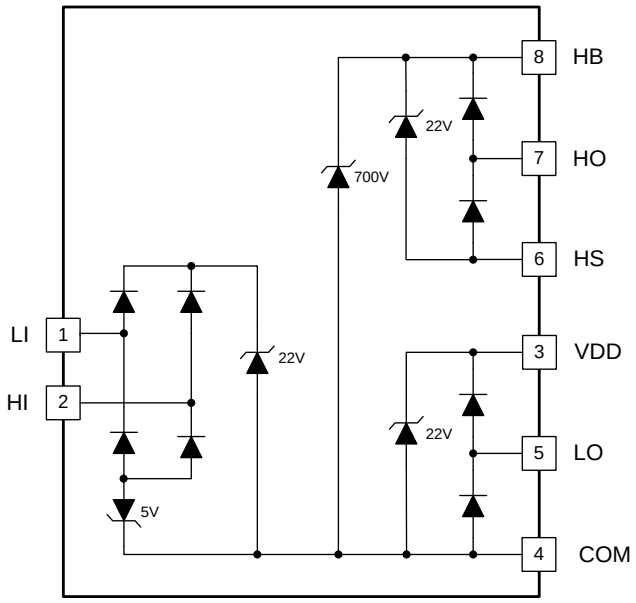


Figure 35. ESD Structure

8.4 Device Functional Modes

8.4.1 Minimum Input Pulse Operation

The UCC27712-Q1 device has a minimum turn-on, turn-off pulse transfer function to the output pin from the input pin. This function ensures UCC27712-Q1 is in the correct state when the input signal is very narrow. The function is summarized in Figure 36 and Figure 37. The t_{ON} which is 25 ns typical is shown in Figure 36 and t_{OFF} which is 35ns typical is shown in Figure 37

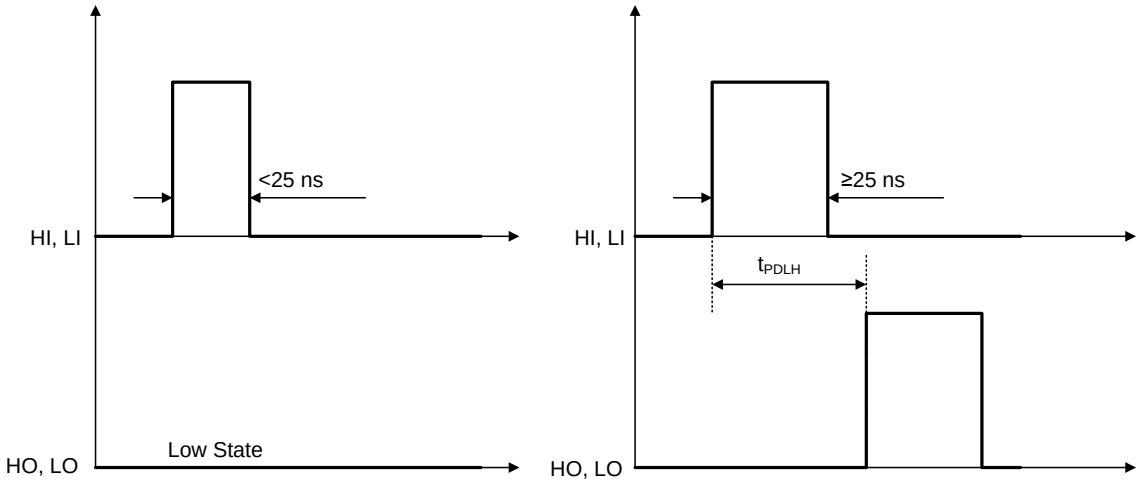


Figure 36. Minimum Turn-On Pulse

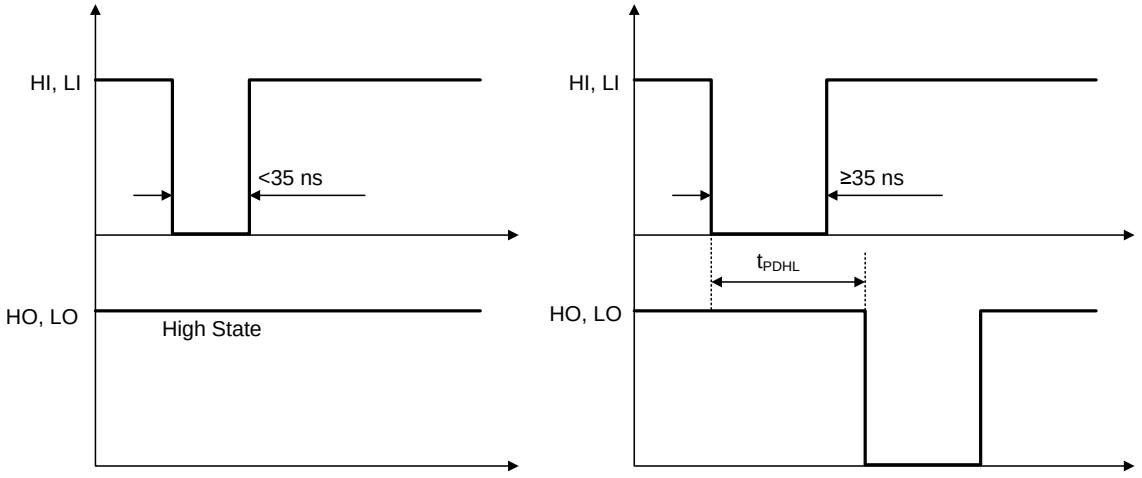


Figure 37. Minimum Turn-Off Pulse

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Device Functional Modes (continued)

8.4.2 Output Interlock and Dead Time

The UCC27712-Q1 has cross-conduction prevention logic, which is a feature that does not allow both the high-side and low-side outputs to be in high state simultaneously. In bridge power supply topologies, such as half-bridge or full-bridge, the UCC27712-Q1 interlock feature will prevent the high-side and low-side power switches to be turned on simultaneously. The UCC27712-Q1 generates a fixed minimum dead time of t_{DT} which is 150ns nominal in the case of LI and HI overlap or no dead time. Figure 38 illustrates the mode of operation where LI and HI have no dead time and HO and LO outputs have the minimum dead time of t_{DT}.

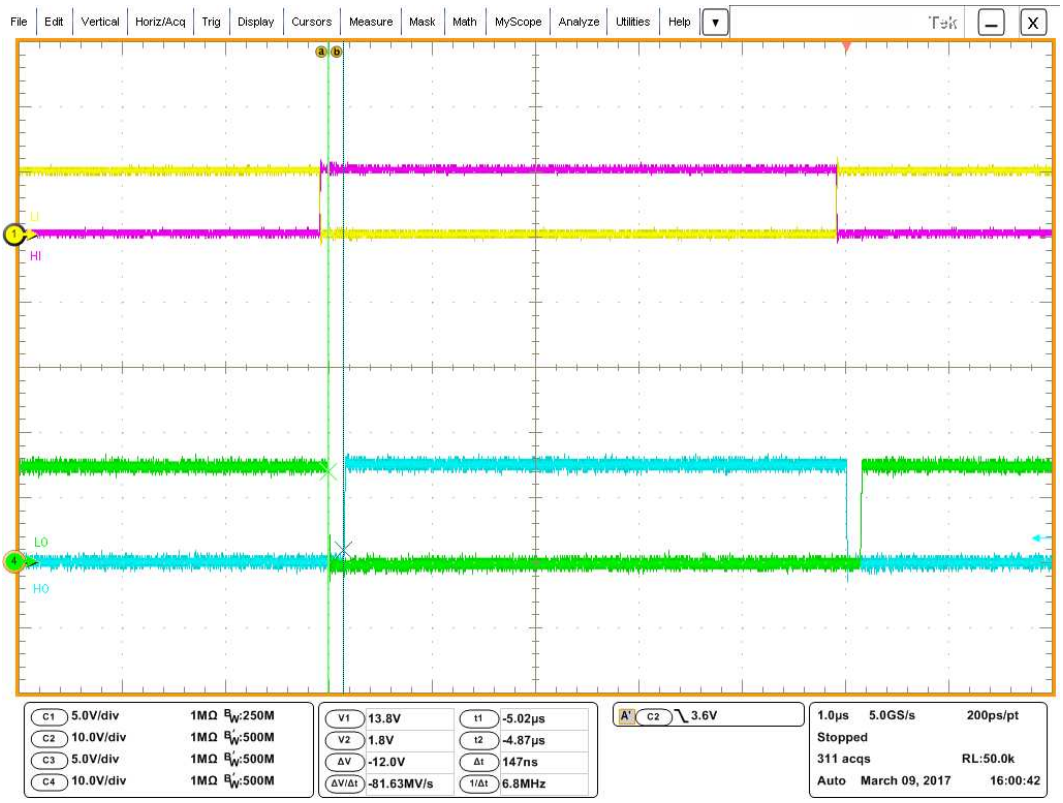


Figure 38. HO and LO Minimum Dead Time with LI HI Complementary

Device Functional Modes (continued)

An input signal's falling edge activates the dead time for the other signal. The output signal's dead time is always set to the longer of either the driver's minimum dead time, t_{DT}, or the input signal's own dead time. If both inputs are high simultaneously, both outputs will immediately be set low. This feature is used to prevent cross conduction, and it does not affect the programmed dead time setting for normal operation. Various driver dead time logic operating conditions are illustrated and explained in Figure 39.

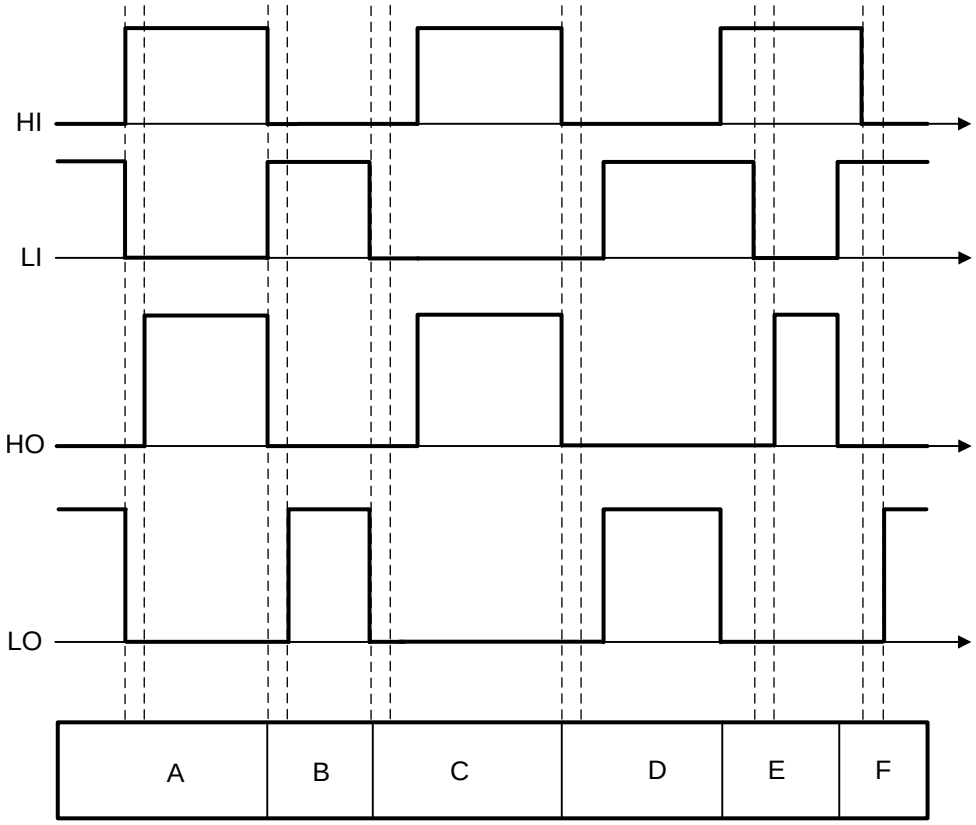


Figure 39. Input and Output Logic Relationship

Condition A: HI goes high, LI goes low. LI sets LO low immediately and assigns t_{DT} to HO. HO is allowed to go high after t_{DT}.

Condition B: LI goes high, HI goes low. HI sets HO low immediately and assigns t_{DT} to HO. LO is allowed to go high after t_{DT}.

Condition C: LI goes low, HI is still low. LI sets LO low immediately and assigns t_{DT} to HO. In this case, the input signal's own dead time is longer than t_{DT}. Thus when HI goes high HO is set high immediately.

Condition D: HI goes low, LI is still low. HI sets HO low immediately and assigns t_{DT} to LO. In this case, the input signal's own dead time is longer than t_{DT}. Thus when LI goes high LO is set high immediately.

Condition E: HI goes high, while LI and LO are still high. To avoid cross-conduction, HI immediately sets LO low and keeps HO low. After some time LI goes low and assigns t_{DT} to HO. LO is already low. After t_{DT} HO is allowed to go high.

Condition F: LI goes high, while HI and HO are still high. To avoid cross-conduction, LI immediately sets HO low and keeps LO low. After some time HI goes low and assigns t_{DT} to LO. HO is already low. After t_{DT} LO is allowed to go high.

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Device Functional Modes (continued)

8.4.3 Operation Under 100% Duty Cycle Condition

The UCC27712-Q1 allows constant on or constant off operation (0% and/or 100% duty cycle) as long as the VDD and VHB bias supplies are maintained above the UVLO thresholds. This is a challenge when boot-strap supplies are used for VHB. However, when a dedicated bias supply is used, constant on or constant off conditions can be supported. Also consider the HI and LI interlock function prevents both outputs from being high.

8.4.4 Operation Under Negative HS Voltage Condition

A typical half-bridge configuration with UCC27712-Q1 is shown in Figure 40. There are parasitic inductances in the power circuit from die bonding and pinning in QT/QB and PCB tracks of power circuit, the parasitic inductances are labeled $L_{K1,2,3,4}$.

During switching of HS caused by turning off HO, the current path of power circuit is changed to current path 2 from current path 1. This is known as current commutation. The current across L_{K3}, L_{K4} and body diode of QB pulls HS lower than COM. The negative voltage of HS with respect to COM causes a logic error of HO if the driver cannot handle negative voltage of HS. However, the UCC27712-Q1 offers robust operation under these conditions of negative voltage on HS.

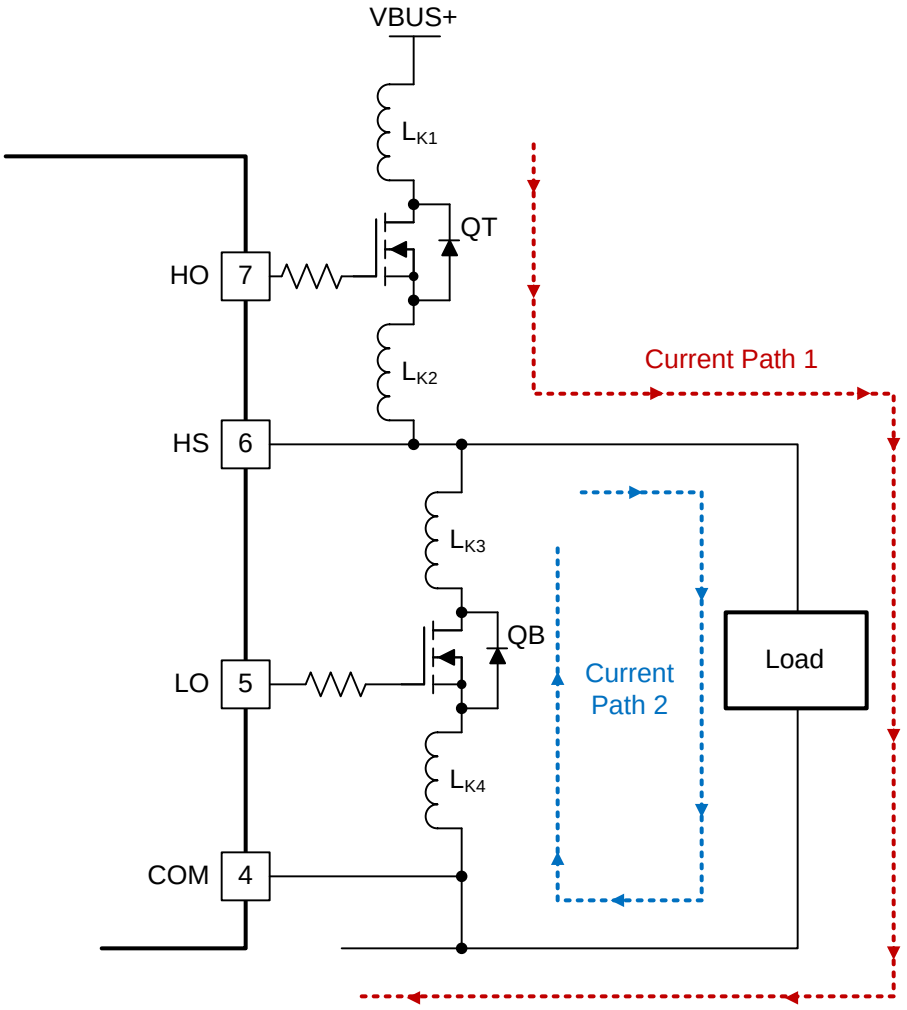


Figure 40. HS Negative Voltage In Half-Bridge Configuration

Device Functional Modes (continued)

The level shifter circuit is with respect to COM (refer to Functional Block Diagram), the voltage from HB to COM is the supply voltage of level shifter. Under the condition of HS is negative voltage with respect to COM, the voltage of HB-COM is decreased, as shown in Figure 41. There is a minimum operational supply voltage of level shifter, if the supply voltage of level shifter is too low, the level shifter cannot pass through HI signal to HO. The minimum supply voltage of level shifter of UCC27712-Q1 is 4 V, so the recommended HS specification is dependent on HB-HS. The specification of recommended HS is –11 V at HB – HS = 15 V.

In general, HS can operate until -11 V when HB – HS = 15 V as the ESD structure in Figure 35 allows a maximum voltage difference of 22 V between both pins. If HB-HS voltage is different, the minimum HS voltage changes accordingly.

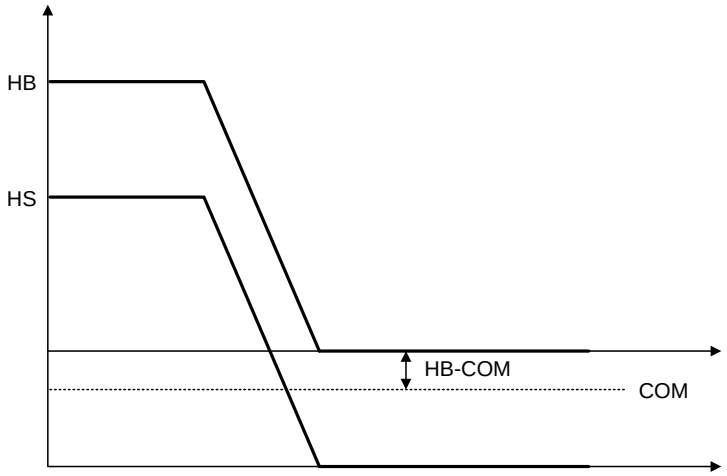


Figure 41. Level Shifter Supply Voltage with Negative HS

NOTE

Logic operational for HS of –11 V to 600 V at HB – HS = 15 V

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Device Functional Modes (continued)

The capability of a typical UCC27712-Q1 device to operate under a negative voltage condition in HS pin is reported in Figure 43. The test method is shown in Figure 42.

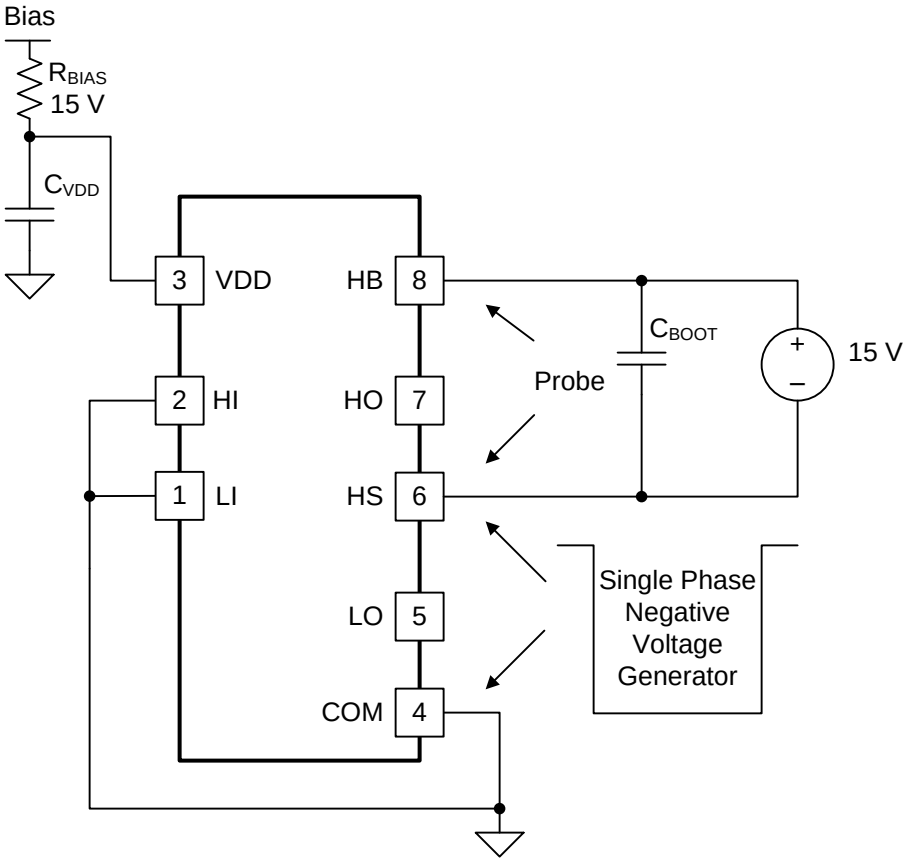


Figure 42. Negative Voltage Test Method

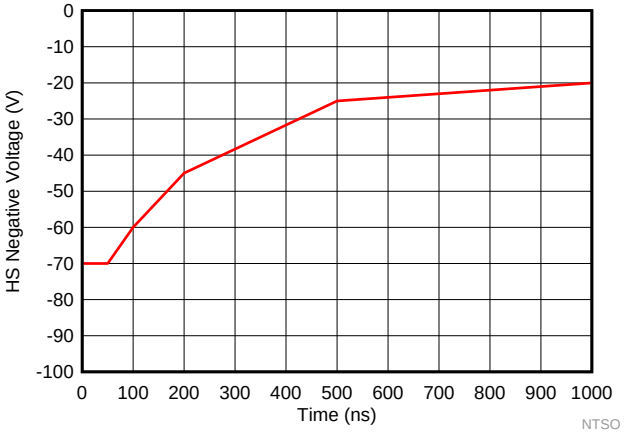


Figure 43. Negative Voltage Chart Pulse Width vs Negative Voltage

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9 Application and Implementation

NOTE

Information in the following Applications section 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.

9.1 Application Information

To effect fast switching of power devices and reduce associated switching power losses, a powerful gate driver is employed between the PWM output of controllers and the gates of the power semiconductor devices. Also, gate drivers are indispensable when it is impossible for the PWM controller to directly drive the gates of the switching devices. With the advent of digital power, this situation will be often encountered because the PWM signal from the digital controller is often a 3.3-V logic signal which cannot effectively turn on a power switch. Level shifting circuitry is needed to boost the 3.3-V signal to the gate-drive voltage (such as 12 V) in order to fully turn on the power device and minimize conduction losses. Traditional buffer drive circuits based on NPN/PNP bipolar transistors in totem-pole arrangement, being emitter follower configurations, prove inadequate with digital power because they lack level-shifting capability.

Gate drivers effectively combine both the level-shifting and buffer-drive functions. Gate drivers also find other needs such as minimizing the effect of high-frequency switching noise by locating the high-current driver physically close to the power switch, driving gate-drive transformers and controlling floating power-device gates, reducing power dissipation and thermal stress in controllers by moving gate charge power losses from the controller into the driver.

9.2 Typical Application

The circuit in Figure 44 shows a reference design example with UCC27712-Q1 driving a typical half-bridge configuration which could be used in several common power converter topologies such as synchronous buck, synchronous boost, half-bridge/full bridge isolated topologies, and motor drive applications.

For more information, please refer to Figure 44.

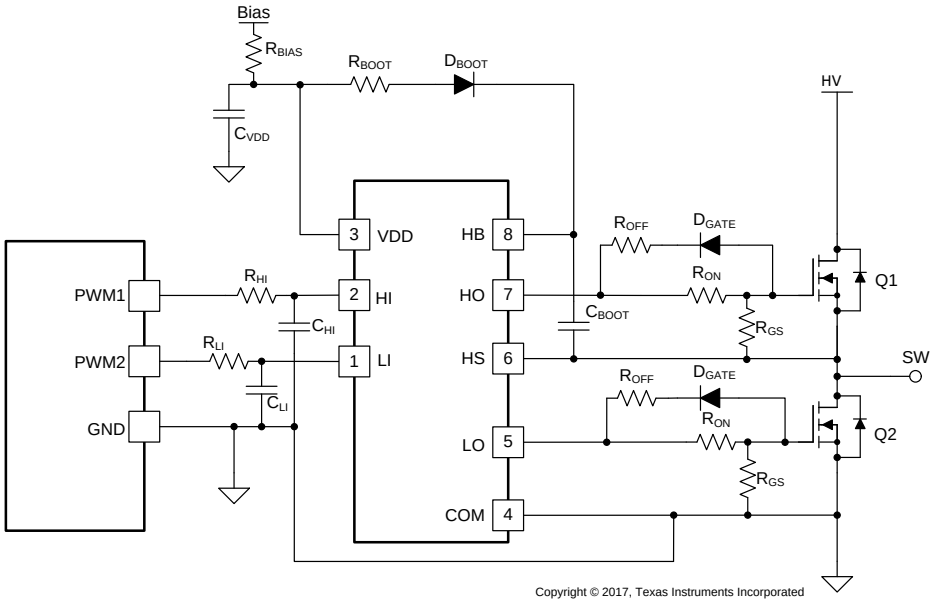


Figure 44. Typical Application Schematic

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Typical Application (continued)

9.2.1 Design Requirements

Table 4 shows the reference design parameters for the example application: UCC27712-Q1 driving 650-V MOSFETs in a high side-low side configuration.

Table 4. UCC27712-Q1 Design Requirements

PARAMETER	VALUE	UNIT
Power transistor	IPB65R190CFD	-
VDD	12	V
Input signal amplitude	3.3	V
Switching frequency (f_{SW})	100	kHz
DC link voltage (V_{HV})	400	V

9.2.2 Detailed Design Procedure

This procedure outlines the steps to design a 600-V high-side, low-side gate driver with 1.8-A source and 2.8-A sink current capability, targeted to drive power MOSFETs or IGBTs using the UCC27712-Q1. Refer to Figure 44 for component names and network locations. For additional design help see the UCC27712EVM-287 User Guide, SLUUBO1.

9.2.2.1 Selecting HI and LI Low Pass Filter Components (R_{HI}, R_{LI}, C_{HI}, C_{LI})

It is recommended that users avoid shaping the input signals to the gate driver in an attempt to slow down (or delay) the signal at the driver output. However it is good practice to have a small RC filter added between PWM controller and input pin of UCC27712-Q1 to filter the high frequency noise, like R_{HI}/C_{HI} and R_{LI}/C_{LI} which is shown in Figure 44.

Such a filter should use a R_{HI}/R_{LI} in the range of 10 Ω to 100 Ω and a C_{HI}/C_{LI} between 10 pF and 220 pF. In the example, a R_{HI}/R_{LI} = 49.9 Ω and a C_{HI}/C_{LI} = 33 pF are selected.

9.2.2.2 Selecting Bootstrap Capacitor (C_{BOOT})

The bootstrap capacitor should be sized to have more than enough energy to drive the gate of FET Q1 high, and maintain a stable gate drive voltage for the power transistor.

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

$$Q_{Total} = Q_G + \frac{I_{QBS}}{f_{SW}} = 68\,nC + \frac{65\,\mu A}{f_{SW}} = 68.65\,nC \quad (1)$$

This design example targets a boot capacitor ripple voltage of 0.5 V. Therefore, the absolute minimum C_{BOOT} requirement is:

$$C_{BOOT} = \frac{Q_{TOTAL}}{\Delta V_{BOOT}} = \frac{68.65\,nC}{0.5\,V} \approx 137\,nF \quad (2)$$

In practice, the value of C_{BOOT} needs to be greater than the calculated value. This allows for capacitance shift from DC bias and temperature, and also skipped cycles that occur during load transients. For this design example 2x 220-nF capacitors were chosen for the bootstrap capacitor.

$$C_{BOOT} = 440\,nF \quad (3)$$

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9.2.2.3 Selecting VDD Bypass/Holdup Capacitor (C_{VDD}) and R_{bias}

The VDD capacitor (C_{VDD}) should be chosen to be at least 10 times larger than C_{BOOT} so there is minimal voltage drop on the VDD capacitor when charging the boot capacitor . For this design example a 4.7-µF capacitor was selected.

$$C_{VDD} \geq 10 \times C_{BOOT} = 4.7\,\mu F \tag{4}$$

A 10-Ω resistor R_{BIAS} in series with bias supply and VDD pin is recommended to make the VDD ramp up time larger than 20 µs to minimize LO and HO rising as shown in Figure 45

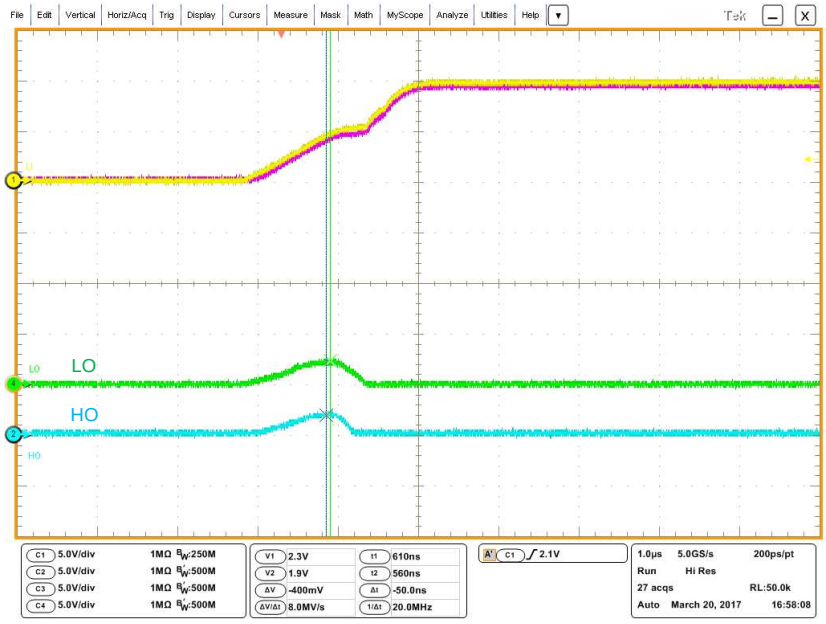


Figure 45. VDD/HB-HS Fast Ramp Up

9.2.2.4 Selecting Bootstrap Resistor (R_{BOOT})

Resistor R_{BOOT} is selected to limit the current in D_{BOOT} and limit the ramp up slew rate of voltage of HB-HS to avoid the phenomenon shown in Figure 45. It is recommended when using the UCC27712-Q1 that R_{BOOT} is between 2 Ω and 20 Ω. For this design we selected an R_{BOOT} current limiting resistor of 2.2 Ω. The bootstrap diode current ($I_{DBOOT(pk)}$) was limited to roughly 5.0 A.

$$I_{DBOOT(pk)} = \frac{V_{DD} - V_{DBOOT}}{R_{BOOT}} = \frac{12\,V - 1V}{2.2\Omega} = 5.0\,A \tag{5}$$

The power dissipation capability of the bootstrap resistor is important. The bootstrap resistor must be able to withstand the short period of high power dissipation during the initial charging sequence of the boot-strap capacitor. This energy is equivalent to 1/2 × CBOOT × V^2. This energy is dissipated during the charging time of the bootstrap capacitor (~3 × R_{BOOT} × C_{BOOT}). Special attention must be paid to use a bigger size R_{BOOT} when a bigger value of C_{BOOT} is chosen.

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9.2.2.5 Selecting Gate Resistor R_{ON}/R_{OFF}

Resistor R_{ON} and R_{OFF} are sized to achieve the following:

- Limit ringing caused by parasitic inductances and capacitances.
- Limit ringing caused by high voltage/current switching dV/dt, dI/dt, and body diode reverse recovery.
- Fine-tune gate drive strength to optimize switching loss.
- Reduce electromagnetic interference (EMI).

As mentioned in Output Stage, the UCC27712-Q1 has a pull up structure with a P-channel MOSFET providing a peak source current of 1.8A.

For this example 3.3-Ω resistors for R_{ON} and 2.2-Ω resistors for R_{OFF} were selected to provide damping for ringing and ample gate drive current.

$$R_{ON} = 3.3\Omega, R_{OFF} = 2.2\Omega \tag{6}$$

Therefore the peak source current can be predicted with:

$$I_{HO+} = MIN\left(1.8\,A, \frac{V_{DD} - V_{DBOOT}}{R_{HOH} + R_{ON} + R_{GFET_Int}}\right) \tag{7}$$

$$I_{LO+} = MIN\left(1.8\,A, \frac{V_{DD}}{R_{LOH} + R_{ON} + R_{GFET_Int}}\right) \tag{8}$$

where

- R_{ON}: External turn-on resistance
- R_{GFET_Int}: Power transistor internal gate resistance, found in the power transistor datasheet.
- I_{O+} = Peak source current. The maximum values between 1.8 A, the UCC27712-Q1 peak source current, and the calculated value based on the gate drive loop resistance.

In this example:

$$I_{HO+} = \frac{V_{DD} - V_{DBOOT}}{R_{HOH} + R_{ON} + R_{GFET_Int}} = \frac{12\,V\text{-}0.6\,V}{3.0\Omega + 3.3\Omega + 1.0\Omega} \approx 1.6\,A \tag{9}$$

$$I_{LO+} = \frac{V_{DD}}{R_{LOH} + R_{ON} + R_{GFET_Int}} = \frac{12\,V}{3.0\Omega + 3.3\Omega + 1.0\Omega} \approx 1.6\,A \tag{10}$$

Therefore, the high-side and low side peak source current is 1.6 A. Similarly, the peak sink current can be calculated with:

$$I_{HO-} = MIN\left(2.8\,A, \frac{V_{DD} - V_{DBOOT} - V_{DGATE}}{R_{HOL} + R_{OFF} + R_{GFET_Int}}\right) \tag{11}$$

$$I_{LO-} = MIN\left(2.8\,A, \frac{V_{DD} - V_{DGATE}}{R_{LOL} + R_{OFF} + R_{GFET_Int}}\right) \tag{12}$$

where

- R_{OFF}: External turn-off resistance
- V_{DGATE}: The diode forward voltage drop which is in series with R_{OFF}. The diode in this example is an MBRM130L.
- I_{O-} = Peak sink current. The maximum values between 2.8 A, the UCC27712-Q1 peak sink current, and the calculated value based on the gate drive loop resistance.

In this example:

$$I_{HO-} = \frac{V_{DD} - V_{DBOOT} - V_{DGATE}}{R_{HOL} + R_{ON} + R_{GFET_Int}} = \frac{12\,V\text{-}0.6\,V\text{-}0.6\,V}{1.5\Omega + 2.2\Omega + 1.0\Omega} \approx 2.3\,A \tag{13}$$

$$I_{LO-} = \frac{V_{DD} - V_{DGATE}}{R_{LOL} + R_{ON} + R_{GFET_Int}} = \frac{12\,V\text{-}0.6\,V}{1.5\Omega + 2.2\Omega + 1.0\Omega} \approx 2.4\,A \tag{14}$$

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9.2.2.6 Selecting Bootstrap Diode

A fast recovery diode should be chosen to avoid charge being taken away from the bootstrap capacitor. Thus, a fast reverse recovery time t_{RR}, low forward voltage V_F and low junction capacitance is recommended.

Suggested parts include MURA160T3G and BYG20J.

9.2.2.7 Estimate the UCC27712-Q1 Power Losses ($P_{UCC27712-Q1}$)

The power losses of UCC27712-Q1 ($P_{UCC27712-Q1}$) are estimated by calculating losses from several components. The gate drive loss in the UCC27712-Q1 is typically dominated by gate drive losses associated with charging and discharging the power device gate charge. There are other losses to consider especially if operating at high switching frequencies outlined below.

To determine the UCC27712-Q1 operating with no driver load, refer to the Typical Characteristics Figure 26 for IDD and IHB to determine the operating current at the appropriate f_{SW}. The operating current power losses with no driver load are calculated in Equation 15:

$$P_Q = V_{VDD} \times \left(I_{VDD,100kHz} + I_{HB,100kHz}\right) = 12\,V \times \left(310\ \mu A + 350\ \mu A\right) \approx 8\,mW \quad (15)$$

Static losses due to leakage current (I_{BL}) are calculated from the HB high-voltage node as shown in Equation 16:

$$P_{IBL} = V_{HB} \times I_{BL} \times D = 400\,V \times 20\,\mu A \times 0.5 = 4\,mW \quad (16)$$

Equation 17 calculates dynamic losses during the operation of the level shifter at HO turn-off edge. Q_P, typically 0.6 nC, is the charge absorbed by the level shifter during operation at each edge. Please note that if high-voltage switching occurs during HO turn-on as well (as in the case of ZVS topologies), then the power loss due to this component must be effectively doubled.

$$P_{LevelShift} = \left[V_{HV} + (V_{HB} - V_{HS})\right] \times Q_P \times f_{SW} = 411.4\,V \times 0.6\,nC \times 100\,kHz = 24.7\,mW \quad (17)$$

where

- V_{HV}: DC link high voltage input in V
- f_{SW}: Switching frequency of converter in Hz.

Dynamic losses incurred due to the gate charge while driving the FETs Q1 and Q2 are calculated Equation 18. Please note that this component typically dominates over the dynamic losses related to the internal VDD and VHB switching logic circuitry in UCC27712-Q1. The losses incurred driving the gate charge are not all dissipated in the gate driver device, this includes losses in the external gate resistance and internal power switch gate resistance.

$$P_{QG1,QG2} = 2 \times V_{VDD} \times Q_G \times f_{SW} = 2 \times 12\,V \times 68\,nC \times 100\,kHz = 163\,mW \quad (18)$$

The UCC27712-Q1 gate driver loss on the output stage ,P_{GDO}, is part of $P_{QG1,QG2}$. If the external gate resistances are zero most of the $P_{QG1,QG2}$ will be dissipated in the UCC27712-Q1. If there are external gate resistances, the total loss will be distributed between the gate driver pull-up/down resistances and the external gate resistances.

The gate drive power dissipated within the UCC27712-Q1 driver can be determined by Equation 19:

$$P_{GDO} = \frac{P_{QG1,QG2}}{2} \times \left(\frac{R_{HOH}}{R_{HOH} + R_{ON} + R_{GFET_Int}} + \frac{R_{HOL}}{R_{HOL} + R_{OFF} + R_{GFET_Int}} \right) \quad (19)$$

In this example the gate drive related losses are approximately 60mW as shown in Equation 20:

$$P_{GDO} = \frac{163\,mW}{2} \times \left(\frac{3\,\Omega}{3\,\Omega + 3.3\,\Omega + 1\,\Omega} + \frac{1.5\,\Omega}{1.5\,\Omega + 2.2\,\Omega + 1\,\Omega} \right) \approx 60\,mW \quad (20)$$

For the conditions, VDD=12V, VHB = 400V, HO On-state Duty cycle D = 50%, Q_G = 68nC, f_{SW} = 100kHz, the total power loss in UCC27712-Q1 driver for a half bridge power supply topology can be estimated as follows:

$$P_{UCC27712} = P_Q + P_{IBL} + P_{LevelShift} + P_{GDO} = 8mW + 4mW + 25mW + 60mW = 97mW \quad (21)$$

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9.2.2.8 Estimating Junction Temperature

The junction temperature can be estimated with:

$$T_J = T_C + \Psi_{JT} \times P_{UCC27712} \quad (22)$$

where

- T_C is the UCC27712-Q1 case-top temperature measured with a thermocouple or some other instrument. and
- Ψ_{JT} is the junction-to-top characterization parameter from the Thermal Information table. Importantly.

Using the junction-to-top characterization parameter (Ψ_{JT}) instead of the junction-to-case thermal resistance ($R_{\theta JC}$) can greatly improve the accuracy of estimating the junction temperature. The majority of the power dissipation of most devices is released into the PCB through the package leads, whereas only a small percentage of the total dissipation is released through the top of the case (where thermocouple measurements are usually taken). $R_{\theta JC}$ can only be used effectively when most of the thermal energy is released through the case, such as with metal packages or a heatsink is applied to the device package. In other cases $R_{\theta JC}$ will inaccurately estimate the true junction temperature of the device. Ψ_{JT} is experimentally derived by assuming the amount of thermal energy dissipated through the top of the device will be similar in both the testing environment and the application environment. As long as the recommended layout guidelines are observed, junction temperature can be estimated accurately to within a few degrees Celsius. For more information, see the Semiconductor and IC Package Thermal Metrics application report.

Additional Considerations: In the application example schematic there are 10-kΩ resistors across the gate and source terminals of FET Q1 and Q2. These resistors are placed across these nodes to ensure FETs Q1 and Q2 are not turned on if the UCC27712-Q1 is not in place or properly soldered to the circuit board or if UCC27712-Q1 is in an unbiased state.

9.2.2.9 Operation With IGBT's

The UCC27712-Q1 is well suited for driving IGBT's in various applications including motor drive and inverters. The design procedure is as the previous MOSFET example but the VDD voltage is typically 15-V to drive IGBT devices. Use the power transistor parameters and application specifications to determine the detail design and component values. See Figure 46 below for a typical IGBT application.

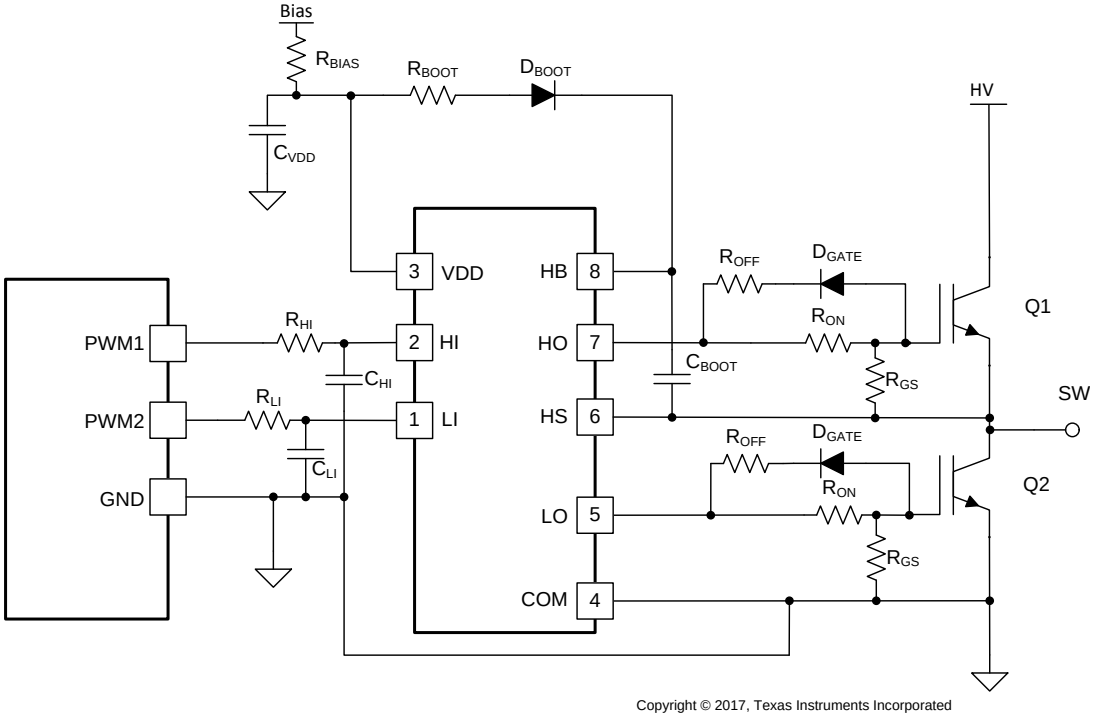


Figure 46. Typical IGBT Application Schematic

Refer to Figure 47 below for the UCC27712-Q1 driving 40-A, 650-V IGBT's in a high voltage sync buck configuration. The input voltage is 400 V, output 100 V with a 150-W output load. Channel 1 is the inductor current, Channel 2 is high-side IGBT VGE, Channel 3 is low-side IGBT VGE, and Channel 4 is the switch node or HS voltage.

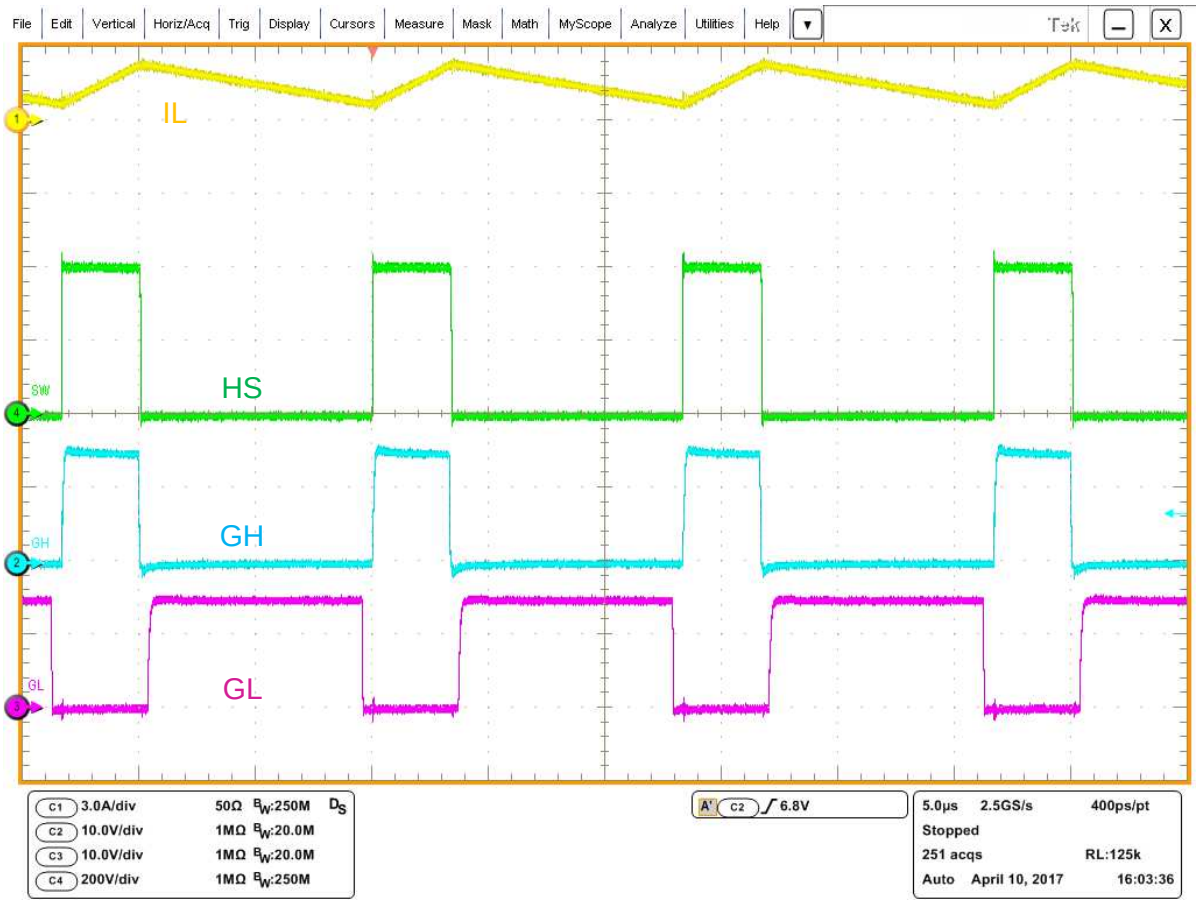


Figure 47. IGBT Sync-Buck Operating at 400 V and 150 W

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9.2.3 Application Curves

Figure 48 and Figure 49 show the measured LI to LO turn-on and turn-off delay of one UCC27712-Q1 device. Channel 3 depicts LI and Channel 4 LO.

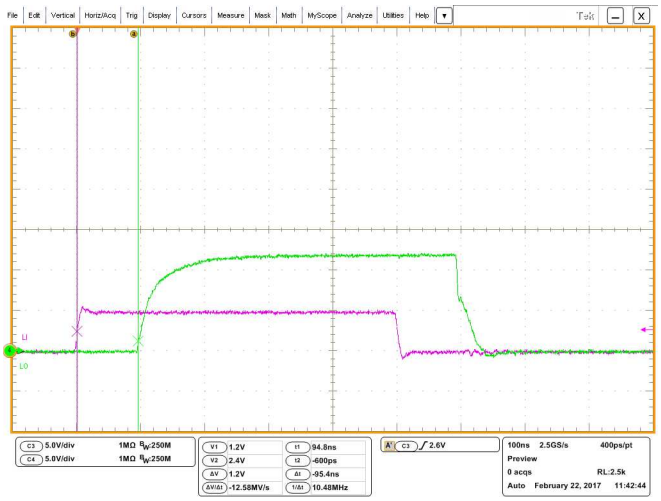


Figure 48. LI to LO Turn-On Propagation Delay

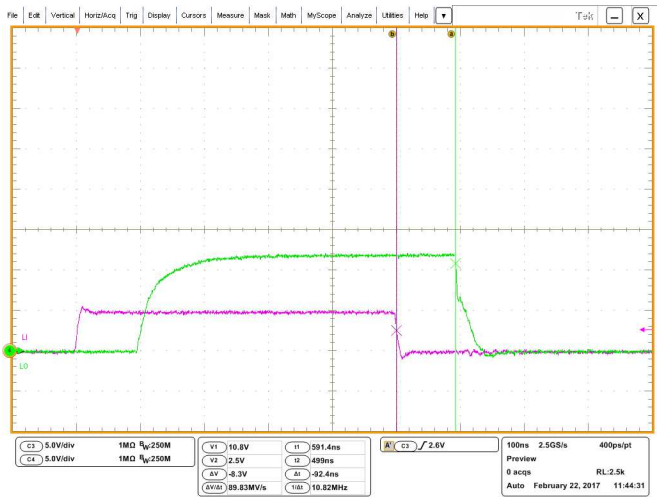


Figure 49. LI to LO Turn-Off Propagation Delay

Figure 50 and Figure 51 show the measured HI to HO turn-on and turn-off delay of one UCC27712-Q1 device. Channel 1 depicts HI and Channel 2 HO.

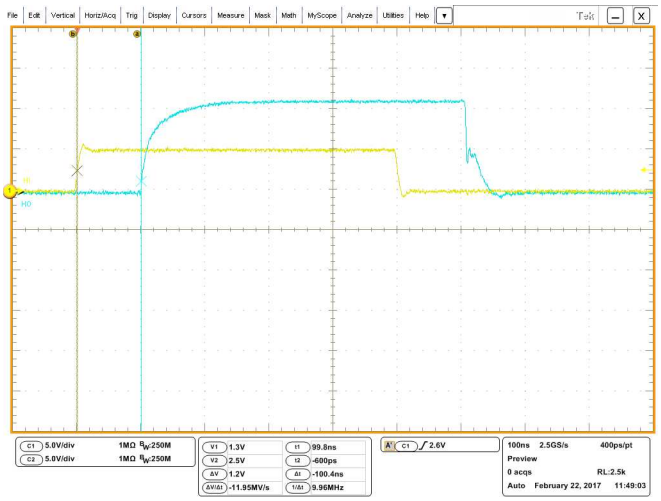


Figure 50. HI to HO Turn-On Propagation Delay

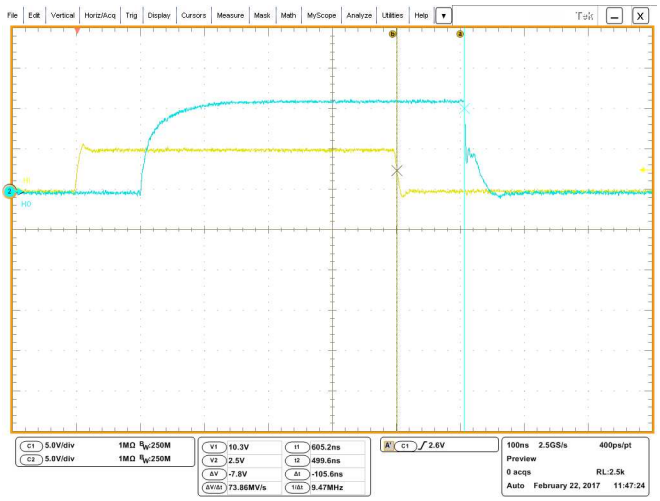


Figure 51. HI to HO Turn-Off Propagation Delay

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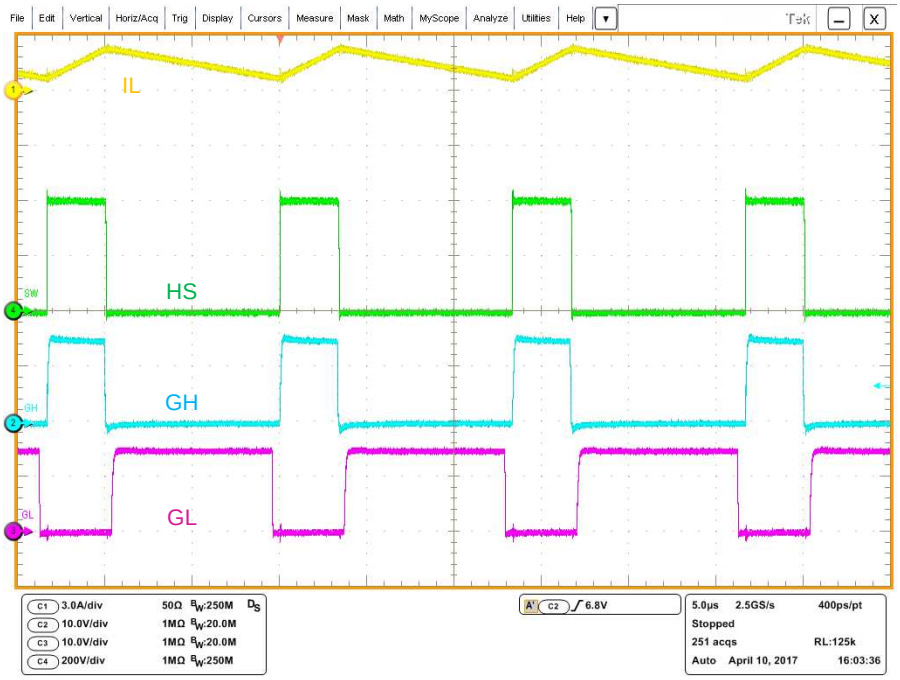


Figure 52. MOSFET Sync-Buck Operating at 400 V and 150 W

Figure 52 shows UCC27712-Q1 operating in a high voltage sync-buck. Channel 1 depicts inductor current, Channel 2 high side MOSFET VGS, Channel 3 low side MOSFET VGS, and Channel 4 high voltage switch node.

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10 Power Supply Recommendations

The VDD power terminal for the device requires the placement of an energy storage capacitor, because of UCC27712-Q1 is 1.8-A, peak-current driver. And requires the placement of low-esr noise-decoupling capacitance as directly as possible from the VDD terminal to the COM terminal, ceramic capacitors with stable dielectric characteristics over temperature are recommended, such as X7R or better.

The recommended storage capacitor is an X7R, 50-V capacitor. The recommended decoupling capacitors are a 1-µF 0805-sized 50-V X7R capacitor, ideally with (but not essential) a second smaller parallel 100-nF 0603-sized 50-V X7R capacitor.

Similarly, a low-esr X7R capacitance is recommended for the HB-HS power terminals which must be placed as close as possible to device pins.

11 Layout

11.1 Layout Guidelines

- Locate UCC27712-Q1 as close as possible to the MOSFETs in order to minimize the length of high-current traces between the HO/LO and the Gate of MOSFETs, as well as the return current path to the driver HS and COM.
- A resistor in series with bias supply and VDD pin is recommended.
- Locate the VDD capacitor (CVDD) and VHB capacitor (CBOOT) as close as possible to the pins of UCC27712-Q1.
- A 2-Ω to 20-Ω resistor series with bootstrap diode is recommended to limit bootstrap current.
- A RC filter with 10 Ω to 100 Ω and 10 pF to 220 pF for HI/LI is recommended.
- Separate power traces and signal traces, such as output and input signals.
- Maintain as much separation as possible from the from the low voltage pins and floating drive HB, HO and HS pins.
- Ensure there is not high switching current flowing in the control ground (input signal reference) from the power train ground.

11.2 Layout Example

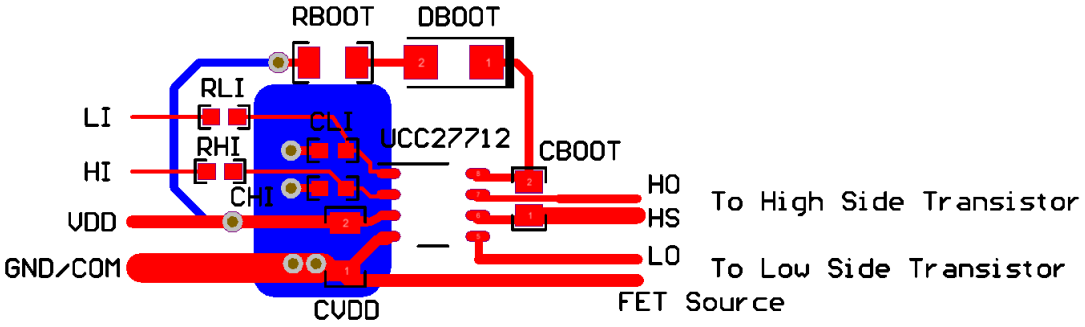


Figure 53. UCC27712-Q1 Layout Example

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

User Guide, *Using the UCC27712EVM-287*, (SLUUBO1)

12.2 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 5. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
UCC27712-Q1	Click here	Click here	Click here	Click here	Click here

12.3 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.

12.4 Trademarks

E2E is a trademark of Texas Instruments.

12.5 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.

12.6 Glossary

SLYZ022 — *TI Glossary*.

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

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.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
UCC27712QDQ1	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 140	27712Q
UCC27712QDQ1.B	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	27712Q
UCC27712QDRQ1	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 140	27712Q
UCC27712QDRQ1.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	27712Q

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **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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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF UCC27712-Q1 :

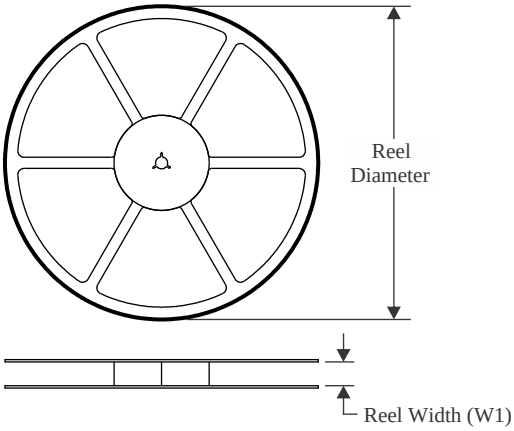
- Catalog : UCC27712

NOTE: Qualified Version Definitions:

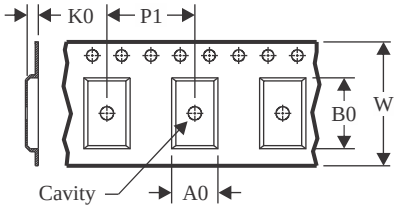
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

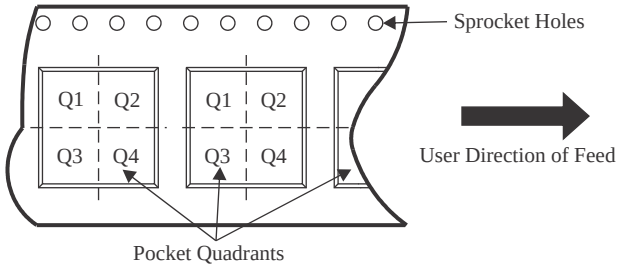


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

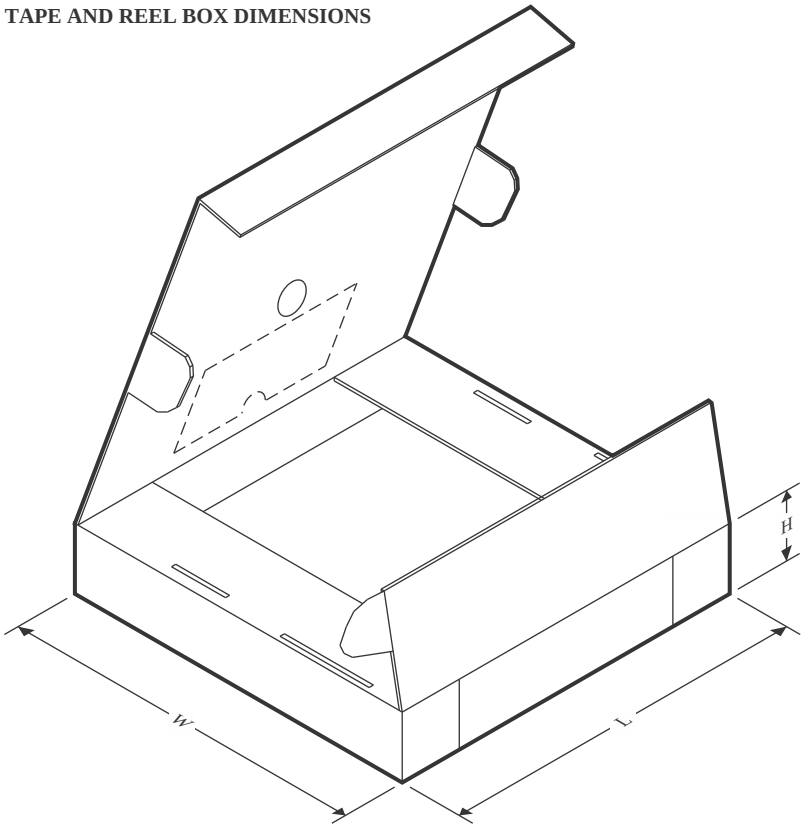
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
UCC27712QDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

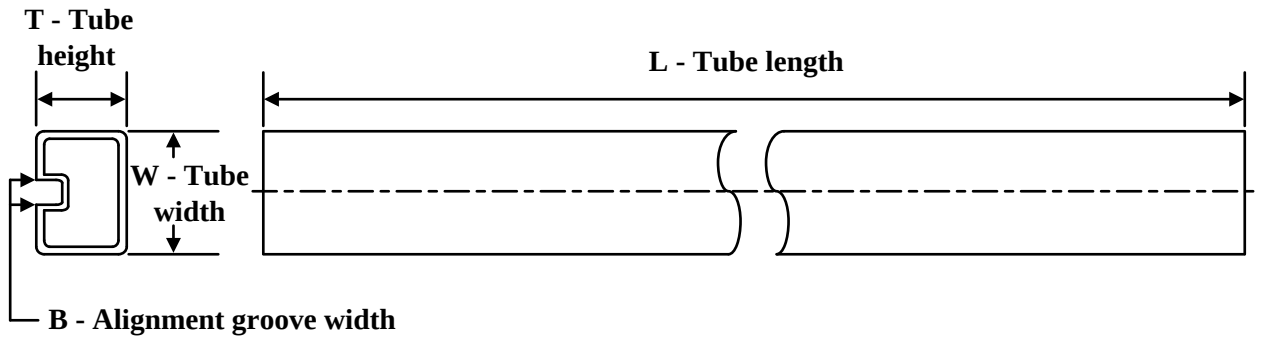
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

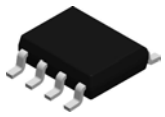
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
UCC27712QDRQ1	SOIC	D	8	2500	353.0	353.0	32.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
UCC27712QDQ1	D	SOIC	8	75	506.6	8	3940	4.32
UCC27712QDQ1.B	D	SOIC	8	75	506.6	8	3940	4.32

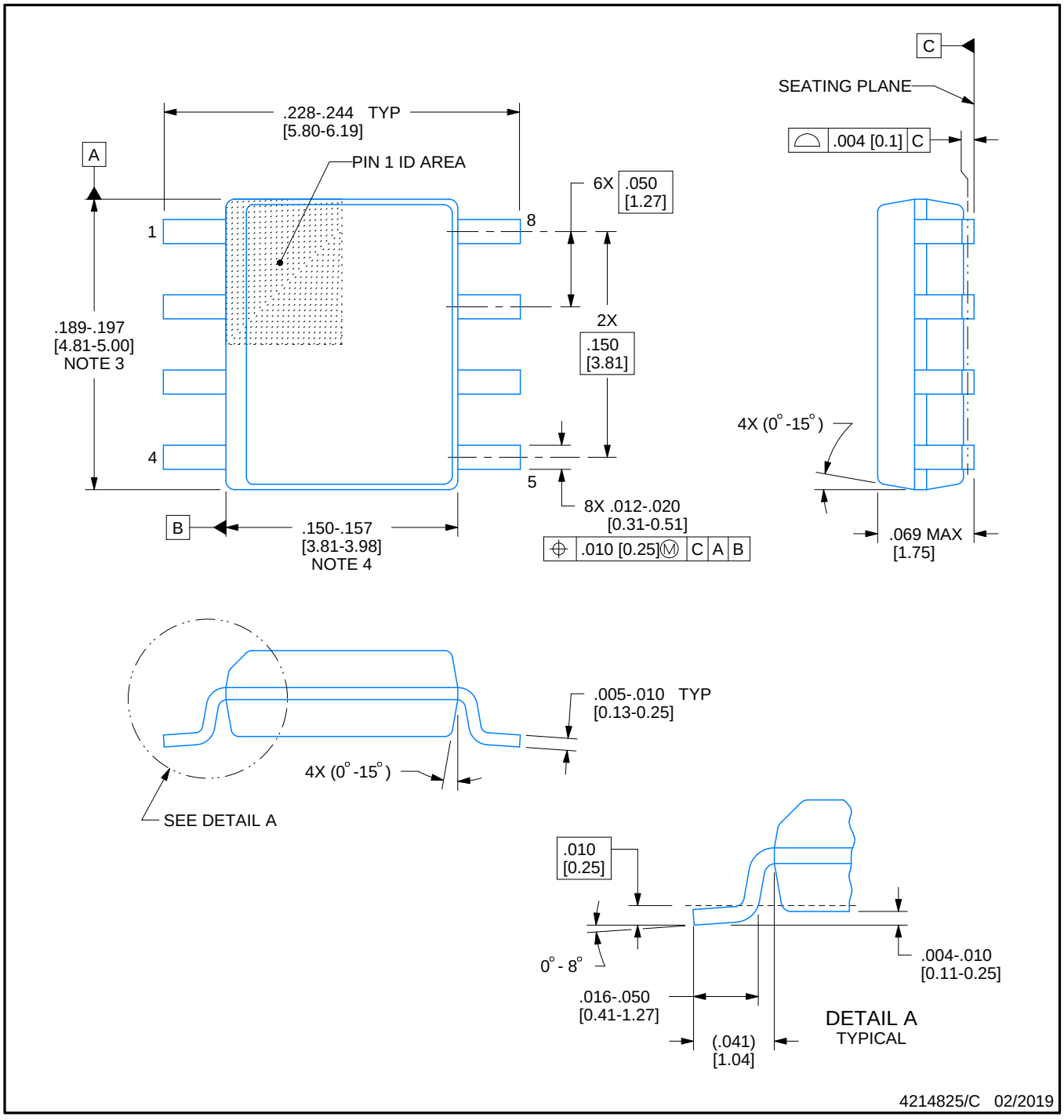


PACKAGE OUTLINE

D0008A

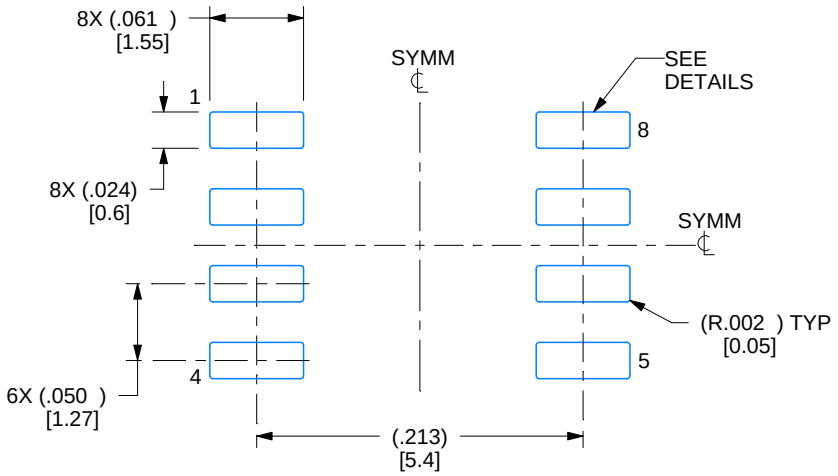
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

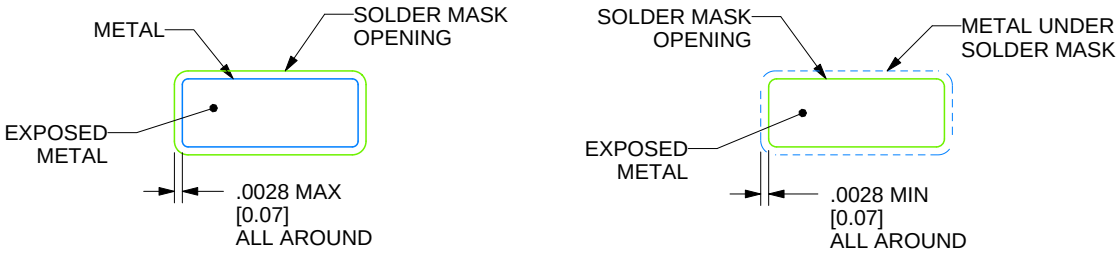


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

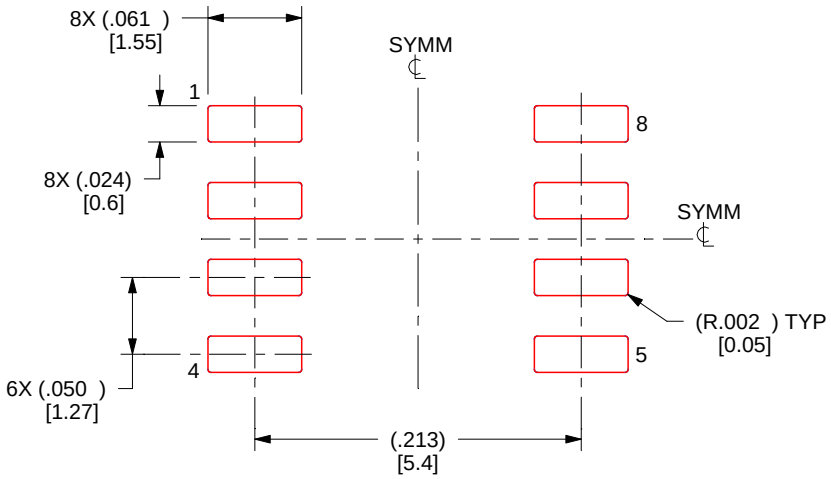
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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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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