ISO5452 High-CMTI 2.5-A and 5-A Isolated IGBT, MOSFET Gate Driver With Split Outputs and Active Protection Features

1 Features

- 50-kV/μs Minimum and 100-kV/μs Typical Common-Mode Transient Immunity (CMTI) at V_{CM} = 1500 V
- Split Outputs to provide 2.5-A Peak Source and 5-A Peak Sink Currents
- Short Propagation Delay: 76 ns (Typ), 110 ns (Max)
- 2-A Active Miller Clamp
- Output Short-Circuit Clamp
- Soft Turn-Off (STO) during Short Circuit
- Fault Alarm upon Desaturation Detection is Signaled on $\overline{FLT}$ and Reset Through $\overline{RST}$
- Input and Output Undervoltage Lockout (UVLO) With Ready (RDY) Pin Indication
- Active Output Pulldown and Default Low Outputs With Low Supply or Floating Inputs
- 2.25-V to 5.5-V Input Supply Voltage
- 15-V to 30-V Output Driver Supply Voltage
- CMOS Compatible Inputs
- Rejects Input Pulses and Noise Transients Shorter Than 20 ns
- Operating Temperature: –40°C to +125°C Ambient
- Isolation Surge Withstand Voltage 10000-V_{PK}
- Safety-Related Certifications:
  - 8000-V_{PK} V_{IOTM} and 1420-V_{PK} V_{IORM} Reinforced Isolation per DIN V VDE V 0884-10 (VDE V 0884-10):2006-12
  - 5700-V_{RMS} Isolation for 1 Minute per UL 1577
  - CSA Component Acceptance Notice 5A, IEC 60950–1 and IEC 60601–1 End Equipment Standards
  - TUV Certification per EN 61010-1 and EN 60950-1
  - GB4943.1-2011 CQC Certification

2 Applications

- Isolated IGBT and MOSFET Drives in:
  - Industrial Motor Control Drives
  - Industrial Power Supplies
  - Solar Inverters
  - HEV and EV Power Modules
  - Induction Heating

3 Description

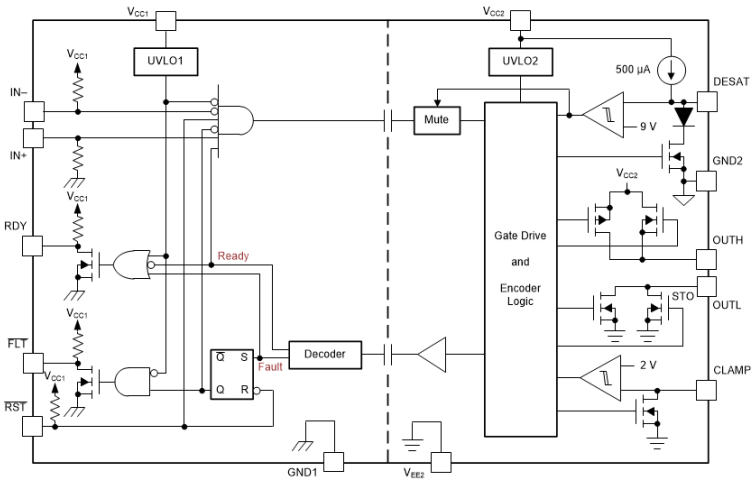
The ISO5452 is a 5.7-kV_{RMS}, reinforced isolated gate driver for IGBTs and MOSFETs with split outputs, OUTH and OUTL, providing 2.5-A source and 5-A sink current. The input side operates from a single 2.25-V to 5.5-V supply. The output side allows for a supply range from minimum 15 V to maximum 30 V. Two complementary CMOS inputs control the output state of the gate driver. The short propagation time of 76 ns assures accurate control of the output stage.

An internal desaturation (DESAT) fault detection recognizes when the IGBT is in an overcurrent condition. Upon a DESAT detect, a Mute logic immediately blocks the output of the isolator and initiates a soft-turn-off procedure which disables OUTH, and pulls OUTL to low over a time span of 2 μs. When OUTL reaches 2 V with respect to the most negative supply potential, V_{EE2}, the gate driver output is pulled hard to V_{EE2} potential, turning the IGBT immediately off.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
ISO5452	SOIC (16)	10.30 mm × 7.50 mm

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



Functional Block Diagram

Table of Contents

1 Features....1
2 Applications....1
3 Description....1
4 Revision History....2
5 Description (continued)....4
6 Pin Configuration and Function....5
7 Specifications....6
7.1 Absolute Maximum Ratings....6
7.2 ESD Ratings....6
7.3 Recommended Operating Conditions....6
7.4 Thermal Information....7
7.5 Power Ratings....7
7.6 Insulation Specifications....8
7.7 Safety-Related Certifications....9
7.8 Safety Limiting Values....9
7.9 Electrical Characteristics....10
7.10 Switching Characteristics....12
7.11 Insulation Characteristics Curves....13
7.12 Typical Characteristics....14
8 Parameter Measurement Information....21
9 Detailed Description....23
9.1 Overview....23
9.2 Functional Block Diagram....23
9.3 Feature Description....24
9.4 Device Functional Modes....25
10 Application and Implementation....26
10.1 Application Information....26
10.2 Typical Applications....26
11 Power Supply Recommendations....35
12 Layout....36
12.1 Layout Guidelines....36
12.2 Layout Example....36
12.3 PCB Material....36
13 Device and Documentation Support....37
13.1 Device Support....37
13.2 Documentation Support....37
13.3 Receiving Notification of Documentation Updates....37
13.4 Support Resources....37
13.5 Trademarks....37
13.6 Electrostatic Discharge Caution....37
13.7 Glossary....37
14 Mechanical, Packaging, and Orderable Information....37

4 Revision History

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

Changes from Revision B (January 2017) to Revision C (May 2023)	Page
• Added Additional manufacturing certification pending in the *Safety-Related Certifications* table	9

Changes from Revision A (September 2015) to Revision B (January 2017)	Page
• Changed the title from *Active Safety Features* to *Active Protection Features*	1
• Changed Feature From: Surge Immunity 10000-V_{PK} (according to IEC 61000-4-5) To: Isolation Surge Withstand Voltage 10000-V_{PK}	1
• Moved *Insulation Specifications* to the *Specifications* section	8
• Changed R_{IO} Test conditions From: T_S To: T_S = 150°C in *Insulation Specifications*	8
• Moved *Safety-Related Certifications* to the *Specifications* section	9
• Moved *Safety Limiting Values* to the *Specifications* section	9
• Moved *Insulation Characteristics Curves* to the *Specifications*	13
• Added text ", but connecting CLAMP output of the gate driver to the IGBT gate is also not an issue." to *Supply and Active Miller Clamp*	24
• Deleted ground symbol on pin 11 of the *Global Shutdown With Inverting Input Configuration* figure	30
• Deleted ground symbol on pin 11 on the inverting input of the *Auto Reset for Noninverting and Inverting Input Configuration* figure	30

Changes from Revision * (August 2015) to Revision A (September 2015)	Page
• Changed from a 1-page Product Preview to the full datasheet	1
• Moved *Features*: "50-kV/µs Minimum and 100-kV/µs Typical Common-Mode Transient Immunity.." to the top of the list	1
• Changed the status of all certifications to complete	1
• Changed the *Functional Block Diagram*, added STO on pin OUTL	1
• Changed R_{IO} Test conditions From: 100°C ≤ T_A ≤ max To: 100°C ≤ T_A ≤ 125°C in *Insulation Specifications*	8

- Changed the *Safety-Related Certifications* table....9

5 Description (continued)

When desaturation is active, a fault signal is sent across the isolation barrier, pulling the $\overline{FLT}$ output at the input side low and blocking the isolator input. Mute logic is activated through the soft-turn-off period. The $\overline{FLT}$ output condition is latched and can be reset only after RDY goes high, through a low-active pulse at the $\overline{RST}$ input.

When the IGBT is turned off during normal operation with bipolar output supply, the output is hard clamp to V_{EE2}. If the output supply is unipolar, an active Miller clamp can be used, allowing Miller current to sink across a low impedance path, preventing IGBT to be dynamically turned on during high voltage transient conditions.

The readiness for the gate driver to be operated is under the control of two undervoltage-lockout circuits monitoring the input side and output side supplies. If either side has insufficient supply the RDY output goes low, otherwise this output is high.

The ISO5452 is available in a 16-pin SOIC package. Device operation is specified over a temperature range from –40°C to +125°C ambient.

6 Pin Configuration and Function

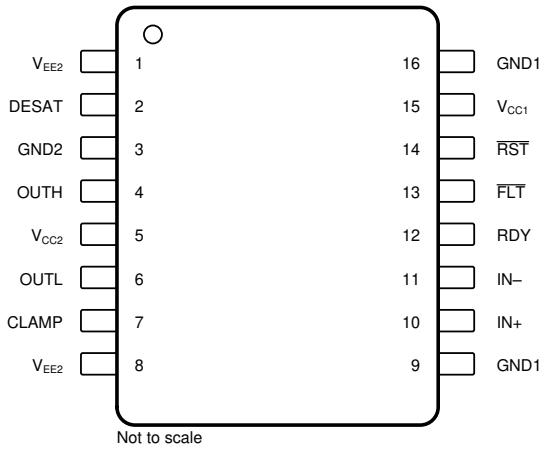


Figure 6-1. DW Package 16-Pin SOIC Top View

Table 6-1. Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	V_{EE2}	—	Output negative supply. Connect to GND2 for Unipolar supply application.
2	DESAT	I	Desaturation voltage input
3	GND2	—	Gate drive common. Connect to IGBT emitter.
4	OUTH	O	Positive gate drive voltage output
5	V_{CC2}	—	Most positive output supply potential.
6	OUTL	O	Negative gate drive voltage output
7	CLAMP	O	Miller clamp output
8	V_{EE2}	—	Output negative supply. Connect to GND2 for Unipolar supply application.
9	GND1	—	Input ground
10	IN+	I	Non-inverting gate drive voltage control input
11	IN–	I	Inverting gate drive voltage control input
12	RDY	O	Power-good output, active high when both supplies are good.
13	$\overline{FLT}$	O	Fault output, low-active during DESAT condition
14	$\overline{RST}$	I	Reset input, apply a low pulse to reset fault latch.
15	V_{CC1}	—	Positive input supply (2.25 V to 5.5 V)
16	GND1	—	Input ground

7 Specifications

7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
V_{CC1}	Supply voltage input side		GND1 – 0.3	6	V
V_{CC2}	Positive supply voltage output side	(V_{CC2} – GND2)	–0.3	35	V
V_{EE2}	Negative supply voltage output side	(V_{EE2} – GND2)	–17.5	0.3	V
$V_{(SUP2)}$	Total supply output voltage	(V_{CC2} – V_{EE2})	–0.3	35	V
$V_{(OUTH)}$	Positive gate driver output voltage		V_{EE2} – 0.3	V_{CC2} + 0.3	V
$V_{(OUTL)}$	Negative gate driver output voltage		V_{EE2} – 0.3	V_{CC2} + 0.3	V
$I_{(OUTH)}$	Gate driver high output current	Gate driver high output current (maximum pulse width = 10 µs, maximum duty cycle = 0.2%)		2.7	A
$I_{(OUTL)}$	Gate driver low output current	Gate driver high output current (maximum pulse width = 10 µs, maximum duty cycle = 0.2%)		5.5	A
$V_{(LIP)}$	Voltage at IN+, IN–, $\overline{FLT}$, RDY, $\overline{RST}$		GND1 - 0.3	V_{CC1} + 0.3	V
$I_{(LOP)}$	Output current of $\overline{FLT}$, RDY			10	mA
$V_{(DESAT)}$	Voltage at DESAT		GND2 - 0.3	V_{CC2} + 0.3	V
$V_{(CLAMP)}$	Clamp voltage		V_{EE2} – 0.3	V_{CC2} + 0.3	V
T_J	Junction temperature		–40	150	°C
T_{STG}	Storage temperature		–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.

7.2 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.

7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CC1}	Supply voltage input side	2.25		5.5	V
V_{CC2}	Positive supply voltage output side (V_{CC2} – GND2)	15		30	V
V_{EE2}	Negative supply voltage output side (V_{EE2} – GND2)	–15		0	V
$V_{(SUP2)}$	Total supply voltage output side (V_{CC2} – V_{EE2})	15		30	V
V_{IH}	High-level input voltage (IN+, IN–, $\overline{RST}$)	0.7 × V_{CC1}		V_{CC1}	V
V_{IL}	Low-level input voltage (IN+, IN–, $\overline{RST}$)	0		0.3 × V_{CC1}	V
t_{UI}	Pulse width at IN+, IN– for full output (C_{LOAD} = 1 nF)	40			ns
t_{RST}	Pulse width at $\overline{RST}$ for resetting fault latch	800			ns
T_A	Ambient temperature	–40		125	°C

7.4 Thermal Information

THERMAL METRIC(1)		ISO5452 DW (SOIC) 16 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	99.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	48.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56.5	°C/W
ψ_{JT}	Junction-to-top characterization parameter	29.2	°C/W
ψ_{JB}	Junction-to-board characterization parameter	56.5	°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 Power Ratings

V_{CC1} = 5.5 V, V_{CC2} = 30 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
P_D	Maximum power dissipation(1)				1255	mW
P_{ID}	Maximum input power dissipation				175	mW
P_{OD}	Maximum output power dissipation				1080	mW

(1) Full chip power dissipation is derated 10.04 mW/°C beyond 25°C ambient temperature. At 125°C ambient temperature, a maximum of 251 mW total power dissipation is allowed. Power dissipation can be optimized depending on ambient temperature and board design, while ensuring that Junction temperature does not exceed 150°C.

7.6 Insulation Specifications

PARAMETER		TEST CONDITIONS	VALUE	UNIT
GENERAL				
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 the insulation	Minimum internal gap (internal clearance)	>21	µm
CTI	Tracking resistance (comparative tracking index)	DIN EN 60112 (VDE 0303-11); IEC 60112; UL 746A	>600	V
	Material Group	According to IEC 60664-1	I	
	Overvoltage category (according to IEC 60664-1)	Rated Mains Voltage ≤ 300 V_{RMS}	I-IV	
		Rated Mains Voltage ≤ 600 V_{RMS}	I-III	
		Rated Mains Voltage ≤ 1000 V_{RMS}	I-II	
DIN V VDE V 0884-10 (VDE V 0884-10):2006-12(2)				
V_{IORM}	Maximum repetitive peak isolation voltage	AC voltage (bipolar)	1420	V_{PK}
V_{IOWM}	Maximum isolation working voltage	AC voltage. Time dependent dielectric breakdown (TDDB) Test, see Figure 7-1	1000	V_{RMS}
		DC voltage	1420	V_{DC}
V_{IOTM}	Maximum transient isolation voltage	V_{TEST} = V_{IOTM}, t = 60 s (qualification), t = 1 s (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} = 10000 V_{PK} (qualification)(3)	6250	V_{PK}
q_{pd}	Apparent charge(4)	Method a: After I/O safety test subgroup 2/3, V_{ini} = V_{IOTM}, t_{ini} = 60 s; $V_{pd(m)}$ = 1.2 × V_{IORM} = 1704 V_{PK}, t_m = 10 s	≤5	pC
		Method a: After environmental tests subgroup 1, V_{ini} = V_{IOTM}, t_{ini} = 60 s; $V_{pd(m)}$ = 1.6 × V_{IORM} = 2272 V_{PK}, t_m = 10 s	≤5	
		Method b1: At routine test (100% production) and preconditioning (type test), V_{ini} = V_{IOTM}, t_{ini} = 60 s; $V_{pd(m)}$ = 1.875× V_{IORM} = 2663 V_{PK}, t_m = 10 s	≤5	
R_{IO}	Isolation resistance, input to output(5)	V_{IO} = 500 V, T_A = 25°C	> 10^{12}	Ω
		V_{IO} = 500 V, 100°C ≤ T_A ≤ 125°C	> 10^{11}	Ω
		V_{IO} = 500 V at T_S = 150°C	> 10^{9}	Ω
C_{IO}	Barrier capacitance, input to output(5)	V_{IO} = 0.4 x sin (2πft), f = 1 MHz	~1	pF
	Pollution degree		2	
	Climatic category		40/125/21	
UL 1577				
V_{ISO}	Withstanding Isolation voltage	V_{TEST} = V_{ISO}, t = 60 s (qualification), V_{TEST} = 1.2 × V_{ISO} = 6840 V_{RMS}, t = 1 s (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

7.7 Safety-Related Certifications

VDE	CSA	UL	CQC	TUV
Certified according to DIN V VDE V 0884-10 (VDE V 0884-10):2006-12 and DIN EN 60950-1 (VDE 0805 Teil 1):2011-01	Certified according to 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	Certified according to EN 61010-1:2010 (3rd Ed) and EN 60950-1:2006/A11:2009/ A1:2010/ A12:2011/A2:2013
Reinforced Insulation Maximum Transient isolation voltage, 8000 V_{PK}; Maximum surge isolation voltage, 6250 V_{PK}, Maximum repetitive peak isolation voltage, 1420 V_{PK}	Isolation Rating of 5700 V_{RMS}; Reinforced insulation per CSA 60950- 1- 07+A1+A2 and IEC 60950-1 (2nd Ed.), 800 V_{RMS} max working voltage (pollution degree 2, material group I) ; 2 MOPP (Means of Patient Protection) per CSA 60601-1:14 and IEC 60601-1 Ed. 3.1, 250 V_{RMS} (354 V_{PK}) max working voltage	Single Protection, 5700 V_{RMS}	Reinforced Insulation, Altitude ≤ 5000m, Tropical climate, 400 V_{RMS} maximum working voltage	5700 V_{RMS} Reinforced insulation per EN 61010-1:2010 (3rd Ed) up to working voltage of 600 V_{RMS} 5700 V_{RMS} Reinforced insulation per EN 60950-1:2006/A11:2009/ A1:2010/ A12:2011/A2:2013 up to working voltage of 800 V_{RMS}
Certification completed Certificate number: 40040142	Certification completed Master contract number: 220991	Certification completed File number: E181974	Certification completed Certificate number: CQC16001141761 Additional manufacturing certification pending	Certification completed Client ID number: 77311

7.8 Safety Limiting Values

Safety limiting intends to minimize 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	MIN	TYP	MAX	UNIT
I_S	Safety input, output or supply current	$R_{\theta JA}$ = 99.6°C/W, V_I = 2.75 V, T_J = 150°C, T_A = 25°C, see Figure 7-2			456	mA
		$R_{\theta JA}$ = 99.6°C/W, V_I = 3.6 V, T_J = 150°C, T_A = 25°C, see Figure 7-2			346	
		$R_{\theta JA}$ = 99.6°C/W, V_I = 5.5 V, T_J = 150°C, T_A = 25°C, see Figure 7-2			228	
		$R_{\theta JA}$ = 99.6°C/W, V_I = 15 V, T_J = 150°C, T_A = 25°C, see Figure 7-2			484	
		$R_{\theta JA}$ = 99.6°C/W, V_I = 30 V, T_J = 150°C, T_A = 25°C, see Figure 7-2			42	
P_S	Safety input, output, or total power	$R_{\theta JA}$ = 99.6°C/W, T_J = 150°C, T_A = 25°C, see Figure 7-3			1255(1)	mW
T_S	Safety temperature				150	°C

(1) Input, output, or the sum of input and output power should not exceed this value

The safety-limiting constraint is the maximum junction temperature specified in the data sheet. 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 *Section 7.4* 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.

7.9 Electrical Characteristics

Over recommended operating conditions unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VOLTAGE SUPPLY						
$V_{IT+(UVLO1)}$	Positive-going UVLO1 threshold voltage input side (V_{CC1} – GND1)				2.25	V
$V_{IT-(UVLO1)}$	Negative-going UVLO1 threshold voltage input side (V_{CC1} – GND1)		1.7			V
$V_{HYS(UVLO1)}$	UVLO1 Hysteresis voltage (V_{IT+} – $V_{IT–}$) input side	T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		0.2		V
$V_{IT+(UVLO2)}$	Positive-going UVLO2 threshold voltage output side (V_{CC2} – GND2)				13	V
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		12		
$V_{IT-(UVLO2)}$	Negative-going UVLO2 threshold voltage output side (V_{CC2} – GND2)		9.5			V
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		11		
$V_{HYS(UVLO2)}$	UVLO2 Hysteresis voltage (V_{IT+} – $V_{IT–}$) output side	T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		1		V
I_{Q1}	Input supply quiescent current				4.5	mA
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2.8		
I_{Q2}	Output supply quiescent current				6	mA
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		3.6		
LOGIC I/O						
$V_{IT+(IN, \overline{RST})}$	Positive-going input threshold voltage (IN+, IN–, $\overline{RST}$)				0.7 × V_{CC1}	V
$V_{IT-(IN, \overline{RST})}$	Negative-going input threshold voltage (IN+, IN–, $\overline{RST}$)		0.3 × V_{CC1}			V
$V_{HYS(IN, \overline{RST})}$	Input hysteresis voltage (IN+, IN–, $\overline{RST}$)	T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		0.15 × V_{CC1}		V
I_{IH}	High-level input leakage at (IN+) (1)	IN+ = V_{CC1}, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		100		µA
I_{IL}	Low-level input leakage at (IN–, $\overline{RST}$) (2)	IN– = GND1, $\overline{RST}$ = GND1, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		–100		µA
I_{PU}	Pullup current of $\overline{FLT}$, RDY	$V_{(RDY)}$ = GND1, $V_{(FLT)}$ = GND1, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		100		µA
V_{OL}	Low-level output voltage at $\overline{FLT}$, RDY	$I_{(FLT)}$ = 5 mA			0.2	V
GATE DRIVER STAGE						
$V_{(OUTPD)}$	Active output pulldown voltage	$I_{(OUTH/L)}$ = 200 mA, V_{CC2} = open			2	V
$V_{(OUTH)}$	High-level output voltage	$I_{(OUTH)}$ = –20 mA	V_{CC2} – 0.5			V
		$I_{(OUTH)}$ = –20 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		V_{CC2} – 0.24		
$V_{(OUTL)}$	Low-level output voltage	$I_{(OUTL)}$ = 20 mA			V_{EE2} + 50	mV
		$I_{(OUTL)}$ = 20 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		V_{EE2} + 13		
$I_{(OUTH)}$	High-level output peak current	IN+ = high, IN– = low, $V_{(OUTH)}$ = V_{CC2} – 15 V	1.5			A
		IN+ = high, IN– = low, $V_{(OUTH)}$ = V_{CC2} – 15 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2.5		
$I_{(OUTL)}$	Low-level output peak current	IN+ = low, IN– = high, $V_{(OUTL)}$ = V_{EE2} + 15 V	3.4			A
		IN+ = low, IN– = high, $V_{(OUTL)}$ = V_{EE2} + 15 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		5		
$I_{(OLF)}$	Low level output current during fault condition	T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		130		mA

7.9 Electrical Characteristics (continued)

Over recommended operating conditions unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ACTIVE MILLER CLAMP						
$V_{(CLP)}$	Low-level clamp voltage	$I_{(CLP)}$ = 20 mA			V_{EE2} + 0.08	V
		$I_{(CLP)}$ = 20 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		V_{EE2} + 0.015		
$I_{(CLP)}$	Low-level clamp current	$V_{(CLAMP)}$ = V_{EE2} + 2.5 V	1.6		3.3	A
		$V_{(CLAMP)}$ = V_{EE2} + 2.5 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2.5		
$V_{(CLTH)}$	Clamp threshold voltage		1.6		2.5	V
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2.1		
SHORT CIRCUIT CLAMPING						
$V_{(CLP\_OUTH)}$	Clamping voltage (V_{OUTH} – V_{CC2})	IN+ = high, IN– = low, t_{CLP} = 10 µs, $I_{(OUTH)}$ = 500 mA		1.1	1.3	V
		IN+ = high, IN– = low, t_{CLP} = 10 µs, $I_{(OUTH)}$ = 500 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V				
$V_{(CLP\_OUTL)}$	Clamping voltage (V_{OUTL} – V_{CC2})	IN+ = high, IN– = low, t_{CLP} = 10 µs, $I_{(OUTL)}$ = 500 mA		1.3	1.5	V
		IN+ = high, IN– = low, t_{CLP} = 10 µs, $I_{(OUTL)}$ = 500 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V				
$V_{(CLP\_CLAMP)}$	Clamping voltage (V_{CLP} – V_{CC2})	IN+ = high, IN– = low, t_{CLP} = 10 µs, $I_{(CLP)}$ = 500 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		1.3		V
	Clamping voltage at CLAMP	IN+ = High, IN– = Low, $I_{(CLP)}$ = 20 mA			1.1	V
		IN+ = High, IN– = Low, $I_{(CLP)}$ = 20 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		0.7		
$V_{(CLP\_OUTL)}$	Clamping voltage at OUTL (V_{CLP} - V_{CC2})	IN+ = High, IN– = Low, $I_{(OUTL)}$ = 20 mA			1.1	V
		IN+ = High, IN– = Low, $I_{(OUTL)}$ = 20 mA, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		0.7		
DESAT PROTECTION						
$I_{(CHG)}$	Blanking capacitor charge current	$V_{(DESAT)}$ – GND2 = 2 V	0.42		0.58	mA
		$V_{(DESAT)}$ – GND2 = 2 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		0.5		
$I_{(DCHG)}$	Blanking capacitor discharge current	$V_{(DESAT)}$ – GND2 = 6 V	9			mA
		$V_{(DESAT)}$ – GND2 = 6 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		14		
$V_{(DSTH)}$	DESAT threshold voltage with respect to GND2		8.3		9.5	V
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		9		
$V_{(DSL)}$	DESAT voltage with respect to GND2, when OUTH/L is driven low		0.4		1	V

(1) I_{IH} for IN–, $\overline{RST}$ pin is zero as they are pulled high internally.
(2) I_{IL} for IN+ is zero, as it is pulled low internally.

7.10 Switching Characteristics

Over recommended operating conditions unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_r	Output signal rise time, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF	12		35	ns
		C_{LOAD} = 1 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		18		
t_f	Output signal fall time, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF	12		37	ns
		C_{LOAD} = 1 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		20		
t_{PLH}, t_{PHL}	Propagation delay, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF		76	110	ns
		C_{LOAD} = 1 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V				
t_{sk-p}	Pulse skew $\lvert t_{PHL} - t_{PLH} \rvert$, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF			20	ns
t_{sk-pp}	Part-to-part skew, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF			30(1)	ns
t_{GF}	Glitch filter on IN+, IN–, $\overline{RST}$, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 1 nF	20		40	ns
		C_{LOAD} = 1 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		30		
$t_{DS\ (90\%)}$	DESAT sense to 90% $V_{OUTH/L}$ delay, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 10 nF			760	ns
		C_{LOAD} = 10 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		553		
$t_{DS\ (10\%)}$	DESAT sense to 10% $V_{OUTH/L}$ delay, see Figure 8-1, Figure 8-2, and Figure 8-3	C_{LOAD} = 10 nF			3.5	µs
		C_{LOAD} = 10 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2		
$t_{DS\ (GF)}$	DESAT glitch filter delay	C_{LOAD} = 1 nF, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		330		ns
$t_{DS\ (\overline{FLT})}$	DESAT sense to $\overline{FLT}$-low delay, see Figure 8-3				1.4	µs
t_{LEB}	Leading edge blanking time, see Figure 8-1and Figure 8-2		310		480	ns
		T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		400		
$t_{GF(RSTFLT)}$	Glitch filter on $\overline{RST}$ for resetting $\overline{FLT}$		300		800	ns
C_I	Input capacitance(2)	V_I = V_{CC1} / 2 + 0.4 × sin (2πft), f = 1 MHz, V_{CC1} = 5 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		2		pF
CMTI	Common-mode transient immunity, see Figure 8-4	V_{CM} = 1500 V	50			kV/µs
		V_{CM} = 1500 V, T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – V_{EE2} = 8 V		100		

(1) Measured at same supply voltage and temperature condition
(2) Measured from input pin to ground.

7.11 Insulation Characteristics Curves

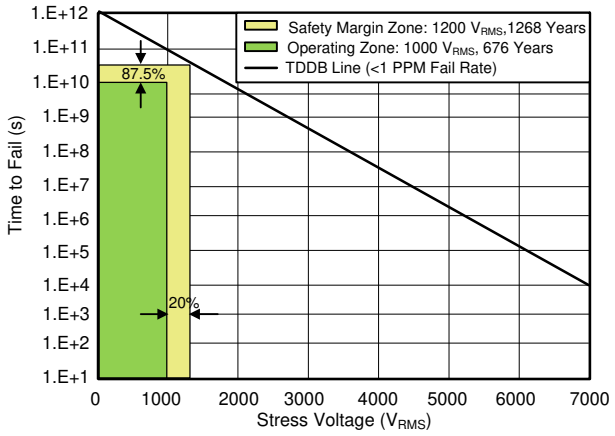


Figure 7-1. Reinforced Isolation Capacitor Lifetime Projection

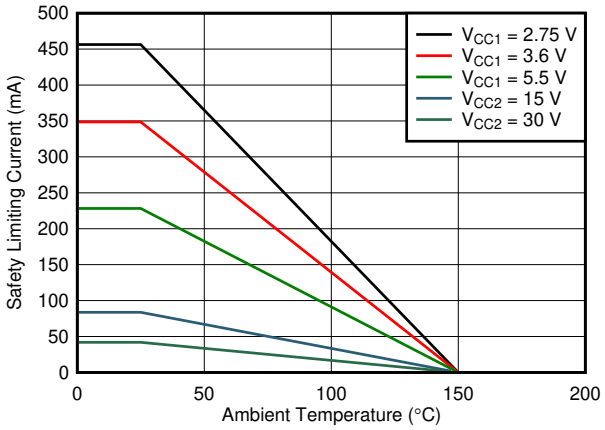


Figure 7-2. Thermal Derating Curve for Safety Limiting Current per VDE

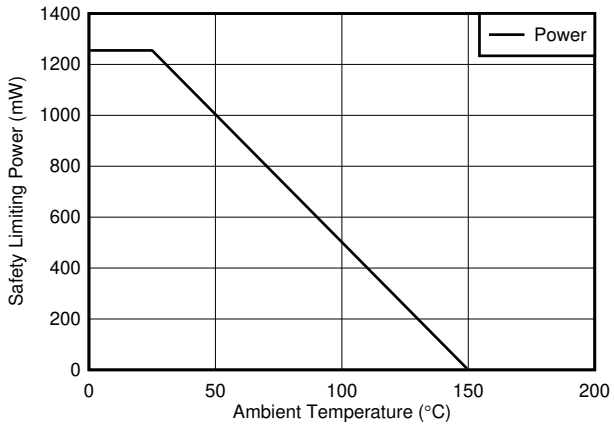


Figure 7-3. Thermal Derating Curve for Safety Limiting Power per VDE

7.12 Typical Characteristics

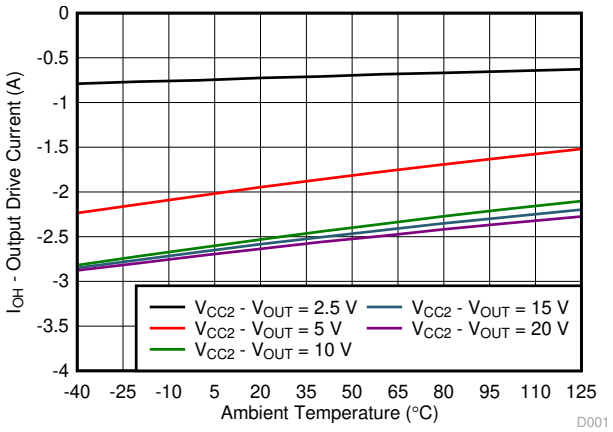


Figure 7-4. Output High Drive Current vs Temperature

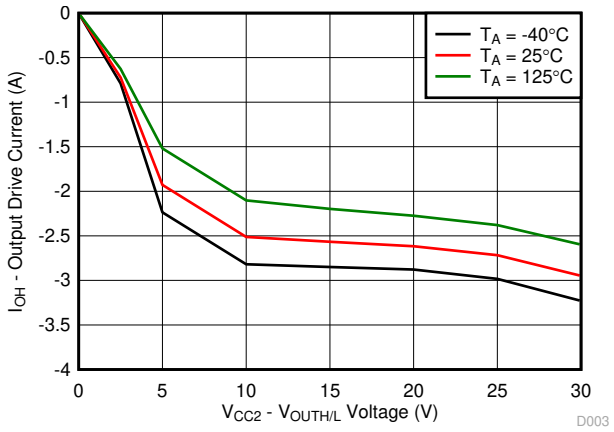


Figure 7-5. Output High Drive Current vs Output Voltage

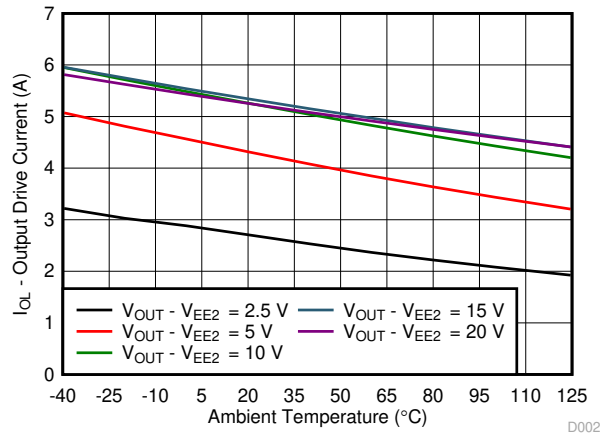


Figure 7-6. Output Low Drive Current vs Temperature

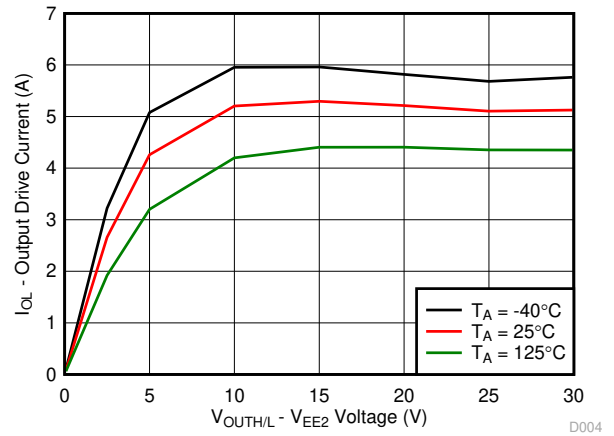
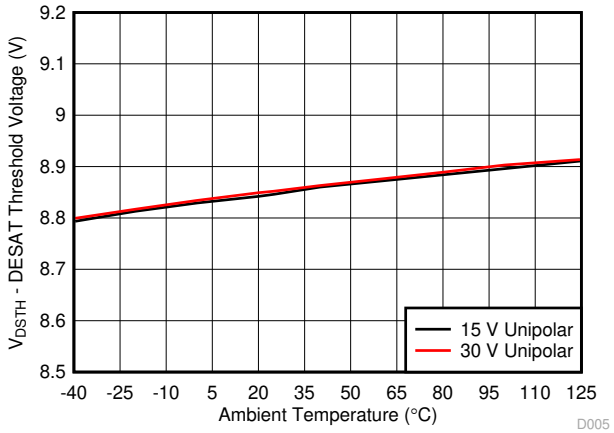


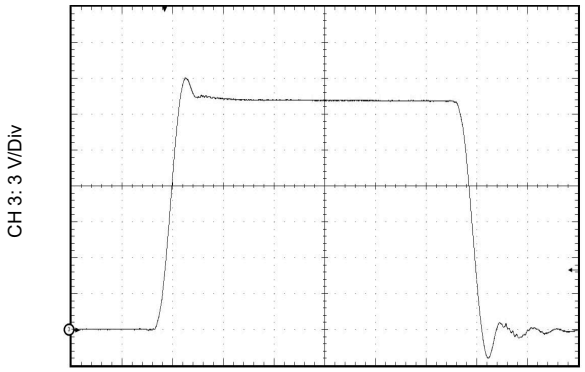
Figure 7-7. Output Low Drive Current vs Output Voltage



Unipolar: $V_{CC2} – V_{EE2} = V_{CC2} – GND2$

Figure 7-8. DESAT Threshold Voltage vs Temperature

7.12 Typical Characteristics (continued)

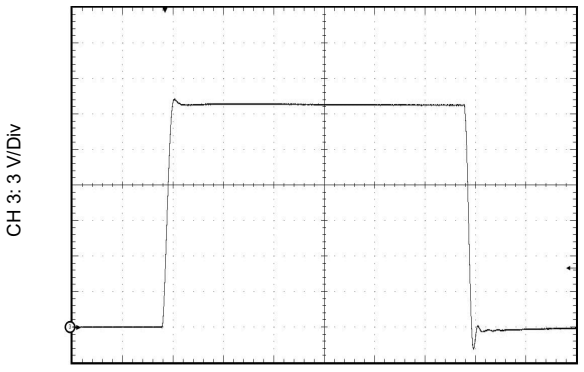


50 ns / Div

C_L = 1 nF R_{GH} = 0 Ω R_{GL} = 0 Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

Figure 7-9. Output Transient Waveform

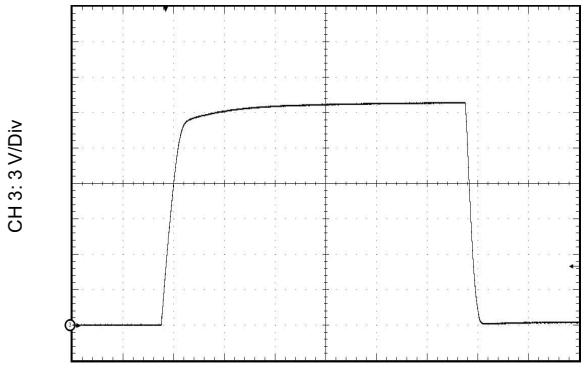


500 ns / Div

C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

Figure 7-10. Output Transient Waveform

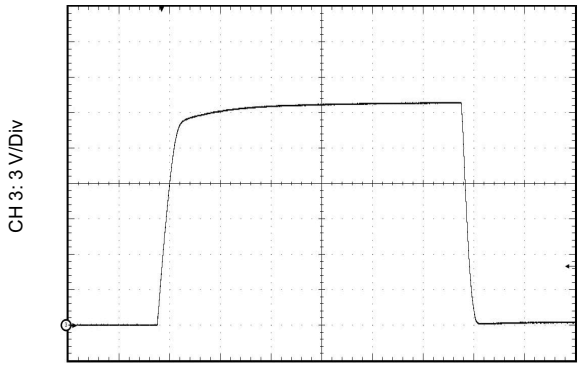


2 µs / Div

C_L = 100 nF R_{GH} = 0 Ω R_{GL} = 0 Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

Figure 7-11. Output Transient Waveform

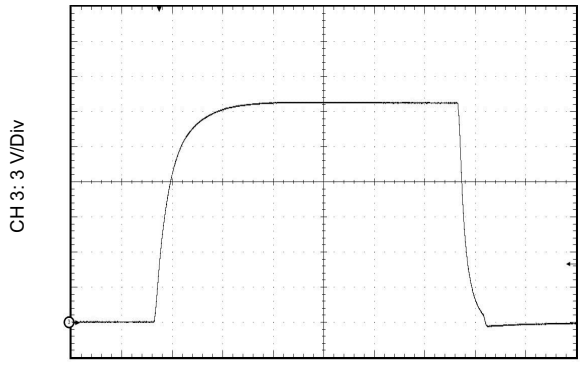


50 ns / Div

C_L = 1 nF R_{GH} = 10 Ω R_{GL} = 5Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

Figure 7-12. Output Transient Waveform

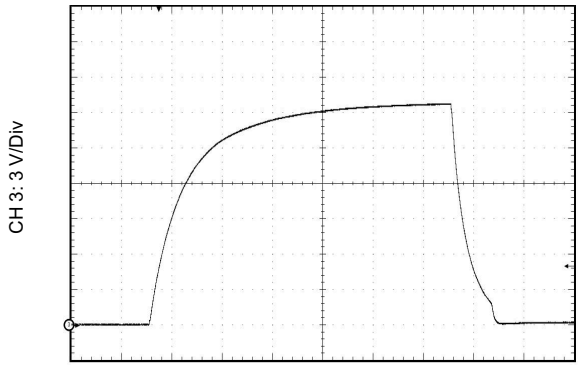


500 ns / Div

C_L = 10 nF R_{GH} = 10 Ω R_{GL} = 5Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

Figure 7-13. Output Transient Waveform



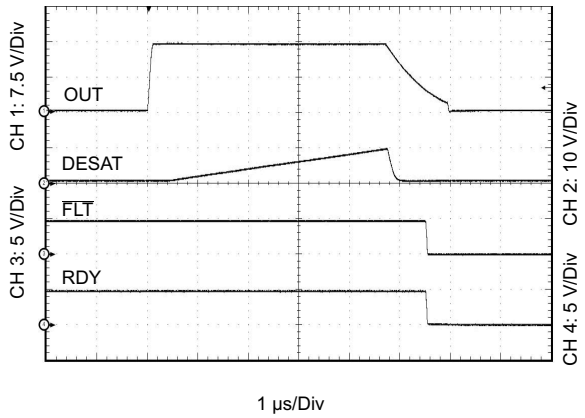
2 µs / Div

C_L = 100 nF R_{GH} = 10 Ω R_{GL} = 5Ω

$V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20$ V

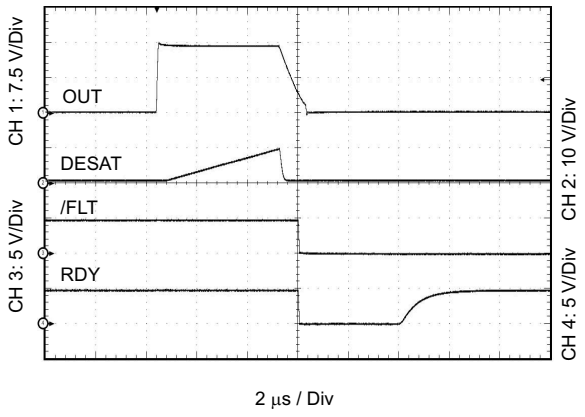
Figure 7-14. Output Transient Waveform

7.12 Typical Characteristics (continued)



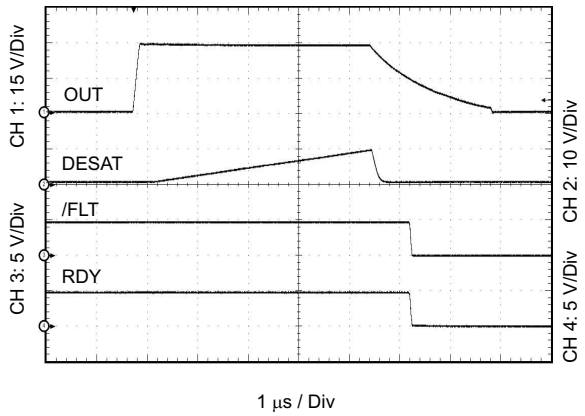
C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
$V_{CC2} – V_{EE2} = V_{CC2} – GND2$ = 15 V DESAT = 220pF

Figure 7-15. Output Transient Waveform DESAT, RDY and $\overline{FLT}$



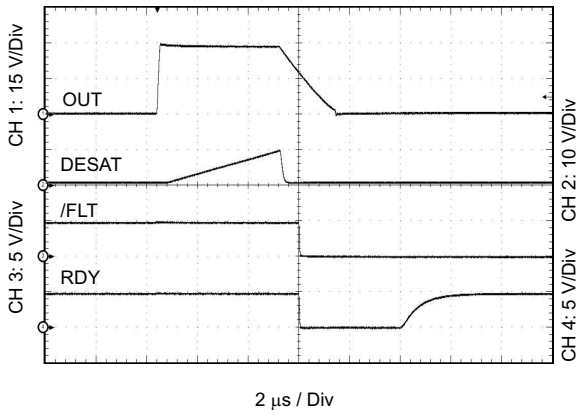
C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
$V_{CC2} – V_{EE2} = V_{CC2} – GND2$ = 15 V DESAT = 220pF

Figure 7-16. Output Transient Waveform DESAT, RDY and $\overline{FLT}$



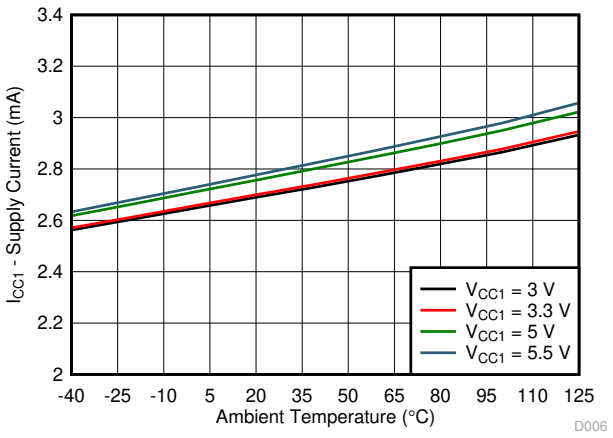
C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
$V_{CC2} – V_{EE2} = V_{CC2} – GND2$ = 30 V DESAT = 220pF

Figure 7-17. Output Transient Waveform DESAT, RDY and $\overline{FLT}$



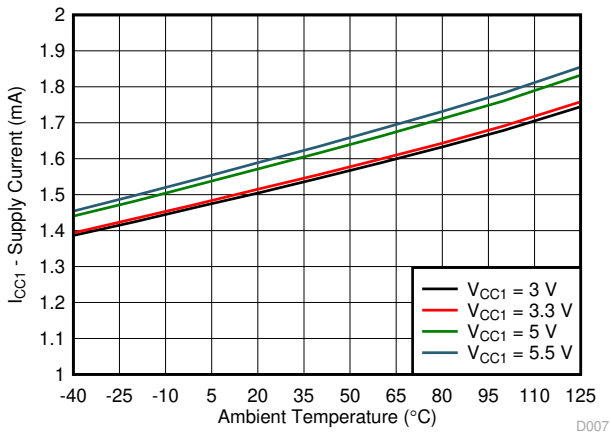
C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
$V_{CC2} – V_{EE2} = V_{CC2} – GND2$ = 30 V DESAT = 220pF

Figure 7-18. Output Transient Waveform DESAT, RDY and $\overline{FLT}$



IN+ = High IN– = Low

Figure 7-19. I_{CC1} Supply Current vs Temperature



IN+ = Low IN– = Low

Figure 7-20. I_{CC1} Supply Current vs Temperature

7.12 Typical Characteristics (continued)

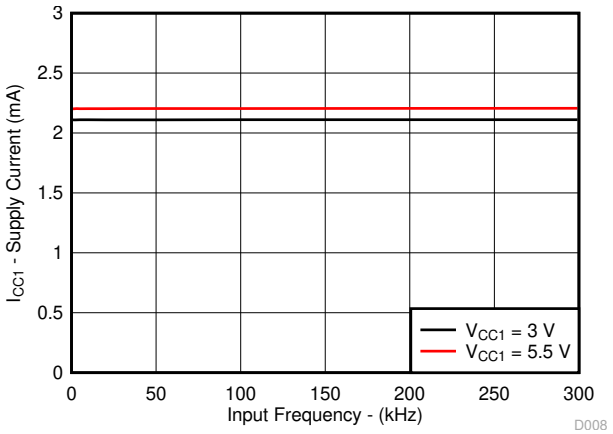
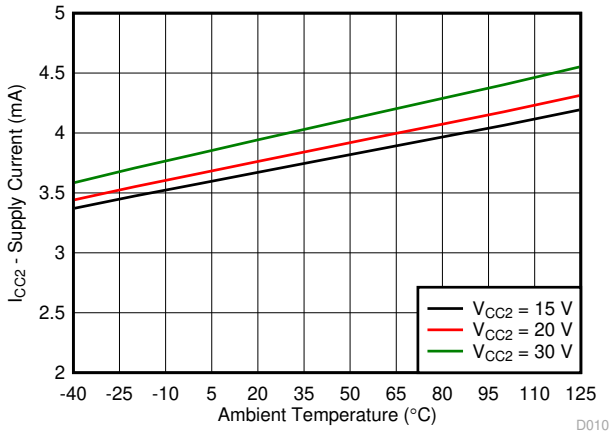
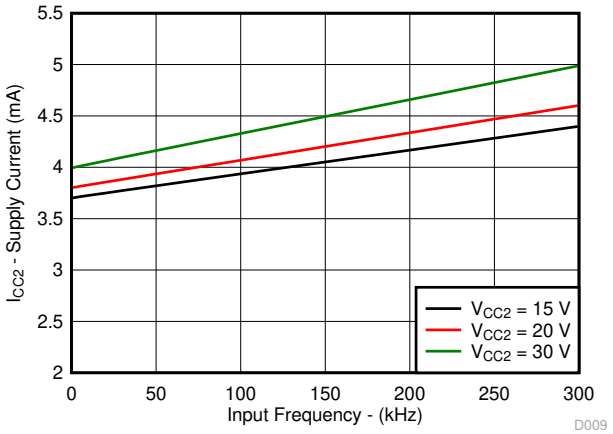


Figure 7-21. I_{CC1} Supply Current vs Input Frequency



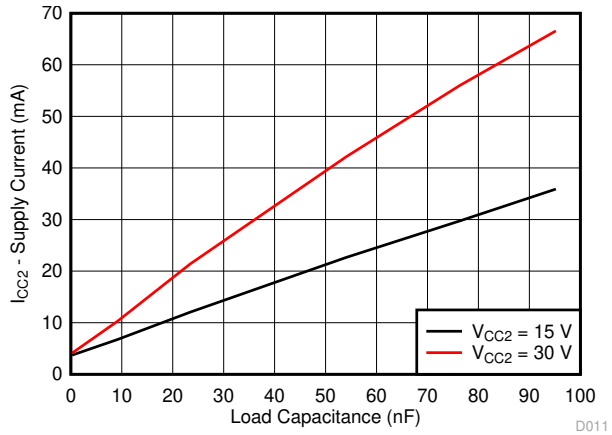
Input frequency = 1 kHz

Figure 7-22. I_{CC2} Supply Current vs Temperature



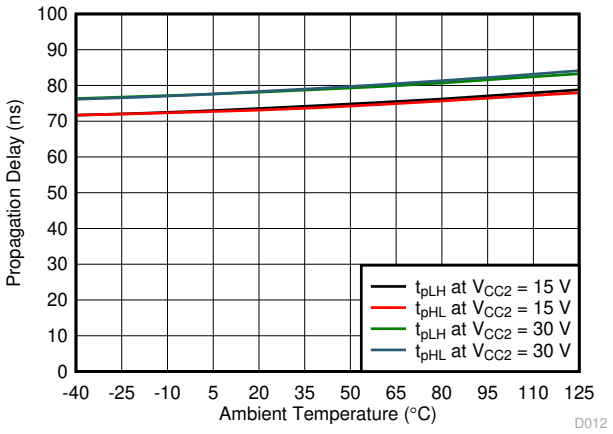
No C_L

Figure 7-23. I_{CC2} Supply Current vs Input Frequency



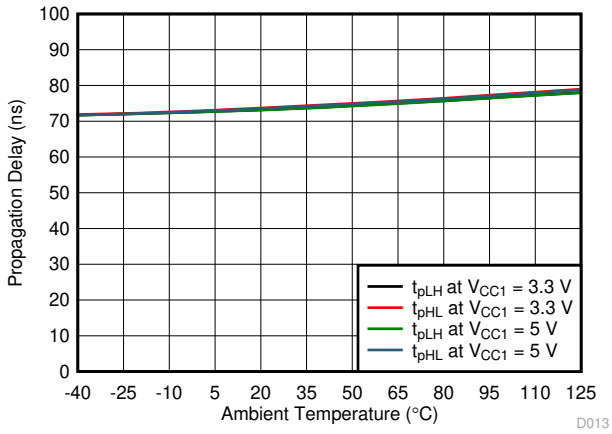
R_{GH} = 10 Ω R_{GL} = 5 Ω, 20 kHz

Figure 7-24. I_{CC2} Supply Current vs Load Capacitance



C_L = 1 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
V_{CC1} = 5 V

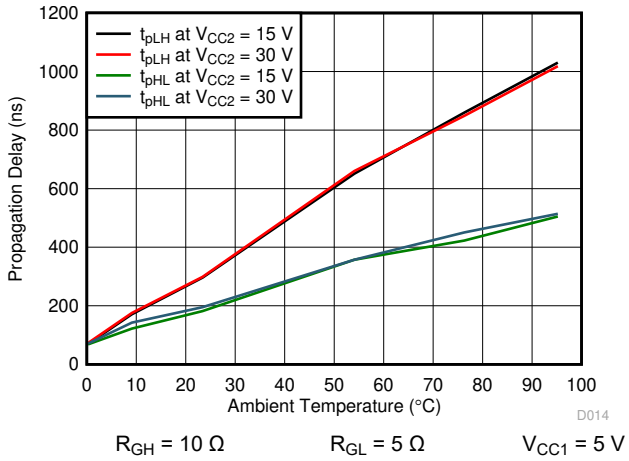
Figure 7-25. Propagation Delay vs Temperature



C_L = 1 nF R_{GH} = 0 Ω R_{GL} = 0 Ω
V_{CC2} = 15 V

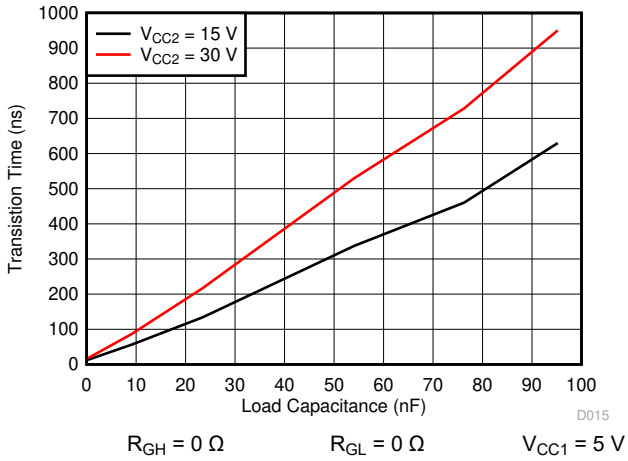
Figure 7-26. Propagation Delay vs Temperature

7.12 Typical Characteristics (continued)



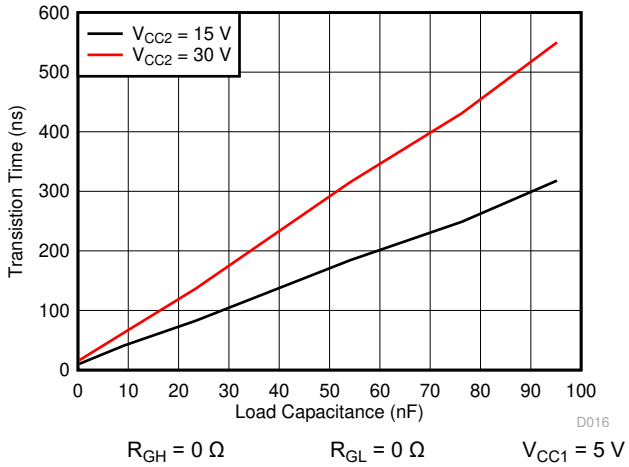
R_{GH} = 10 Ω R_{GL} = 5 Ω V_{CC1} = 5 V

Figure 7-27. Propagation Delay vs Load Capacitance



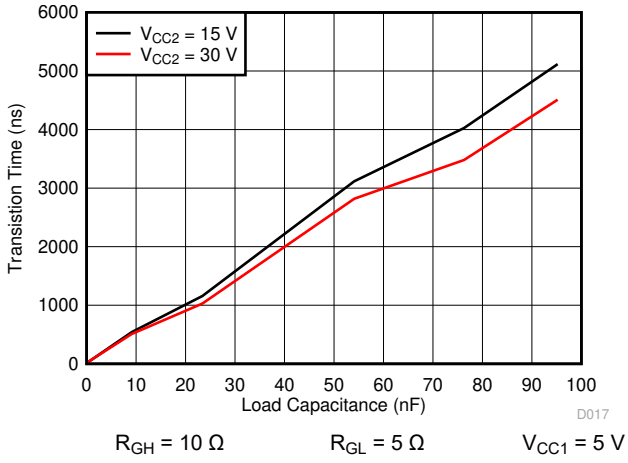
R_{GH} = 0 Ω R_{GL} = 0 Ω V_{CC1} = 5 V

Figure 7-28. t_r Rise Time vs Load Capacitance



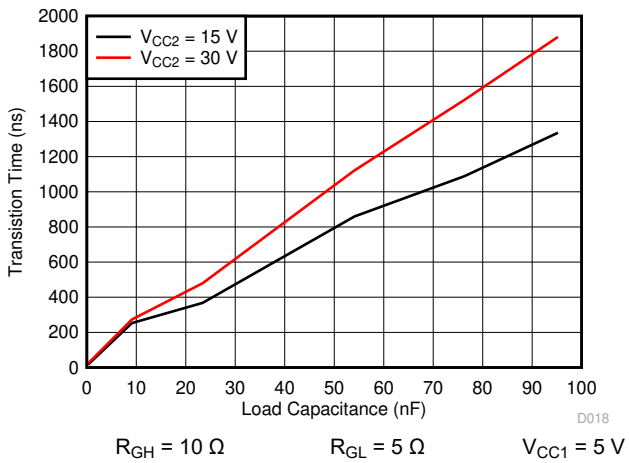
R_{GH} = 0 Ω R_{GL} = 0 Ω V_{CC1} = 5 V

Figure 7-29. t_f Fall Time v. Load Capacitance



R_{GH} = 10 Ω R_{GL} = 5 Ω V_{CC1} = 5 V

Figure 7-30. t_r Rise Time vs Load Capacitance



R_{GH} = 10 Ω R_{GL} = 5 Ω V_{CC1} = 5 V

Figure 7-31. t_f Fall Time vs Load Capacitance

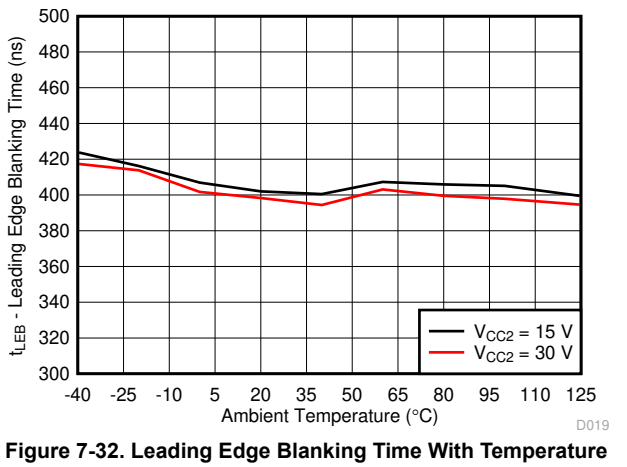
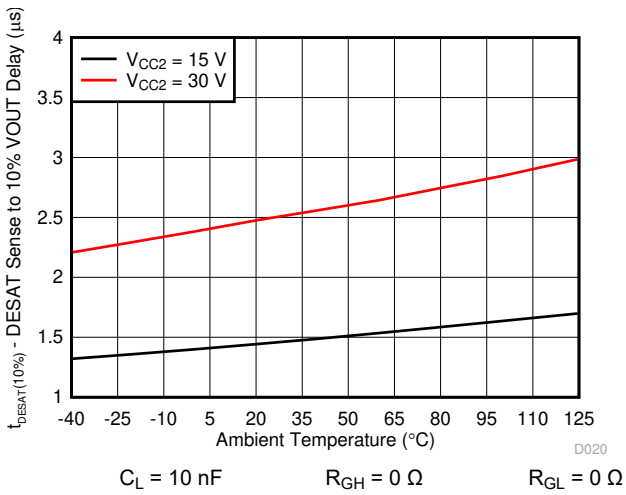


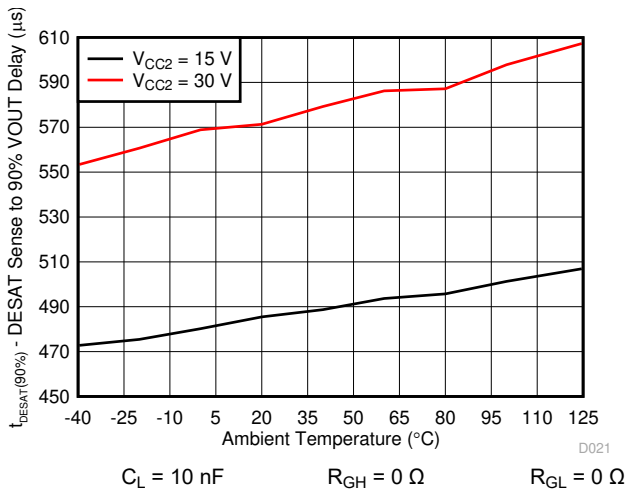
Figure 7-32. Leading Edge Blanking Time With Temperature

7.12 Typical Characteristics (continued)



C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω

Figure 7-33. DESAT Sense to $V_{OUTH/L}$ 10% Delay vs Temperature



C_L = 10 nF R_{GH} = 0 Ω R_{GL} = 0 Ω

Figure 7-34. DESAT Sense to $V_{OUTH/L}$ 90% Delay vs Temperature

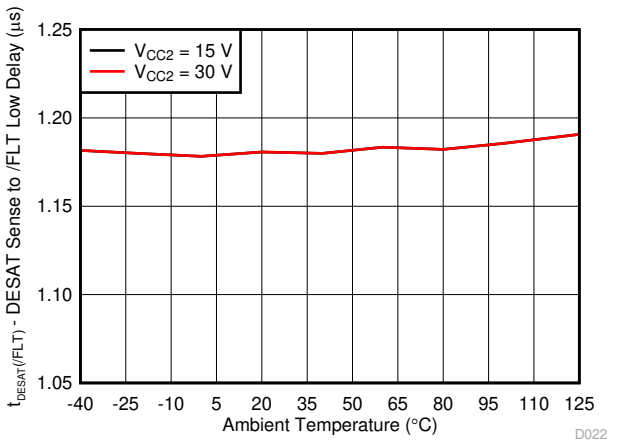


Figure 7-35. DESAT Sense to Fault Low Delay vs Temperature

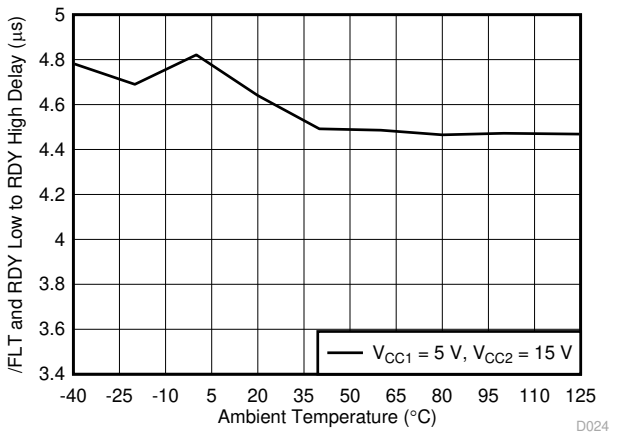


Figure 7-36. Fault and RDY Low to RDY High Delay vs Temperature

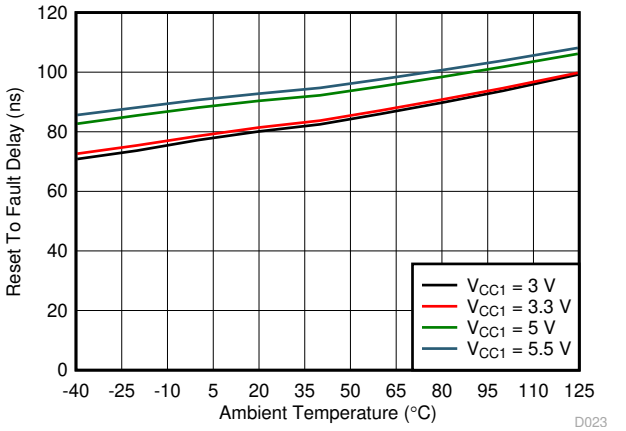


Figure 7-37. Reset to Fault Delay Across Temperature

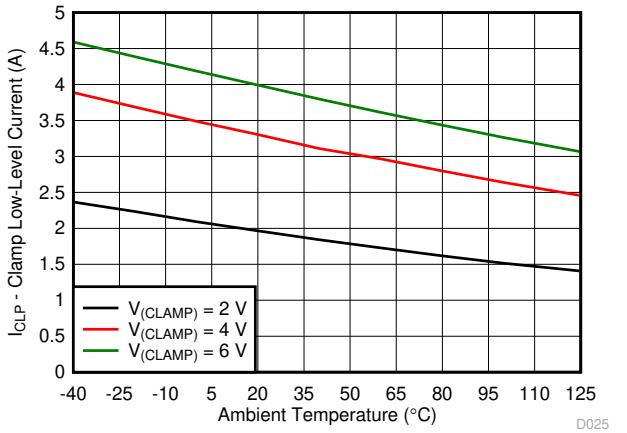


Figure 7-38. Miller Clamp Current vs Temperature

7.12 Typical Characteristics (continued)

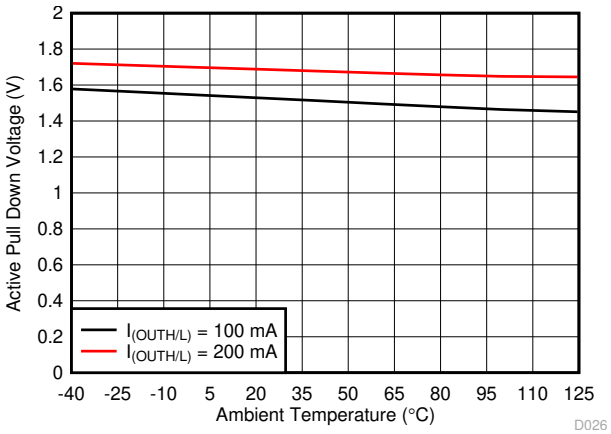


Figure 7-39. Active Pull Down Voltage vs Temperature

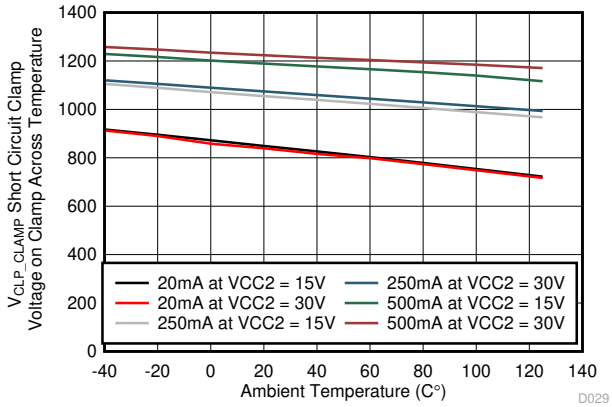


Figure 7-40. V_{CLP_CLAMP} - Short Circuit Clamp Voltage on Clamp Across Temperature

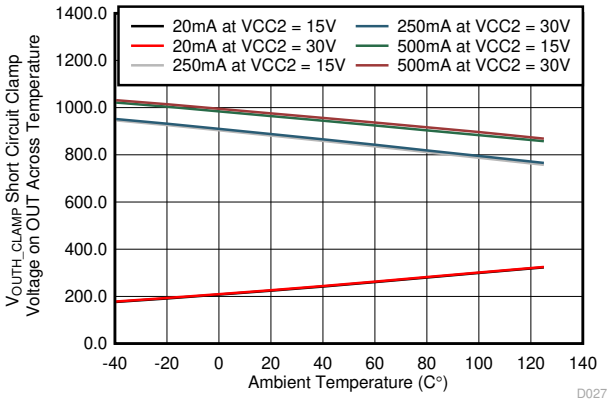


Figure 7-41. V_{OUTH_CLAMP} - Short Circuit Clamp Voltage on OUTH Across Temperature

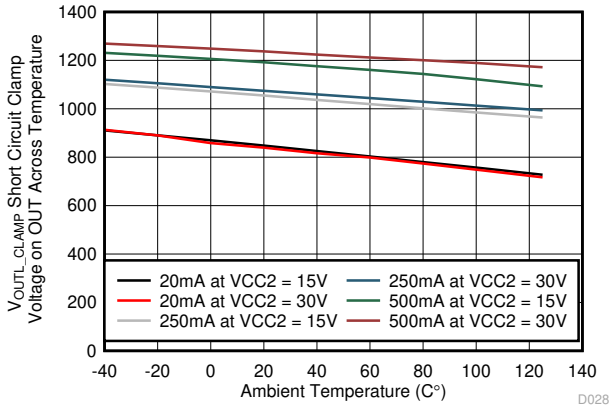
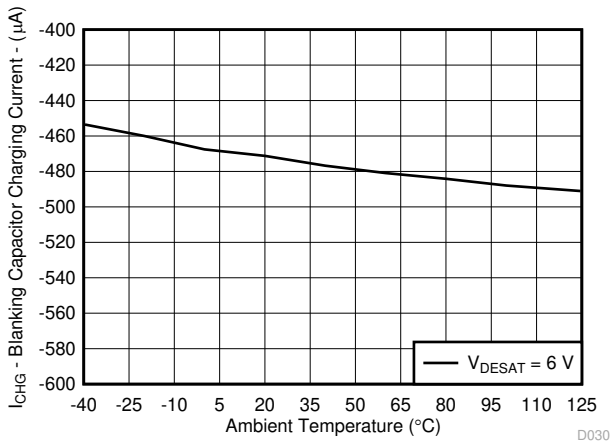


Figure 7-42. V_{OUTL_CLAMP} - Short Circuit Clamp Voltage on OUTL Across Temperature



V_{CC2} = 15 V DESAT = 6 V

Figure 7-43. Blanking Capacitor Charging Current vs Temperature

8 Parameter Measurement Information

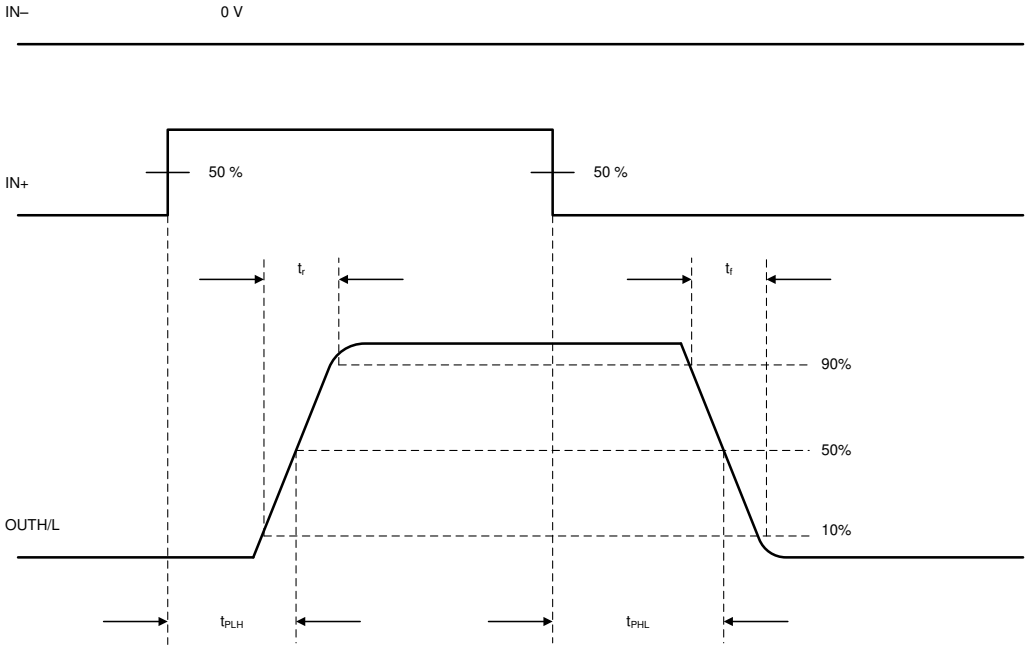


Figure 8-1. OUTH and OUTL Propagation Delay, Noninverting Configuration

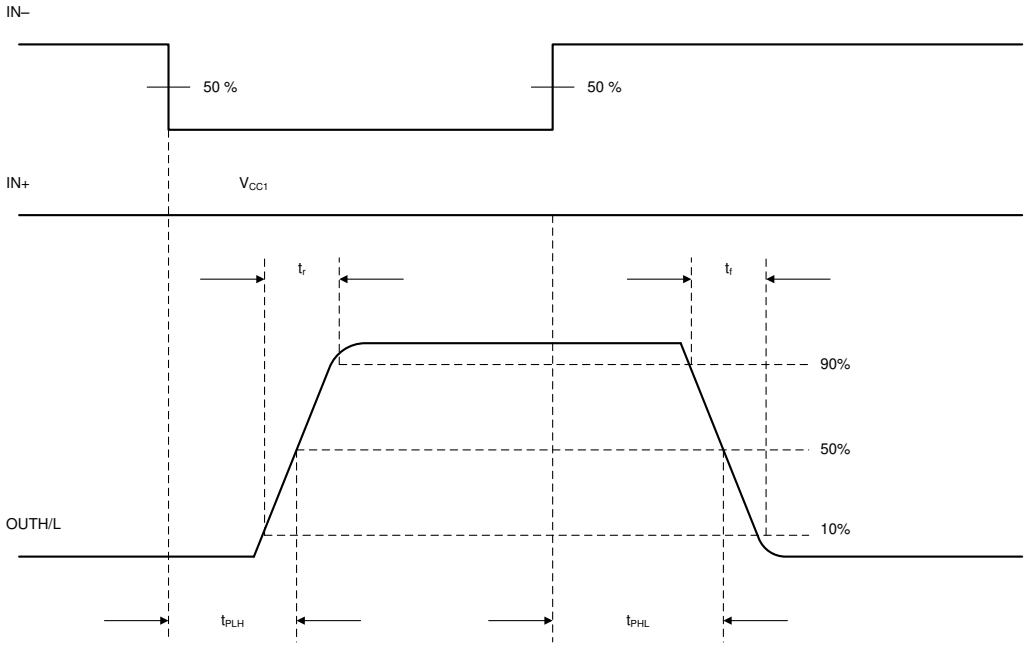


Figure 8-2. OUTH and OUTL Propagation Delay, Inverting Configuration

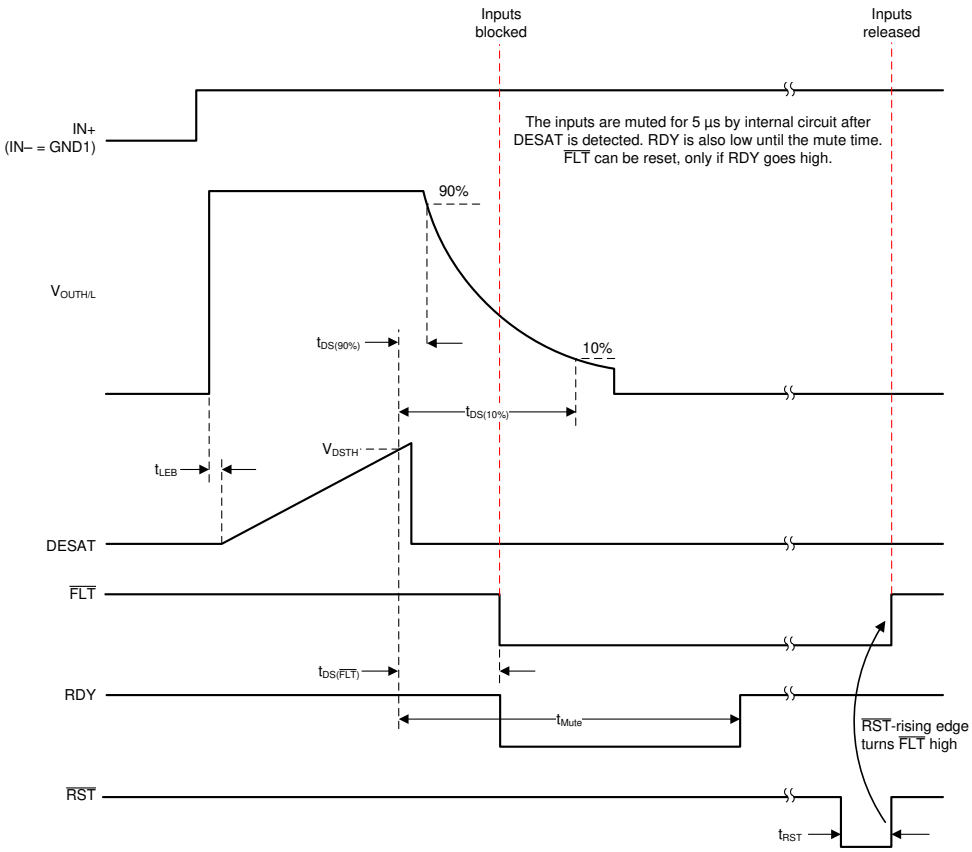


Figure 8-3. DESAT, OUTH, OUTL, FLT, RST Delay

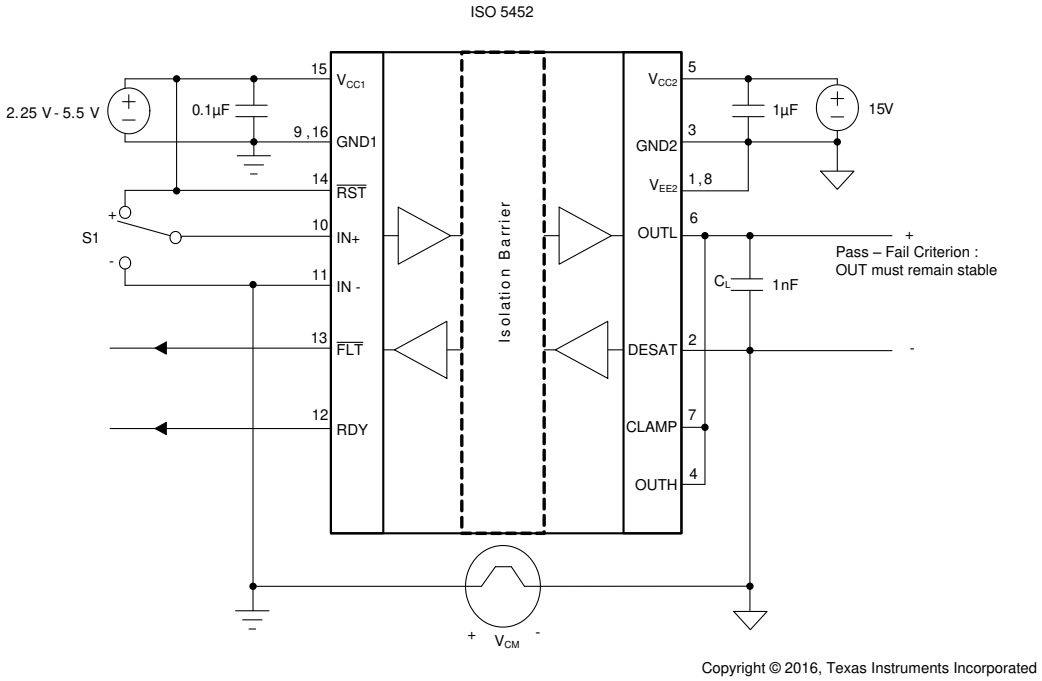


Figure 8-4. Common-Mode Transient Immunity Test Circuit

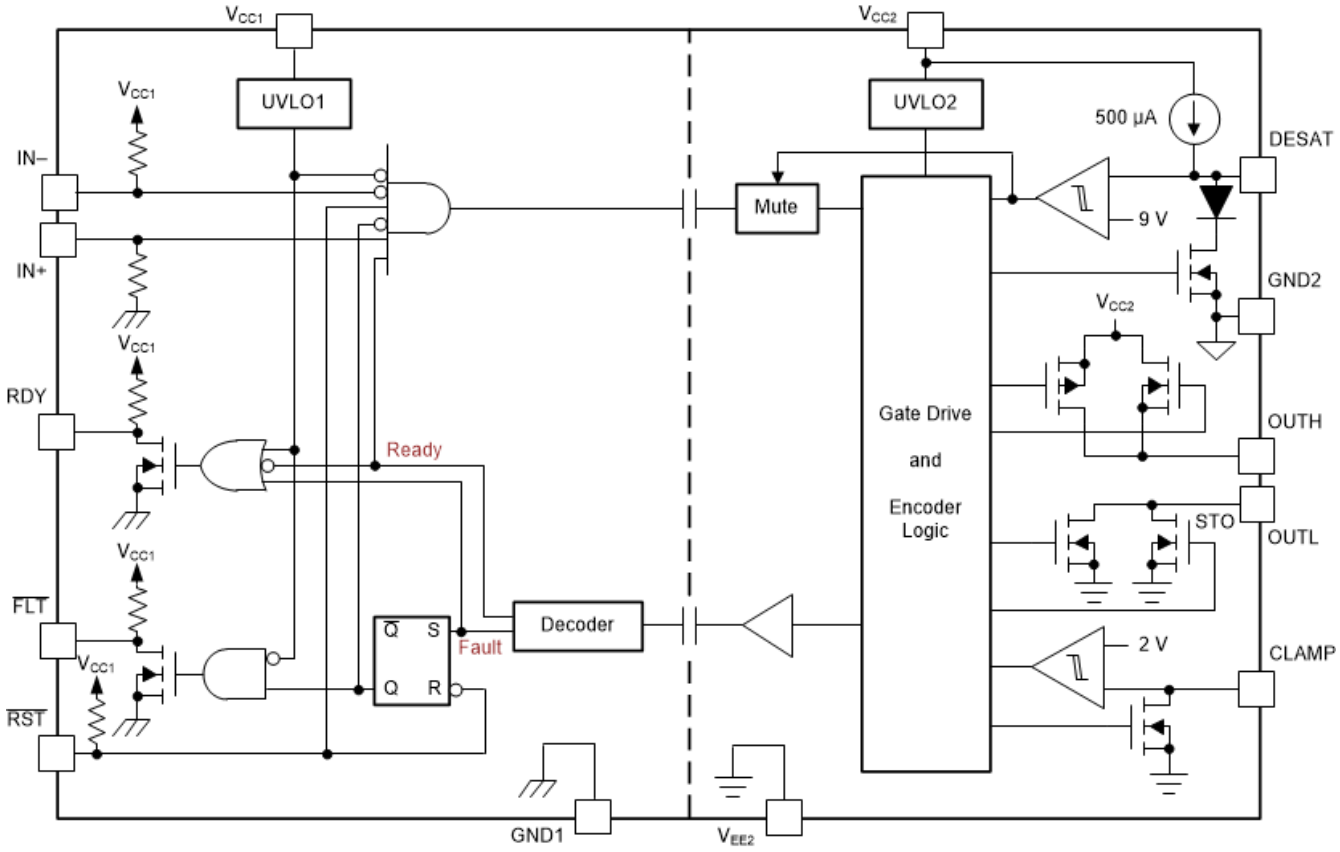
9 Detailed Description

9.1 Overview

The ISO5452 device is an isolated gate driver for IGBTs and MOSFETs. Input CMOS logic and output power stage are separated by a Silicon dioxide (SiO_2) capacitive isolation.

The IO circuitry on the input side interfaces with a microcontroller and consists of gate-drive control and RESET ($\overline{RST}$) inputs, READY (RDY) and FAULT ($\overline{FLT}$) alarm outputs. The power stage consists of power transistors to supply 2.5-A pullup and 5-A pulldown currents to drive the capacitive load of the external power transistors, as well as DESAT detection circuitry to monitor IGBT collector-emitter overvoltage under short-circuit events. The capacitive isolation core consists of transmit circuitry to couple signals across the capacitive isolation barrier, and receive circuitry to convert the resulting low-swing signals into CMOS levels. The ISO5452 device also has undervoltage lockout circuitry to prevent insufficient gate drive to the external IGBT, and active output pulldown feature which ensures that the gate-driver output is held low, if the output supply voltage is absent. The ISO5452 device also has an active Miller clamp function which can be used to prevent parasitic turnon of the external power transistor, because of Miller effect, for unipolar supply operation.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 Supply and Active Miller Clamp

The ISO5452 device supports both bipolar and unipolar power supply with active Miller clamp.

For operation with bipolar supplies, the IGBT is turned off with a negative voltage on the gate with respect to the emitter. This prevents the IGBT from unintentionally turning on because of current induced from the collector to the gate because Miller effect. In this condition connecting the CLAMP output of the gate driver to the IGBT gate is not necessary, but connecting the CLAMP output of the gate driver to the IGBT gate is also not an issue. Typical values of V_{CC2} and V_{EE2} for bipolar operation are 15 V and –8 V with respect to GND2.

For operation with unipolar supply, typically, V_{CC2} is connected to 15 V with respect to GND2, and V_{EE2} is connected to GND2. In this use case, the IGBT can turn on because of additional charge from IGBT Miller capacitance caused by a high-voltage slew-rate transition on the IGBT collector. To prevent IGBT from turning on, the CLAMP pin is connected to IGBT gate and Miller current is sinked through a low-impedance CLAMP transistor.

Miller CLAMP is designed for miller current up to 2 A. When the IGBT is turned off and the gate voltage transitions below 2 V and the CLAMP current output is activated.

9.3.2 Active Output Pull-down

The active output pulldown feature ensures that the IGBT gate OUTH/L is clamped to V_{EE2} to ensure safe IGBT off-state, when the output side is not connected to the power supply.

9.3.3 Undervoltage Lockout (UVLO) with Ready (RDY) Pin Indication Output

Undervoltage lockout (UVLO) ensures correct switching of IGBT. The IGBT is turned off, if the supply V_{CC1} drops below $V_{IT-(UVLO1)}$, irrespective of IN+, IN– and RST input until V_{CC1} goes above $V_{IT+(UVLO1)}$.

In similar manner, the IGBT is turned off if the supply V_{CC2} drops below $V_{IT-(UVLO2)}$, irrespective of IN+, IN– and RST input till V_{CC2} goes above $V_{IT+(UVLO2)}$.

The RDY pin indicates status of input and output side UVLO internal protection feature. If either side of device have insufficient supply (V_{CC1} or V_{CC2}), the RDY pin output goes low; otherwise, RDY pin output is high. The RDY pin also serves as an indication to the micro-controller that the device is ready for operation.

9.3.4 Soft Turn-Off, Fault ($\overline{\text{FLT}}$) and Reset ($\overline{\text{RST}}$)

During IGBT overcurrent condition, a mute logic initiates a soft-turn-off procedure which disables OUTH and pulls OUTL to low over a time span of 2 µs. When desaturation is active, a fault signal is sent across the isolation barrier pulling the $\overline{\text{FLT}}$ output at the input side low and blocking the isolator input. Mute logic is activated through the soft-turn-off period. The $\overline{\text{FLT}}$ output condition is latched and can be reset only after RDY goes high, through a low-active pulse at the $\overline{\text{RST}}$ input. $\overline{\text{RST}}$ has an internal filter to reject noise and glitches. By asserting $\overline{\text{RST}}$ for at least the specified minimum duration (800ns), device input logic can be enabled or disabled.

9.3.5 Short Circuit Clamp

Under short-circuit events currents can be induced back into the gate-driver OUTH/L and CLAMP pins because of parasitic Miller capacitance between the IGBT collector and gate terminals. Internal protection diodes on OUTH/L and CLAMP help to sink these currents while clamping the voltages on these pins to values slightly higher than the output side supply.

9.4 Device Functional Modes

For OUTH/L of the ISO5452 device to follow IN+ in normal functional mode, the $\overline{RST}$ and RDY pins must be in the high state. Table 9-1 lists the device functional modes

Table 9-1. Function Table(1)

V_{CC1}	V_{CC2}	IN+	IN–	$\overline{RST}$	RDY	OUTH/L
PU	PD	X	X	X	Low	Low
PD	PU	X	X	X	Low	Low
PU	PU	X	X	Low	High	Low
PU	Open	X	X	X	Low	Low
PU	PU	Low	X	X	High	Low
PU	PU	X	High	X	High	Low
PU	PU	High	Low	High	High	High

(1) PU: Power Up (V_{CC1} ≥ 2.25-V, V_{CC2} ≥ 13-V), PD: Power Down (V_{CC1} ≤ 1.7-V, V_{CC2} ≤ 9.5-V), X: Irrelevant

10 Application and Implementation

Note

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

10.1 Application Information

The ISO5452 device is an isolated gate driver for power semiconductor devices such as IGBTs and MOSFETs. The device is intended for use in applications such as motor control, industrial inverters, and switched mode power supplies. In these applications, sophisticated PWM control signals are required to turn the power devices on and off, which at the system level eventually may determine, for example, the speed, position, and torque of the motor or the output voltage, frequency and phase of the inverter. These control signals are usually the outputs of a micro controller, and are at low voltage levels such as 2.5 V, 3.3 V or 5 V. The gate controls required by the MOSFETs and IGBTs, on the other hand, are in the range of 30 V (using unipolar output supply) to 15 V (using bipolar output supply), and require high current capability to be able to drive the large capacitive loads offered by those power transistors. Not only that, the gate drive must be applied with reference to the emitter of the IGBT (Source for MOSFET), and by construction, the emitter node in a gate drive system may swing between 0 to the DC bus voltage, that can be several 100s of volts in magnitude.

The ISO5452 device is therefore used to level shift the incoming 2.5-V, 3.3-V and 5-V control signals from the microcontroller to the 30 V (using unipolar output supply) to 15 V (using bipolar output supply) drive required by the power transistors while ensuring high-voltage isolation between the driver side and the microcontroller side.

10.2 Typical Applications

Figure 10-1 shows the typical application of a three-phase inverter using six ISO5452 isolated gate drivers. Three-phase inverters are used for variable-frequency drives to control the operating speed and torque of AC motors and for high power applications such as high-voltage DC (HVDC) power transmission.

The basic three-phase inverter consists of six power switches, and each switch is driven by one SO5452. The switches are driven on and off at high switching frequency with specific patterns to convert DC bus voltage to three-phase AC voltages.

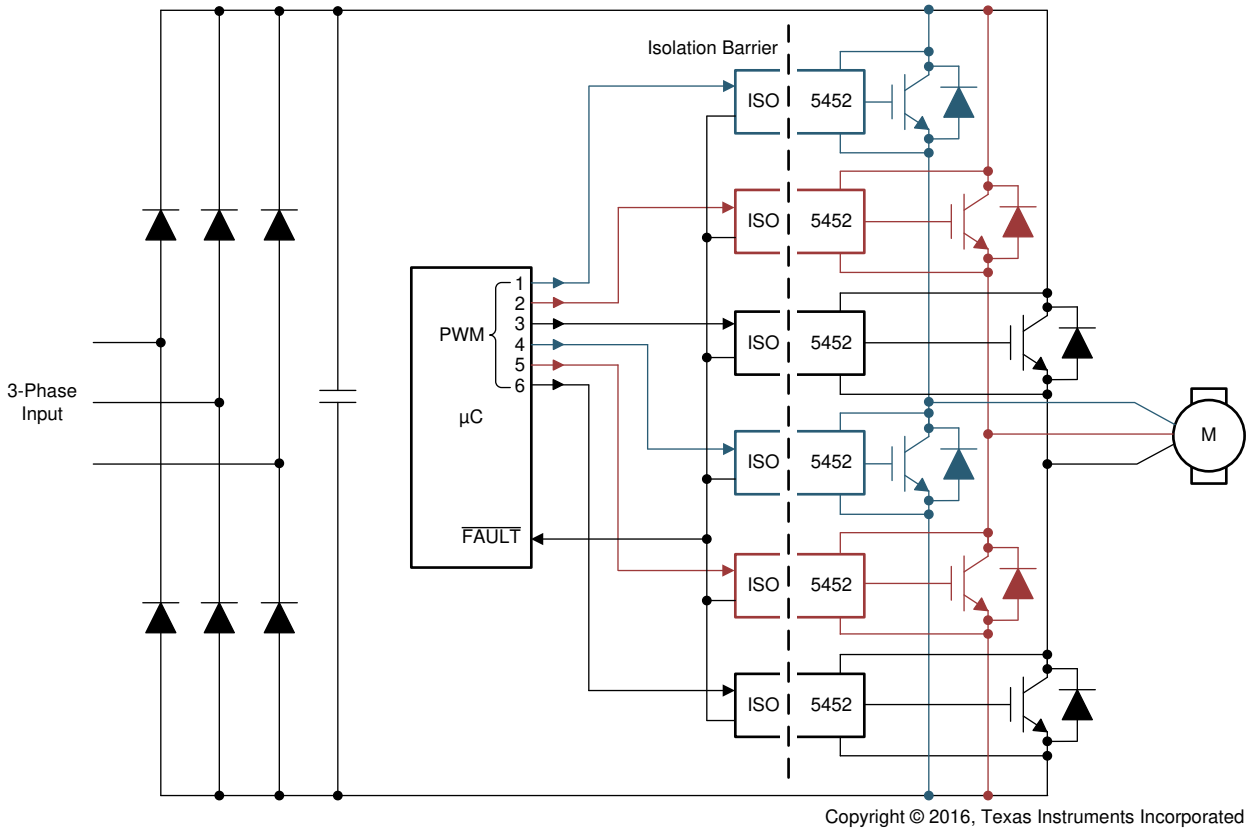


Figure 10-1. Typical Motor Drive Application

10.2.1 Design Requirements

Unlike optocoupler-based gate drivers which require external current drivers and biasing circuitry to provide the input control signals, the input control to the ISO5452 device is CMOS and can be directly driven by the microcontroller. Other design requirements include decoupling capacitors on the input and output supplies, a pullup resistor on the common drain $\overline{FLT}$ output signal, and a high-voltage protection diode between the IGBT collector and the DESAT input. Further details are explained in the subsequent sections. Table 10-1 shows the allowed range for input and output supply voltage, and the typical current output available from the gate-driver.

Table 10-1. Design Parameters

PARAMETER	VALUE
Input supply voltage	2.25 V to 5.5 V
Unipolar output supply voltage (V_{CC2} – GND2 = V_{CC2} – V_{EE2})	15 V to 30 V
Bipolar output supply voltage (V_{CC2} – V_{EE2})	15 V to 30 V
Bipolar output supply voltage (GND2 – V_{EE2})	0 V to 15 V
Output current	2.5 A

10.2.2 Detailed Design Procedure

10.2.2.1 Recommended ISO5452 Application Circuit

The ISO5452 has both, inverting and non-inverting gate control inputs, an active low reset input, and an open-drain fault output suitable for wired-OR applications. The recommended application circuit in Figure 10-2 shows a typical gate driver implementation with unipolar output supply and Figure 10-3 shows a typical gate driver implementation with bipolar output supply using the ISO5452 device.

A 0.1-µF bypass capacitor, recommended at input supply pin V_{CC1} and 1-µF bypass capacitor, recommended at output supply pin V_{CC2}, provide the large transient currents necessary during a switching transition to ensure

reliable operation. The 220-pF blanking capacitor disables DESAT detection during the off-to-on transition of the power device. The DESAT diode (D_{DST}) and the 1-kΩ series resistor are external protection components. The R_G gate resistor limits the gate charge current and indirectly controls the IGBT collector voltage rise and fall times. The open-drain $\overline{FLT}$ output and RDY output has a passive 10-kΩ pullup resistor. In this application, the IGBT gate driver is disabled when a fault is detected and will not resume switching until the microcontroller applies a reset signal.

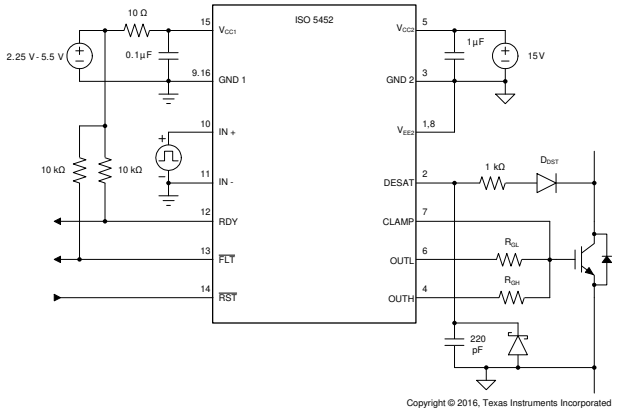


Figure 10-2. Unipolar Output Supply

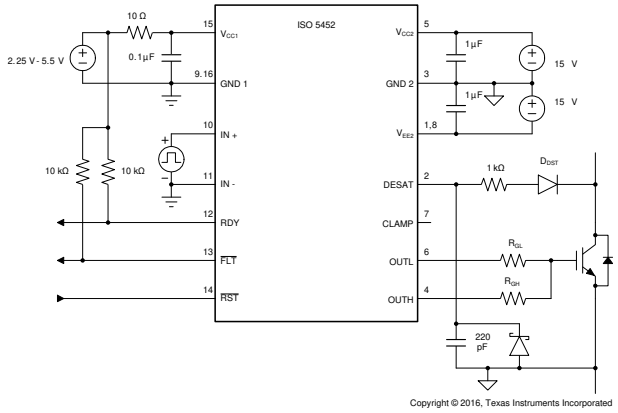


Figure 10-3. Bipolar Output Supply

10.2.2.2 $\overline{FLT}$ and RDY Pin Circuitry

A 50-kΩ pullup resistor is internally connected on the $\overline{FLT}$ and RDY pins. The $\overline{FLT}$ and RDY pins are an open-drain output. A 10-kΩ pullup resistor can be used to make it faster rise and to provide logic high when $\overline{FLT}$ and RDY is inactive, as shown in Figure 10-4.

Fast common mode transients can inject noise and glitches on $\overline{FLT}$ and RDY pins because of parasitic coupling. This is dependent on board layout. If required, additional capacitance (100 pF to 300 pF) can be included on the $\overline{FLT}$ and RDY pins.

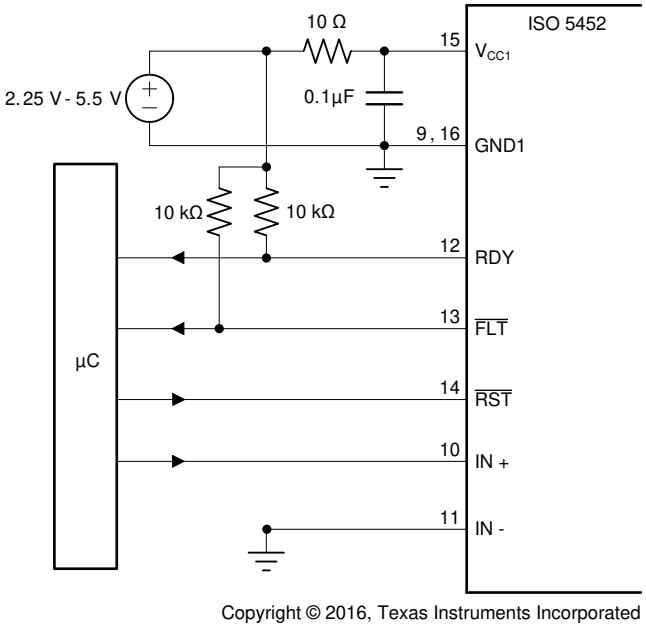


Figure 10-4. $\overline{FLT}$ and RDY Pin Circuitry for High CMTI

10.2.2.3 Driving the Control Inputs

The amount of common-mode transient immunity (CMTI) can be curtailed by the capacitive coupling from the high-voltage output circuit to the low-voltage input side of the ISO5452 device. For maximum CMTI performance, the digital control inputs, IN+ and IN–, must be actively driven by standard CMOS, push-pull drive circuits. This type of low-impedance signal source provides active drive signals that prevent unwanted switching of the ISO5452 output under extreme common-mode transient conditions. Passive drive circuits, such as open-drain configurations using pullup resistors, must be avoided. A 20-ns glitch filter can filter a glitch up to 20 ns on IN+ or IN–.

10.2.2.4 Local Shutdown and Reset

In applications with local shutdown and reset, the $\overline{FLT}$ output of each gate driver is polled separately, and the individual reset lines are asserted low independently to reset the motor controller after a fault condition.

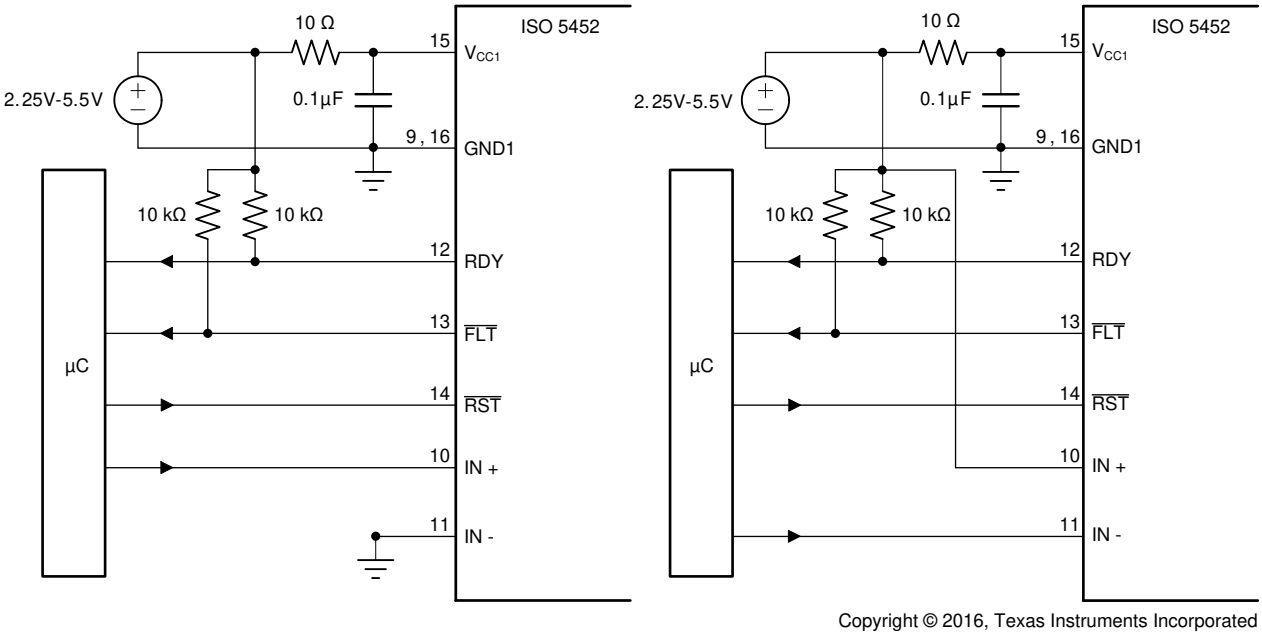


Figure 10-5. Local Shutdown and Reset for Noninverting (left) and Inverting Input Configuration (right)

10.2.2.5 Global-Shutdown and Reset

When configured for inverting operation, the ISO5452 device can be configured to shutdown automatically in the event of a fault condition by tying the $\overline{FLT}$ output to IN+. For high reliability drives, the open drain $\overline{FLT}$ outputs of multiple ISO5452 devices can be wired together forming a single, common fault bus for interfacing directly to the micro-controller. When any of the six gate drivers of a three-phase inverter detects a fault, the active low $\overline{FLT}$ output disables all six gate drivers simultaneously.

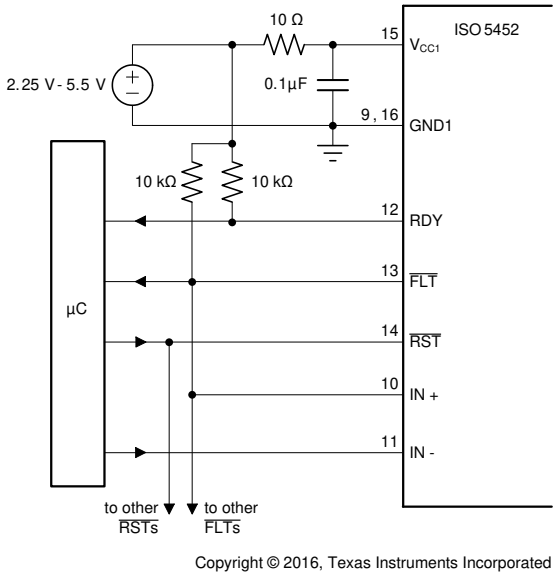


Figure 10-6. Global Shutdown With Inverting Input Configuration

10.2.2.6 Auto-Reset

In this case, the gate control signal at IN+ is also applied to the $\overline{RST}$ input to reset the fault latch every switching cycle. Incorrect $\overline{RST}$ makes output go low. A fault condition, however, the gate driver remains in the latched fault state until the gate control signal changes to the *gate low* state and resets the fault latch.

If the gate control signal is a continuous PWM signal, the fault latch will always be reset before IN+ goes high again. This configuration protects the IGBT on a cycle by cycle basis and automatically resets before the next *on* cycle.

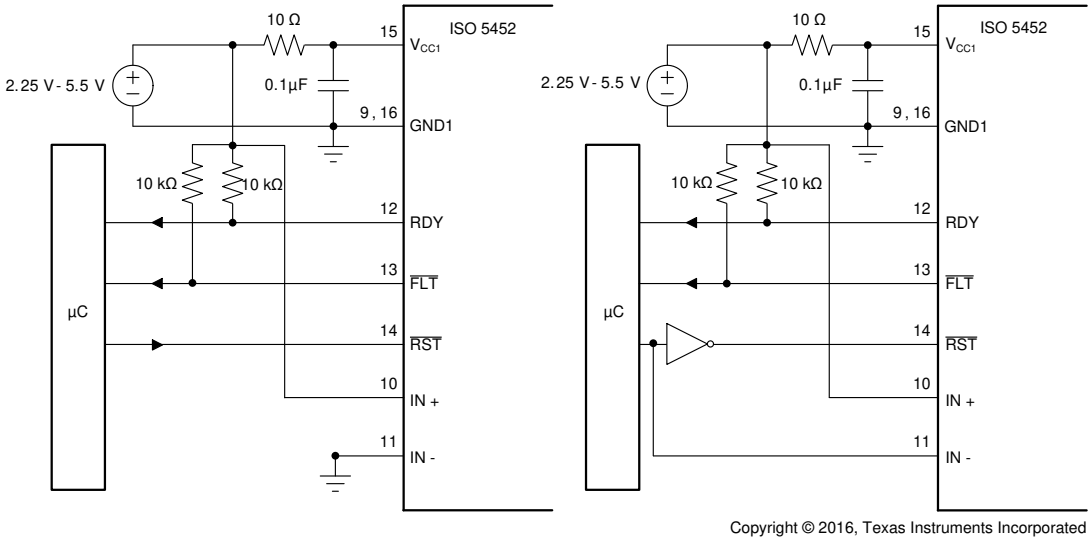


Figure 10-7. Auto Reset for Noninverting and Inverting Input Configuration

10.2.2.7 DESAT Pin Protection

Switching inductive loads causes large instantaneous forward voltage transients across the freewheeling diodes of IGBTs. These transients result in large negative voltage spikes on the DESAT pin which draw substantial current out of the device. To limit this current below damaging levels, a 100-Ω to 1-kΩ resistor is connected in series with the DESAT diode.

Further protection is possible through an optional Schottky diode, whose low forward voltage assures clamping of the DESAT input to GND2 potential at low voltage levels.

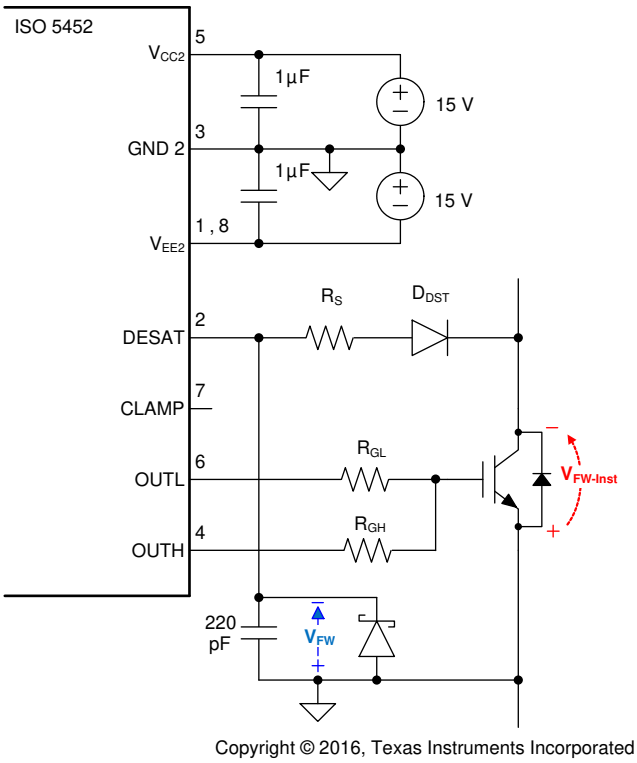


Figure 10-8. DESAT Pin Protection with Series Resistor and Schottky Diode

10.2.2.8 DESAT Diode and DESAT Threshold

The DESAT function of the diode is used to conduct forward current, allowing sensing of the saturated collector-to-emitter voltage of the IGBT, $V_{(DESAT)}$, (when the IGBT is on) and to block high voltages (when the IGBT is off). During the short transition time when the IGBT is switching, a commonly a high dV_{CE}/dt voltage ramp rate occurs across the IGBT. This results in a charging current $I_{CHARGE} = C_{(D\text{-}DESAT)} \times d_{VCE}/dt$, charging the blanking capacitor. $C_{(D\text{-}DESAT)}$ is the diode capacitance at DESAT.

To minimize this current and avoid false DESAT triggering, fast switching diodes with low capacitance are recommended. As the diode capacitance builds a voltage divider with the blanking capacitor, large collector voltage transients appear at DESAT attenuated by the ratio of $1+ C_{(BLANK)} / C_{(D\text{-}DESAT)}$.

Because the sum of the DESAT diode forward-voltage and the IGBT collector-emitter voltage make up the voltage at the DESAT-pin, $V_F + V_{CE} = V_{(DESAT)}$, the V_{CE} level, which triggers a fault condition, can be modified by adding multiple DESAT diodes in series as shown in Equation 1.

$$V_{CE\text{-}FAULT(TH)} = 9\ V - n \times V_F \quad (1)$$

where

- *n* is the number of DESAT diodes

When using two diodes instead of one, diodes with half the required maximum reverse-voltage rating may be chosen.

10.2.2.9 Determining the Maximum Available, Dynamic Output Power, P_{OD-max}

The ISO5452 maximum allowed total power consumption of P_D = 251 mW consists of the total input power, P_{ID}, the total output power, P_{OD}, and the output power under load, P_{OL}:

$$P_D = P_{ID} + P_{OD} + P_{OL} \tag{2}$$

With:

$$P_{ID} = V_{CC1\text{-}max} \times I_{CC1\text{-}max} = 5.5\ V \times 4.5\ mA = 24.75\ mW \tag{3}$$

and:

$$P_{OD} = (V_{CC2} - V_{EE2}) \times I_{CC2\text{-}max} = (15V - (-8V)) \times 6\ mA = 138\ mW \tag{4}$$

then:

$$P_{OL} = P_D - P_{ID} - P_{OD} = 251\ mW - 24.75\ mW - 138\ mW = 88.25\ mW \tag{5}$$

In comparison to P_{OL}, the actual dynamic output power under worst case condition, $P_{OL\text{-}WC}$, depends on a variety of parameters:

$$P_{OL\text{-}WC} = 0.5 \times f_{INP} \times Q_G \times \left(V_{CC2} - V_{EE2}\right) \times \left(\frac{r_{on\text{-}max}}{r_{on\text{-}max} + R_G} + \frac{r_{off\text{-}max}}{r_{off\text{-}max} + R_G}\right) \tag{6}$$

where

- f_{INP} = signal frequency at the control input IN+
- Q_G = power device gate charge
- V_{CC2} = positive output supply with respect to GND2
- V_{EE2} = negative output supply with respect to GND2
- $r_{on\text{-}max}$ = worst case output resistance in the on-state: 4 Ω
- $r_{off\text{-}max}$ = worst case output resistance in the off-state: 2.5 Ω
- R_G = gate resistor

When R_G is determined, Equation 6 is to be used to verify whether $P_{OL\text{-}WC} < P_{OL}$. Figure 10-9 shows a simplified output stage model for calculating $P_{OL\text{-}WC}$.

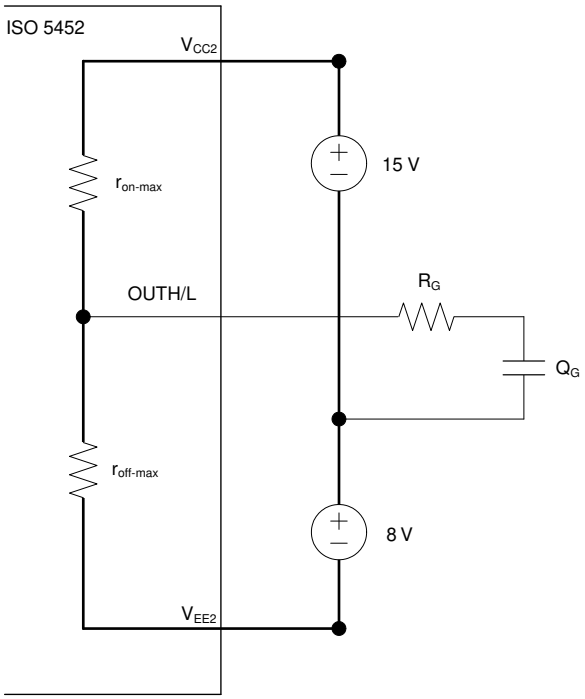


Figure 10-9. Simplified Output Model for Calculating P_{OL-WC}

10.2.2.10 Example

This examples considers an IGBT drive with the following parameters:

$$I_{ON-PK} = 2\ A,\ Q_G = 650\ nC,\ f_{INP} = 20\ kHz,\ V_{CC2} = 15V,\ V_{EE2} = -8\ V \tag{7}$$

Apply the value of the gate resistor $R_G = 10\ \Omega$.

Then, calculating the worst-case output power consumption as a function of R_G, using Equation 6 r_{on-max} = worst case output resistance in the on-state: 4 Ω, $r_{off-max}$ = worst case output resistance in the off-state: 2.5 Ω, R_G = gate resistor yields

$$P_{OL-WC} = 0.5 \times 20\ kHz \times 650\ nC \times (15\ V - (-8\ V)) \times \left(\frac{4\ \Omega}{4\ \Omega + 10\ \Omega} + \frac{2.5\ \Omega}{2.5\ \Omega + 10\ \Omega} \right) = 72.61\ mW \tag{8}$$

Because P_{OL-WC} = 72.61 mW is less than the calculated maximum of P_{OL} = 88.25 mW, the resistor value of R_G = 10 Ω is suitable for this application.

10.2.2.11 Higher Output Current Using an External Current Buffer

To increase the IGBT gate drive current, a non-inverting current buffer (such as the npn/pnp buffer shown in Figure 10-10) may be used. Inverting types are not compatible with the desaturation fault protection circuitry and must be avoided. The MJD44H11/MJD45H11 pair is appropriate for currents up to 8 A, the D44VH10/ D45VH10 pair for up to 15 A maximum.

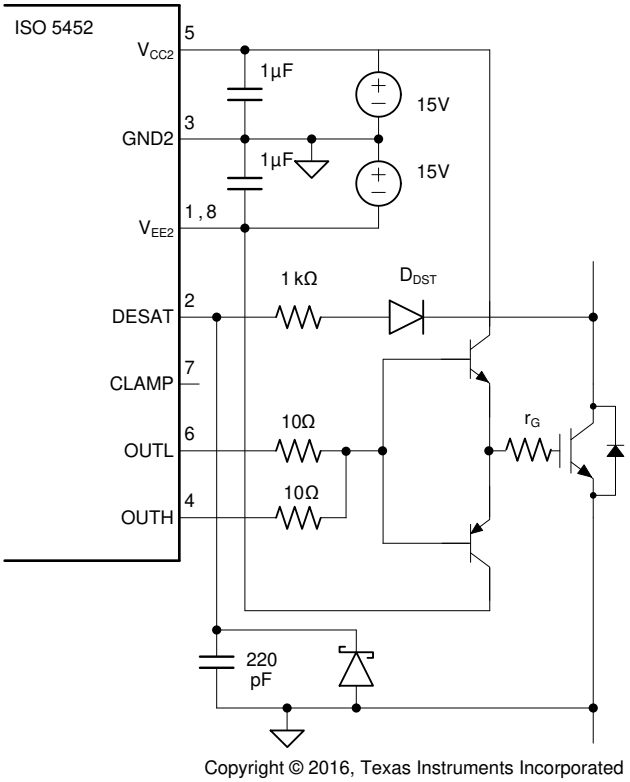
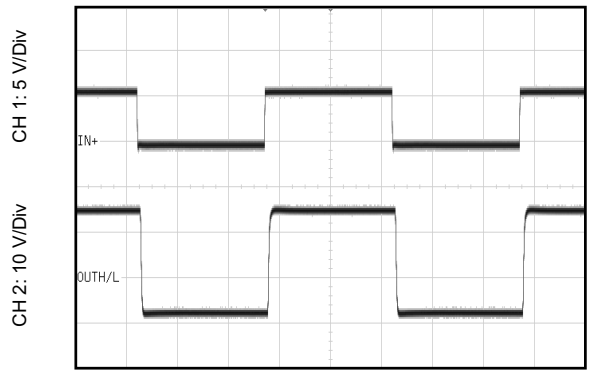


Figure 10-10. Current Buffer for Increased Drive Current

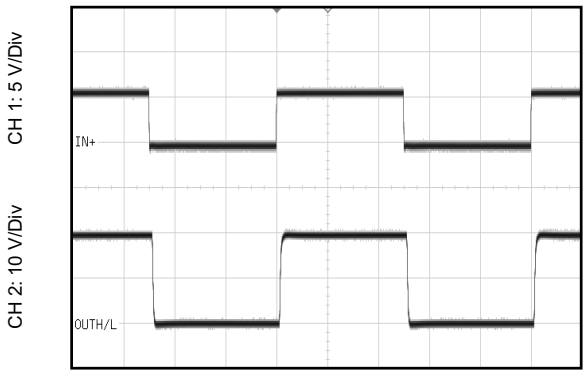
10.2.3 Application Curves



5 µs/Div

C_L = 1 nF R_{GH} = 10 Ω R_{GL} = 10 Ω
V_{CC2} – GND2 = 15 V GND2 – V_{EE2} = 8 V
(V_{CC2} – V_{EE2} = 23 V)

Figure 10-11. Normal Operation - Bipolar Supply



5 µs/Div

C_L = 1 nF R_{GH} = 10 Ω R_{GL} = 10 Ω
V_{CC2} – V_{EE2} = V_{CC2} – GND2 = 20 V

Figure 10-12. Normal Operation - Unipolar Supply

11 Power Supply Recommendations

To help ensure reliable operation at all data rates and supply voltages, a 0.1-µF bypass capacitor is recommended at the input supply pin, V_{CC1}, and 1-µF bypass capacitor is recommended at the output supply pin, V_{CC2}. The capacitors should be placed as close to the supply pins as possible. The recommended placement of capacitors is 2-mm (maximum) from input and output power supply pin (V_{CC1} and V_{CC2}).

12 Layout

12.1 Layout Guidelines

A minimum of four layers is required to accomplish a low EMI PCB design (see Figure 12-1). Layer stacking should be in the following order (top-to-bottom): high-current or sensitive signal layer, ground plane, power plane and low-frequency signal layer.

- Routing the high-current or sensitive traces on the top layer avoids the use of vias (and the introduction of their inductances) and allows for clean interconnects between the gate driver and the microcontroller and power transistors. Gate driver control input, gate driver output OUTH and OUTL, and DESAT should be routed in the top layer.
- Placing a solid ground plane next to the sensitive signal layer provides an excellent low-inductance path for the return current flow. On the driver side, use GND2 as the ground plane.
- Placing the power plane next to the ground plane creates additional high-frequency bypass capacitance of approximately 100 pF/inch^2. On the gate-driver V_{EE2} and V_{CC2} can be used as power planes. They can share the same layer on the PCB as long as they are not connected together.
- Routing the slower speed control signals on the bottom layer allows for greater flexibility as these signal links usually have margin to tolerate discontinuities such as vias.

For detailed layout recommendations, see the *Digital Isolator Design Guide* (SLLA284).

12.2 Layout Example

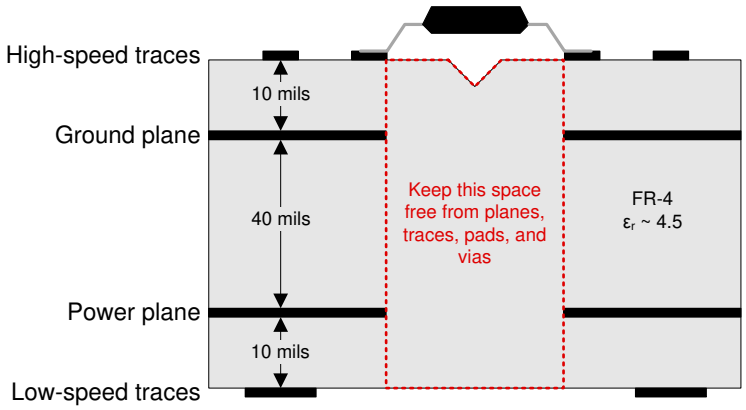


Figure 12-1. Recommended Layer Stack

12.3 PCB Material

For digital circuit boards operating at less than 150 Mbps, (or rise and fall times greater than 1 ns), and trace lengths of up to 10 inches, use standard FR-4 UL94V-0 printed circuit board. This PCB is preferred over cheaper alternatives because of lower dielectric losses at high frequencies, less moisture absorption, greater strength and stiffness, and the self-extinguishing flammability-characteristics.

13 Device and Documentation Support

13.1 Device Support

13.1.1 Third-Party Products Disclaimer

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13.2 Documentation Support

13.2.1 Related Documentation

For related documentation see the following:

- *ISO5852S Evaluation Module (EVM) User's Guide*
- *Digital Isolator Design Guide*
- *Isolation Glossary*

13.3 Receiving Notification of Documentation Updates

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

13.4 Support Resources

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

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13.6 Electrostatic Discharge Caution

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

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

13.7 Glossary

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

14 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
ISO5452DW	ACTIVE	SOIC	DW	16	40	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	ISO5452	Samples
ISO5452DWR	ACTIVE	SOIC	DW	16	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	ISO5452	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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

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

OTHER QUALIFIED VERSIONS OF ISO5452 :

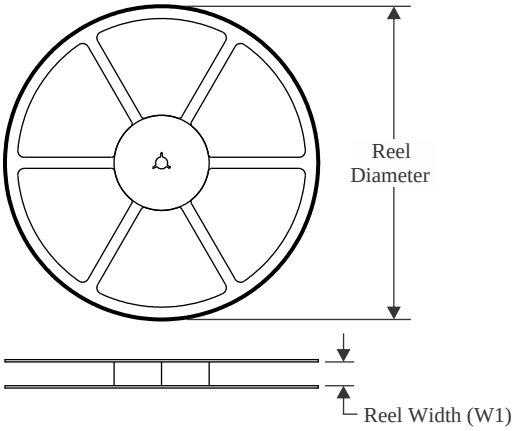
- Automotive : ISO5452-Q1

NOTE: Qualified Version Definitions:

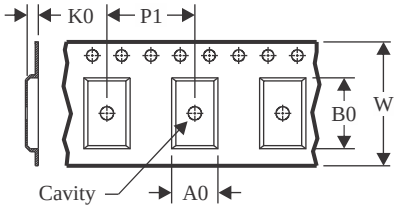
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

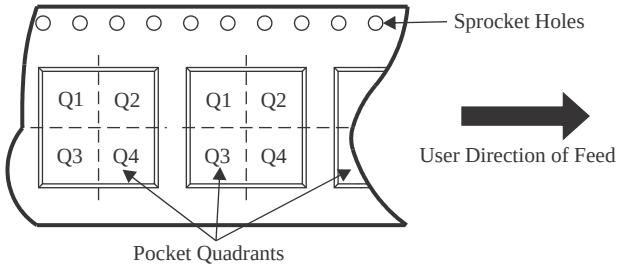


TAPE DIMENSIONS



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

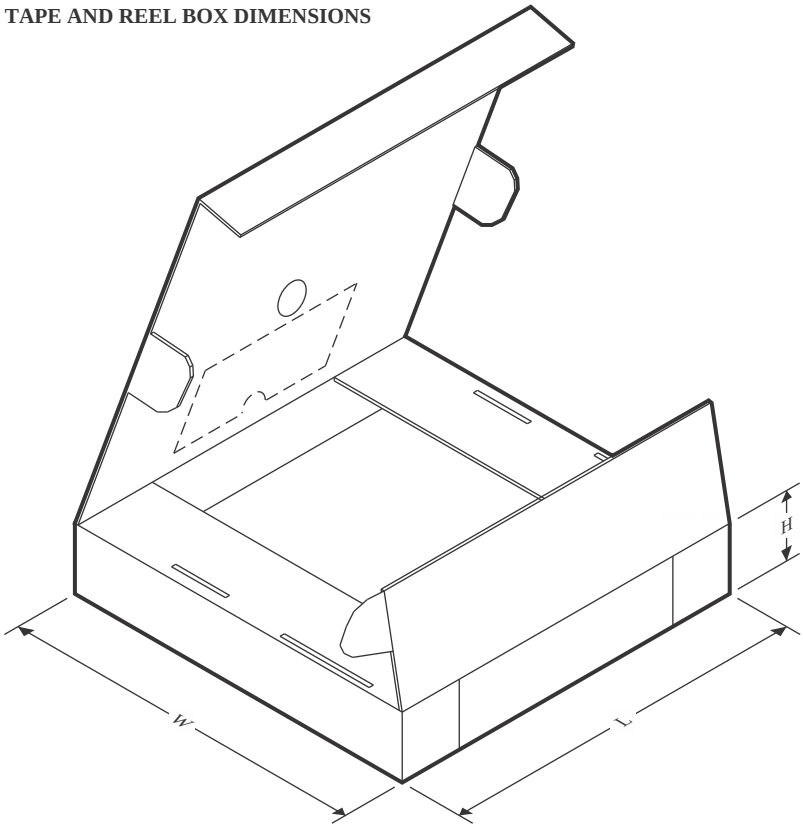
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ISO5452DWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
ISO5452DWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1

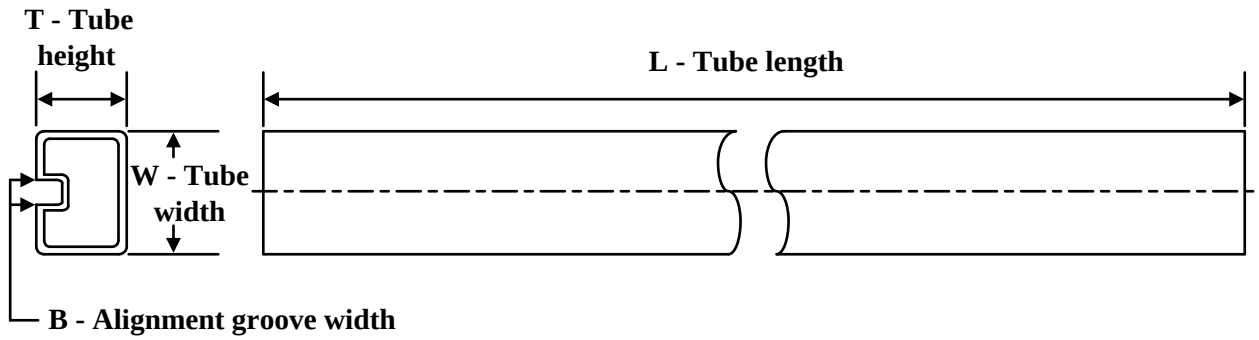
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ISO5452DWR	SOIC	DW	16	2000	356.0	356.0	35.0
ISO5452DWR	SOIC	DW	16	2000	350.0	350.0	43.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
ISO5452DW	DW	SOIC	16	40	506.98	12.7	4826	6.6
ISO5452DW	DW	SOIC	16	40	507	12.83	5080	6.6

GENERIC PACKAGE VIEW

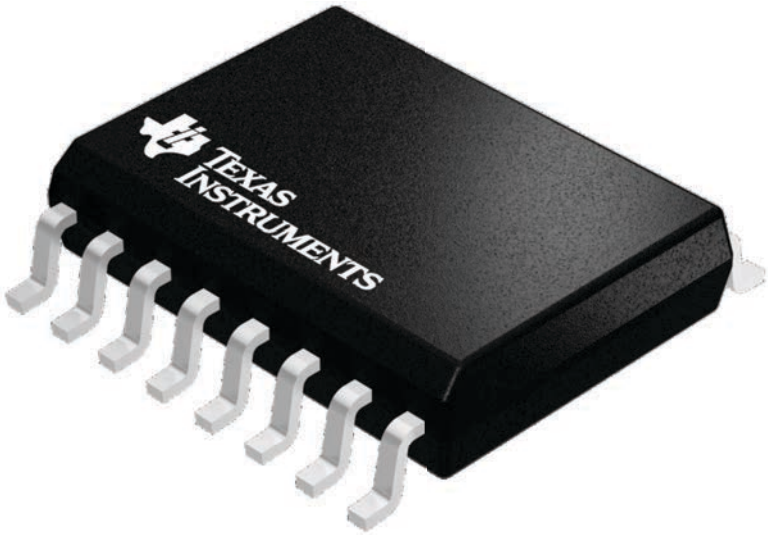
DW 16

SOIC - 2.65 mm max height

7.5 x 10.3, 1.27 mm pitch

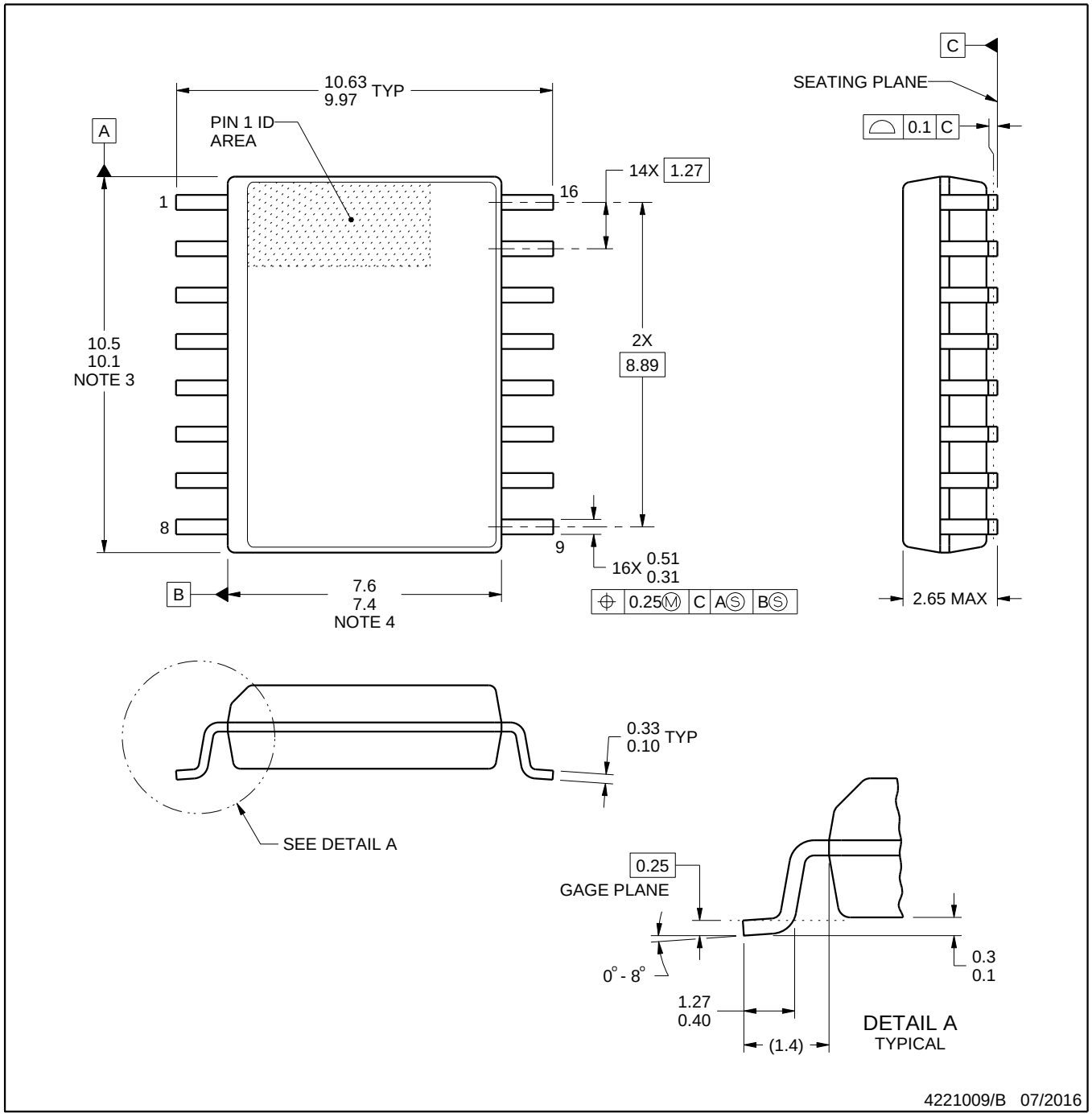
SMALL OUTLINE INTEGRATED CIRCUIT

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



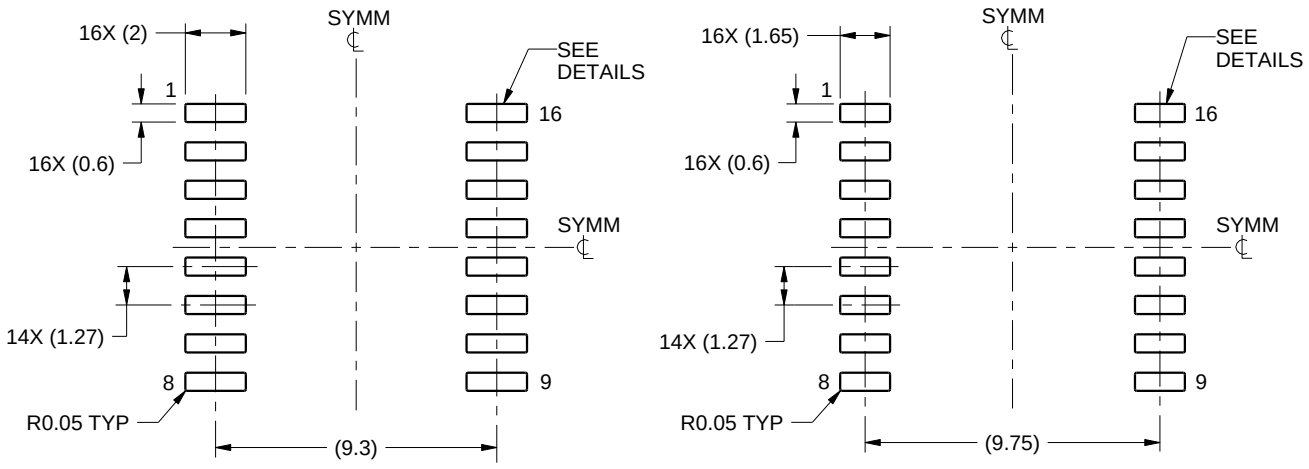
4224780/A

SOIC



NOTES:

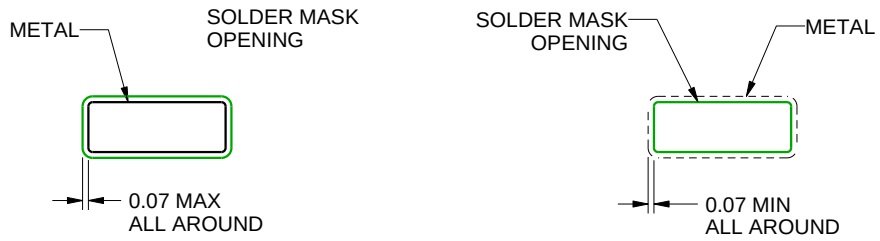
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate 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.



IPC-7351 NOMINAL
7.3 mm CLEARANCE/CREEPAGE

HV / ISOLATION OPTION
8.1 mm CLEARANCE/CREEPAGE

LAND PATTERN EXAMPLE
SCALE:4X



NON SOLDER MASK DEFINED

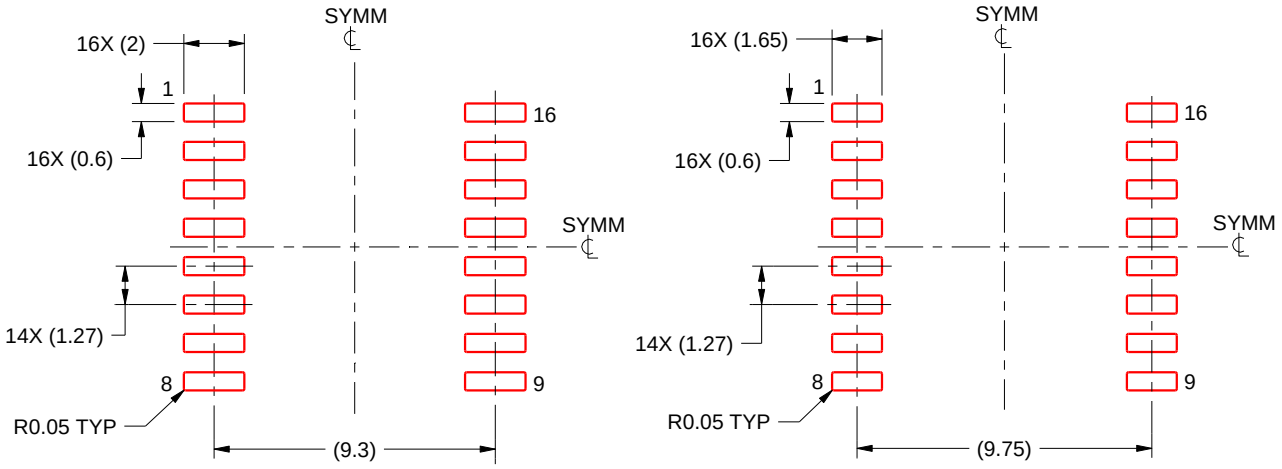
SOLDER MASK DEFINED

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.



IPC-7351 NOMINAL
7.3 mm CLEARANCE/CREEPAGE

HV / ISOLATION OPTION
8.1 mm CLEARANCE/CREEPAGE

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

4221009/B 07/2016

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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