



UCC20520 单输入 4A/6A、5.7 kV_{RMS} 隔离式双通道栅极驱动器

1 特性

- 单输入，双输出
- 工作温度范围：-40°C 至 +125°C
- 开关参数：
 - 19ns 典型传播延迟
 - 10ns 最小脉冲宽度
 - 5ns 最大延迟匹配度
 - 5ns 最大脉宽失真度
- 共模瞬态抗扰度 (CMTI) 大于 100V/ns
- 浪涌抗扰度高达 12.8kV
- 隔离栅寿命 > 40 年
- 4A 峰值拉电流，6A 峰值灌电流输出
- TTL 和 CMOS 兼容输入
- 3V 至 18V 输入 VCCI 范围，可连接数字和模拟控制器
- 高达 25V 的 VDD 输出驱动电源
- 可编程死区时间
- 抑制短于 5ns 的输入脉冲和瞬态噪声
- 可针对电源排序快速禁用
- 符合行业标准的宽体 SOIC-16 (DW) 封装
- 安全相关及管理批准：
 - 8000 V_{PK} 隔离，符合 DIN V VDE V 0884-10 (VDE V0884-10):2006-12 标准
 - 符合 UL 1577 标准且长达 1 分钟的 5700 V_{RMS} 隔离
 - CSA 组件验收通知 5A，IEC 60950-1 和 IEC 60601-1 终端设备标准（计划）
 - 通过 GB4943.1-2011 CQC 认证

2 应用

- 离线交流-直流电源中的隔离式转换器
- 服务器、电信、IT 和工业基础设施
- 电机驱动和直流-交流太阳能逆变器
- LED 照明
- 感应加热
- 不间断电源 (UPS)
- HEV 和 BEV 电池充电器

3 说明

UCC20520 是一款隔离式单输入、双通道栅极驱动器，其峰值拉电流为 4A，峰值灌电流为 6A。该器件设计用于驱动高达 5MHz 的功率 MOSFET、IGBT 和 SiC MOSFET，具有一流的传播延迟和脉宽失真度。

输入侧通过一个 5.7 kV_{RMS} 增强型隔离栅与两个输出驱动器隔离，共模瞬态抗扰度 (CMTI) 的最小值为 100V/ns。两个次级侧驱动器之间施加内部功能隔离，支持的工作电压高达 1500 V_{DC}。

该驱动器可用于通过编程设定死区时间 (DT) 的半桥驱动器。禁用引脚在设为高电平时可同时关断两个输出，在悬空或接地时允许器件正常运行。作为一种故障安全机制，一次侧逻辑故障会强制两个输出为低电平。

该器件接受的 VDD 电源电压高达 25V。凭借 3V 至 18V 宽输入 VCCI 电压范围，该驱动器适用于连接数字和模拟控制器。所有电源电压引脚均具有欠压闭锁 (UVLO) 保护。

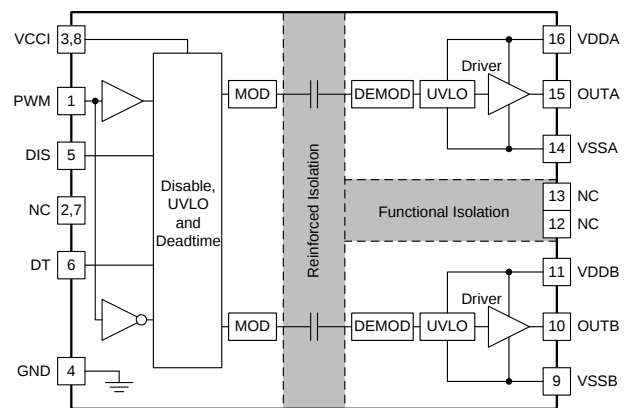
凭借上述所有高级特性，UCC20520 能够满足各类电源应用中对于高效率、高电源密度和稳健性的要求。

器件信息⁽¹⁾

器件型号	封装	封装尺寸（标称值）
UCC20520DW	DW SOIC (16)	10.30mm x 7.50mm

(1) 要了解所有可用封装，请见数据表末尾的可订购产品附录。

功能框图



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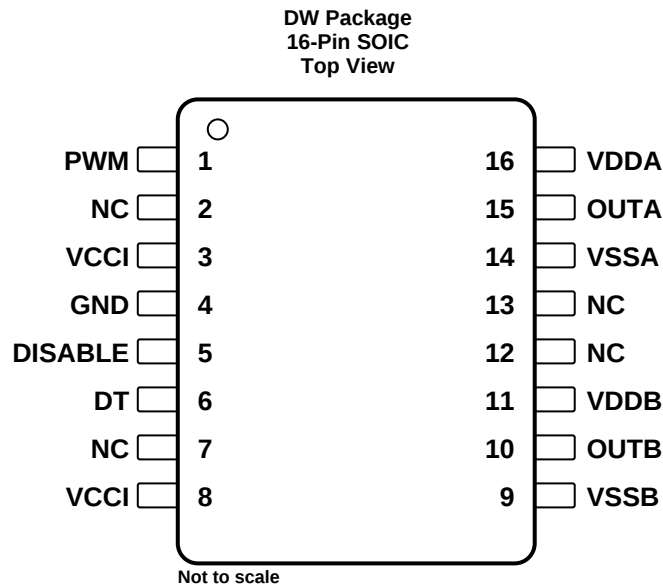
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4 修订历史

日期	修订版本	注释
2016 年 11 月	*	最初发布版本。

5 Pin Configuration and Functions



Pin Functions

PIN		I/O ⁽¹⁾	DESCRIPTION
NAME	NO.		
DISABLE	5	I	Disables both driver outputs if asserted high, enables if set low or left open. This pin is pulled low internally if left open. It is recommended to tie this pin to ground if not used to achieve better noise immunity.
DT	6	I	Programmable dead time function. Tying DT to VCCI disables the DT function with dead time $\approx$ 0ns. Leaving DT open sets the dead time to <15 ns. Placing a 500- Ω to 500-k Ω resistor (R_{DT}) between DT and GND adjusts dead time according to: DT (in ns) = $10 \times R_{DT}$ (in k Ω). It is recommended to parallel a ceramic capacitor, 2.2nF or above, with R_{DT} to achieve better noise immunity.
GND	4	P	Primary-side ground reference. All signals in the primary side are referenced to this ground.
NC	2	–	No connection.
NC	7	–	No connection.
NC	12	–	No connection.
NC	13	–	No connection.
OUTA	15	O	Output of driver A. Connect to the gate of the A channel FET or IGBT. Output A is in phase with PWM input with a propagation delay
OUTB	10	O	Output of driver B. Connect to the gate of the B channel FET or IGBT. Output B is always complementary to output A with a programmed dead time.
PWM	1	I	PWM input has a TTL/CMOS compatible input threshold. This pin is pulled low internally if left open.
VCCI	3	P	Primary-side supply voltage. Locally decoupled to GND using a low ESR/ESL capacitor located as close to the device as possible.
VCCI	8	P	Primary-side supply voltage. This pin is internally shorted to pin 3.
VDDA	16	P	Secondary-side power for driver A. Locally decoupled to VSSA using a low ESR/ESL capacitor located as close to the device as possible.
VDDB	11	P	Secondary-side power for driver B. Locally decoupled to VSSB using a low ESR/ESL capacitor located as close to the device as possible.
VSSA	14	P	Ground for secondary-side driver A. Ground reference for secondary side A channel.
VSSB	9	P	Ground for secondary-side driver B. Ground reference for secondary side B channel.

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

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
Input bias pin supply voltage	VCCI to GND	−0.3	20	V
Driver bias supply	VDDA-VSSA, VDDB-VSSB	−0.3	30	V
Output signal voltage	OUTA to VSSA, OUTB to VSSB	−0.3	V _{VDDA} +0.3, V _{VDDB} +0.3	V
	OUTA to VSSA, OUTB to VSSB, Transient for 200 ns	−2	V _{VDDA} +0.3, V _{VDDB} +0.3	V
Input signal voltage	PWM, DIS, DT to GND	−0.3	V _{VCCI} +0.3	V
	PWM Transient for 50ns	−5	V _{VCCI} +0.3	V
Channel to channel voltage	VSSA-VSSB, VSSB-VSSA		1500	V
Junction temperature, T _J ⁽²⁾		−40	150	°C
Storage temperature, T _{stg}		−65	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) To maintain the recommended operating conditions for T_J, see the [Thermal Information](#).

6.2 ESD Ratings

		VALUE	UNIT
V _(ESD) Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±4000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1500	

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

		MIN	MAX	UNIT
VCCI	VCCI Input supply voltage	3	18	V
VDDA, VDDB	Driver output bias supply	9.2	25	V
T _A	Ambient Temperature	−40	125	°C
T _J	Junction Temperature	−40	130	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		UCC20520	UNIT
		DW-16 (SOIC)	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	78.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	11.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	48.4	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	12.5	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	48.4	°C/W

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

6.5 Power Ratings

			VALUE	UNIT
P_D	Power dissipation by UCC20520DW	VCCI = 18 V, VDDA/B = 12 V, PWM = 3.3 V, 3 MHz 50% duty cycle square wave 1-nF load	1.05	W
P_{DI}	Power dissipation by primary side of UCC20520DW		0.05	W
P_{DA}, P_{DB}	Power dissipation by secondary driver side of UCC20520DW		0.5	W

6.6 Insulation Specifications

PARAMETER		TEST CONDITIONS	VALUE	UNIT
CLR	External clearance ⁽¹⁾	Shortest terminal to terminal distance through air	> 8	mm
CPG	External creepage ⁽¹⁾	Shortest terminal to terminal distance across the package surface	> 8	mm
DTI	Distance through insulation	Distance through internal isolation (internal clearance)	>21	μm
CTI	Comparative tracking index	DIN EN 60112 (VDE 0303-11); IEC 60112	> 600	V
	Material group	According to IEC 60664-1	I	
	Overvoltage category per IEC 60664-1	Rated mains voltage ≤ 600 V _{RMS}	I-IV	
		Rated mains voltage ≤ 1000 V _{RMS}	I-III	
DIN V VDE 0884-10 (VDE V 0884-10): 2006-2012 ⁽²⁾				
V _{IORM}	Maximum repetitive peak isolation voltage	AC voltage (bipolar)	2121	V _{PK}
V _{IOWM}	Maximum isolation working voltage	Time dependent dielectric breakdown (TDDb) test, (See 图 1)	1500	V _{RMS}
			2121	V _{DC}
V _{IOTM}	Maximum transient isolation voltage	V _{TEST} = V _{IOTM} t = 60 sec (qualification) t = 1 sec (100% production)	8000	V _{PK}
V _{IOSM}	Maximum surge isolation voltage ⁽³⁾	Test method per IEC 60065, 1.2/50 μs waveform, V _{TEST} = 1.6 × V _{IOSM} = 12800 V _{PK} (qualification)	8000	V _{PK}
q _{pd}	Apparent charge ⁽⁴⁾	Method a, After Input/Output safety test subgroup 2/3. V _{ini} = V _{IOTM} , t _{ini} = 60s; V _{pd(m)} = 1.2 X V _{IORM} = 2545 V _{PK} , t _m = 10s	<5	pC
		Method a, After environmental tests subgroup 1. V _{ini} = V _{IOTM} , t _{ini} = 60s; V _{pd(m)} = 1.6 X V _{IORM} = 3394 V _{PK} , t _m = 10s	<5	
		Method b1; At routine test (100% production) and preconditioning (type test) V _{ini} = V _{IOTM} ; t _{ini} = 1s; V _{pd(m)} = 1.875 * V _{IORM} = 3977 V _{PK} , t _m = 1s	<5	
C _{IO}	Barrier capacitance, input to output ⁽⁵⁾	V _{IO} = 0.4 sin (2πft), f =1 MHz	1.2	pF
R _{IO}	Isolation resistance, input to output	V _{IO} = 500 V at T _A = 25°C	> 10 ¹²	Ω
		V _{IO} = 500 V at 100°C ≤ T _A ≤ 125°C	> 10 ¹¹	
		V _{IO} = 500 V at T _S =150°C	> 10 ⁹	
	Pollution degree		2	
	Climatic category		40/125/21	
UL 1577				
V _{ISO}	Withstand isolation voltage	V _{TEST} = V _{ISO} = 5700 V _{RMS} , t = 60 sec. (qualification), V _{TEST} = 1.2 × V _{ISO} = 6840V _{RMS} , t = 1 sec (100% production)	5700	V _{RMS}

- (1) Creepage and clearance requirements should be applied according to the specific equipment isolation standards of an application. Care should be taken to maintain the creepage and clearance distance of a board design to ensure that the mounting pads of the isolator on the printed-circuit board do not reduce this distance. Creepage and clearance on a printed-circuit board become equal in certain cases. Techniques such as inserting grooves and/or ribs on a printed circuit board are used to help increase these specifications.
- (2) This coupler is suitable for basic electrical insulation only within the maximum operating ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits.
- (3) Testing is carried out in air or oil to determine the intrinsic surge immunity of the isolation barrier.
- (4) Apparent charge is electrical discharge caused by a partial discharge (pd).
- (5) All pins on each side of the barrier tied together creating a two-terminal device.

6.7 Safety-Related Certifications

VDE	CSA	UL	CQC
Certified according to DIN VDE V 0884-10 (VDE V 0884-10):2006-12 and DIN EN 60950-1 (VDE 0805 Teil 1):2011-01	Approved under CSA Component Acceptance Notice 5A, IEC 60950-1 and IEC 60601-1	Certified according to UL 1577 Component Recognition Program	Certified according to GB 4943.1-2011
Reinforced Insulation Maximum Transient Isolation voltage, 8000 V _{PK} ; Maximum Repetitive Peak Isolation Voltage, 2121 V _{PK} ; Maximum Surge Isolation Voltage, 8000 V _{PK}	Reinforced insulation per CSA 60950-1-07+A1+A2 and IEC 60950-1 2nd Ed.	Single protection, 5700 V _{RMS}	Reinforced Insulation, Altitude ≤ 5000 m, Tropical Climate, 400V _{RMS} maximum working voltage
Certification number: 40040142	Agency Qualification Planned	File number: E181974	Certification number: CQC16001155011

6.8 Safety-Limiting Values

Safety limiting intends to prevent potential damage to the isolation barrier upon failure of input or output circuitry. A failure of the I/O can allow low resistance to ground or the supply and, without current limiting, dissipate sufficient power to overheat the die and damage the isolation barrier potentially leading to secondary system failures.

PARAMETER	TEST CONDITIONS	SIDE	MIN	TYP	MAX	UNIT
I _S Safety output supply current	R _{θJA} = 78.1°C/W, VDDA/B = 12 V, T _A = 25°C, T _J = 150°C See Figure 2	DRIVER A, DRIVER B			64	mA
	R _{θJA} = 78.1°C/W, VDDA/B = 25 V, T _A = 25°C, T _J = 150°C	DRIVER A, DRIVER B			31	mA
P _S Safety supply power	R _{θJA} = 78.1°C/W, T _A = 25°C, T _J = 150°C See Figure 3	INPUT			50	mW
		DRIVER A			775	
		DRIVER B			775	
		TOTAL			1600	
T _S Safety temperature					150	°C

The maximum safety temperature is the maximum junction temperature specified for the device. The power dissipation and junction-to-air thermal impedance of the device installed in the application hardware determines the junction temperature. The assumed junction-to-air thermal resistance in the [Thermal Information](#) table is that of a device installed on a High-K test board for leaded surface mount packages. The power is the recommended maximum input voltage times the current. The junction temperature is then the ambient temperature plus the power times the junction-to-air thermal resistance.

6.9 Electrical Characteristics

$V_{VCCI} = 3.3\text{ V}$ or 5 V , $0.1\text{-}\mu\text{F}$ capacitor from V_{CCI} to GND, $V_{VDDA} = V_{VDDB} = 12\text{ V}$, $1\text{-}\mu\text{F}$ capacitor from V_{DDA} and V_{DDB} to V_{SSA} and V_{SSB} , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY CURRENTS						
I_{VCCI}	V_{CCI} quiescent current	DISABLE = V_{CCI}		1.5	2.0	mA
I_{VDDA}, I_{VDDB}	V_{DDA} and V_{DDB} quiescent current	DISABLE = V_{CCI}		1.0	1.8	mA
I_{VCCI}	V_{CCI} operating current	(f = 500 kHz) current per channel, $C_{OUT} = 100\text{ pF}$		2.5		mA
I_{VDDA}, I_{VDDB}	V_{DDA} and V_{DDB} operating current	(f = 500 kHz) current per channel, $C_{OUT} = 100\text{ pF}$		2.5		mA
VCCI SUPPLY UNDERVOLTAGE LOCKOUT THRESHOLDS						
V_{VCCI_ON}	Rising threshold V_{CCI_ON}		2.55	2.7	2.85	V
V_{VCCI_OFF}	Falling threshold V_{CCI_OFF}		2.35	2.5	2.65	V
V_{VCCI_HYS}	Threshold hysteresis			0.2		V
VDDA/VDDB SUPPLY UNDERVOLTAGE LOCKOUT THRESHOLDS						
V_{VDDA_ON}, V_{VDDB_ON}	Rising threshold V_{DDA_ON}, V_{DDB_ON}		8	8.5	9	V
$V_{VDDA_OFF}, V_{VDDB_OFF}$	Falling threshold V_{DDA_OFF}, V_{DDB_OFF}		7.5	8	8.5	V
$V_{VDDA_HYS}, V_{VDDB_HYS}$	Threshold hysteresis			0.5		V
PWM AND DISABLE						
V_{PWMH}, V_{DISH}	Input high voltage		1.6	1.8	2	V
V_{PWML}, V_{DISL}	Input low voltage		0.8	1	1.2	V
V_{PWM_HYS}, V_{DIS_HYS}	Input hysteresis			0.8		V
V_{PWM}	Negative transient, ref to GND, 50 ns pulse	Not production tested, bench test only	-5			V

Electrical Characteristics (continued)

$V_{VCCI} = 3.3 \text{ V}$ or 5 V , $0.1\text{-}\mu\text{F}$ capacitor from V_{VCCI} to GND, $V_{VDDA} = V_{VDDB} = 12 \text{ V}$, $1\text{-}\mu\text{F}$ capacitor from V_{VDDA} and V_{VDDB} to V_{SSA} and V_{SSB} , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
OUTPUT					
I_{OA+} , I_{OB+} Peak output source current	$C_{VDD} = 10 \text{ }\mu\text{F}$, $C_{LOAD} = 0.18 \text{ }\mu\text{F}$, $f = 1 \text{ kHz}$, bench measurement		4		A
I_{OA-} , I_{OB-} Peak output sink current	$C_{VDD} = 10 \text{ }\mu\text{F}$, $C_{LOAD} = 0.18 \text{ }\mu\text{F}$, $f = 1 \text{ kHz}$, bench measurement		6		A
R_{OHA} , R_{OHB} Output resistance at high state	$I_{OUT} = -10 \text{ mA}$, $T_A = 25^\circ\text{C}$, R_{OHA} , R_{OHB} do not represent drive pull-up performance. See t_{RISE} in Switching Characteristics and Output Stage for details.		5		Ω
R_{OLA} , R_{OLB} Output resistance at low state	$I_{OUT} = 10 \text{ mA}$, $T_A = 25^\circ\text{C}$		0.55		Ω
V_{OHA} , V_{OHB} Output voltage at high state	V_{VDDA} , $V_{VDDB} = 12 \text{ V}$, $I_{OUT} = -10 \text{ mA}$, $T_A = 25^\circ\text{C}$		11.95		V
V_{OLA} , V_{OLB} Output voltage at low state	V_{VDDA} , $V_{VDDB} = 12 \text{ V}$, $I_{OUT} = 10 \text{ mA}$, $T_A = 25^\circ\text{C}$		5.5		mV
DEADTIME AND OVERLAP PROGRAMMING					
Dead time	Pull DT pin to V_{VCCI}		0		ns
	DT pin is left open, min spec characterized only, tested for outliers		8	15	ns
	$R_{DT} = 20 \text{ k}\Omega$	160	200	240	ns

6.10 Switching Characteristics

$V_{VCCI} = 3.3 \text{ V}$ or 5 V , $0.1\text{-}\mu\text{F}$ capacitor from V_{VCCI} to GND, $V_{VDDA} = V_{VDDB} = 12 \text{ V}$, $1\text{-}\mu\text{F}$ capacitor from V_{VDDA} and V_{VDDB} to V_{SSA} and V_{SSB} , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, (unless otherwise noted).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{RISE} Output rise time, 20% to 80% measured points	$C_{OUT} = 1.8 \text{ nF}$		6	16	ns
t_{FALL} Output fall time, 90% to 10% measured points	$C_{OUT} = 1.8 \text{ nF}$		7	12	ns
t_{PWmin} Minimum pulse width	Output off for less than minimum, $C_{OUT} = 0 \text{ pF}$			20	ns
t_{PDHL} Propagation delay from INx to $OUTx$ falling edges			19	30	ns
t_{PDLH} Propagation delay from INx to $OUTx$ rising edges			19	30	ns
t_{PWD} Pulse width distortion $ t_{PDLH} - t_{PDHL} $				5	ns
t_{DM} Propagation delays matching between V_{OUTA} , V_{OUTB}	$f = 100 \text{ kHz}$			5	ns
CMTI Static common-mode transient immunity (See CMTI Testing)	Slew rate of GND versus V_{SSA} and V_{SSB} , PWM is tied to GND or V_{VCCI}	100			V/ns

6.11 Insulation Characteristics Curves

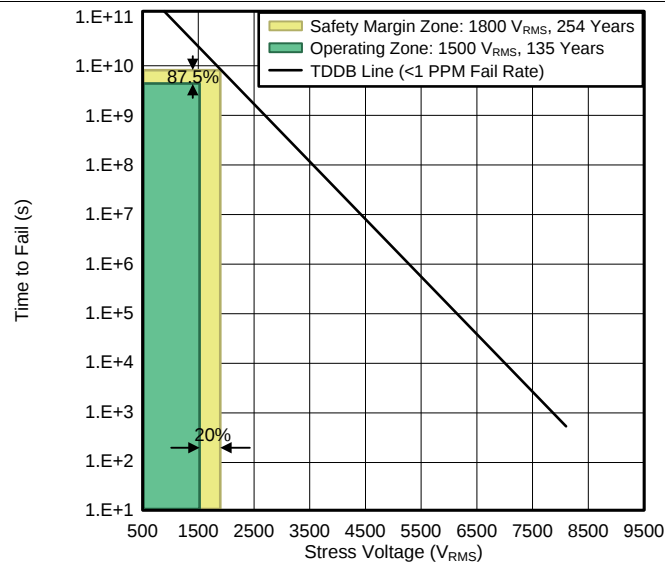


图 1. Reinforced Isolation Capacitor
Life Time Projection

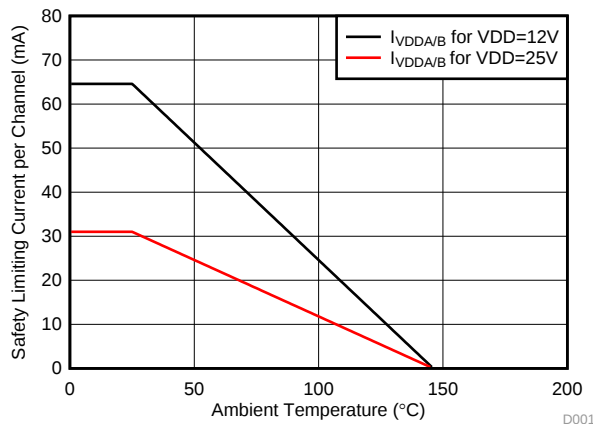


图 2. Thermal Derating Curve for Safety-Related Limiting
Current
(Current in Each Channel with Both Channels Running
Simultaneously)

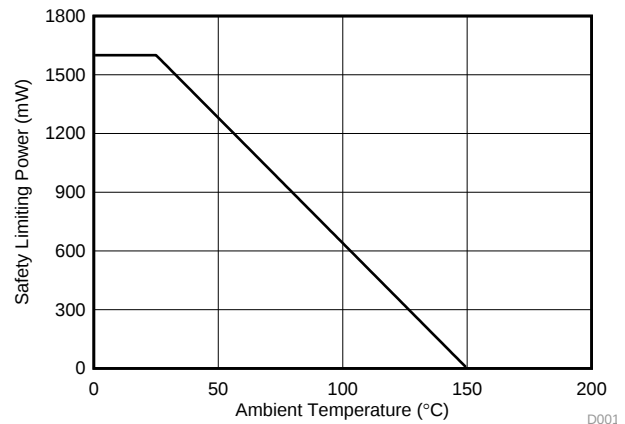


图 3. Thermal Derating Curve for Safety-Related Limiting
Power

6.12 Typical Characteristics

VDDA = VDDB = 12 V, VCCI = 3.3 V, T_A = 25°C, No load unless otherwise noted.

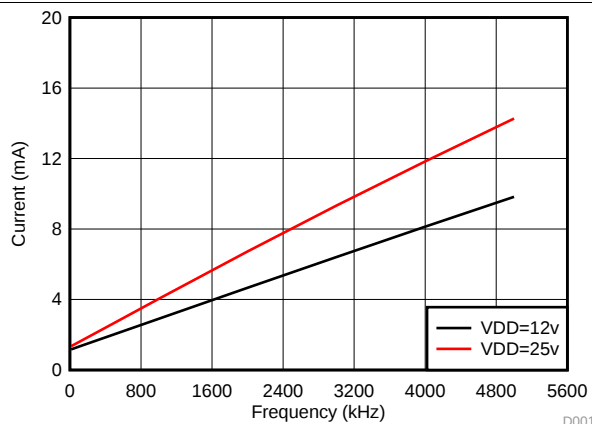


图 4. Per Channel Current Consumption vs. Frequency (No Load, VDD = 12 V or 25 V)

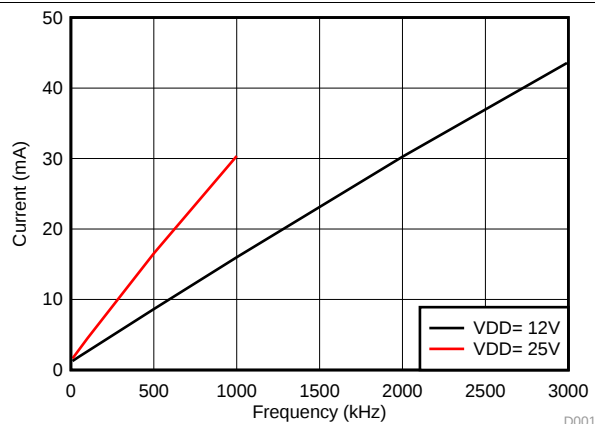


图 5. Per Channel Current Consumption ($I_{VDDA/B}$) vs. Frequency (1-nF Load, VDD = 12 V or 25 V)

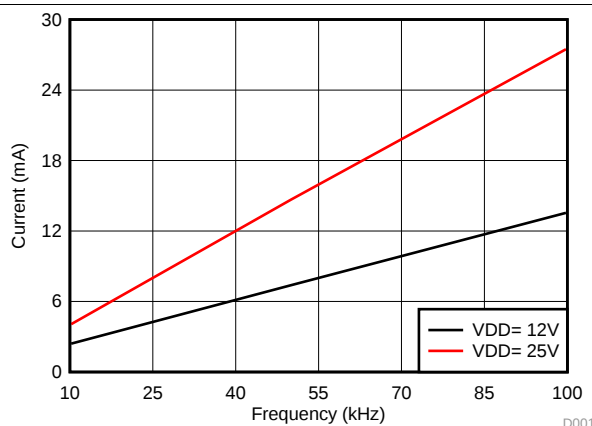


图 6. Per Channel Current Consumption ($I_{VDDA/B}$) vs. Frequency (10-nF Load, VDD = 12 V or 25 V)

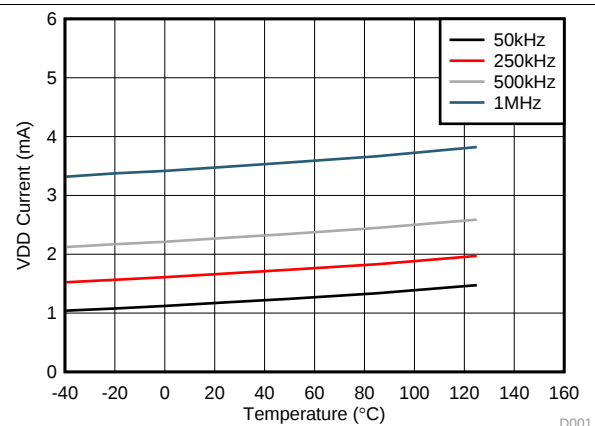


图 7. Per Channel ($I_{VDDA/B}$) Supply Current vs. Temperature (No Load, Different Switching Frequencies)

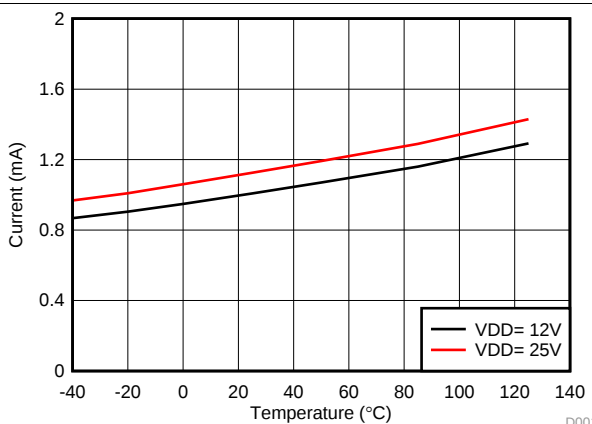


图 8. Per Channel ($I_{VDDA/B}$) Quiescent Supply Current vs Temperature (No Load, Input Low, No Switching)

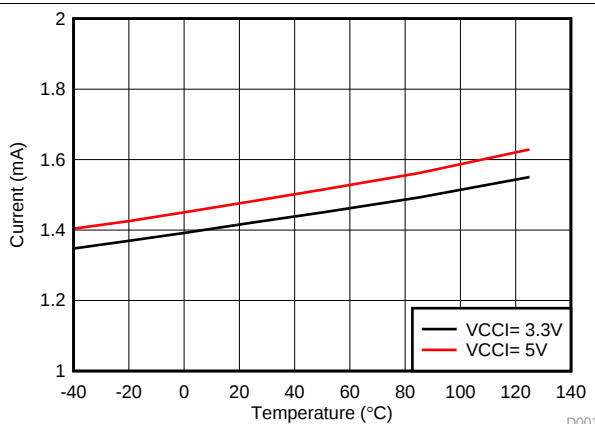


图 9. I_{VCCI} Quiescent Supply Current vs Temperature (No Load, DIS is High, No Switching)

Typical Characteristics (接下页)

VDDA = VDD = 12 V, VCCI = 3.3 V, $T_A = 25^\circ\text{C}$, No load unless otherwise noted.

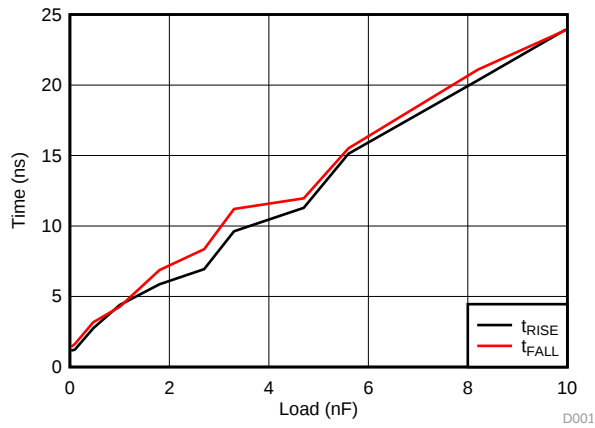


图 10. Rising and Falling Times vs. Load (VDD = 12 V)

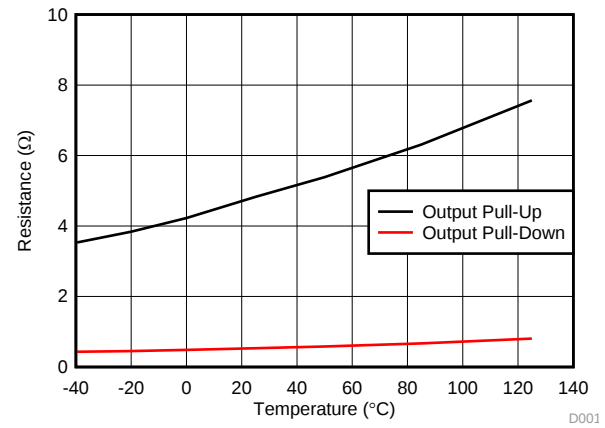


图 11. Output Resistance vs. Temperature

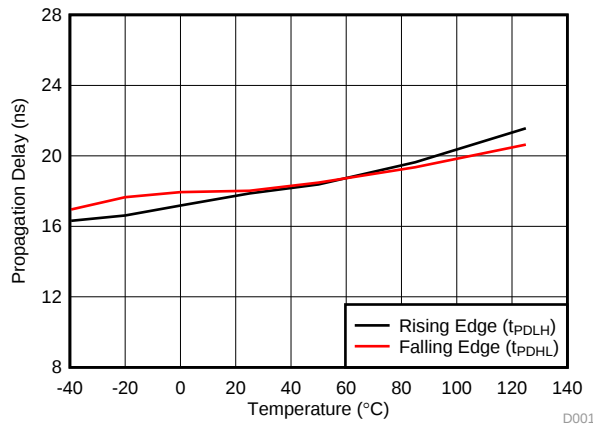


图 12. Propagation Delay vs. Temperature

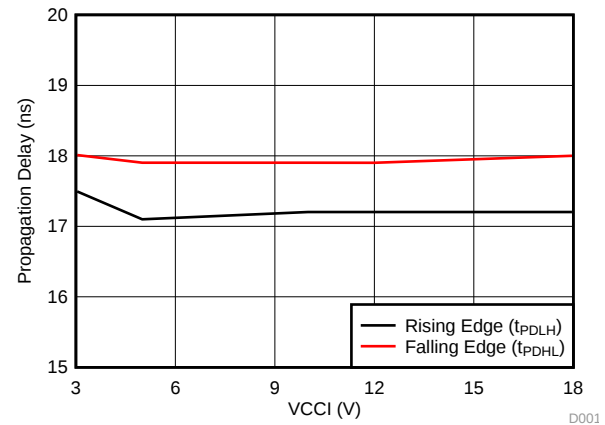


图 13. Propagation Delay vs. VCCI

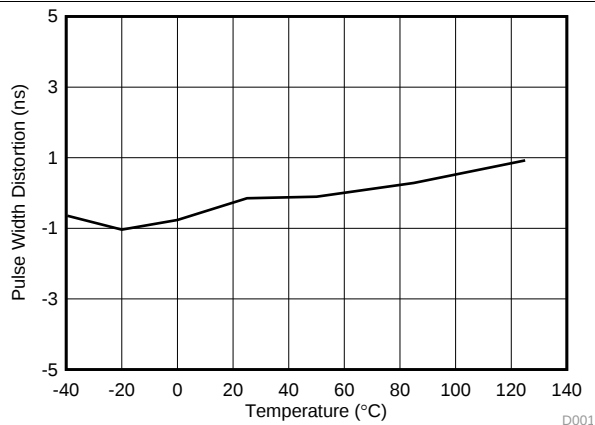


图 14. Pulse Width Distortion vs. Temperature

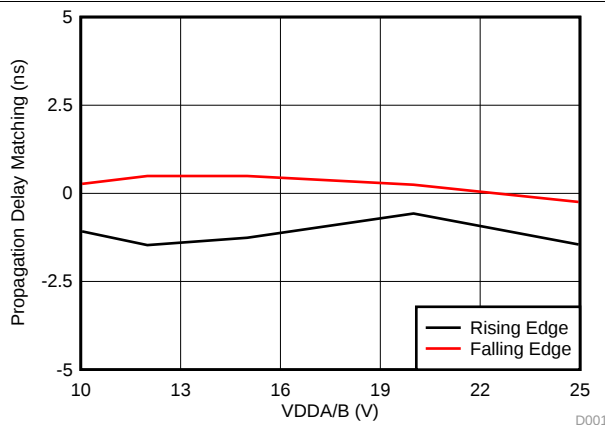


图 15. Propagation Delay Matching (t_{DM}) vs. VDD

Typical Characteristics (接下页)

VDDA = VDDB = 12 V, VCCI = 3.3 V, $T_A = 25^\circ\text{C}$, No load unless otherwise noted.

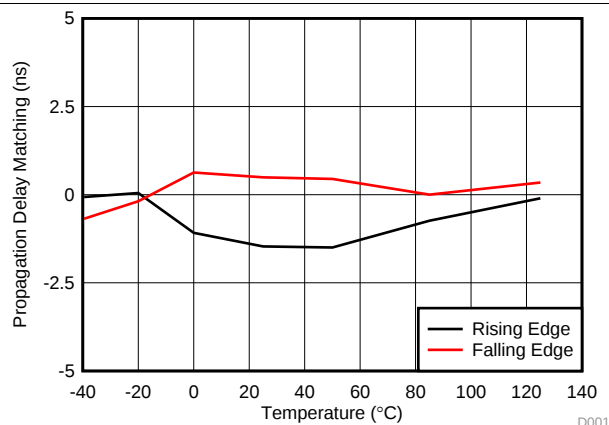


图 16. Propagation Delay Matching (t_{DM}) vs. Temperature

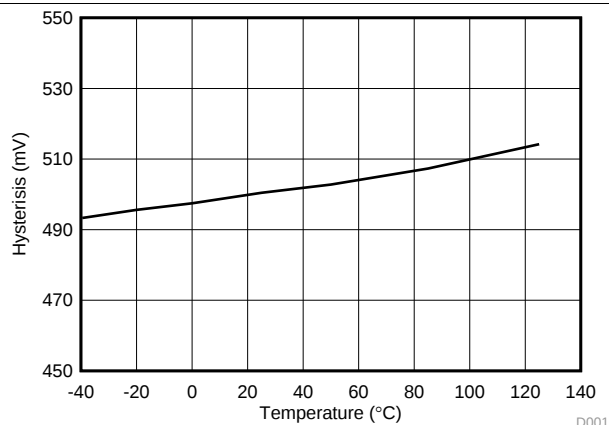


图 17. VDD UVLO Hysteresis vs. Temperature

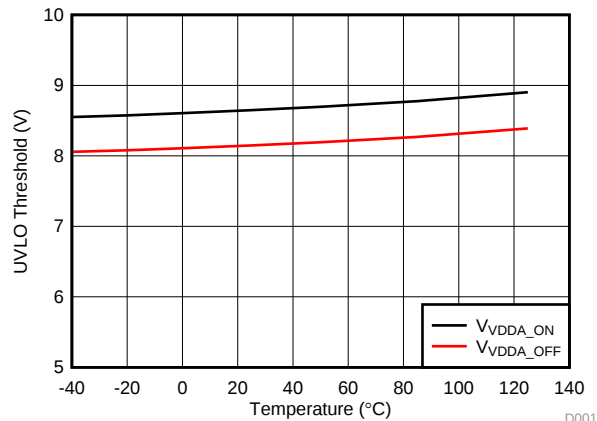


图 18. VDD UVLO Threshold vs. Temperature

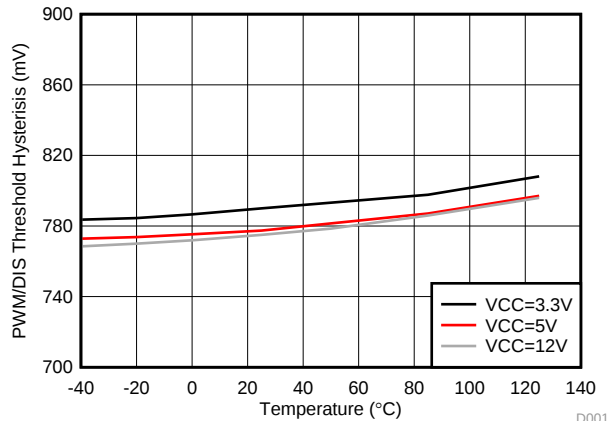


图 19. PWM/DIS Hysteresis vs. Temperature

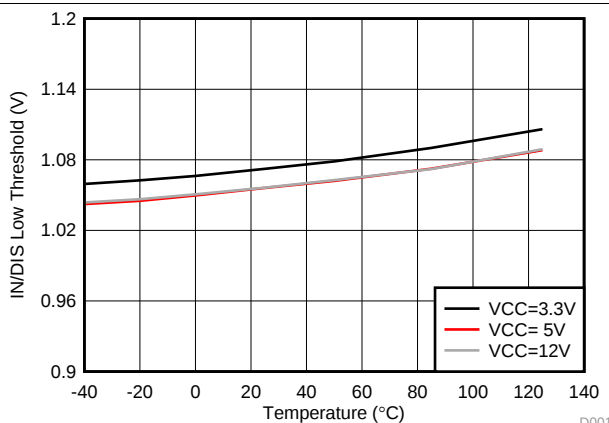


图 20. PWM/DIS Low Threshold

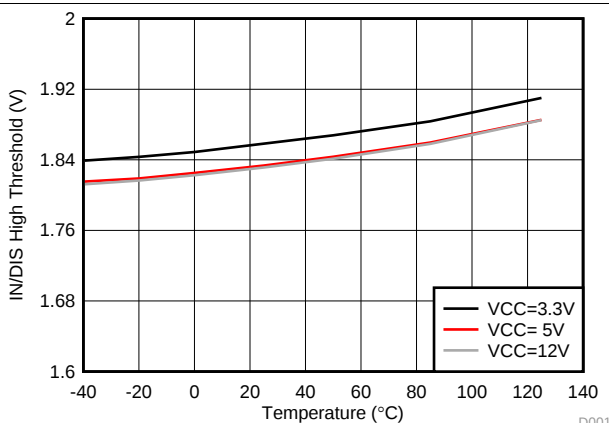


图 21. PWM/DIS High Threshold

Typical Characteristics (接下页)

VDDA = VDDB = 12 V, VCCI = 3.3 V, $T_A = 25^\circ\text{C}$, No load unless otherwise noted.

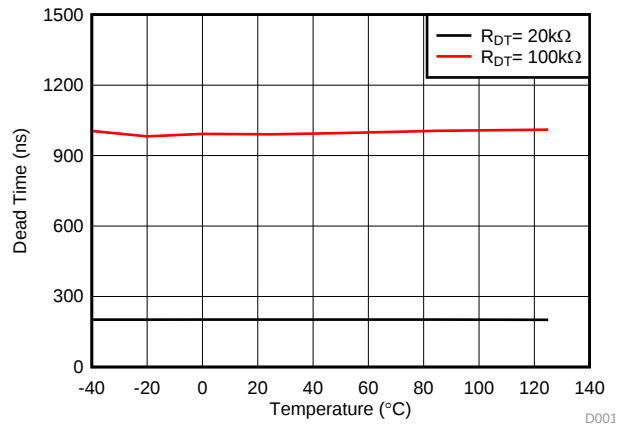


图 22. Dead Time vs. Temperature (with $R_{DT} = 20\text{ k}\Omega$ and $100\text{ k}\Omega$)

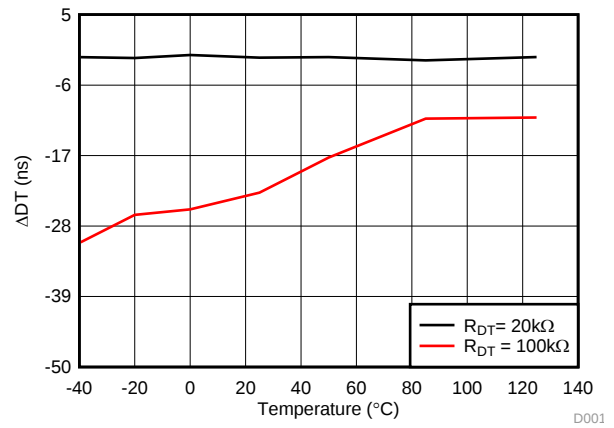


图 23. Dead Time Matching vs. Temperature (with $R_{DT} = 20\text{ k}\Omega$ and $100\text{ k}\Omega$)

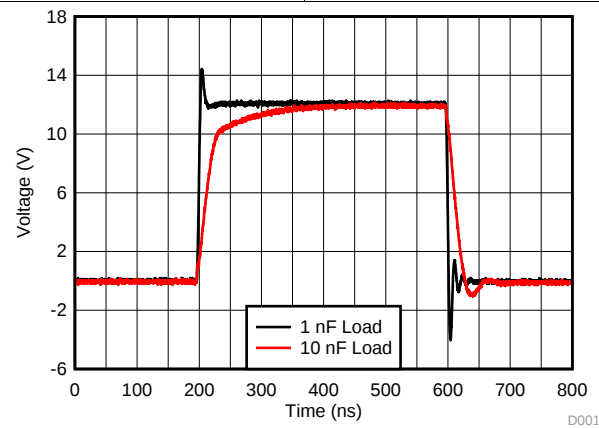


图 24. Typical Output Waveforms

7 Parameter Measurement Information

7.1 Propagation Delay and Pulse Width Distortion

图 25 shows how one calculates pulse width distortion (t_{PWD}) and delay matching (t_{DM}) from the propagation delays of channels A and B. It can be measured by disabling the dead time function by shorting the DT Pin to VCC.

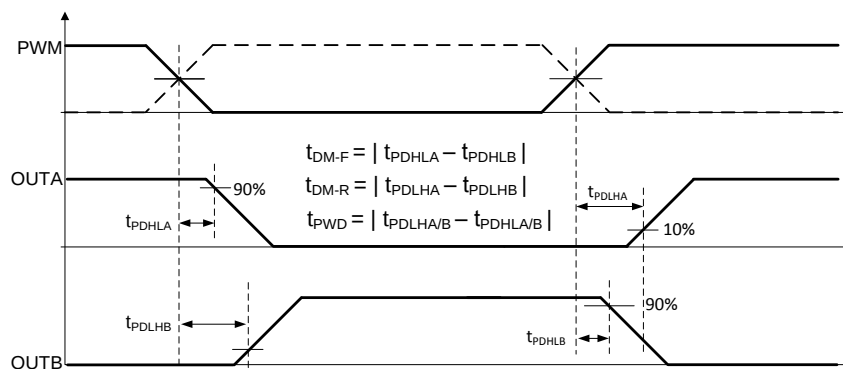


图 25. Propagation Delay Matching and Pulse Width Distortion

7.2 Rising and Falling Time

图 26 shows the criteria for measuring rising (t_{RISE}) and falling (t_{FALL}) times. For more information on how short rising and falling times are achieved see [Output Stage](#)

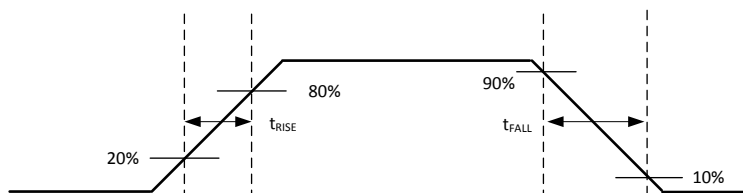


图 26. Rising and Falling Time Criteria

7.3 PWM Input and Disable Response Time

图 27 shows the response time of the disable function. For more information, see [Disable Pin](#).

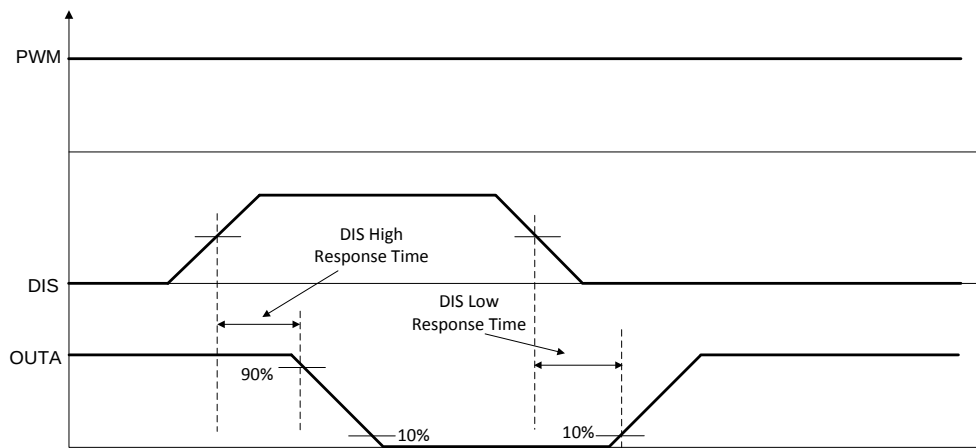


图 27. Disable Pin Timing

7.4 Programmable Dead Time

Leaving the DT pin open or tying it to GND through an appropriate resistor (R_{DT}) sets a dead-time interval. For more details on dead time, refer to [Programmable Dead Time \(DT\) Pin](#).

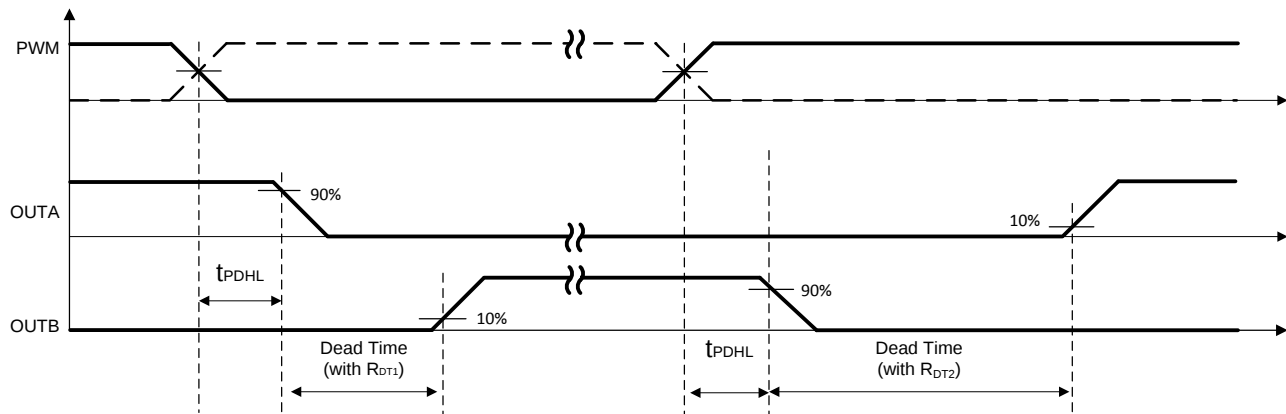
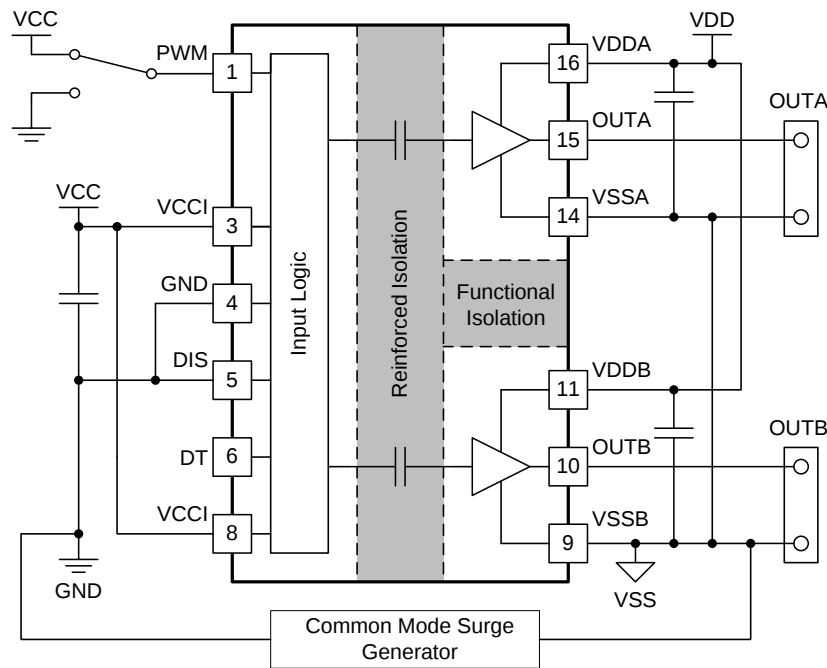


图 28. Dead-Time Switching Parameters

7.5 CMTI Testing

图 29 is a simplified diagram of the CMTI testing configuration.



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图 29. Simplified CMTI Testing Setup

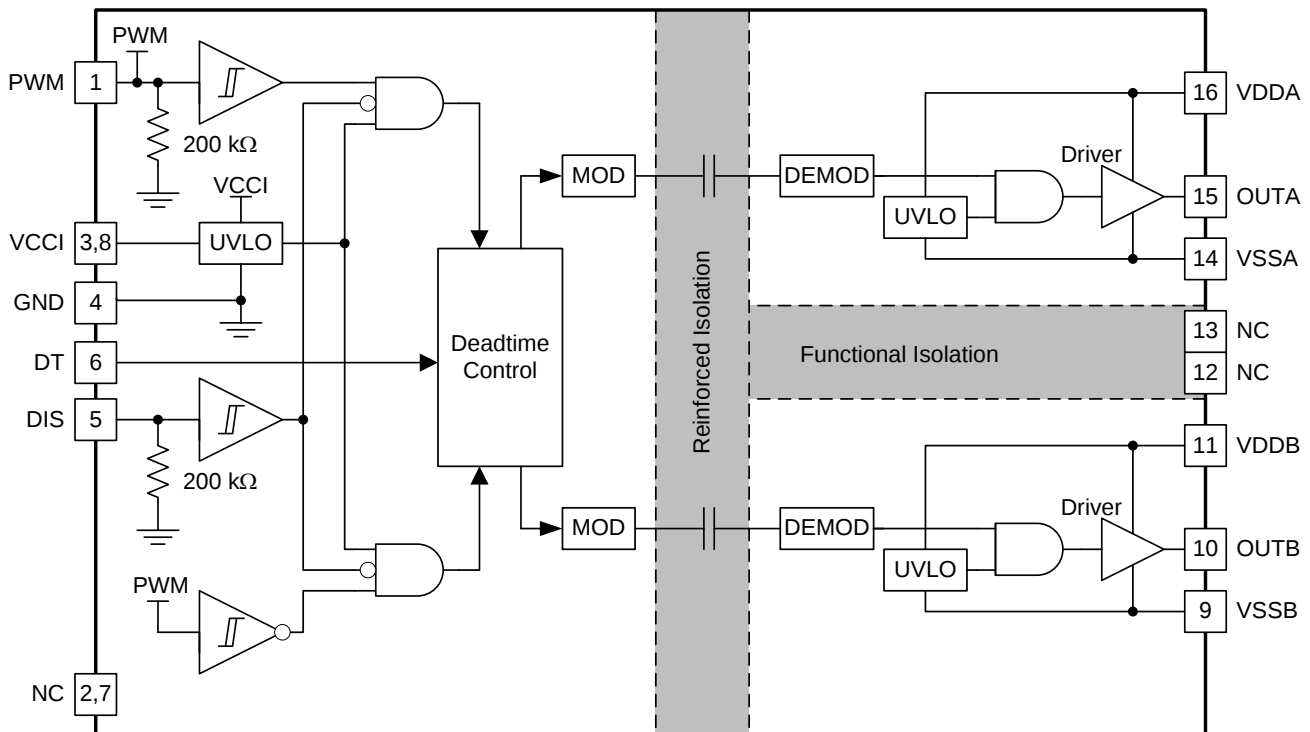
8 Detailed Description

8.1 Overview

In order to switch power transistors rapidly and reduce switching power losses, high-current gate drivers are often placed between the output of control devices and the gates of power transistors. There are several instances where controllers are not capable of delivering sufficient current to drive the gates of power transistors. This is especially the case with digital controllers, since the input signal from the digital controller is often a 3.3-V logic signal capable of only delivering a few mA.

The UCC20520 is a flexible dual gate driver which can be configured to fit a variety of power supply and motor drive topologies, as well as drive several types of transistors, including SiC MOSFETs. UCC20520 has many features that allow it to integrate well with control circuitry and protect the gates it drives such as: resistor-programmable dead time (DT) control, a DISABLE pin, and under voltage lock out (UVLO) for both input and output voltages. The UCC20520 also holds its OUTA low when the PWM is left open or when the PWM pulse is not wide enough. The driver input PWM is CMOS and TTL compatible for interfacing to digital and analog power controllers alike. Importantly, Channel A is in phase with PWM input and Channel B is always complimentary with Channel A with programmed deadtime.

8.2 Functional Block Diagram



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8.3 Feature Description

8.3.1 VDD, VCCI, and Under Voltage Lock Out (UVLO)

The UCC20520 has an internal under voltage lock out (UVLO) protection feature on the supply circuit blocks between the VDD and VSS pins for both outputs. When the VDD bias voltage is lower than V_{VDD_ON} at device start-up or lower than V_{VDD_OFF} after start-up, the VDD UVLO feature holds the effected outputs low, regardless of the status of the input pin (PWM).

When the output stages of the driver are in an unbiased or UVLO condition, the driver outputs are held low by an active clamp circuit that limits the voltage rise on the driver outputs (Illustrated in 图 30). In this condition, the upper PMOS is resistively held off by R_{HI_Z} while the lower NMOS gate is tied to the driver output through R_{CLAMP} . In this configuration, the output is effectively clamped to the threshold voltage of the lower NMOS device, typically less than 1.5V, when no bias power is available.

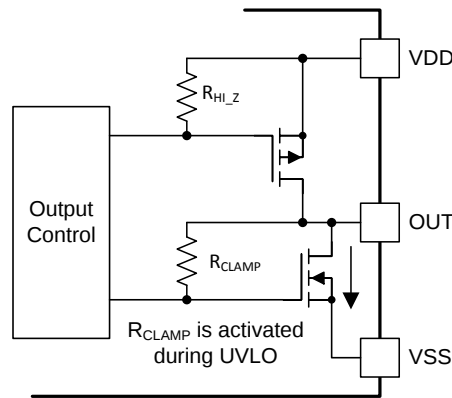


图 30. Simplified Representation of Active Pull Down Feature

The VDD UVLO protection has a hysteresis feature (V_{VDD_HYS}). This hysteresis prevents chatter when there is ground noise from the power supply. Also this allows the device to accept small drops in bias voltage, which is bound to happen when the device starts switching and operating current consumption increases suddenly.

The input side of the UCC20520 also has an internal under voltage lock out (UVLO) protection feature. The device isn't active unless the voltage, VCCI, is going to exceed V_{VCCI_ON} on start up. And a signal will cease to be delivered when that pin receives a voltage less than V_{VCCI_OFF} . And, just like the UVLO for VDD, there is hysteresis (V_{VCCI_HYS}) to ensure stable operation.

Feature Description (接下页)

All versions of the UCC20520 can withstand an absolute maximum of 30 V for VDD, and 20 V for VCCI.

表 1. UCC20520 VCCI UVLO Feature Logic

CONDITION	INPUT	OUTPUTS	
	PWM	OUTA	OUTB
VCCI-GND < V _{VCCI_ON} during device start up	H	L	L
VCCI-GND < V _{VCCI_ON} during device start up	L	L	L
VCCI-GND < V _{VCCI_OFF} after device start up	H	L	L
VCCI-GND < V _{VCCI_OFF} after device start up	L	L	L

表 2. UCC20520 VDD UVLO Feature Logic

CONDITION	INPUT	OUTPUTS	
	PWM	OUTA	OUTB
VDD-VSS < V _{VDD_ON} during device start up	H	L	L
VDD-VSS < V _{VDD_ON} during device start up	L	L	L
VDD-VSS < V _{VDD_OFF} after device start up	H	L	L
VDD-VSS < V _{VDD_OFF} after device start up	L	L	L

8.3.2 Input and Output Logic Table

Assume VCCI, VDDA, VDDDB are powered up. See [VDD, VCCI, and Under Voltage Lock Out \(UVLO\)](#) for more information on UVLO operation modes.

表 3. INPUT/OUTPUT Logic Table⁽¹⁾

INPUT PWM	DISABLE	OUTPUTS		NOTE
		OUTA	OUTB	
L or Left Open	L or Left Open	L	H	Output transitions occur after the dead time expires. See Programmable Dead Time (DT) Pin
H	L or Left Open	H	L	
X	H	L	L	-

(1) "X" means L, H or left open.

8.3.3 Input Stage

The input pins (PWM and DIS) of UCC20520 are based on a TTL and CMOS compatible input-threshold logic that is totally isolated from the VDD supply voltage. The input pins are easy to drive with logic-level control signals (Such as those from 3.3-V micro-controllers), since UCC20520 has a typical high threshold (V_{PWMH}) of 1.8 V and a typical low threshold of 1 V, which vary little with temperature (see [图 20](#), [图 21](#)). A wide hysteresis (V_{PWM_HYS}) of 0.8 V makes for good noise immunity and stable operation. If any of the inputs are ever left open, internal pull-down resistors force the pin low. These resistors are typically 200 kΩ (See [Functional Block Diagram](#)). However, it is still recommended to ground an input if it is not being used.

Since the input side of UCC20520 is isolated from the output drivers, the input signal amplitude can be larger or smaller than VDD, provided that it doesn't exceed the recommended limit. This allows greater flexibility when integrating with control signal sources, and allows the user to choose the most efficient VDD for their chosen gate. That said, the amplitude of any signal applied to PWM must *never* be at a voltage higher than VCCI.

8.3.4 Output Stage

The UCC20520's output stages features a pull-up structure which delivers the highest peak-source current when it is most needed, during the Miller plateau region of the power-switch turn on transition (when the power switch drain or collector voltage experiences dV/dt). The output stage pull-up structure features a P-channel MOSFET and an additional *Pull-Up* N-channel MOSFET in parallel. The function of the N-channel MOSFET is to provide a brief boost in the peak-sourcing current, enabling fast turn on. This is accomplished by briefly turning on the N-channel MOSFET during a narrow instant when the output is changing states from low to high. The on-resistance of this N-channel MOSFET (R_{NMOS}) is approximately $1.47\ \Omega$ when activated.

The R_{OH} parameter is a DC measurement and it is representative of the on-resistance of the P-channel device only. This is because the *Pull-Up* N-channel device is held in the off state in DC condition and is turned on only for a brief instant when the output is changing states from low to high. Therefore the effective resistance of the UCC20520 pull-up stage during this brief turn-on phase is much lower than what is represented by the R_{OH} parameter. Therefore, the value of R_{OH} belies the fast nature of the UCC20520's turn-on time.

The pull-down structure in UCC20520 is simply composed of an N-channel MOSFET. The R_{OL} parameter, which is also a DC measurement, is representative of the impedance of the pull-down state in the device. Both outputs of the UCC20520 are capable of delivering 4-A peak source and 6-A peak sink current pulses. The output voltage swings between VDD and VSS provides rail-to-rail operation, thanks to the MOS-out stage which delivers very low drop-out.

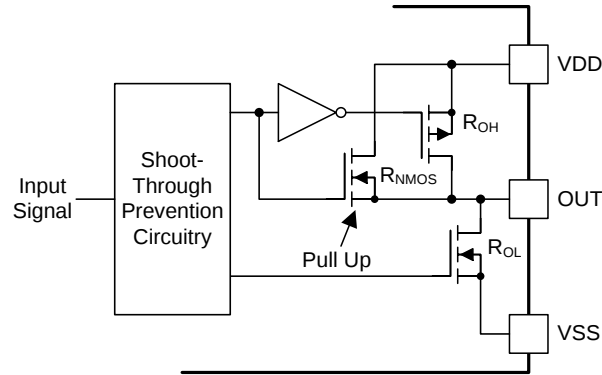


图 31. Output Stage

8.3.5 Diode Structure in UCC20520

图 32 illustrates the multiple diodes involved in the ESD protection components of the UCC20520. This provides a pictorial representation of the absolute maximum rating for the device.

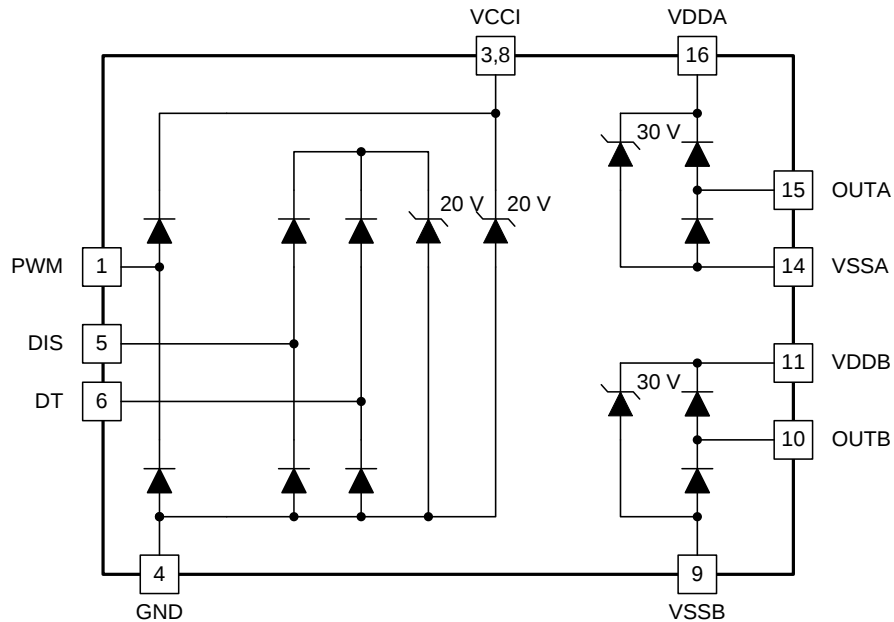


图 32. ESD Structure

8.4 Device Functional Modes

8.4.1 Disable Pin

Setting the DISABLE pin high shuts down both outputs simultaneously. Grounding (or left open) the DISABLE pin allows UCC20520 to operate normally. The DISABLE response time is in the range of 20ns and quite responsive, which is as fast as propagation delay. The DISABLE pin is only functional (and necessary) when VCCI stays above the UVLO threshold. It is recommended to tie this pin to ground if the DISABLE pin is not used to achieve better noise immunity.

8.4.2 Programmable Dead Time (DT) Pin

UCC20520 allows the user to adjust dead time (DT) in the following ways:

8.4.2.1 Tying the DT Pin to VCC

If DT pin is tied to VCC, dead time function between OUTA and OUTB is disabled and the deadtime between the two output channels is around 0ns.

Device Functional Modes (接下页)

8.4.2.2 DT Pin Left Open or Connected to a Programming Resistor between DT and GND Pins

If the DT pin is left open, the dead time duration (t_{DT}) is set to <15 ns. One can program t_{DT} by placing a resistor, R_{DT} , between the DT pin and GND. The appropriate R_{DT} value can be determined from [公式 1](#), where R_{DT} is in k Ω and t_{DT} in ns:

$$t_{DT} \approx 10 \times R_{DT} \quad (1)$$

The steady state voltage at DT pin is around 0.8V, and the DT pin current will be less than 10uA when $R_{DT}=100k\Omega$. Therefore, It is recommended to parallel a ceramic capacitor, 2.2nF or above, with R_{DT} to achieve better noise immunity and better deadtime matching between two channels, especially when the dead time is larger than 300ns. The major consideration is that the current through the R_{DT} is used to set the dead time, and this current decreases as R_{DT} increases.

PWM input signal's falling edge activates the programmed dead time for the other signal. The output signals' dead time is always set to the driver's programmed dead time. Various driver dead time logic operating conditions are illustrated and explained in [图 33](#):

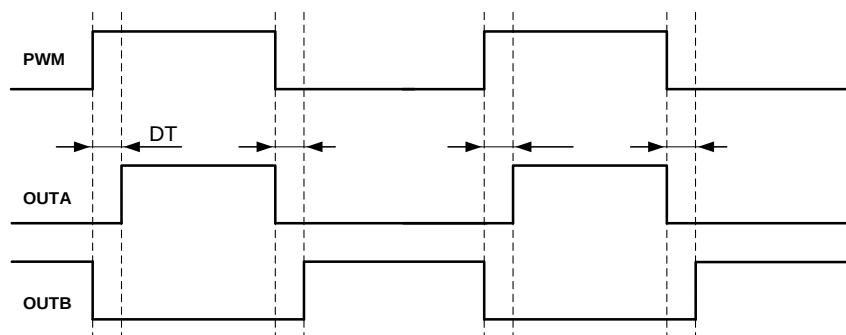


图 33. Input and Output Logic Relationship with Dead Time

9 Application and Implementation

注

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.

9.1 Application Information

The UCC20520 effectively combines both isolation and buffer-drive functions. The flexible, universal capability of the UCC20520 (with up to 18-V VCCI and 25-V VDDA/Vddb) allows the device to be used as a low-side, high-side, high-side/low-side or half-bridge driver for MOSFETs, IGBTs or SiC MOSFETs. With integrated components, advanced protection features (UVLO, dead time, and disable) and optimized switching performance; the UCC20520 enables designers to build smaller, more robust designs for enterprise, telecom, automotive, and industrial applications with a faster time to market.

9.2 Typical Application

The circuit in 图 34 shows a reference design with UCC20520 driving a typical half-bridge configuration which could be used in several popular power converter topologies such as synchronous buck, synchronous boost, half-bridge/full bridge isolated topologies, and 3-phase motor drive applications.

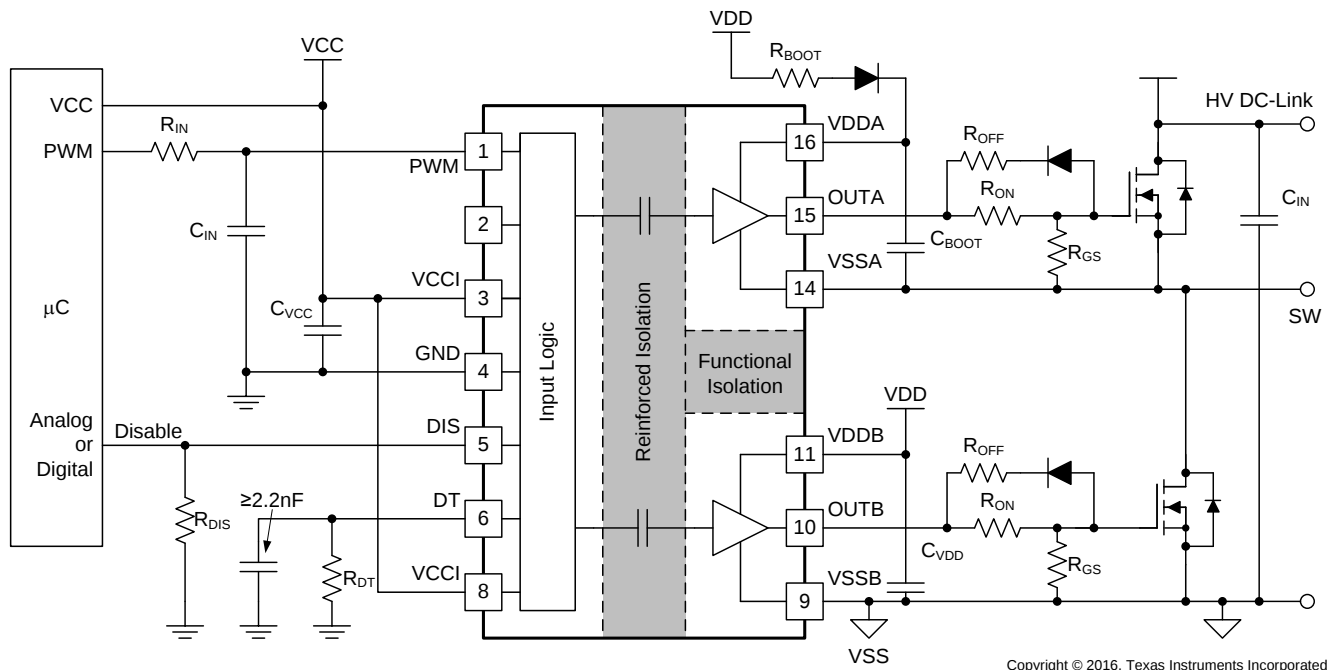


图 34. Typical Application Schematic

Typical Application (接下页)

9.2.1 Design Requirements

表 4 lists reference design parameters for the example application: UCC20520 driving 1200-V SiC-MOSFETs in a high side-low side configuration.

表 4. UCC20520 Design Requirements

PARAMETER	VALUE	UNITS
Power transistor	C2M0080120D	-
VCC	5.0	V
VDD	20	V
Input signal amplitude	0 ↔ 3.3	V
Switching frequency (f_s)	100	kHz
DC link voltage	800	V

9.2.2 Detailed Design Procedure

9.2.2.1 Designing PWM Input Filter

It is recommended that users avoid shaping the signals to the gate driver in an attempt to slow down (or delay) the signal at the output. However, a small input R_{IN} - C_{IN} filter can be used to filter out the ringing introduced by non-ideal layout or long PCB traces.

Such a filter should use an R_{IN} in the range of 0 Ω to 100 Ω and a C_{IN} between 10 pF and 100 pF. In the example, an $R_{IN} = 51 \Omega$ and a $C_{IN} = 33$ pF are selected, with a corner frequency of approximately 100 MHz.

When selecting these components, it is important to pay attention to the trade-off between good noise immunity and propagation delay.

9.2.2.2 Select External Bootstrap Diode and its Series Resistor

The bootstrap capacitor is charged by VDD through an external bootstrap diode every cycle when the low side transistor turns on. Charging the capacitor involves high-peak currents, and therefore transient power dissipation in the bootstrap diode may be significant. Conduction loss also depends on the diode's forward voltage drop. Both the diode conduction losses and reverse recovery losses contribute to the total losses in the gate driver circuit.

When selecting external bootstrap diodes, it is recommended that one chose high voltage, fast recovery diodes or SiC Schottky diodes with a low forward voltage drop and low junction capacitance in order to minimize the loss introduced by reverse recovery and related grounding noise bouncing. In the example, the DC-link voltage is 800 V_{DC}. The voltage rating of the bootstrap diode should be higher than the DC-link voltage with a good margin. Therefore, a 1200-V SiC diode, C4D02120E, is chosen in this example.

A bootstrap resistor, R_{BOOT} , is used to reduce the inrush current in D_{BOOT} and limit the ramp up slew rate of voltage of VDDA-VSSA during each switching cycle, especially when the VSSA(SW) pin has an excessive negative transient voltage. The recommended value for R_{BOOT} is between 1 Ω and 20 Ω depending on the diode used. In the example, a current limiting resistor of 2.2 Ω is selected to limit the inrush current of bootstrap diode. The estimated worst case peak current through D_{BOOT} is,

$$I_{DBoot(pk)} = \frac{V_{DD} - V_{BDF}}{R_{Boot}} = \frac{20V - 2.5V}{2.2\Omega} \approx 8A$$

where

- V_{BDF} is the estimated bootstrap diode forward voltage drop at 8 A. (2)

9.2.2.3 Gate Driver Output Resistor

The external gate driver resistors, R_{ON}/R_{OFF} , are used to:

1. Limit ringing caused by parasitic inductances/capacitances.
2. Limit ringing caused by high voltage/current switching dv/dt , di/dt , and body-diode reverse recovery.
3. Fine-tune gate drive strength, i.e. peak sink and source current to optimize the switching loss.
4. Reduce electromagnetic interference (EMI).

As mentioned in [Output Stage](#), the UCC20520 has a pull-up structure with a P-channel MOSFET and an additional *pull-up* N-channel MOSFET in parallel. The combined peak source current is 4 A. Therefore, the peak source current can be predicted with:

$$I_{OA+} = \min \left(4A, \frac{V_{DD} - V_{BDF}}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET_Int}} \right) \quad (3)$$

$$I_{OB+} = \min \left(4A, \frac{V_{DD}}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET_Int}} \right)$$

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 minimum value between 4 A, the gate driver peak source current, and the calculated value based on the gate drive loop resistance. (4)

In this example:

$$I_{OA+} = \frac{V_{DD} - V_{BDF}}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET_Int}} = \frac{20V - 0.8V}{1.47\Omega \parallel 5\Omega + 2.2\Omega + 4.6\Omega} \approx 2.4A \quad (5)$$

$$I_{OB+} = \frac{V_{DD}}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET_Int}} = \frac{20V}{1.47\Omega \parallel 5\Omega + 2.2\Omega + 4.6\Omega} \approx 2.5A \quad (6)$$

Therefore, the high-side and low-side peak source current is 2.4 A and 2.5 A respectively. Similarly, the peak sink current can be calculated with:

$$I_{OA-} = \min \left(6A, \frac{V_{DD} - V_{BDF} - V_{GDF}}{R_{OL} + R_{OFF} \parallel R_{ON} + R_{GFET_Int}} \right) \quad (7)$$

$$I_{OB-} = \min \left(6A, \frac{V_{DD} - V_{GDF}}{R_{OL} + R_{OFF} \parallel R_{ON} + R_{GFET_Int}} \right)$$

where

- R_{OFF} : External turn-off resistance;
- V_{GDF} : The anti-parallel diode forward voltage drop which is in series with R_{OFF} . The diode in this example is an MSS1P4.
- I_{O-} : Peak sink current – the minimum value between 6 A, the gate driver peak sink current, and the calculated value based on the gate drive loop resistance. (8)

In this example,

$$I_{OA-} = \frac{V_{DD} - V_{BDF} - V_{GDF}}{R_{OL} + R_{OFF} \parallel R_{ON} + R_{GFET_Int}} = \frac{20V - 0.8V - 0.75V}{0.55\Omega + 0\Omega + 4.6\Omega} \approx 3.6A \quad (9)$$

$$I_{OB-} = \frac{V_{DD} - V_{GDF}}{R_{OL} + R_{OFF} \parallel R_{ON} + R_{GFET_Int}} = \frac{20V - 0.75V}{0.55\Omega + 0\Omega + 4.6\Omega} \approx 3.7A \quad (10)$$

Therefore, the high-side and low-side peak sink current is 3.6 A and 3.7 A respectively.

Importantly, the estimated peak current is also influenced by PCB layout and load capacitance. Parasitic inductance in the gate driver loop can slow down the peak gate drive current and introduce overshoot and undershoot. Therefore, it is strongly recommended that the gate driver loop should be minimized. On the other hand, the peak source/sink current is dominated by loop parasitics when the load capacitance (C_{ISS}) of the power transistor is very small (typically less than 1 nF), because the rising and falling time is too small and close to the parasitic ringing period.

9.2.2.4 Estimate Gate Driver Power Loss

The total loss, P_G , in the gate driver subsystem includes the power losses of the UCC20520 (P_{GD}) and the power losses in the peripheral circuitry, such as the external gate drive resistor. Bootstrap diode loss is not included in P_G and not discussed in this section.

P_{GD} is the key power loss which determines the thermal safety-related limits of the UCC20520, and it can be estimated by calculating losses from several components.

The first component is the static power loss, P_{GDO} , which includes quiescent power loss on the driver as well as driver self-power consumption when operating with a certain switching frequency. P_{GDO} is measured on the bench with no load connected to OUTA and OUTB at a given V_{CCI} , V_{DDA}/V_{DDB} , switching frequency and ambient temperature. 图 4 shows the per output channel current consumption vs. operating frequency with no load. In this example, $V_{VCCI} = 5V$ and $V_{VDD} = 20V$. The current on each power supply, with PWM switching from 0 V to 3.3 V at 100 kHz is measured to be $I_{VCCI} = 2.5mA$, and $I_{VDDA} = I_{VDDB} = 1.5mA$. Therefore, the P_{GDO} can be calculated with

$$P_{GDO} = V_{VCCI} \times I_{VCCI} + V_{VDDA} \times I_{DDB} + V_{VDDB} \times I_{DDB} \approx 72mW \quad (11)$$

The second component is switching operation loss, P_{GDO} , with a given load capacitance which the driver charges and discharges the load during each switching cycle. Total dynamic loss due to load switching, P_{GSW} , can be estimated with

$$P_{GSW} = 2 \times V_{DD} \times Q_G \times f_{SW}$$

where

- Q_G is the gate charge of the power transistor. (12)

If a split rail is used to turn on and turn off, then VDD is going to be equal to difference between the positive rail to the negative rail.

So, for this example application:

$$P_{GSW} = 2 \times 20V \times 60nC \times 100kHz = 240mW \quad (13)$$

Q_G represents the total gate charge of the power transistor switching 800 V at 20 A, and is subject to change with different testing conditions. The UCC20520 gate driver loss on the output stage, P_{GDO} , is part of P_{GSW} . P_{GDO} will be equal to P_{GSW} if the external gate driver resistances are zero, and all the gate driver loss is dissipated inside the UCC20520. If there are external turn-on and turn-off resistance, the total loss will be distributed between the gate driver pull-up/down resistances and external gate resistances. Importantly, the pull-up/down resistance is a linear and fixed resistance if the source/sink current is not saturated to 4 A/6 A, however, it will be non-linear if the source/sink current is saturated. Therefore, P_{GDO} is different in these two scenarios.

Case 1 - Linear Pull-Up/Down Resistor:

$$P_{GDO} = P_{GSW} \times \left(\frac{R_{OH} \parallel R_{NMOS}}{R_{OH} \parallel R_{NMOS} + R_{ON} + R_{GFET_Int}} + \frac{R_{OL}}{R_{OL} + R_{OFF} \parallel R_{ON} + R_{GFET_Int}} \right) \quad (14)$$

In this design example, all the predicted source/sink currents are less than 4 A/6 A, therefore, the UCC20520 gate driver loss can be estimated with:

$$P_{GDO} = 240\text{mW} \times \left(\frac{5\Omega \parallel 1.47\Omega}{5\Omega \parallel 1.47\Omega + 2.2\Omega + 4.6\Omega} + \frac{0.55\Omega}{0.55\Omega + 0\Omega + 4.6\Omega} \right) \approx 60\text{mW} \quad (15)$$

Case 2 - Nonlinear Pull-Up/Down Resistor:

$$P_{GDO} = 2 \times f_{SW} \times \left[4A \times \int_0^{T_{R_Sys}} (V_{DD} - V_{OUTA/B}(t)) dt + 6A \times \int_0^{T_{F_Sys}} V_{OUTA/B}(t) dt \right]$$

where

- $V_{OUTA/B}(t)$ is the gate driver OUTA and OUTB pin voltage during the turn on and off transient, and it can be simplified that a constant current source (4 A at turn-on and 6 A at turn-off) is charging/discharging a load capacitor. Then, the $V_{OUTA/B}(t)$ waveform will be linear and the T_{R_Sys} and T_{F_Sys} can be easily predicted. (16)

For some scenarios, if only one of the pull-up or pull-down circuits is saturated and another one is not, the P_{GDO} will be a combination of Case 1 and Case 2, and the equations can be easily identified for the pull-up and pull-down based on the above discussion. Therefore, total gate driver loss dissipated in the gate driver UCC20520, P_{GD} , is:

$$P_{GD} = P_{GDQ} + P_{GDO} \quad (17)$$

which is equal to 127 mW in the design example.

9.2.2.5 Estimating Junction Temperature

The junction temperature (T_J) of the UCC20520 can be estimated with:

$$T_J = T_C + R_{\theta JC} \times P_{GD}$$

where

- T_C is the UCC20520 case-top temperature measured with a thermocouple or some other instrument, $R_{\theta JC}$ is the Junction-to-case-top thermal resistance from the [Thermal Information](#) table. Importantly, $R_{\theta JA}$, the junction to ambient thermal impedance provided in the Thermal Information table, is developed based on JEDEC standard PCB board and it is subject to change when the PCB board layout is different. (18)

9.2.2.6 Selecting VCCI, VDDA/B Capacitor

Bypass capacitors for VCCI, VDDA, and VDDB are essential for achieving reliable performance. It is recommended that one choose low ESR and low ESL surface-mount multi-layer ceramic capacitors (MLCC) with sufficient voltage ratings, temperature coefficients and capacitance tolerances. Importantly, DC bias on an MLCC will impact the actual capacitance value. For example, a 25-V, 1-μF X7R capacitor is measured to be only 500 nF when a DC bias of 15 V_{DC} is applied.

9.2.2.6.1 Selecting a VCCI Capacitor

A bypass capacitor connected to VCCI supports the transient current needed for the primary logic and the total current consumption, which is only a few mA. Therefore, a 50-V MLCC with over 100 nF is recommended for this application. If the bias power supply output is a relatively long distance from the VCCI pin, a tantalum or electrolytic capacitor, with a value over 1 μF, should be placed in parallel with the MLCC.

9.2.2.6.2 Selecting a VDDA (Bootstrap) Capacitor

A VDDA capacitor, also referred to as a *bootstrap capacitor* in bootstrap power supply configurations, allows for gate drive current transients up to 6 A, and needs to maintain a stable gate drive voltage for the power transistor.

The total charge needed per switching cycle can be estimated with

$$Q_{\text{Total}} = Q_G + \frac{I_{\text{VDD}} @ 100\text{kHz (No Load)}}{f_{\text{SW}}} = 60\text{nC} + \frac{1.5\text{mA}}{100\text{kHz}} = 75\text{nC}$$

where

- Q_G : Gate charge of the power transistor.
- I_{VDD} : The channel self-current consumption with no load at 100kHz. (19)

Therefore, the absolute minimum C_{Boot} requirement is:

$$C_{\text{Boot}} = \frac{Q_{\text{Total}}}{\Delta V_{\text{VDDA}}} = \frac{75\text{nC}}{0.5\text{V}} = 150\text{nF}$$

where

- ΔV_{VDDA} is the voltage ripple at VDDA, which is 0.5 V in this example. (20)

In practice, the value of C_{Boot} is greater than the calculated value. This allows for the capacitance shift caused by the DC bias voltage and for situations where the power stage would otherwise skip pulses due to load transients. Therefore, it is recommended to include a safety-related margin in the C_{Boot} value and place it as close to the VDD and VSS pins as possible. A 50-V 1-μF capacitor is chosen in this example.

$$C_{\text{Boot}} = 1\mu\text{F} \quad (21)$$

To further lower the AC impedance for a wide frequency range, it is recommended to have bypass capacitor with a low capacitance value, in this example a 100 nF, in parallel with C_{Boot} to optimize the transient performance.

注

Too large C_{BOOT} is not good. C_{BOOT} may not be charged within the first few cycles and V_{BOOT} could stay below UVLO. As a result, the high-side FET does not follow input signal command. Also during initial C_{BOOT} charging cycles, the bootstrap diode has highest reverse recovery current and losses.

9.2.2.6.3 Select a VDDDB Capacitor

Channel B has the same current requirements as Channel A, Therefore, a VDDDB capacitor (Shown as C_{VDD} in [Figure 34](#)) is needed. In this example with a bootstrap configuration, the VDDDB capacitor will also supply current for VDDA through the bootstrap diode. A 50-V, 10- μ F MLCC and a 50-V, 220-nF MLCC are chosen for C_{VDD} . If the bias power supply output is a relatively long distance from the VDDDB pin, a tantalum or electrolytic capacitor, with a value over 10 μ F, should be used in parallel with C_{VDD} .

9.2.2.7 Dead Time Setting Guidelines

For power converter topologies utilizing half-bridges, the dead time setting between the top and bottom transistor is important for preventing shoot-through during dynamic switching.

The UCC20520 dead time specification in the electrical table is defined as the time interval from 90% of one channel's falling edge to 10% of the other channel's rising edge (see [Figure 28](#)). This definition ensures that the dead time setting is independent of the load condition, and guarantees linearity through manufacture testing. However, this dead time setting may not reflect the dead time in the power converter system, since the dead time setting is dependent on the external gate drive turn-on/off resistor, DC-Link switching voltage/current, as well as the input capacitance of the load transistor.

Here is a suggestion on how to select an appropriate dead time for UCC20520:

$$DT_{\text{Setting}} = DT_{\text{Req}} + T_{F_Sys} + T_{R_Sys} - T_{D(on)}$$

where

- DT_{Setting} : UCC20520 dead time setting in ns, $DT_{\text{Setting}} = 10 \times RDT(\text{in k}\Omega)$.
- DT_{Req} : System required dead time between the real V_{GS} signal of the top and bottom switch with enough margin, or ZVS requirement.
- T_{F_Sys} : In-system gate turn-off falling time at worst case of load, voltage/current conditions.
- T_{R_Sys} : In-system gate turn-on rising time at worst case of load, voltage/current conditions.
- $T_{D(on)}$: Turn-on delay time, from 10% of the transistor gate signal to power transistor gate threshold. (22)

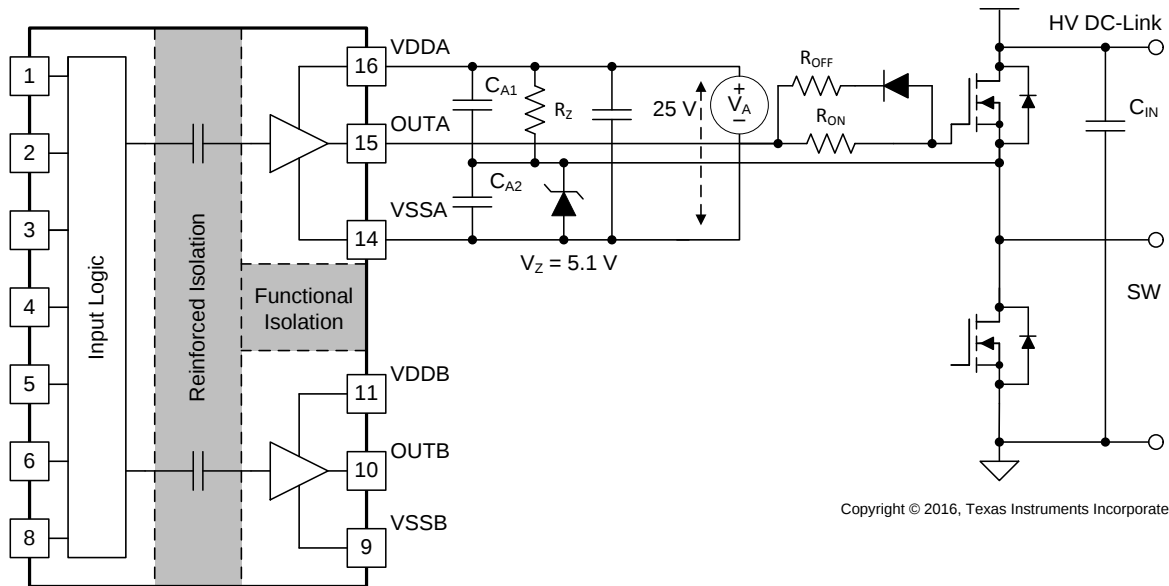
In the example, DT_{Setting} is set to 250 ns.

It should be noted that the UCC20520 dead time setting is decided by the DT pin configuration (See [Programmable Dead Time \(DT\) Pin](#)), and it cannot automatically fine-tune the dead time based on system conditions, i.e. zero voltage switching conditions. It is recommended to parallel a ceramic capacitor, 2.2nF or above, with R_{DT} to achieve better noise immunity and deadtime matching.

9.2.2.8 Application Circuits with Output Stage Negative Bias

When parasitic inductances are introduced by non-ideal PCB layout and long package leads (e.g. TO-220 and TO-247 type packages), there could be ringing in the gate-source drive voltage of the power transistor during high di/dt and dv/dt switching. If the ringing is over the threshold voltage, there is the risk of unintended turn-on and even shoot-through. Applying a negative bias on the gate drive is a popular way to keep such ringing below the threshold. Below are a few examples of implementing negative gate drive bias.

图 35 shows the first example with negative bias turn-off on the channel-A driver using a Zener diode on the isolated power supply output stage. The negative bias is set by the Zener diode voltage. If the isolated power supply, V_A , is equal to 25 V, the turn-off voltage will be -5.1 V and turn-on voltage will be 25 V $- 5.1$ V ≈ 20 V. The channel-B driver circuit is the same as channel-A, therefore, this configuration needs two power supplies for a half-bridge configuration, and there will be steady state power consumption from R_Z .



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图 35. Negative Bias with Zener Diode on Iso-Bias Power Supply Output

图 36 shows another example which uses two supplies (or single-input-double-output power supply). Power supply V_{A+} determines the positive drive output voltage and V_{A-} determines the negative turn-off voltage. The configuration for channel B is the same as channel A. This solution requires more power supplies than the first example, however, it provides more flexibility when setting the positive and negative rail voltages.

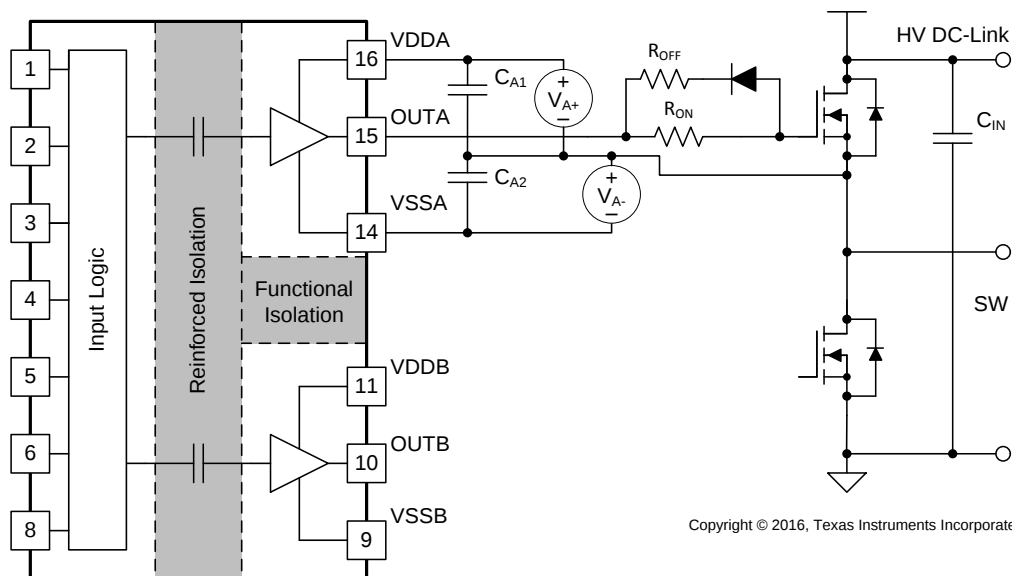


图 36. Negative Bias with Two Iso-Bias Power Supplies

The last example, shown in 图 37, is a single power supply configuration and generates negative bias through a Zener diode in the gate drive loop. The benefit of this solution is that it only uses one power supply and the bootstrap power supply can be used for the high side drive. This design requires the least cost and design effort among the three solutions. However, this solution has limitations:

1. The negative gate drive bias is not only determined by the Zener diode, but also by the duty cycle, which means the negative bias voltage will change when the duty cycle changes. Therefore, converters with a fixed duty cycle (~50%) such as variable frequency resonant converters or phase shift converters which favor this solution.
2. The high side VDDA-VSSA must maintain enough voltage to stay in the recommended power supply range, which means the low side switch must turn-on or have free-wheeling current on the body (or anti-parallel) diode for a certain period during each switching cycle to refresh the bootstrap capacitor. Therefore, a 100% duty cycle for the high side is not possible unless there is a dedicated power supply for the high side, like in the other two example circuits.

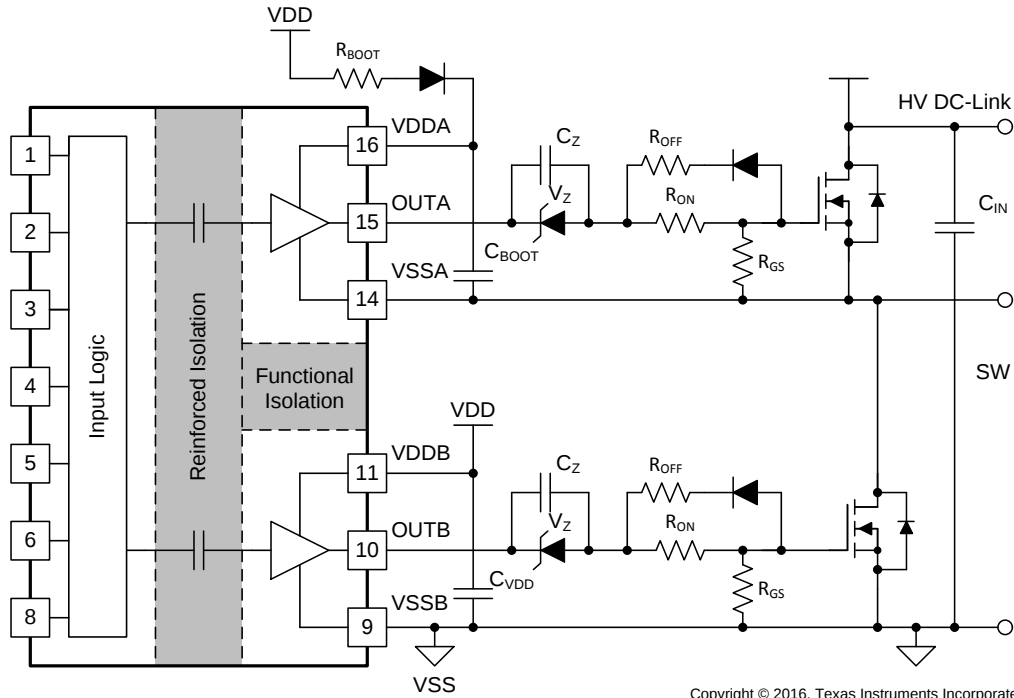


图 37. Negative Bias with Single Power Supply and Zener Diode in Gate Drive Path

9.2.3 Application Curves

图 38 和 图 39 显示了设计示例中所示的图 34 的基准测试波形，在这些条件下： $V_{CC} = 5\text{ V}$ ， $V_{DD} = 20\text{ V}$ ， $f_{SW} = 100\text{ kHz}$ ， $V_{DC-Link} = 0\text{ V}$ 。

Channel 1 (Yellow): UCC20520 PWM pin signal.

Channel 2 (Blue): Gate-source signal on the high side power transistor.

Channel 3 (Pink): Gate-source signal on the low side power transistor.

在图 38 中，PWM 信号以 50% 占空比信号发送。功率晶体管的栅极驱动信号具有 250-ns 死时间，如图 38 的测量部分所示。

图 39 显示了图 38 波形的放大版本，具有传播延迟和上升/下降时间的测量。光标还用于测量死时间。重要的是，输出波形是在功率晶体管的栅极和源极引脚之间测量的，而不是直接从驱动器 OUTA 和 OUTB 引脚测量的。由于开通和关断电阻 (R_{ON} , R_{OFF}) 和不同的sink和源电流，不同的上升 (16 ns) 和下降时间 (9 ns) 在图 39 中观察到。

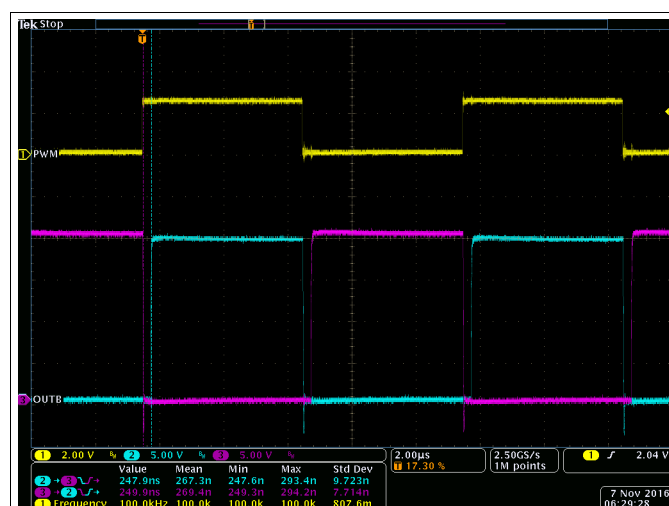


图 38. Bench Test Waveform for PWM and OUTA/B

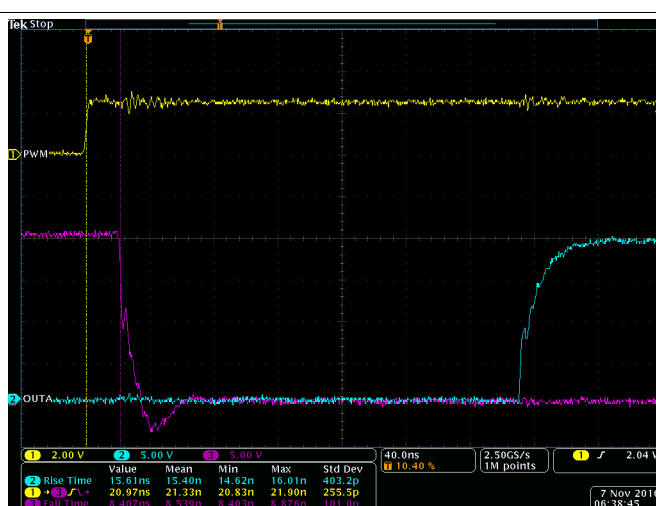


图 39. Zoomed-In bench-test waveform

10 Power Supply Recommendations

The recommended input supply voltage (VCCI) for UCC20520 is between 3-V and 18-V. The recommended output bias supply voltage (VDDA/Vddb) range is between 9.2-V to 25-V. The lower end of this bias supply range is governed by the internal under voltage lockout (UVLO) protection feature of each device. One mustn't let VDD or VCCI fall below their respective UVLO thresholds (For more information on UVLO see [VDD](#), [VCCI](#), and [Under Voltage Lock Out \(UVLO\)](#)). The upper end of the VDDA/Vddb range depends on the maximum gate voltage of the power device being driven by UCC20520.

A local bypass capacitor should be placed between the VDD and VSS pins. This capacitor should be positioned as close to the device as possible. A low ESR, ceramic surface mount capacitor is recommended. It is further suggested that one place two such capacitors: one with a value of between 220 nF and 10 μ F for device biasing, and an additional 100-nF capacitor in parallel for high frequency filtering.

Similarly, a bypass capacitor should also be placed between the VCCI and GND pins. Given the small amount of current drawn by the logic circuitry within the input side of UCC20520, this bypass capacitor has a minimum recommended value of 100 nF.

11 Layout

11.1 Layout Guidelines

One must pay close attention to PCB layout in order to achieve optimum performance for the UCC20520. Below are some key points.

Component Placement:

- Low-ESR and low-ESL capacitors must be connected close to the device between the VCCI and GND pins and between the VDD and VSS pins to support high peak currents when turning on the external power transistor.
- To avoid large negative transients on the switch node VSSA (HS) pin, the parasitic inductances between the source of the top transistor and the source of the bottom transistor must be minimized.
- It is recommended to place the dead time setting resistor, R_{DT} , and its bypassing capacitor close to DT pin of UCC20520.

Grounding Considerations:

- It is essential to confine the high peak currents that charge and discharge the transistor gates to a minimal physical area. This will decrease the loop inductance and minimize noise on the gate terminals of the transistors. The gate driver must be placed as close as possible to the transistors.
- Pay attention to high current path that includes the bootstrap capacitor, bootstrap diode, local VSSB-referenced bypass capacitor, and the low-side transistor body/anti-parallel diode. The bootstrap capacitor is recharged on a cycle-by-cycle basis through the bootstrap diode by the VDD bypass capacitor. This recharging occurs in a short time interval and involves a high peak current. Minimizing this loop length and area on the circuit board is important for ensuring reliable operation.

High-Voltage Considerations:

- To ensure isolation performance between the primary and secondary side, one should avoid placing any PCB traces or copper below the driver device. A PCB cutout is recommended in order to prevent contamination that may compromise the UCC20520's isolation performance.
- For half-bridge, or high-side/low-side configurations, where the channel A and channel B drivers could operate with a DC-link voltage up to 1500 V_{DC}, one should try to increase the creepage distance of the PCB layout between the high and low-side PCB traces.

Thermal Considerations:

- A large amount of power may be dissipated by the UCC20520 if the driving voltage is high, the load is heavy, or the switching frequency is high (Refer to [Estimate Gate Driver Power Loss](#) for more details). Proper PCB layout can help dissipate heat from the device to the PCB and minimize junction to board thermal impedance (θ_{JB}).
- Increasing the PCB copper connecting to VDDA, VDDB, VSSA and VSSB pins is recommended (See [图 41](#) and [图 42](#)). However, high voltage PCB considerations mentioned above must be maintained.
- If there are multiple layers in the system, it is also recommended to connect the VDDA, VDDB, VSSA and VSSB pins to internal ground or power planes through multiple vias of adequate size. However, keep in mind that there shouldn't be any traces/coppers from different high voltage planes overlapping.

11.2 Layout Example

图 40 shows a 2-layer PCB layout example with the signals and key components labeled.

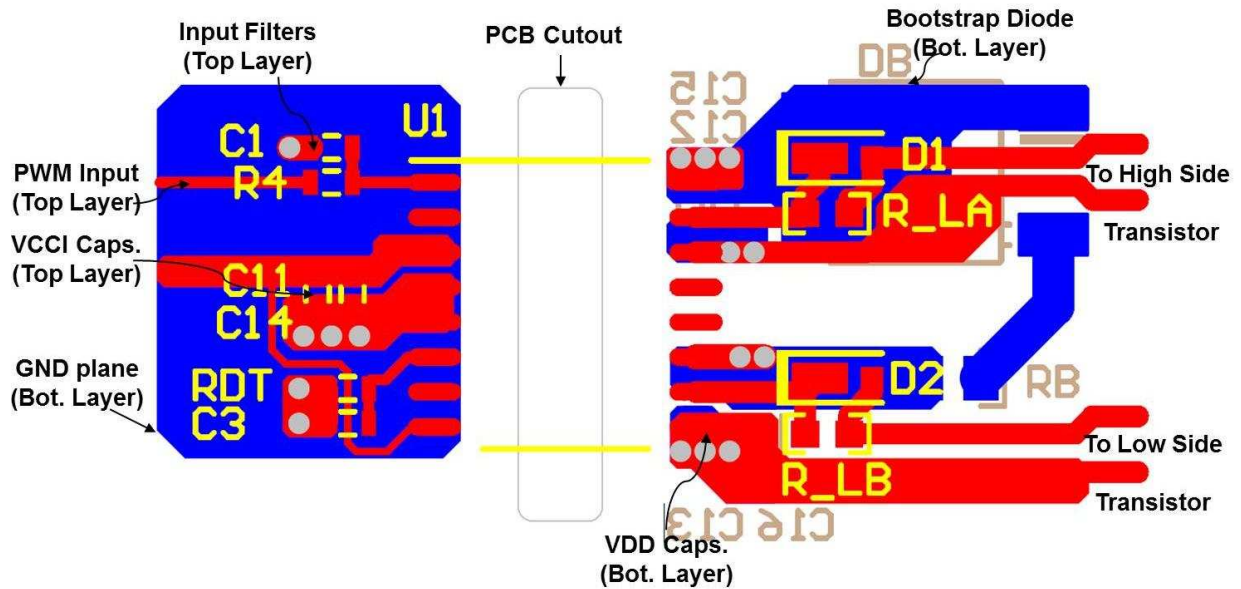


图 40. Layout Example

图 41 and 图 42 shows top and bottom layer traces and copper.

注

There are no PCB traces or copper between the primary and secondary side, which ensures isolation performance.

Layout Example (接下页)

PCB traces between the high-side and low-side gate drivers in the output stage are increased to maximize the creepage distance for high-voltage operation, which will also minimize cross-talk between the switching node VSSA (SW), where high dv/dt may exist, and the low-side gate drive due to the parasitic capacitance coupling.

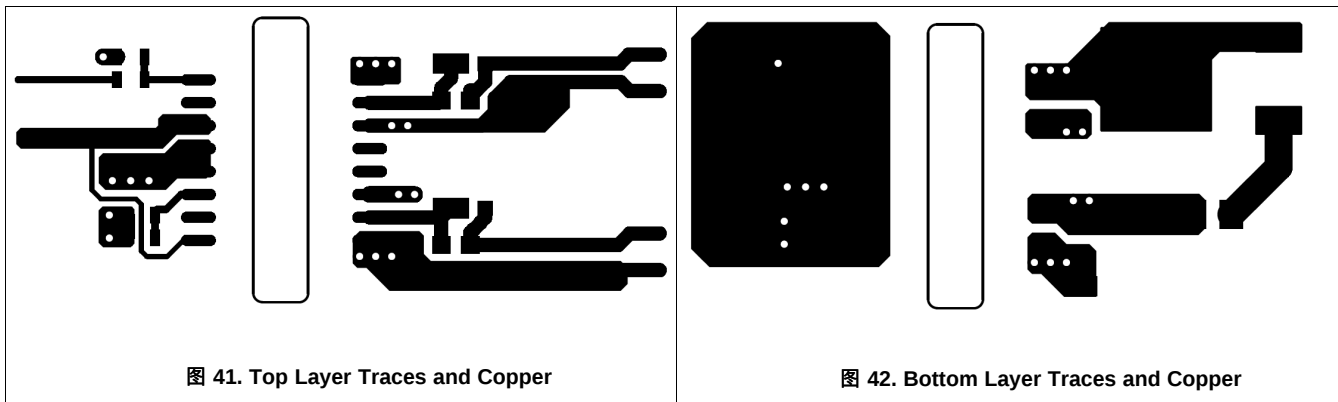
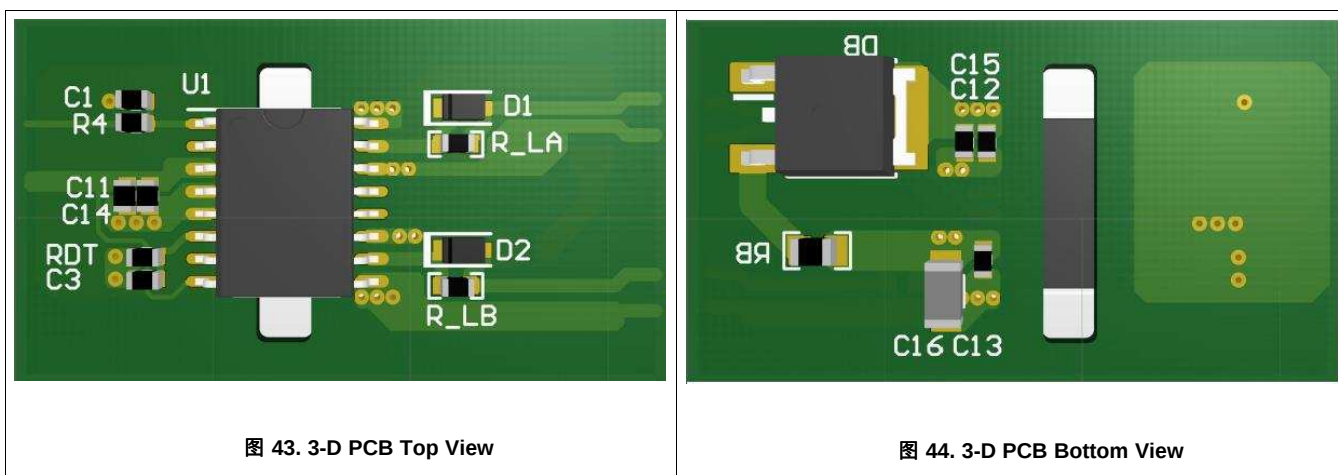


图 43 和 图 44 是 3D layout pictures with top view and bottom views.

注

The location of the PCB cutout between the primary side and secondary sides, which ensures isolation performance.



12 器件和文档支持

12.1 文档支持

12.1.1 相关文档

相关文档如下：

- [隔离相关术语](#)

12.2 认证

UL 在线认证目录, [“FPPT2.E181974 非光学隔离器件 - 组件”](#)证书编号: 20160516-E181974, (SLUQ001)

VDE 在线认证目录, [“工厂监控符合性认证”](#)证书编号: 40040142

CQC 在线认证目录, [“GB4943.1-2011 数字隔离器认证”](#)证书编号: CQC16001155011

12.3 接收文档更新通知

如需接收文档更新通知, 请访问 www.ti.com.cn 网站上的器件产品文件夹。点击右上角的提醒我 (Alert me) 注册后, 即可每周定期收到已更改的产品信息。有关更改的详细信息, 请查阅已修订文档中包含的修订历史记录。

12.4 社区资源

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12.7 Glossary

[SLYZ022](#) — *TI Glossary*.

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

13 机械、封装和可订购信息

以下页中包括机械封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本, 请查阅左侧的导航栏。

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数字音频	www.ti.com.cn/audio	通信与电信	www.ti.com.cn/telecom
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数据转换器	www.ti.com.cn/dataconverters	消费电子	www.ti.com.cn/consumer-apps
DLP® 产品	www.dlp.com	能源	www.ti.com.cn/energy
DSP - 数字信号处理器	www.ti.com.cn/dsp	工业应用	www.ti.com.cn/industrial
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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
UCC20520DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	UCC20520	Samples
UCC20520DWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	UCC20520	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

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

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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

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

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

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

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

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GENERIC PACKAGE VIEW

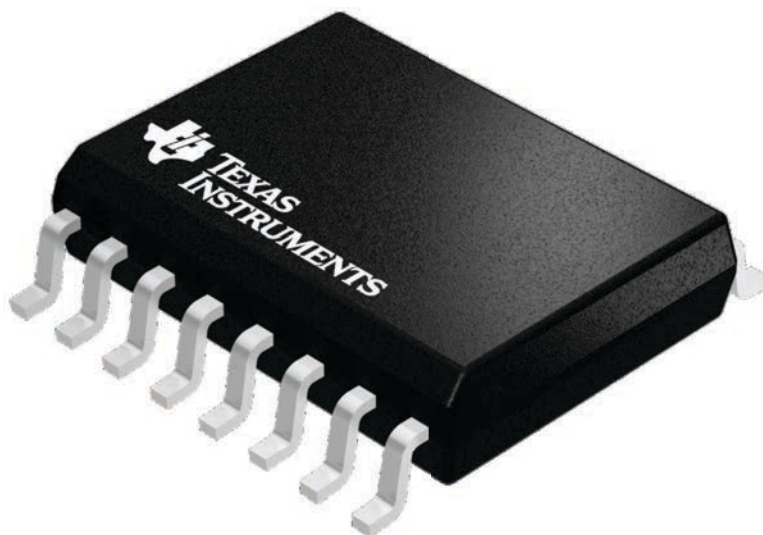
DW 16

SOIC - 2.65 mm max height

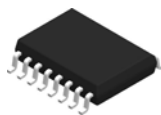
7.5 x 10.3, 1.27 mm pitch

SMALL OUTLINE INTEGRATED CIRCUIT

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4224780/A

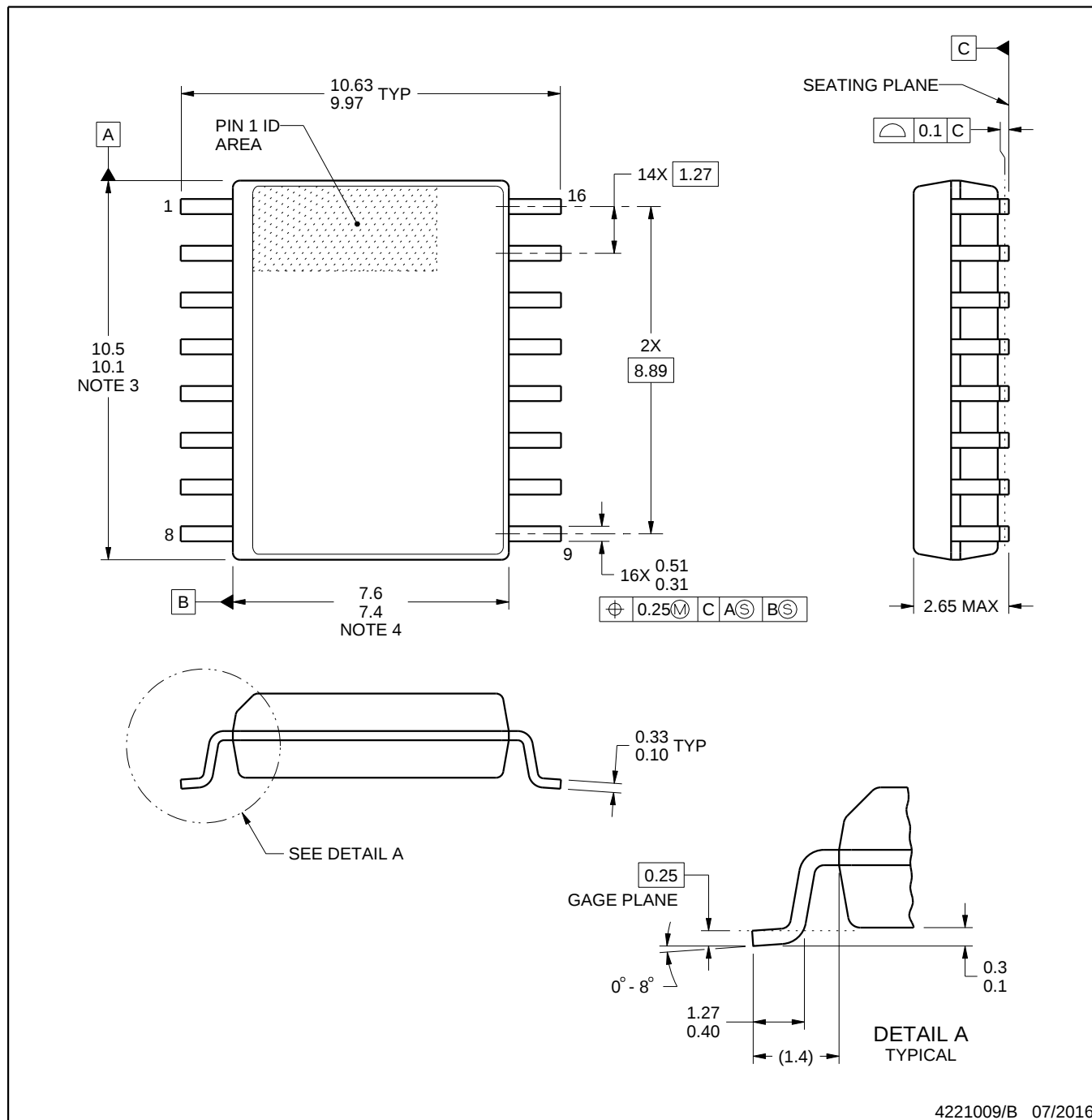


DW0016B

PACKAGE OUTLINE

SOIC - 2.65 mm max height

SOIC



4221009/B 07/2016

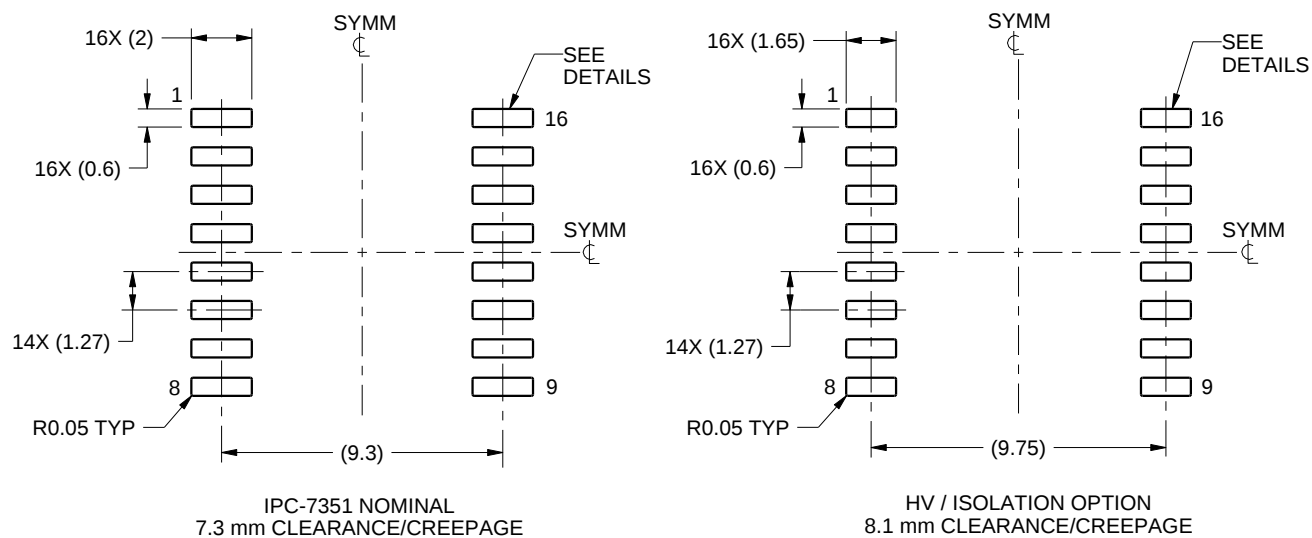
NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. 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 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.
5. Reference JEDEC registration MS-013.

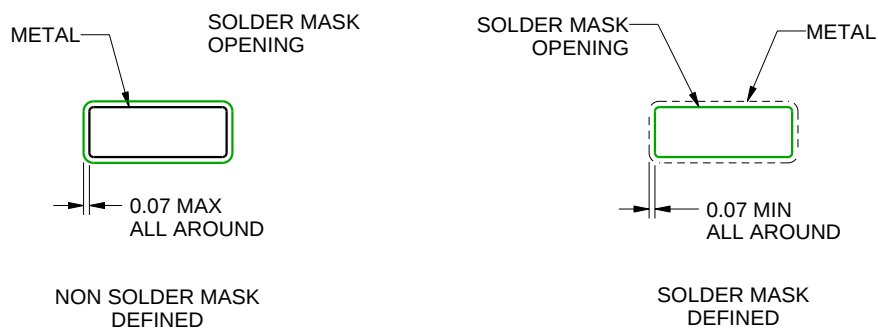
DW0016B

SOIC - 2.65 mm max height

SOIC



LAND PATTERN EXAMPLE
SCALE:4X



SOLDER MASK DETAILS

4221009/B 07/2016

NOTES: (continued)

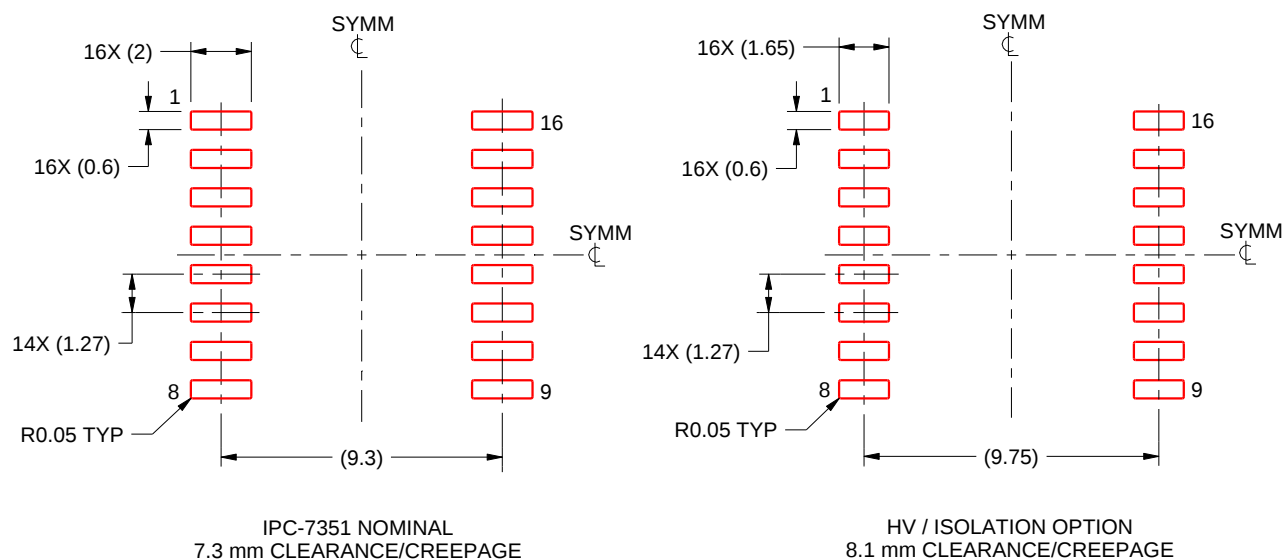
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DW0016B

SOIC - 2.65 mm max height

SOIC



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:4X

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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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