ISO5851 High-CMTI 2.5-A / 5-A Isolated IGBT, MOSFET Gate Driver with Active Safety Features

1 Features

- 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
- Fault Alarm upon Desaturation Detection is Signaled on $\overline{\text{FLT}}$ and Reset Through $\overline{\text{RST}}$
- Input and Output Under Voltage Lock-Out (UVLO) with Ready (RDY) Pin Indication
- Active Output Pull-down and Default Low Outputs with Low Supply or Floating Inputs
- 3-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
- 100-kV/μs Minimum Common-Mode Transient Immunity (CMTI) at V_{CM} = 1500 V
- Operating Temperature: –40°C to 125°C Ambient
- Safety and Regulatory Approvals:
  - 8000-V_{PK} V_{IOTM} and 2121-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, IEC 60601-1 and IEC 61010-1 End Equipment Standards
  - CQC Certification per GB4943.1-2011
  - All Certifications are Planned

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 ISO5851 is a 5.7-kV_{RMS}, reinforced isolated gate driver for IGBTs and MOSFETs with 2.5-A source and 5-A sink current. The input side operates from a single 3-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 overload condition. Upon a DESAT detect the gate driver output is driven low to V_{EE2} potential turning the IGBT immediately off.

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. The $\overline{\text{FLT}}$ output condition is latched and can be reset through a low-active pulse at the $\overline{\text{RST}}$ input.

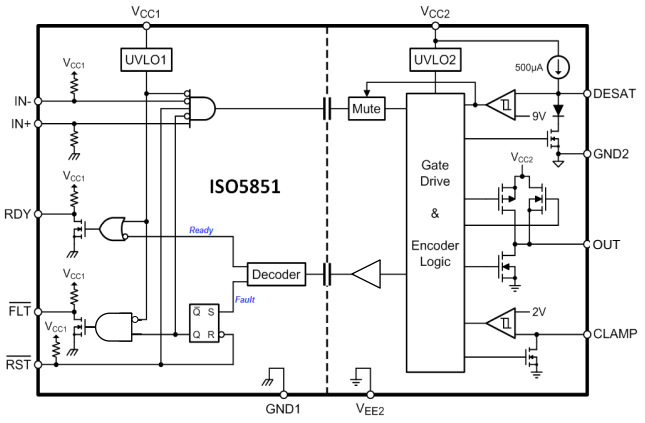
When the IGBT is turned off during normal operation with bipolar output supply, the output is hard clamp to V_{EE2}. If the output supply is unipolar, an active Miller clamp can be used, allowing Miller current to sink across a low impedance path preventing IGBT to be dynamically turned on during high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

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
ISO5851	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



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4 Revision History

Changes from Original (June 2015) to Revision A **Page**

- Changed from a 1-page Product Preview to the full datasheet. ... 1

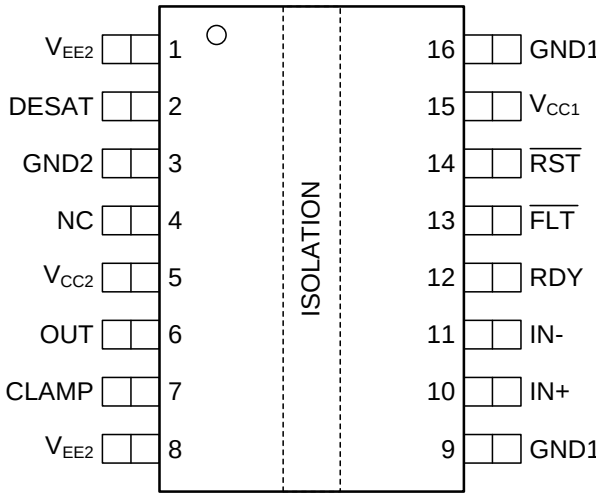
5 Description (continued)

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 ISO5851 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

DW Package
16-Pin SOIC
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
V_{EE2}	1, 8	-	Output negative supply. Connect to GND2 for Unipolar supply application.
DESAT	2	I	Desaturation voltage input
GND2	3	-	Gate drive common. Connect to IGBT emitter.
NC	4	-	Not connected
V_{CC2}	5	-	Most positive output supply potential.
OUT	6	O	Gate drive voltage output
CLAMP	7	O	Miller clamp output
GND1	9, 16	-	Input ground
IN+	10	I	Non-inverting gate drive voltage control input
IN-	11	I	Inverting gate drive voltage control input
RDY	12	O	Power-good output, active high when both supplies are good.
$\overline{FLT}$	13	O	Fault output, low-active during DESAT condition
$\overline{RST}$	14	I	Reset input, apply a low pulse to reset fault latch.
V_{CC1}	15	-	Positive input supply (3 V to 5.5 V)

7 Specifications

7.1 Absolute Maximum Ratings(1)

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

			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	0.2	V
$V_{(SUP2)}$	Total supply output voltage	(V_{CC2} - V_{EE2})	–0.3	35	V
V_{OUT}	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 (max pulse width = 10 µs, max duty cycle = 0.2%)		2.7	A
$I_{(OUTL)}$	Gate driver low output current			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
$V_{(SURGE)}$	Surge Immunity per IEC 61000-4-5		12800		V
T_J	Junction temperature		–40	150	°C
T_{STG}	Storage temperature		–65	150	°C
P_{ID}	Input power dissipation	V_{CC1} = 5.5-V, V_{CC2} = 30-V, T_A = 85°C		100	mW
P_{OD}	Output power dissipation			600	mW
P_D	Full chip power dissipation			700(2)	mW

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability
(2) Full chip power dissipation is de-rated 10.7 mW/°C beyond 85°C ambient temperature. At 125°C ambient temperature, a maximum of 272 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.

7.2 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)	±500	

(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	3		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 x V_{CC1}		V_{CC1}	V
V_{IL}	Low-level input voltage (IN+, IN-, $\overline{RST}$)	0		0.3 x V_{CC1}	V
t_{UI}	Pulse width at IN+, IN- for full output (C_{LOAD} = 1nF)	40			ns
t_{RST}	Pulse width at $\overline{RST}$ for resetting fault latch	800			ns
T_A	Ambient temperature	-40	25	125	°C

7.4 Thermal Information

THERMAL METRIC(1)		DW (SOIC) 16 PINS	UNIT
θ_{JA}	Junction-to-ambient thermal resistance	91.8	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	51.9	
θ_{JB}	Junction-to-board thermal resistance	56.6	
ψ_{JT}	Junction-to-top characterization parameter	20.2	
ψ_{JB}	Junction-to-board characterization parameter	56.1	

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

7.5 Electrical Characteristics

Over recommended operating conditions unless otherwise noted. All typical values are at T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – $V_{(EE2)}$ = 8 V

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
VOLTAGE SUPPLY						
$V_{IT+(UVLO1)}$	Positive-going UVLO1 threshold voltage input side				2.25	V
$V_{IT-(UVLO1)}$	Negative-going UVLO1 threshold voltage input side		1.7			V
$V_{HYS(UVLO1)}$	UVLO1 Hysteresis voltage ($V_{IT+} – V_{IT–}$) input side			0.24		V
$V_{IT+(UVLO2)}$	Positive-going UVLO2 threshold voltage output side			12	13	V
$V_{IT-(UVLO2)}$	Negative-going UVLO2 threshold voltage output side		9.5	11		V
$V_{HYS(UVLO2)}$	UVLO2 Hysteresis voltage ($V_{IT+} – V_{IT–}$) output side			1		V
I_{Q1}	Input supply quiescent current			2.8	4.5	mA
I_{Q2}	Output supply quiescent current			3.6	6	mA
LOGIC I/O						
$V_{IT+(IN,\overline{RST})}$	Positive-going input threshold voltage (IN+, IN-, $\overline{RST}$)				0.7 x V_{CC1}	V
$V_{IT-(IN,\overline{RST})}$	Negative-going input threshold voltage (IN+, IN-, $\overline{RST}$)		0.3 x V_{CC1}			V
$V_{HYS(IN,\overline{RST})}$	Input hysteresis voltage (IN+, IN-, $\overline{RST}$)			0.15 x V_{CC1}		V
I_{IH}	High-level input leakage at (IN+)	IN+ = V_{CC1}		100		µA
I_{IL}	Low-level input leakage at (IN-, $\overline{RST}$)	IN- = GND1, $\overline{RST}$ = GND1		-100		µA
I_{PU}	Pull-up current of $\overline{FLT}$, RDY	$V_{(RDY)}$ = GND1, $V_{(FLT)}$ = GND1		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 pull-down voltage	I_{OUT} = 200 mA, V_{CC2} = open			2	V
$V_{(OUTH)}$	High-level output voltage	I_{OUT} = –20 mA	V_{CC2} - 0.5	V_{CC2} - 0.24		V
$V_{(OUTL)}$	Low-level output voltage	I_{OUT} = 20 mA		13	50	mV
$I_{(OUTH)}$	High-level output peak current	IN+ = high, IN- = low, V_{OUT} = V_{CC2} - 15 V	1.5	2.5		A
$I_{(OUTL)}$	Low-level output peak current	IN+ = low, IN- = high, V_{OUT} = $V_{(EE2)}$ + 15 V	3.4	5		A
ACTIVE MILLER CLAMP						
$V_{(CLP)}$	Low-level clamp voltage	$I_{(CLP)}$ = 20 mA		$V_{(EE2)}$ + 0.015	V_{EE2} + 0.08	V
$I_{(CLP)}$	Low-level clamp current	V_{OUT} = $V_{(EE2)}$ + 2.5 V	1.6	2.5		A
$V_{(CLTH)}$	Clamp threshold voltage		1.6	2.1	2.5	V
SHORT CIRCUIT CLAMPING						
$V_{(CLP\_OUT)}$	Clamping voltage (V_{OUT} - V_{CC2})	IN+ = high, IN- = low, t_{CLP}=10 µs, $I_{(OUTH)}$ = 500 mA		0.8	1.3	V
$V_{(CLP\_CLAMP)}$	Clamping voltage (V_{CLP} - V_{CC2})	IN+ = high, IN- = low, t_{CLP}=10 µs, $I_{(CLP)}$ = 500 mA		1.3		V
		IN+ = High, IN- = Low, $I_{(CLP)}$ = 20 mA		0.7	1.1	V

Electrical Characteristics (continued)

Over recommended operating conditions unless otherwise noted. All typical values are at T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – $V_{(EE2)}$ = 8 V

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DESAT PROTECTION						
$I_{(CHG)}$	Blanking capacitor charge current	$V_{(DESAT)}$ - $V_{(GND2)}$ = 2 V	0.42	0.5	0.58	mA
$I_{(DCHG)}$	Blanking capacitor discharge current	$V_{(DESAT)}$ - $V_{(GND2)}$ = 6 V	9	14		mA
$V_{(DSTH)}$	DESAT threshold voltage with respect to GND2		8.3	9	9.5	V
$V_{(DSL)}$	DESAT voltage with respect to GND2, when OUT is driven low		0.4		1	V

7.6 Switching Characteristics

Over recommended operating conditions unless otherwise noted. All typical values are at T_A = 25°C, V_{CC1} = 5 V, V_{CC2} – GND2 = 15 V, GND2 – $V_{(EE2)}$ = 8 V

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_r	Output signal rise time	C_{LOAD} = 1 nF, see Figure 13, Figure 14, and Figure 15	12	20	35	ns
t_f	Output signal fall time		12	20	37	ns
t_{PLH}, t_{PHL}	Propagation Delay			76	110	ns
t_{sk-p}	Pulse Skew $\lvert t_{PHL} - t_{PLH} \rvert$				20	ns
t_{sk-pp}	Part-to-part skew				30 (1)	ns
t_{GF}	Glitch filter on IN+, IN-, $\overline{RST}$		20	30	40	ns
$t_{DESAT\ (10\%)}$	DESAT sense to 10% OUT delay		300	415	500	ns
$t_{DESAT\ (GF)}$	DESAT glitch filter delay			330		ns
$t_{DESAT\ (\overline{FLT})}$	DESAT sense to $\overline{FLT}$-low delay	see Figure 15		2000	2420	ns
t_{LEB}	Leading edge blanking time	see Figure 13 and Figure 14	330	400	500	ns
$t_{GF(RSTFLT)}$	Glitch filter on $\overline{RST}$ for resetting $\overline{FLT}$		300		800	ns
C_I	Input capacitance (2)	V_I = V_{CC1} /2 + 0.4 x sin (2πft), f = 1 MHz, V_{CC1} = 5 V		2		pF
CMTI	Common-mode transient immunity	V_{CM} = 1500 V, see Figure 16	100	120		kV/µs

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

7.7 Typical Characteristics

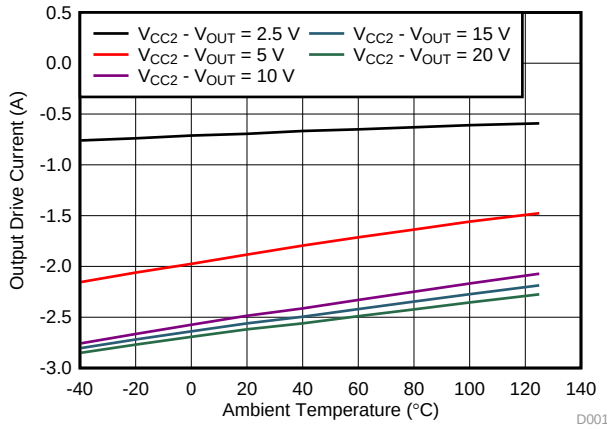


Figure 1. Output High Drive Current vs Temperature

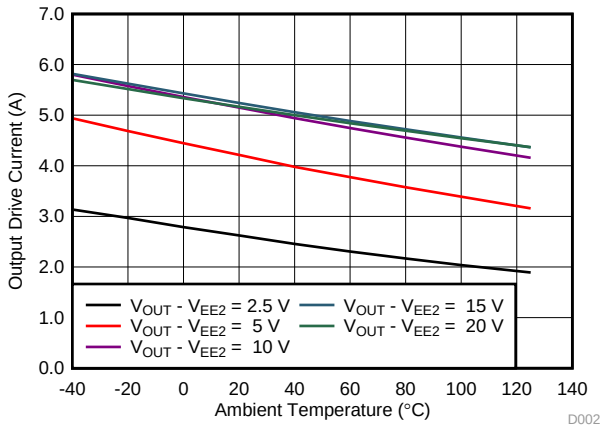


Figure 2. Output Low Drive Current vs Temperature

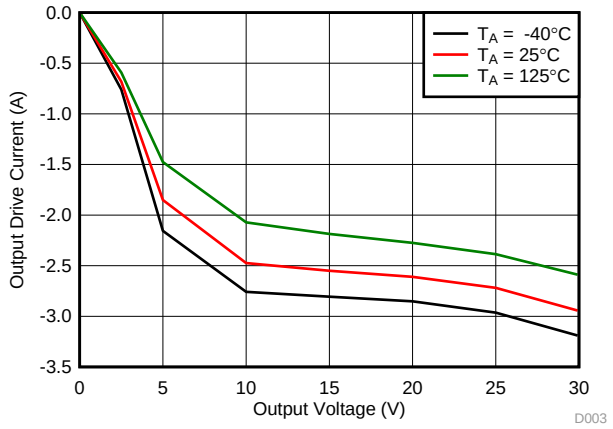


Figure 3. Output High Drive Current vs (V_{CC2} - V_{OUT})

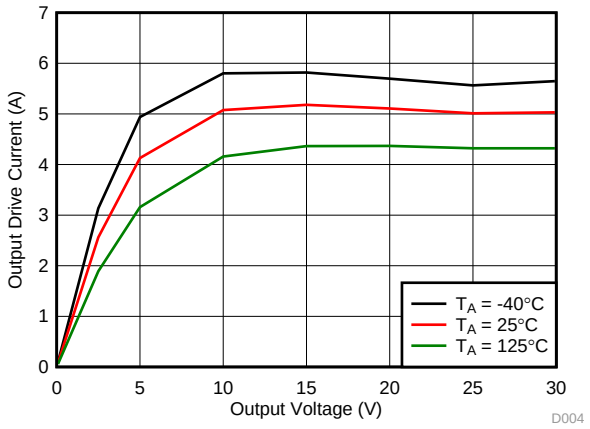


Figure 4. Output Low Drive Current vs (V_{OUT} - V_{EE2})

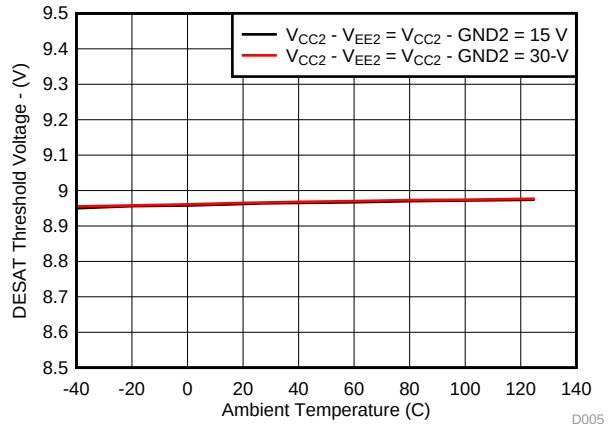
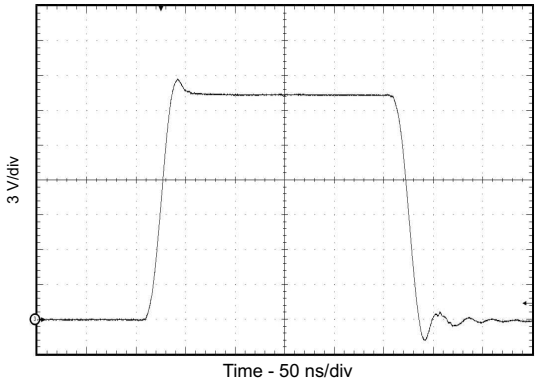


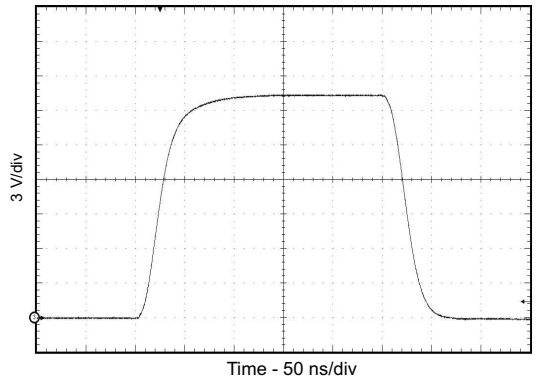
Figure 5. DESAT Threshold Voltage vs Temperature



C_L = 1 nF R_G = 0 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

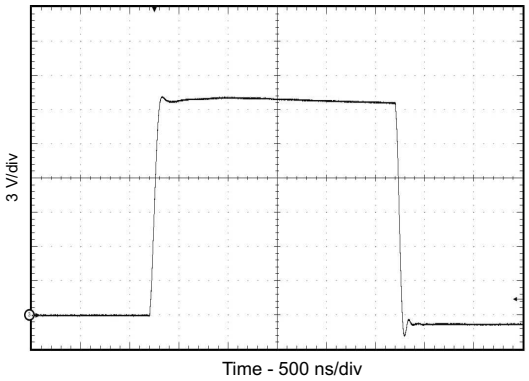
Figure 6. OUT Transient Waveform

Typical Characteristics (continued)



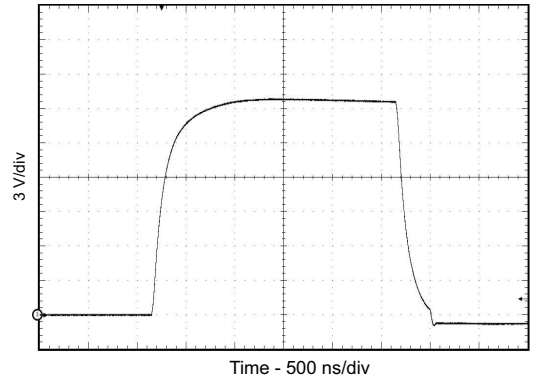
C_L = 1 nF R_G = 10 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 7. OUT Transient Waveform



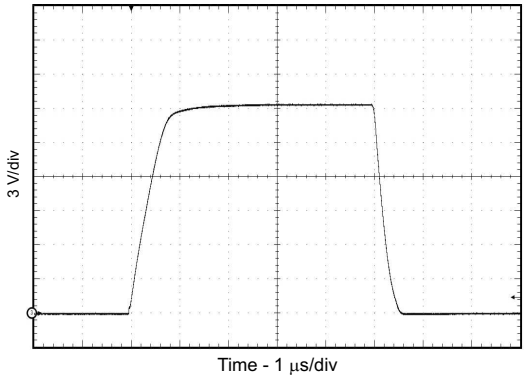
C_L = 10 nF R_G = 0 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 8. OUT Transient Waveform



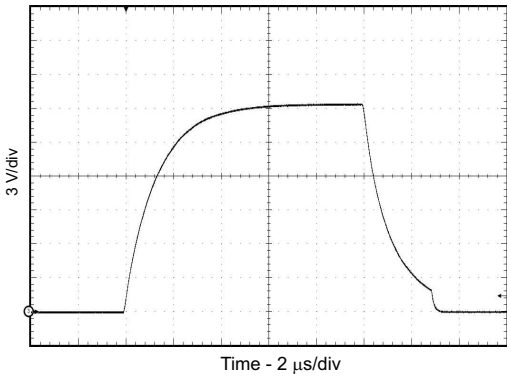
C_L = 10 nF R_G = 10 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 9. OUT Transient Waveform



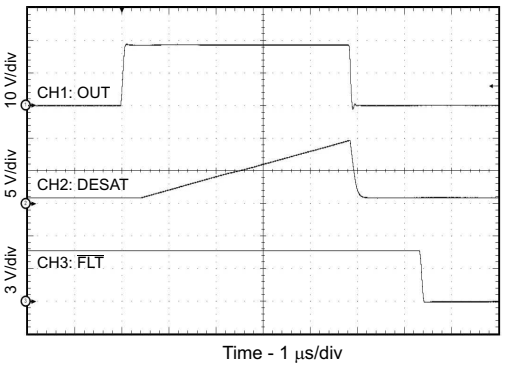
C_L = 100 nF R_G = 0 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 10. OUT Transient Waveform



C_L = 100 nF R_G = 10 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 11. OUT Transient Waveform



C_L = 100 nF R_G = 10 Ω
V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 12. OUT Transient Waveform DESAT and $\overline{FLT}$

8 Parameter Measurement Information

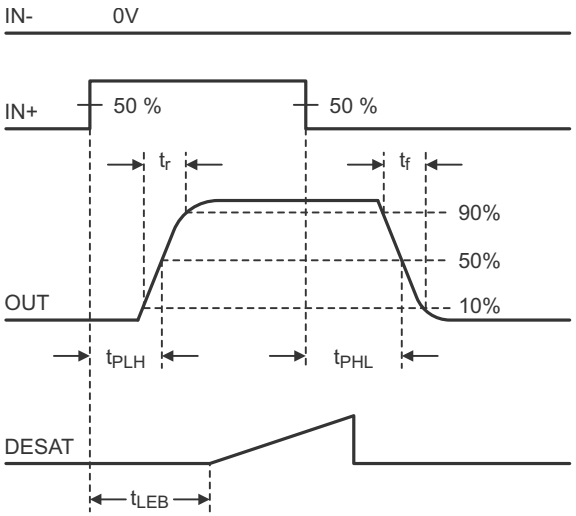


Figure 13. OUT Propagation Delay, Non-Inverting Configuration

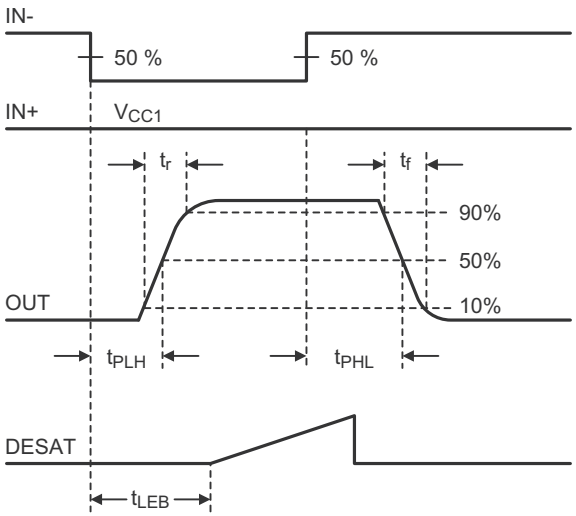


Figure 14. OUT Propagation Delay, Inverting Configuration

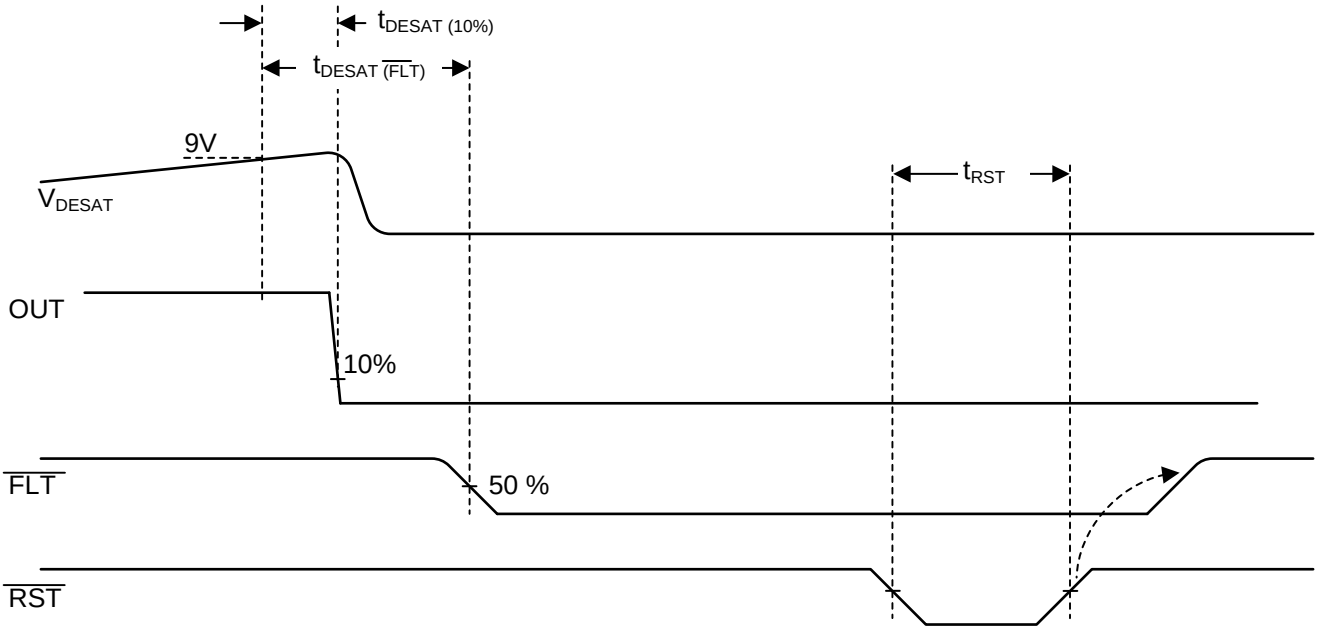


Figure 15. DESAT, OUT, $\overline{FLT}$, $\overline{RST}$ Delay

Parameter Measurement Information (continued)

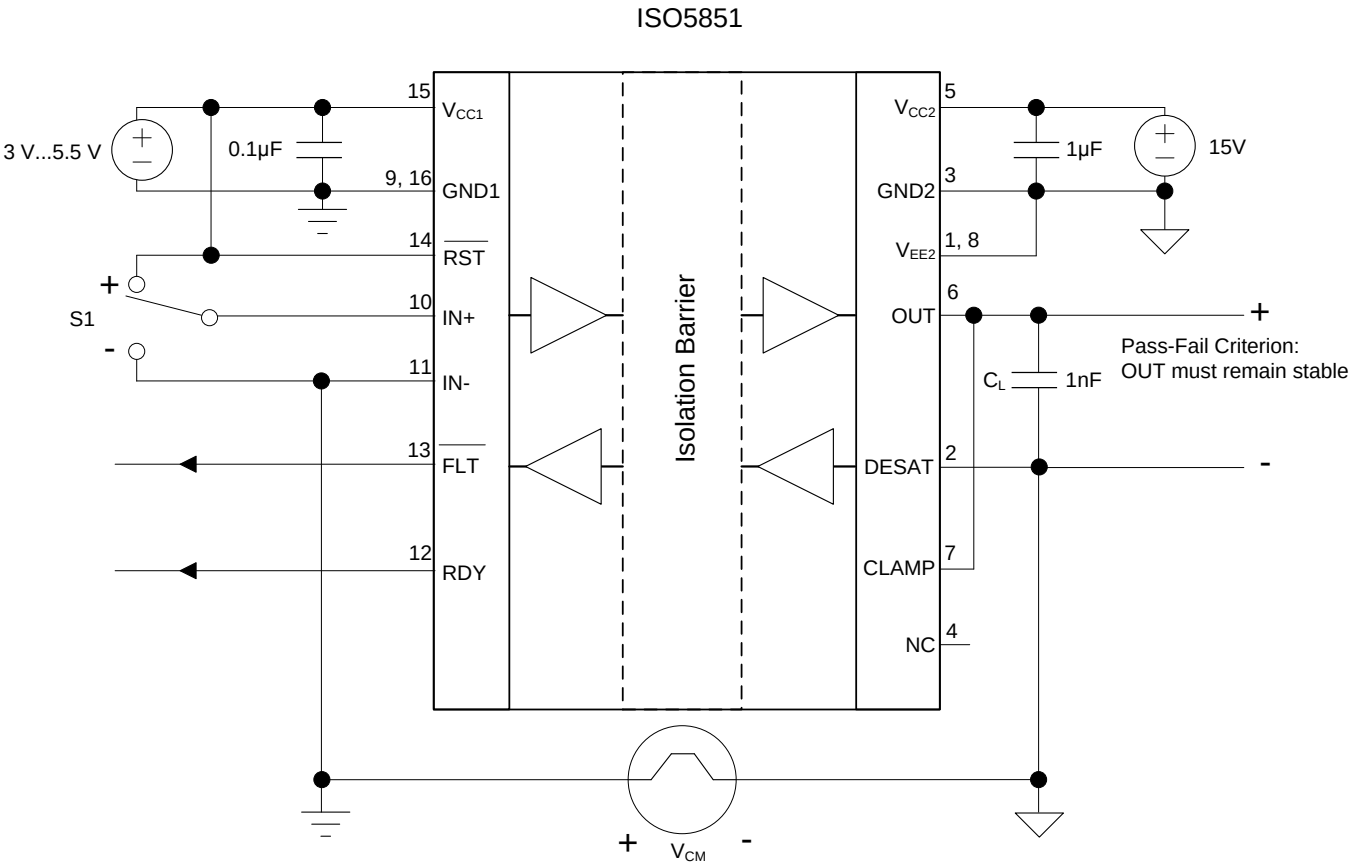


Figure 16. Common-Mode Transient Immunity Test Circuit

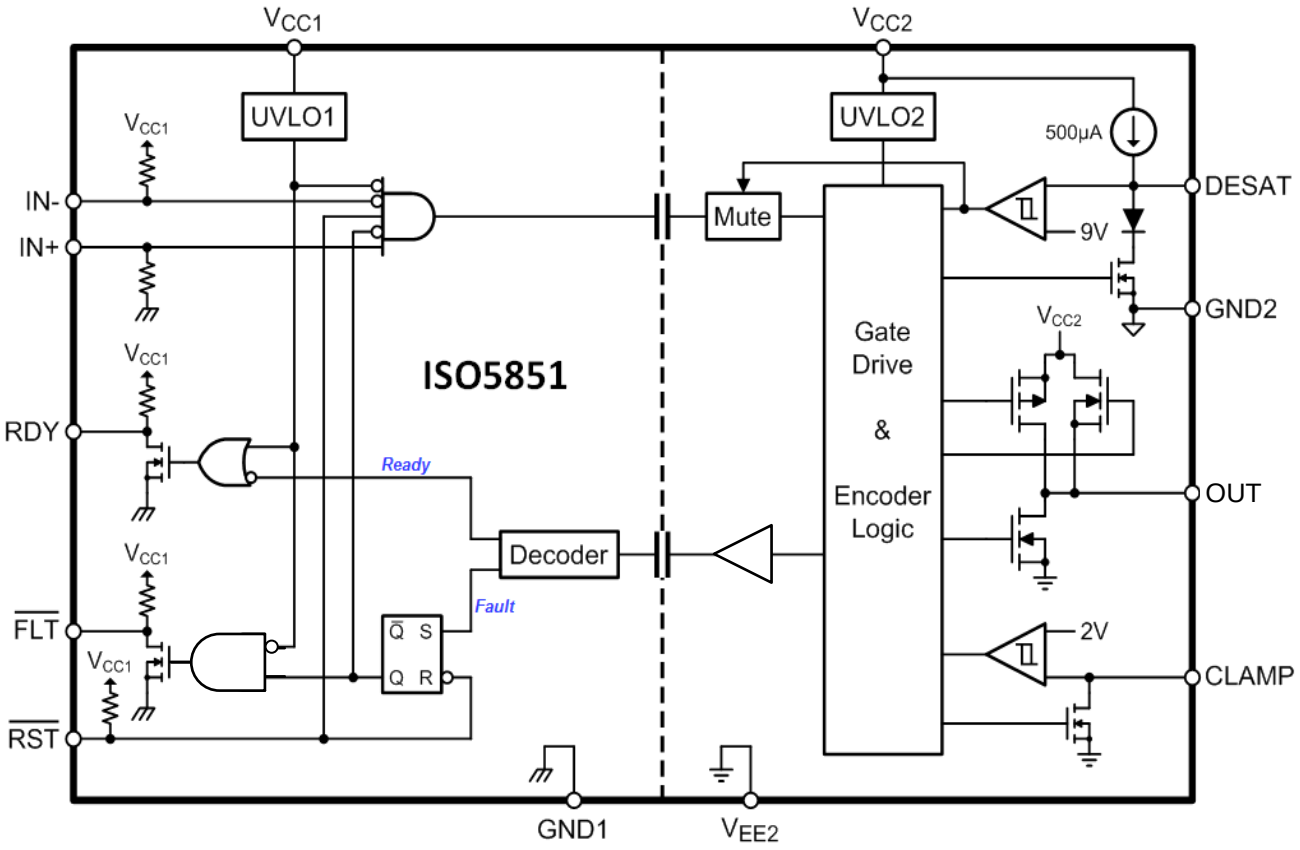
9 Detailed Description

9.1 Overview

The ISO5851 is an isolated gate driver for IGBTs and MOSFETs. Input CMOS logic and output power stage are separated by a capacitive, silicon dioxide (SiO_2), isolation barrier.

The IO circuitry on the input side interfaces with a micro controller 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 pull-up and 5-A pull-down 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 ISO5851 also contains under voltage lockout circuitry to prevent insufficient gate drive to the external IGBT, and active output pull-down feature which ensures that the gate-driver output is held low, if the output supply voltage is absent. The ISO5851 also has an active Miller clamp which can be used to prevent parasitic turn-on of the external power transistor, due to Miller effect, for unipolar supply operation.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 Supply and active Miller clamp

The ISO5851 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 its gate with respect to its emitter. This prevents the IGBT from unintentionally turning on because of current induced from its collector to its gate due to Miller effect. In this condition it is not necessary to connect CLAMP output of the gate driver to the IGBT gate. 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 due to additional charge from IGBT Miller capacitance caused by a high voltage slew rate transition on the IGBT collector. To prevent IGBT to turn 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 the CLAMP current output is activated.

9.3.2 Active Output Pull-down

The Active output pull-down feature ensures that the IGBT gate OUT 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 till 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 $V_{IT+(UVLO2)}$.

Ready (RDY) pin indicates status of input and output side Under Voltage Lock-Out (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. RDY pin also serves as an indication to the micro-controller that the device is ready for operation.

9.3.4 Fault ($\overline{\text{FLT}}$) and Reset ($\overline{\text{RST}}$)

During IGBT overload condition, to report desaturation error $\overline{\text{FLT}}$ goes low. If $\overline{\text{RST}}$ is held low for the specified duration, $\overline{\text{FLT}}$ is cleared at rising edge of $\overline{\text{RST}}$. $\overline{\text{RST}}$ has an internal filter to reject noise and glitches. By asserting $\overline{\text{RST}}$ for at-least the specified minimum duration, device input logic can be enabled or disabled.

9.3.5 Short Circuit Clamp

Under short circuit events it is possible that currents are induced back into the gate-driver OUT and CLAMP pins due to parasitic Miller capacitance between the IGBT collector and gate terminals. Internal protection diodes on OUT and CLAMP help to sink these currents while clamping the voltages on these pins to values slightly higher than the output side supply.

Feature Description (continued)

9.3.6 High Voltage Feature Description

9.3.6.1 Package Insulation and Safety-Related Specifications

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
L(I01)	Minimum air gap (clearance)	Shortest terminal-to-terminal distance through air	8			mm
L(I02)(1)	Minimum external tracking (creepage)	Shortest terminal-to-terminal distance across the package surface	8			mm
CTI	Tracking resistance (comparative tracking index)	DIN EN 60112 (VDE 0303-11); IEC 60112; UL 746A	600			V
R_{IO}	Isolation resistance, input to output(2)	V_{IO} = 500 V, T_A = 25°C	10^{12}			Ω
		V_{IO} = 500 V, 100°C ≤ T_A ≤ max	10^{11}			Ω
C_{IO}	Barrier capacitance, input to output(2)	V_{IO} = 0.4 x sin (2πft), f = 1 MHz		1		pF

(1) Per JEDEC package dimensions.
(2) All pins on each side of the barrier tied together creating a two-terminal device.

NOTE

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.

9.3.6.2 Insulation Characteristics

PARAMETER		TEST CONDITIONS	SPECIFICATION	UNIT
DTI	Distance through the insulation	Minimum internal gap (internal clearance)	21	µm
V_{IOWM}	Maximum isolation working voltage	Time dependent dielectric breakdown (TDDB) Test	1500	V_{RMS}
			2121	V_{DC}
DIN V VDE V 0884-10 (VDE V 0884-10):2006-12				
V_{IORM}	Maximum repetitive peak isolation voltage		2121	V_{PK}
V_{PR}	Input to output test voltage	Method A, After Input/Output safety test subgroup 2/3, V_{PR} = 1.2 x V_{IORM}, t = 10 sec, Partial discharge < 5 pC	2545	
		Method A, After environmental tests subgroup 1, V_{PR} = 1.6 × V_{IORM}, t = 10 sec (qualification) Partial discharge < 5 pC	3393	
		Method B1, 100% Production test, V_{PR} = 1.875 × V_{IORM}, t = 1 sec Partial discharge < 5 pC	3976	
V_{IOTM}	Maximum Transient isolation voltage	V_{TEST} = V_{IOTM}, t = 60 sec (qualification), t = 1 sec (100% production)	8000	
V_{IOSM}	Maximum surge isolation voltage	Test method per IEC 60065, 1.2/50 µs waveform, V_{TEST} = 1.6 x V_{IOSM} = 12800 V_{PK} (qualification)	8000	
R_S	Insulation resistance	V_{IO} = 500 V at T_S	> 10^9	Ω
	Pollution degree		2	
UL 1577				
V_{ISO}	Withstanding Isolation voltage	V_{TEST} = V_{ISO}, t = 60 sec (qualification), V_{TEST} = 1.2 × V_{ISO} = 6840 V_{RMS}, t = 1 sec (100% production)	5700	V_{RMS}

9.3.6.3 Regulatory Information

VDE	CSA	UL	CQC
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	Approved under CSA Component Acceptance Notice 5A, IEC 60950-1, IEC 61010-1, and IEC 60601-1	Recognized under 1577 Component Recognition Program	Certified according to GB 4943.1-2011
Reinforced Insulation Maximum Transient isolation voltage, 8000 V_{PK}; Maximum surge isolation voltage, 8000 V_{PK}, Maximum repetitive peak isolation voltage, 2121 V_{PK}	Reinforced insulation per CSA 61010-1-12 and IEC 61010-1 (3rd Ed.), 300 V_{RMS} max working voltage); 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} (1)	Reinforced Insulation, Altitude ≤ 5000m, Tropical climate, 250 V_{RMS} maximum working voltage
Certification planned	Certification planned	Certification planned	Certification planned

(1) Production tested ≥ 6840 V_{RMS} for 1 second in accordance with UL 1577.

9.3.6.4 IEC 60664-1 Rating Table

PARAMETER	TEST CONDITIONS	SPECIFICATION
Basic Isolation Group	Material Group	I
Installation Classification	Rated Mains Voltage ≤ 600 V_{RMS}	I-IV
	Rated Mains Voltage ≤ 1000 V_{RMS}	I-III

9.3.6.5 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	MIN	TYP	MAX	UNIT
I_S	Safety Limiting Current	θ_{JA} = 91.8°C/W, V_I = 3.6 V, T_J = 150°C, T_A = 25°C			378	mA
		θ_{JA} = 91.8°C/W, V_I = 5.5 V, T_J = 150°C, T_A = 25°C			248	
		θ_{JA} = 91.8°C/W, V_I = 30 V, T_J = 150°C, T_A = 25°C			45	
T_S	Case Temperature				150	°C

The safety-limiting constraint is the absolute-maximum junction temperature specified in the *Absolute Maximum Ratings* table. 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 in the 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.

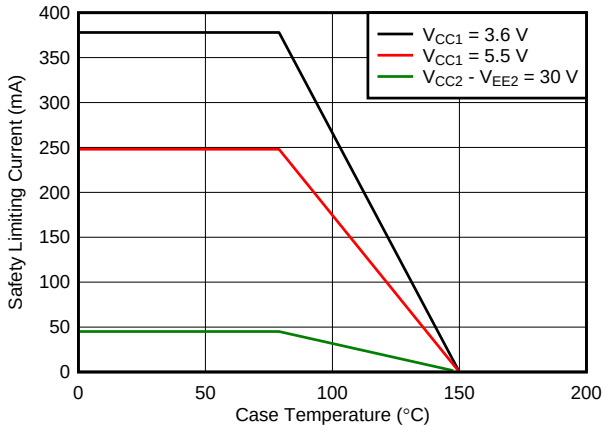


Figure 17. DW-16 θ_{JC} Thermal Derating Curve

9.4 Device Functional Modes

In ISO5851 OUT to follow IN+ in normal functional mode, $\overline{FLT}$ needs to be in high state.

Table 1. Function Table(1)

V_{CC1}	V_{CC2}	IN+	IN-	$\overline{RST}$	RDY	OUT
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. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

The ISO5851 is an isolated gate driver for power semiconductor devices such as IGBTs and MOSFETs. It 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 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 need high current capability to be able to drive the large capacitive loads offered by those power transistors. Not only that, the gate drive needs to be applied with reference to the Emitter of the IGBT (Source for MOSFET), and by construction, the Emitter node in a gate drive system swings between 0 to the DC bus voltage, that can be several 100s of volts in magnitude.

The ISO5851 is thus used to level shift the incoming 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 18 shows the typical application of a three-phase inverter using six ISO5851 isolated gate drivers. Three-phase inverters are used for variable-frequency drives to control the operating speed of AC motors and for high power applications such as High-Voltage DC (HVDC) power transmission.

The basic three-phase inverter consists of three single-phase inverter switches each comprising two ISO5851 devices that are connected to one of the three load terminals. The operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform, thus creating a six-step line-to-line output waveform. In this type of applications, carrier-based PWM techniques are applied to retain waveform envelope and cancel harmonics.

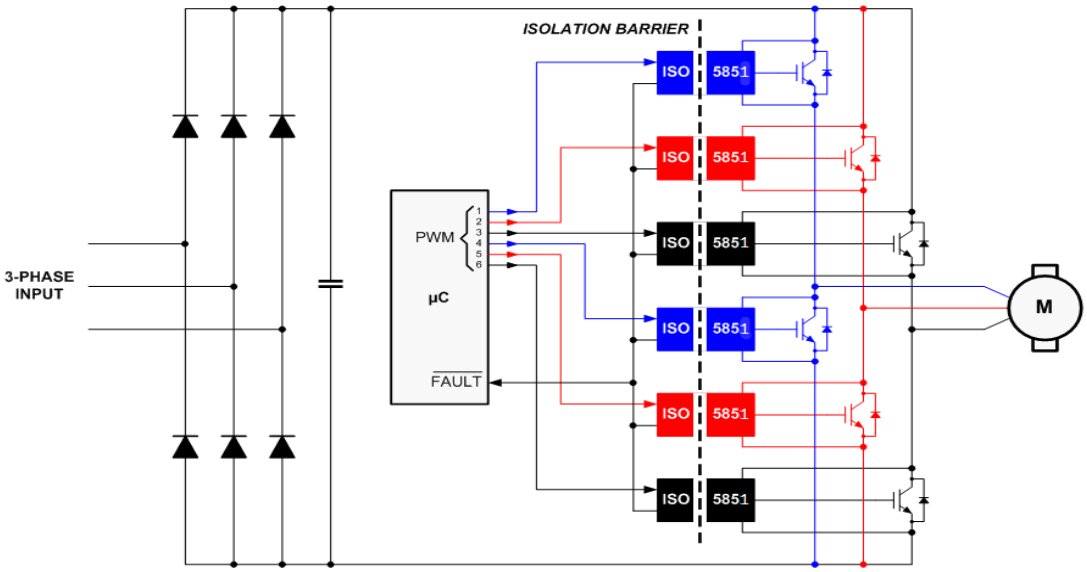


Figure 18. Typical Motor Drive Application

Typical Applications (continued)

10.2.1 Design Requirements

Unlike optocoupler based gate drivers which need external current drivers and biasing circuitry to provide the input control signals, the input control to the ISO5851 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 2 shows the allowed range for Input and Output supply voltage, and the typical current output available from the gate-driver.

Table 2. Design Parameters

PARAMETER	VALUE
Input supply voltage	3-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 ISO5851 Application Circuit

The ISO5851 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 19 illustrates a typical gate driver implementation with Unipolar Output Supply and Figure 20 illustrates a typical gate driver implementation with Bipolar Output Supply using the ISO5851.

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 its 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 pull-up resistor and a 220-pF filtering capacitor. In this application, the IGBT gate driver is disabled when a fault is detected and will not resume switching until the micro-controller applies a reset signal.

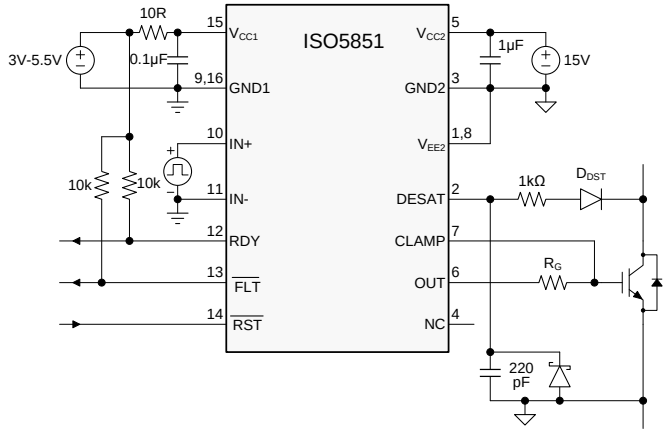


Figure 19. Unipolar Output Supply

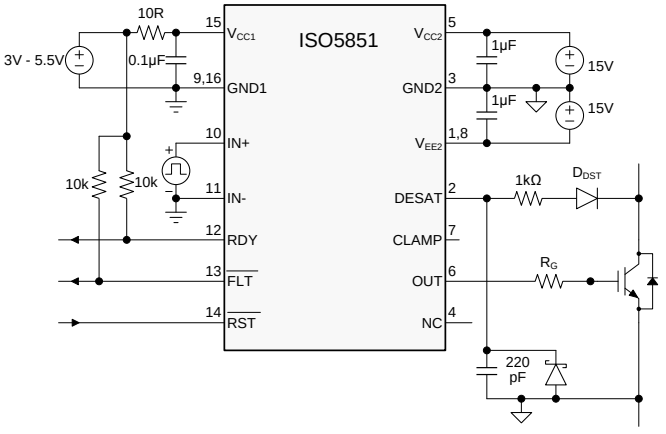


Figure 20. Bipolar Output Supply

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

There is 50k pull-up resistor internally. The $\overline{FLT}$ and RDY pin is an open-drain output requiring a 10-kΩ pull-up resistor to provide logic high when $\overline{FLT}$ and RDY is inactive, as shown in Figure 21.

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

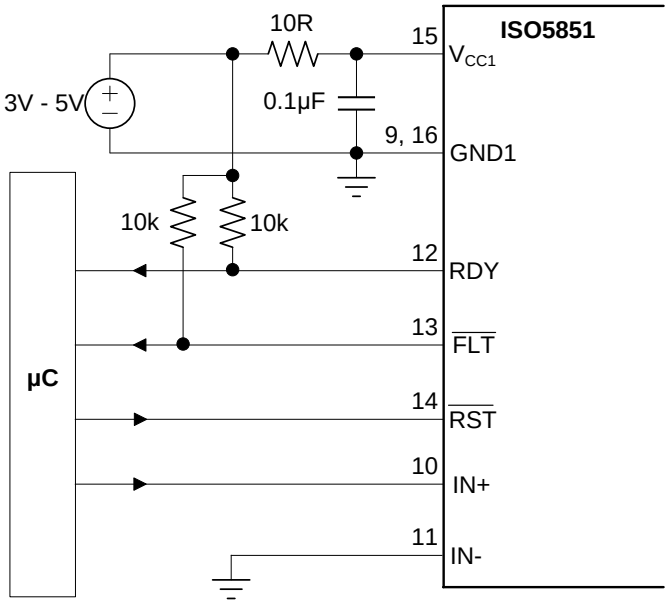


Figure 21. $\overline{FLT}$ and RDY Pin Circuitry for High CMTI

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 ISO5851. 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 ISO5851 output under extreme common-mode transient conditions. Passive drive circuits, such as open-drain configurations using pull-up resistors, must be avoided. There is a 20 ns glitch filter which 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.

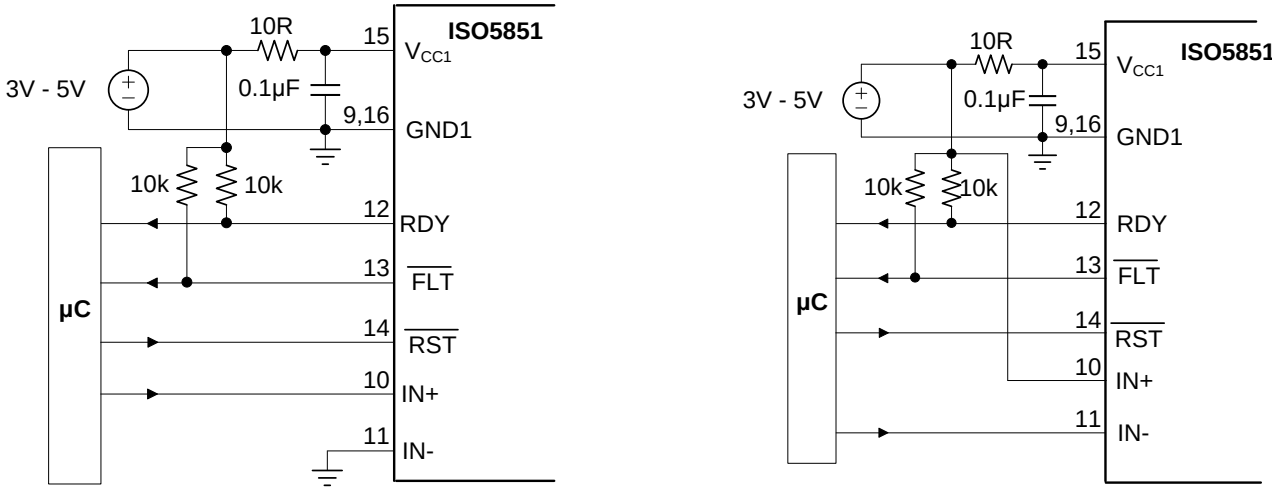


Figure 22. Local Shutdown and Reset for Noninverting (left) and Inverting Input Configuration (right)

10.2.2.5 Global-Shutdown and Reset

When configured for inverting operation, the ISO5851 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 ISO5851 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; thereby, providing protection against further catastrophic failures.

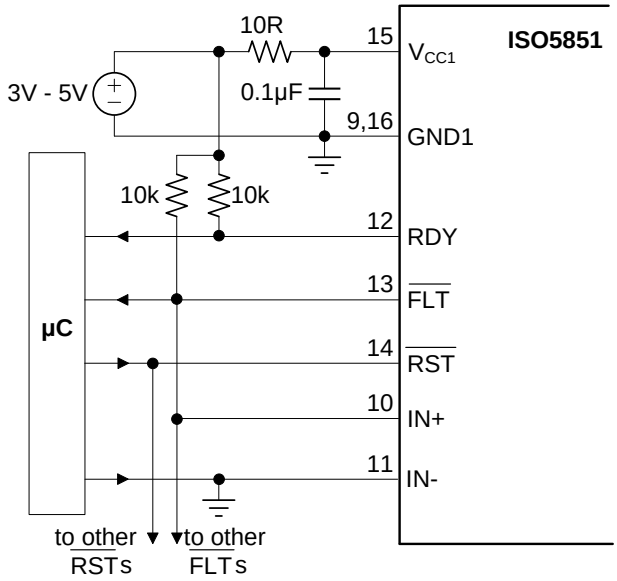


Figure 23. Global Shutdown with Inverting Input Configuration

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.

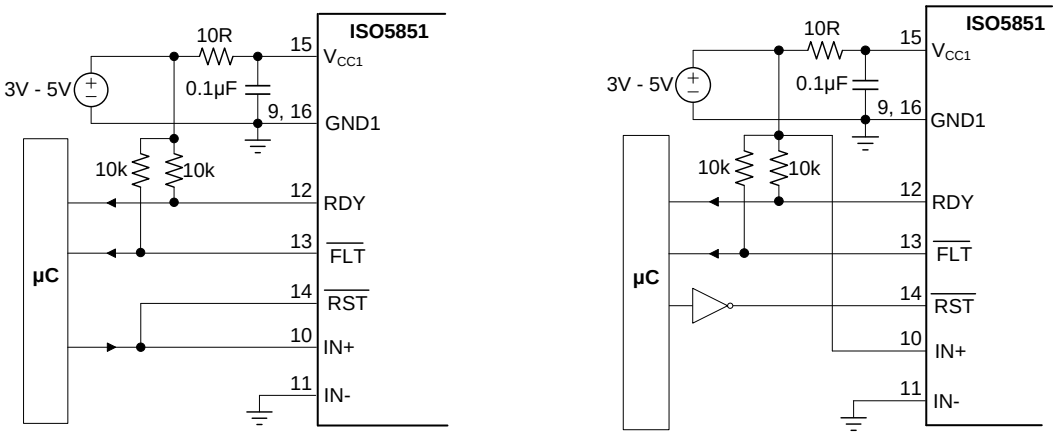


Figure 24. Auto Reset for Non-inverting and Inverting Input Configuration

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.

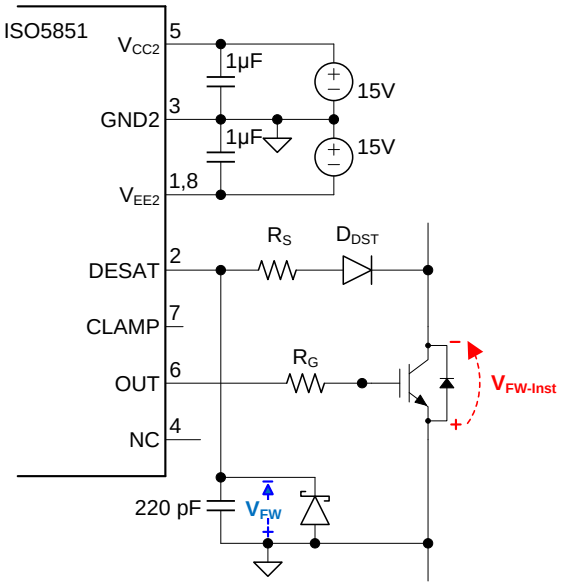


Figure 25. DESAT Pin Protection with Series Resistor and Schottky Diode

10.2.2.8 DESAT Diode and DESAT Threshold

The DESAT diode's function is to conduct forward current, allowing sensing of the IGBT's saturated collector-to-emitter voltage, V_{CESAT}, (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, there is commonly a high dV_{CE}/dt voltage ramp rate 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: $V_{CE\text{-}FAULT(TH)} = 9\ V – n \times VF$ (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, $P_{OD\text{-}max}$

The ISO5851 maximum allowed total power consumption of $P_D = 272$ mW consists of the total input power, P_{ID}, the total output power, P_{OD}, and the output power under load, P_{OL}:

$$P_D = P_{ID} + P_{OD} + P_{OL} \quad (1)$$

With:

$$P_{ID} = V_{CC1\text{-}max} \times I_{CC1\text{-}max} = 5.5\ V \times 4.5\ mA = 24.75\ mW \quad (2)$$

and:

$$P_{OD} = (V_{CC2} – V_{EE2}) \times I_{CC2\text{-}max} = (15\ V – (–8\ V)) \times 6\ mA = 138\ mW \quad (3)$$

then:

$$P_{OL} = P_D – P_{ID} – P_{OD} = 272\ mW – 24.75\ mW – 138\ mW = 109.25\ mW \quad (4)$$

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

$$P_{OL\text{-}WC} = 0.5 \times f_{INP} \times Q_G \times (V_{CC2} – V_{EE2}) \times \left(\frac{r_{on\text{-}max}}{r_{on\text{-}max} + R_G} + \frac{r_{off\text{-}max}}{r_{off\text{-}max} + R_G} \right) \quad (5)$$

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: 4Ω
- $r_{off\text{-}max}$ = worst case output resistance in the off-state: 2.5Ω
- R_G = gate resistor

Once R_G is determined, Equation 5 is to be used to verify whether $P_{OL\text{-}WC} < P_{OL}$. Figure 26 shows a simplified output stage model for calculating $P_{OL\text{-}WC}$.

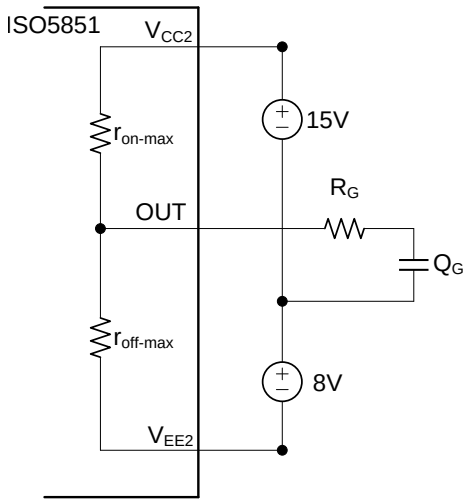


Figure 26. Simplified Output Model for Calculating P_{OL-WC}

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 (6)

Applying the value of the gate resistor R_G = 10 Ω.

Then, calculating the worst-case output power consumption as a function of R_G, using Equation 5 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

$$P_{OL-WC} = 0.5 \times 20\ \text{kHz} \times 650\ \text{nC} \times (15\ \text{V} - (-8\ \text{V})) \times \left(\frac{4\ \Omega}{4\ \Omega + 10\ \Omega} + \frac{2.5\ \Omega}{2.5\ \Omega + 10\ \Omega} \right) = 72.61\ \text{mW} \quad (7)$$

Because P_{OL-WC} = 72.61 mW is below the calculated maximum of P_{OL} = 109.25 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 27) 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.

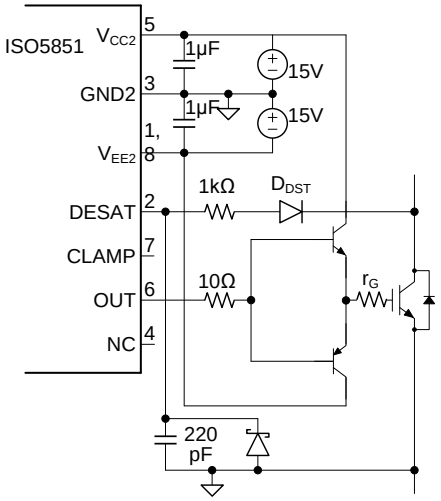
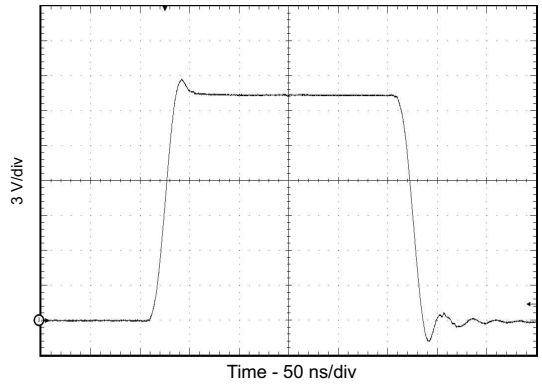


Figure 27. Current Buffer for Increased Drive Current

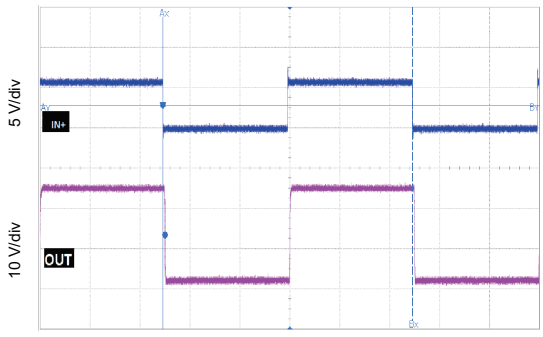
10.2.3 Application Curve



C_L = 1 nF R_G = 0 Ω

V_{CC2} - V_{EE2} = V_{CC2} - GND2 = 20 V

Figure 28. OUT Transient Waveform



C_L = 10 nF R_G = 10 Ω

V_{CC2} - V_{EE2}= 23 V GND2 - V_{EE2} = 8 V

Figure 29. Normal Operation-Bipolar Supply

11 Power Supply Recommendations

To ensure reliable operation at all data rates and supply voltages, a 0.1-µF bypass capacitor is recommended at input supply pin V_{CC1} and 1-µF bypass capacitor is recommended at output supply pin V_{CC2}. The capacitors should be placed as close to the supply pins as possible. Recommended placement of capacitors needs to be 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 30). 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 OUT 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 more detailed layout recommendations, including placement of capacitors, impact of vias, reference planes, routing etc. see Application Note SLLA284, *Digital Isolator Design Guide*.

12.2 PCB Material

Standard FR-4 epoxy-glass is recommended as PCB material. FR-4 (Flame Retardant 4) meets the requirements of Underwriters Laboratories UL94-V0, and is preferred over cheaper alternatives due to its lower dielectric losses at high frequencies, less moisture absorption, greater strength and stiffness, and its self-extinguishing flammability-characteristics.

12.3 Layout Example

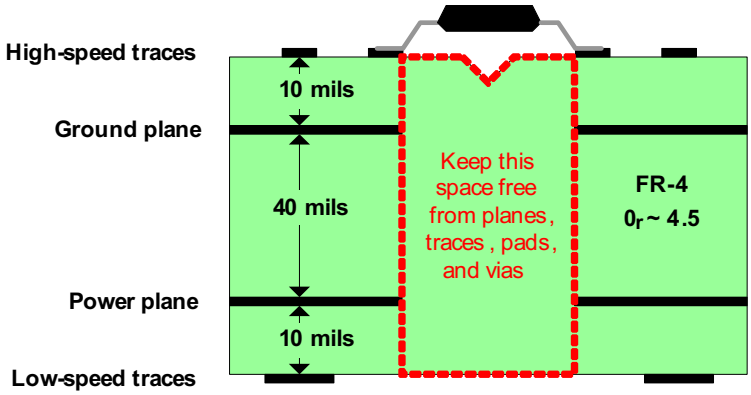


Figure 30. Recommended Layer Stack

13 Device and Documentation Support

13.1 Documentation Support

13.1.1 Related Documentation

For related documentation see the following:

- *ISO5851 Evaluation Module (EVM) User's Guide*, SLLU218
- *Digital Isolator Design Guide*, SLLA284
- *Isolation Glossary* (SLLA353)

13.2 Community Resources

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

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

13.3 Trademarks

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13.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

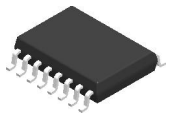
13.5 Glossary

SLYZ022 — *TI Glossary*.

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

14 Mechanical, Packaging, and Orderable Information

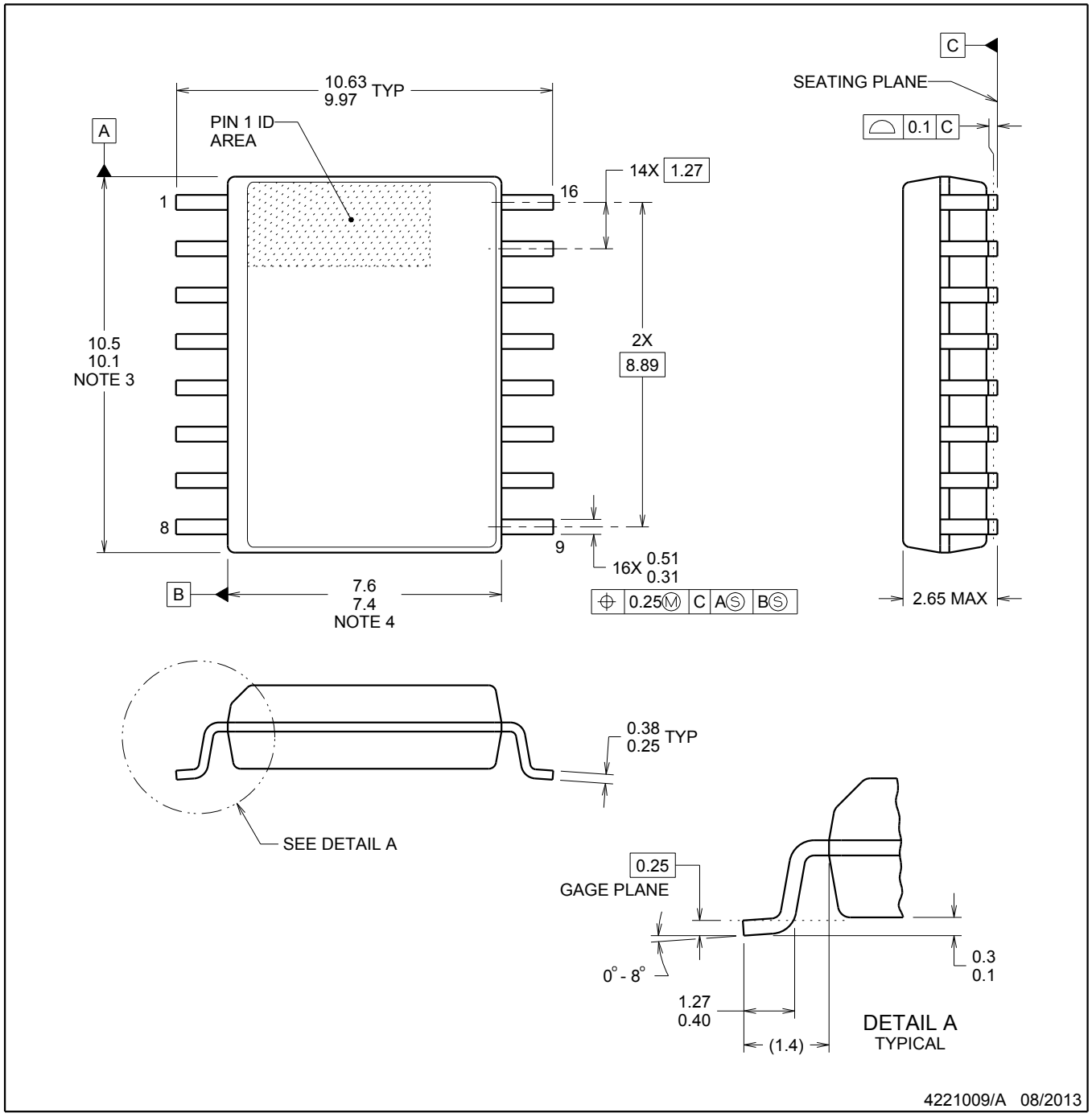
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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



DW0016B

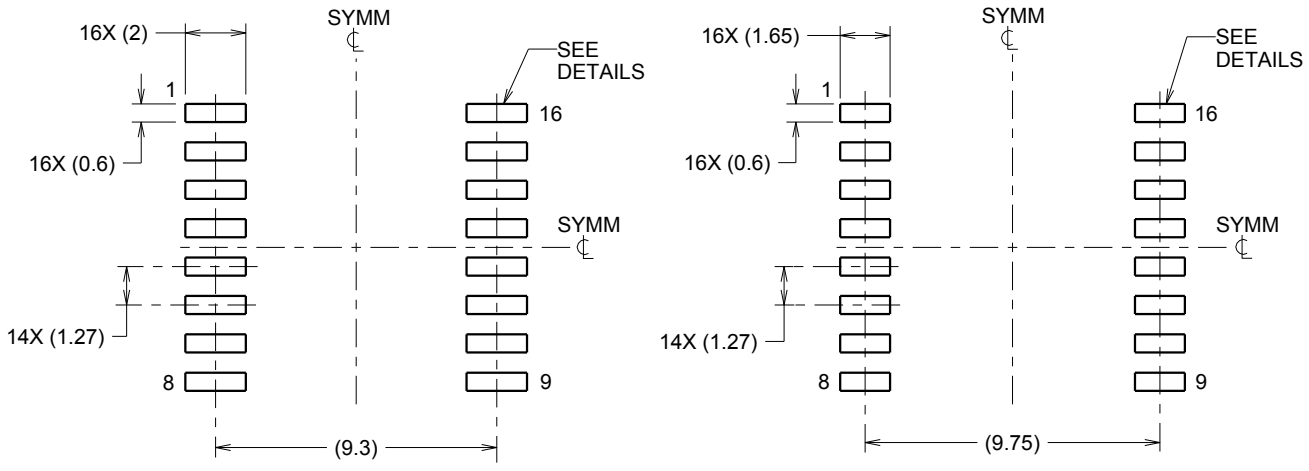
SOIC - 2.65 mm max height

SOIC



NOTES:

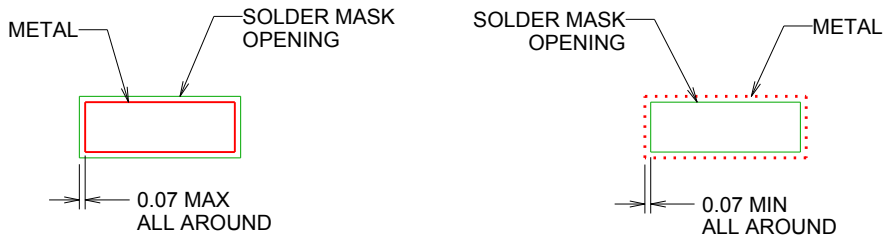
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate 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 MO-013, variation AA.



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/A 08/2013

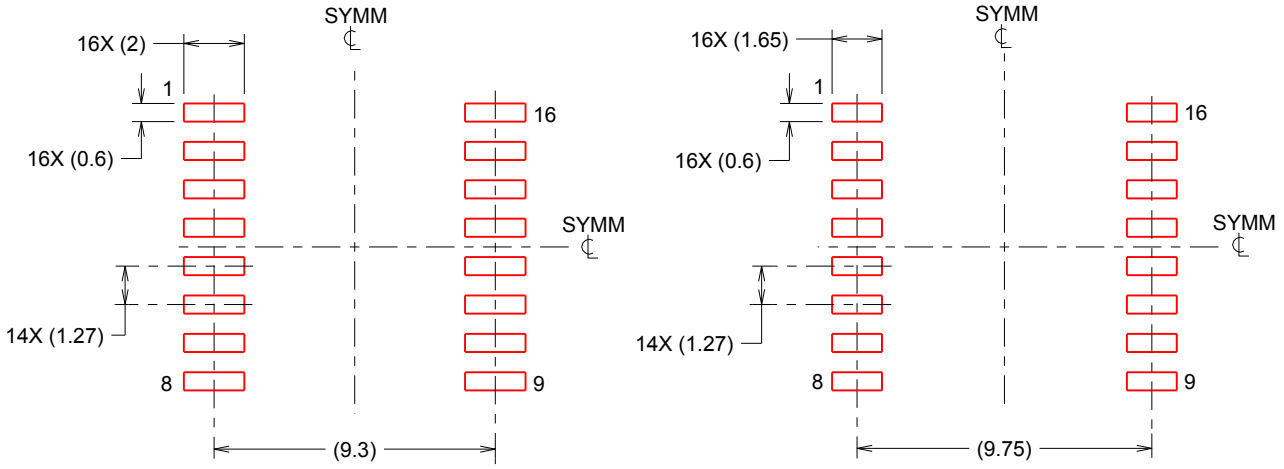
NOTES: (continued)

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

DW0016B

SOIC - 2.65 mm max height

SOIC



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/A 08/2013

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.

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
ISO5851DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	ISO5851	Samples
ISO5851DWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	ISO5851	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.

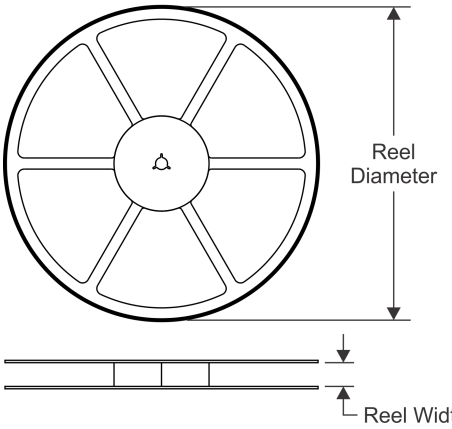
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(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.

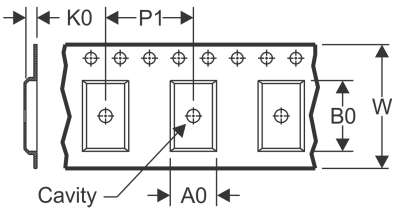
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

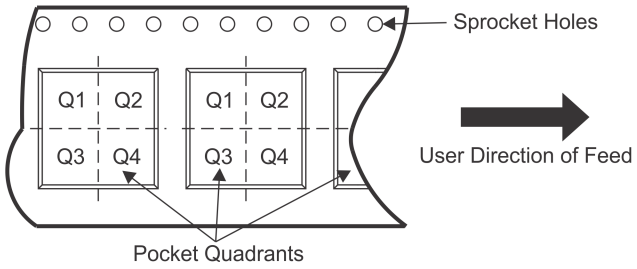


TAPE DIMENSIONS



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

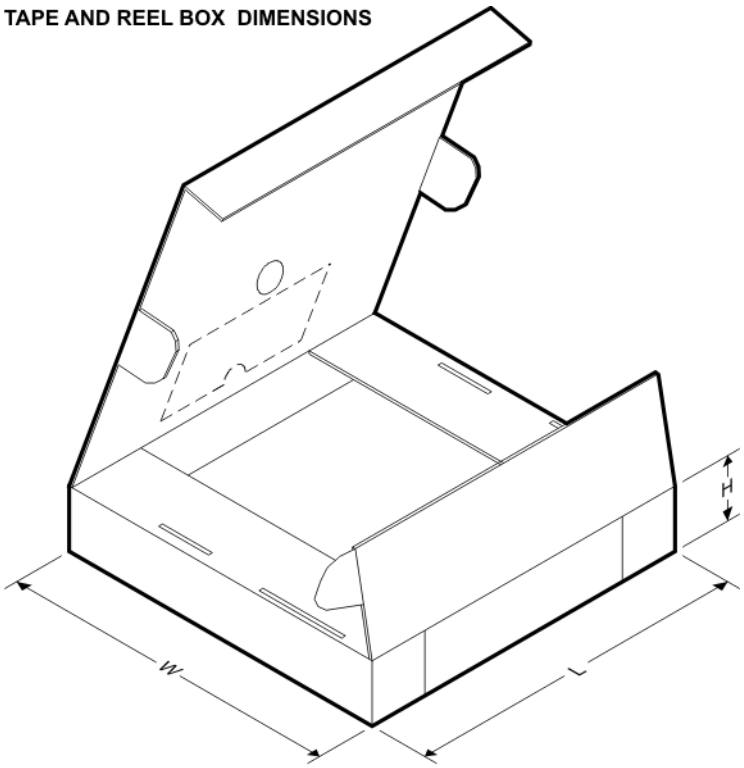
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ISO5851DWR	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)
ISO5851DWR	SOIC	DW	16	2000	367.0	367.0	38.0

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